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Scientific Director . . . . . James E. Andrews  
Editor . . . . . C.J. Fox

## ACOUSTICS

**Elastic Wave Propagation Meeting . . . . . David Feit 1**

Selected presentations given at this meeting, held in March 1988 in Galway, Ireland, are reviewed. Topics include: surface waves, wave propagation in layered and bounded media, fluid/solid wave interaction, scattering of elastic waves, general theory of elastic wave propagation, and magnetoelastic wave propagation.

## AERONAUTICS

**Aeronautical Research at CERT, Toulouse, France . . . . . Daniel J. Collins 5**

This article discusses the fluid mechanics, control theory, and computer science research which is taking place in the Centre d'Etudes et de Recherche de l'Espace (CERT), in Toulouse. Since Toulouse is both the educational and industrial center for aeronautic research in France, the discussion involves a good basis for evaluating the quality of French work in these areas.

## BEHAVIORAL SCIENCES

**The First Joint Meeting of Portuguese and Spanish Social Psychology:  
A Conference Sponsored by the Office of Naval Research, London . . . . . William Crano 10**

This meeting, a landmark event for Iberian social psychology researchers, was held at Tomar, Portugal. The sessions concerned: epistemological questions, basic social psychological questions, and applied social psychology. The author sees this new cooperation between the Spanish and Portuguese research communities as a promising sign of a productive future for their work.

**Management of Combat Stress: Recent Developments in  
Israel and England . . . . . William Crano 17**

Studies of combat stress by Major Zahara Solomon are reviewed and highlights of the results given. The relevance of the studies to the recognition by other countries of the importance of the combat stress problem is shown by a brief discussion of the function and objectives of the British Field Psychiatric Teams.

## BIOLOGICAL SCIENCES

**Biochemistry Conference: Ion Channels as Drug Targets . . . . . Claire E. Zomzely-Neurath 20**

Topics at this conference, held in London, UK, were: ionic channels as targets for drug action, potassium channel blockers and neuronal function, smooth muscle potassium channel openers, ligand

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interactions at the calcium channel, electrostatic models of ion channels and pumps, molecular approaches towards the understanding of the GABA receptor, a chemically gated ion channel, role of membranes in cataracts of the lens. These topics are briefly summarized.

## CHEMISTRY

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An overview of the papers presented at this meeting, held at Cambridge, UK, is given. Topics include postharvest decay, biodeterioration of timber (and its prevention), biofilms, hydrocarbons, plastics and rubber, marine structures, and preservation of museum and archive material.

## CONTROL SYSTEMS

- Nonlinear System Theory at France's Laboratoire des Signaux et Systems . . . . . Daniel J. Collins 27**

The discussion of this laboratory, located at Gif-Sur-Yvette, concentrates on the work of the Systems Division, particularly on the nonlinear and modeling and control group. The author observes that the new approach of differential algebra introduced by the Division's M. Fliess into nonlinear system and control theory is a major advance that should lead to a renovation of the entire field.

## MATERIAL SCIENCES

- Materials Meeting in Bordeaux: EXPERMAT '87 . . . . . Louis Cartz 29**

A very wide-ranging conference on materials was held in France. Hard materials are being sought from compounds having crystal structures similar to WC. Levitation methods of crystal growth are described to provide pure high-temperature materials. Ferroelectric compounds containing bismuth, are being investigated over a wide range of cation substitutions.

- Ceramics at EXPERMAT '87 . . . . . Louis Cartz 32**

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## MECHANICS

- Fluid Mechanics Research at IMST, Marseille, France . . . . . Daniel J. Collins 34**

Fluid mechanics research efforts at the St. Charles and Luminy laboratories of France's Institut de Mécanique Statistique de la Turbulence (IMST) are reviewed. The work ranges from several concerns in aerodynamics applications of the research to hydrodynamics – particularly the mechanics of wind/wave interaction in the sea. This hydrodynamic work is heavily bolstered by the Luminy laboratory's unique wind-wave facility.

- Turbulence and Fluid Mechanic Calculations at the University of Paris Sud . . . . . Daniel J. Collins 36**

Two aspects of the research at the Laboratoire d'Analysis Numerique are reviewed: turbulence and numerical analysis. The author concludes that R. Temam and his group are doing very innovative work in turbulence. That work is discussed in some detail.

**The Combustion Research Laboratory at Marseille . . . . . Daniel J. Collins 38**

Combustion research at this laboratory is mainly focused on problems concerning turbulent flame fronts. The analytical, experimental, and numerical methods employed are briefly discussed.

**PHYSICS**

**Photon-Localization, Detection, Amplification, and Antibunching:  
an ONRL Supported Workshop . . . . . Paul Roman 39**

In January 1988, the Office of Naval Research Branch Office, London, sponsored an international workshop in Italy with the title given above. (The workshop preceded a NATO Institute on squeezed and nonclassical light.) This paper reviews the invited talks, which can be grouped as follows: (1) basic aspects of nonclassical light [2 talks], (2) selected nonclassical phenomena [4 talks], (3) localization, detection, amplification [3 talks].

**Young British Scientist Proposes Sophisticated Research in Molecular Physics . . . . Paul Roman 41**

Recently concluded and planned experiments are described which are based on static Kerr effect dispersion-spectroscopy, optical Kerr effect studies, and both electric and magnetic resonance molecular beam spectroscopy. These advanced techniques are used to measure with great precision molecular parameters, such polarizabilities and dipole moments in excited states, and transition moments. Also, structure of aqueous solutions and electromagnetic properties of metal-metal or metal-nonmetal clusters are amenable to the proposed research.

**Optronic '88 in Hannover . . . . . Paul Roman 43**

This is a very brief review of a few presentations in laser metrology and in lasers in communication and computing that were given at the meeting held in April 1988 at Hannover, West Germany.

**Optimal Structures and Slaving: An ONRL- Supported Seminar Session . . . . . Paul Roman 44**

At a very small seminar in the Tirolean mountains, questions in the area of synergetics, with an emphasis on heterogeneous systems, were discussed in depth.

**SUPERCONDUCTIVITY**

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on Superconductivity . . . . . Alan F. Clark 46**

This meeting, held in March 1988 at Interlaken, Switzerland, is summarized by a discussion of the highlights of the conference and a separate review of selected papers.

**New Magnetic Materials . . . . . Alan F. Clark 48**

The lectures given at this 1-day conference on new magnetic materials, held in April 1988 at London, England, are briefly reported.

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# ACOUSTICS

## Elastic Wave Propagation Meeting

by David Feit. Dr Feit is the Liaison Scientist for Acoustics and Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until January 1990 from the David Taylor Research Center, where he is a research scientist in the Ship Acoustics Department.

A Symposium on Elastic Wave Propagation was held at University College in Galway, Ireland, 20 through 25 March 1988. The symposium was organized under the auspices of the Royal Irish Academy and University College, Galway, and sponsored by the International Union of Theoretical and Applied Mechanics, the International Union of Pure and Applied Physics, and the US Office of Naval Research. The objective of the meeting was to exchange information and assess progress achieved in our understanding of linear and nonlinear elastic wave propagation over the past decade. A similar meeting on this subject was held in 1977 at Northwestern University in Evanston, Illinois. An IUTAM Symposium on Elastic Wave Propagation and Ultrasonic Nondestructive Evaluation is planned for next year at the University of Colorado at Boulder, Colorado.

The meeting attracted a wide-ranging, fairly large number of international investigators. There were over 120 participants from 22 different countries. More than 25 percent of the attendees were from the US., about 15 percent from the UK, and about 10 percent each from France, the Republic of Ireland, and the Netherlands. The remainder came from other countries in Europe, the Americas, Asia, and Australia. A total of 97 talks were presented orally, 28 of which were given in two poster sessions. There were seven invited lectures presented by individuals well known in their particular areas of specialization. Generally, each of these talks was scheduled to start off the session devoted to the related specialized topic. The session topics were: surface waves, nonlinear elastic waves, wave propagation in layered and bounded media, fluid/solid wave interaction, scattering of elastic waves, general theory of elastic wave propagation, and magnetoelastic wave propagation. In addition, there was a special overview session, chaired by A. Tucker of ONR, Washington, entitled "Wave Propagation in Complex Systems." The meeting program contained abstracts of each of the papers presented. The proceedings of the meeting, containing the written version of all papers including those presented in the poster sessions, will be published by (Professors M.F. McCarthy and M. Hayes as editors) Elsevier, North Holland, and should be available by November 1988.

Since there were no parallel sessions, I was able to attend all the sessions. A selective discussion of some of the

sessions and papers most relevant to structural acoustics now follows:

### Surface Waves

P. Chadwick (University of East Anglia, Norwich, UK) reviewed recent developments in surface wave theory, especially those developed as a result of utilizing the approach developed by D.M. Barnett (Stratford University, California) and J. Lothe (University of Oslo, Norway), which was based on earlier work of Stroh. This approach allowed one to establish the existence and uniqueness, and determine the properties of surface waves in anisotropic elastic media. The theory has been recently refined, freeing it from its dependence on an analogy between surface and line dislocations.

Further progress in algebraic manipulations has been achieved by virtue of the introduction of a surface impedance tensor. The theory has been generalized to surface waves in a prestrained semi-infinite elastic body, and finally, a systematic approach has been developed to determine the nature of surface waves in bodies with cubic and transverse isotropy. The characteristics of surface waves are exploited in the development of microelectronic devices.

Solid-state and microelectronics technologies make wide use of microscopically sized structural elements in the form of thin films of materials such as polycrystalline silicon, silicon nitrides, etc. In the manufacture of such films a relatively large component of in-plane stress is induced. G.C. Johnson (University of California, Berkeley, California) discussed the influence of such stress on wave speeds in these films. The material studied is characterized by a cubic strain energy function, and he finds that the flexural wave speed is effectively increased while there is little effect on the extensional wave speed.

This session also had two of the few symposium papers devoted to experimental investigations. One was presented by H.P. Rossmannith (Technical University of Vienna, Vienna, Austria). He used a photomechanical shadow-spot technique to show the shape and intensity of a Rayleigh wave caustic formed in a thin plastic plate impacted by an edge force. By comparing measurements and calculations one can determine the contact force without a sensor at the contact point.

E. Dieulesaint (Laboratoire d'Acoustoélectricité, Paris, France) reviewed experimental techniques, especially optical, that can be used to measure surface displacements on the order of 1 Angstrom. A probe having a resolution of 1 tetra-Angstrom/Hz<sup>1/2</sup> using interferometry techniques was described. Other techniques using piezoelectric and photothermal methods were also discussed. Some skepticism was expressed by a member of the audience regarding the resolution capabilities of the interferometric device.

### Wave Propagation in Layered and Bounded Media

In an invited lecture J.J. McCoy (Catholic University of America, Washington, DC) discussed the basis of a method for propagating acoustic waves in a range- and depth-dependent sound channel. The method, called wavefield factorization, constructs a governing equation for a one-way propagating field in the form of a phase path space integral. The discretized form of this integral can be used to construct the numerical algorithm for calculating or marching the field into the domain of the range-dependent sound speed. McCoy talked about the difficulties in the factorization method when applied to the linear elastodynamics wave problem, and, finally, presented some results of a numerical study on the accuracy of the method as applied to the acoustic problem.

L. Felsen (Weber Research Institute, New York City), who played a large illuminating role in the meeting with his probing questions and discussion, presented a paper by himself and coworkers related to the propagation of a beam-shaped waveform in a multilayered aluminum plate. Felsen used this problem to show the utility of characterizing the input in terms of a self-consistent hybrid beam-mode representation. This field interacts with a weak debonding flaw and is tracked as it is scattered by the flaw. The resultant displacements are examined to find those characteristics which are related to flaw features such as location and type.

During the course of the meeting Felsen consistently advocated the early identification of an appropriate physical observable that is to be calculated or examined in any given problem. This initial identification allows one to choose the mathematical strategy best suited for the problem at hand.

An impressive display of numerically generated results was presented by F.B. Jensen (SACLANT ASW Research Center, LaSpezia, Italy), who dealt with the reflection of bounded acoustic beams from a thin surface layer overlaying a homogeneous elastic half space. For a high-velocity surface layer, the Rayleigh wave generated at the interfaces becomes "double leaky"—i.e., energy leaks back into both the half space beneath the layer and the fluid overlying the layer. The solution was displayed

using color graphics, and it was shown that the thickness of the layer could be determined from the reflectivity characteristics. I found it interesting that this paper was just about the only paper that made extensive use of a computer in both the solution phase and in the final presentation of results.

In one of a number of papers on scattering of transient elastodynamic waves by flaws in elastic media, B.J. Kooij (Delft University of Technology, the Netherlands) sought an exact analytic space-time solution for the canonical problem of a finite crack in an elastic half space. The crack is oriented parallel to the free surface of the solid, and the problem is reduced to the solution of a matrix Wiener-Hopf equation. An iterative scheme reduces the problem to a series of problems previously solved. A modified version of the Cagniard-DeHoop method is used for each iterate to yield an exact expression for the transient solution valid for a limited time.

### Fluid/Solid Wave Interaction

One of the canonical problems of structural acoustics is that of two structurally dissimilar coplanar plates connected on their edges. The manner in which the edges are joined gives rise to a number of different joint conditions. P. Brazier-Smith (Topexpress Ltd., Cambridge, England) has pursued this problem using a numerical integration in the complex plane. The scattered waves are strongly influenced by the joint conditions and the relative thicknesses of the plate. This solution will prove to be very useful and has direct applications to naval-related problems. A more detailed version of this paper has been published (Brazier-Smith, 1987).

M. Piau (Institute de Méchanique de Grenoble, Domaine Universitaire, France) together with a coworker investigated the vibrations of a point-impacted infinite elastic plate in a fluid medium. This problem was motivated by an industrial problem directed to the detection of cavitation in a flowing fluid. The classical solution for a plate excited by a time harmonic point source was extended to the case of transient excitation, and the analytical results obtained were compared to experimental measurements. The comparison was not as good as expected, and Piau said that the reasons for the differences have not yet been determined.

### Scattering of Elastic Waves

A survey paper on acoustic scattering from submerged elastic bodies was presented by G.C. Gaunard (Naval Surface Weapons Center, White Oak, Maryland). This paper, rather than being a general overview, concentrated on the work done by Gaunard and his collaborators. Their work concerns scatterers whose geometric configurations conform to separable boun-

aries for the Helmholtz equation and, where elastic scatterers are involved, the elastodynamic equations. The approach Gaunard used has come to be known as the "resonance scattering theory." In it the classical forms of the solutions, which in these cases are all well known, are manipulated into a form where the scattered field is an additive combination of that which comes from a background term (i.e., the solution to the problem of either a rigid scatterer or a "pressure release,  $p=0$  on the boundary" type) and whatever is left over. When one identifies the frequencies at which the latter term is a maximum, they are referred to as resonance frequencies. Experimental results that are in good agreement with the theoretically derived resonance results were shown to validate the analytics.

A. deHoop (Laboratory for Electromagnetic Research, Delft, the Netherlands) talked about time domain reciprocity theorems for elastodynamics in media with relaxation. The theorem allows one to use a computationally generated solution to generate the field for a desired problem which may be less amenable to computational techniques. Applications of this theorem to inverse source and inverse constituency (determination of properties) is suggested. In another paper presented by H.J. Stam the interrelation between reciprocity and the finite element method is investigated.

In two papers presented by P. Olsson and colleagues (Chalmers University of Technology, Göteborg, Sweden) the "null field" approach, first introduced by P.C. Waterman for electromagnetic scattering problems and now extensively developed for acoustic and elastodynamic problems, was applied to a nonplanar crack problem and to scattering from an inclusion with a thin interface layer. This null field technique was extensively reported on in the first elastic wave propagation meeting mentioned in the introduction to this report, and now is a tool that has been implemented at a number of institutions, both in Europe and the US.

In an invited presentation, J. Coronas (Ames Laboratory, Iowa), discussed the one-dimensional inverse scattering problem for both elastic and viscoelastic media. The problem is most conveniently treated in the transient domain using the wave splitting and invariant imbedding techniques. Although not explicitly stated, wave splitting is akin to the factorization technique discussed by McCoy in an earlier session. Transient reflected and transmitted wave characteristics for a sample problem of a stratified medium were used to determine the material property profiles by the inverse techniques. The calculations were performed without additive noise present in the synthesized data. A question remains as to the applicability of the techniques to multidimensional problems.

A. Beltzer (University of Alberta, Edmonton, Canada) considered wave propagation in composite media where they are distributed randomly in the host

medium. This is by now considered to be a rather classical problem, but Beltzer points out some of the difficulties with the usual approaches, such as static effective moduli or configurational averaging theories. He formulates the problem in terms of the "generalized extinction cross section," which is related to the total energy withdrawn from the incident beam by a single inhomogeneity. This accounts for both the energy absorbed as well as scattered by the inclusion. For a dilute mixture the effect of the inhomogeneities is then related to the attenuation coefficient. This is combined with the Kramers-Kronig relations to find the effective wave velocity, as a function of frequency. Random media with multiple scattering effects included are treated by developing an evolution equation for the total attenuation. Classical transform techniques can then be used with the frequency-dependent wave number developed in Beltzer's work.

### General Theory of Elastic Wave Propagation

The introductory lecture for this session was given by A.N. Norris (Rutgers University, New Jersey), who discussed the use of Gaussian wave packets (GWP) to model wave propagation in anisotropic elastic solids. The GWP is localized about a central point which propagates along a ray, and its space/time dependence follows from a ray equation. The local variations are described by an envelope tensor. This tensor is directionally dependent in anisotropic media, and examples of its behavior were shown for transversely isotropic, fiber-reinforced materials.

A number of other papers in this session were devoted to elastic wave propagation in anisotropic media and, in addition, one paper on coupling effects and another on the use of characteristics for multidimensional wave propagation. The latter paper, by M. Ziv (Center for Technical Education, Holon, Israel), uses the theory of characteristics and shows how a multidimensional problem requires two additional steps compared to the usual application of characteristics to one-dimensional problems. One is the extension to the theory of the possibility of strong discontinuities, and the other is that the numerical integration along the characteristics must be confined to the region of influence determined by the boundary input. Professor Ziv strongly advocated the use of characteristics throughout the meeting, making several pleas for their use during the special session.

The paper on coupling effects, presented by M. Sayir (Swiss Federal Institute of Technology, Zurich, Switzerland), discussed both the theoretical and experimental aspects of three problems. These were: reflection and transmission of flexural waves at the right angle corner of a unidirectionally fiber-reinforced beam, elastic impact of spherical objects on shells, and elastic-plastic impact on a rectangular clamped frame perpendicular to its plane.

## Magnetoelastic Wave Propagation

This was the last session of the symposium. H. Tiersten (Rensselaer Polytechnic Institute, Troy, New York) gave the lead-off lecture, in which he discussed electroelastic nonlinearities, biasing deformations, and piezoelectric vibrations. He showed that there is an intrinsic nonlinearity in the equations of motion for a deformable insulator in the presence of a quasi-static electric field bias. The linear piezoelectric equations pertain only in the absence of a bias. The nonlinearity is also significant even in the case of a stress-free thermal deformation, which is a fairly ubiquitous situation. An accurate calculation of the temperature dependence of high-precision quartz resonators is more easily obtained by using reference coordinates which pertain only in the nonlinear formulation. Tiersten also described both the very accurate asymptotic equations for the transverse thickness modes used in high-precision contoured quartz crystal resonators, and the very important phenomenon of energy trapping – useful in technological applications.

The final paper of this session, which treated the dielectrics with a polarization gradient, was given by J.P. Nowacki (Polish Academy of Sciences, Warsaw, Poland). The general equations governing such problems were presented and then the fundamental solutions derived by using the Helmholtz decomposition and the Laplace-Fourier transform.

## Overview Session: Wave Propagation in Complex Systems

This session, chaired, as stated above, by A. Tucker, consisted of a panel of speakers who made some introductory comments; then the floor was opened up to the general audience. The panel members were L. Felsen, J.J. McCoy, R. Burridge (Schlumberger-Doll Research Center, Richfield, Connecticut), F. Ziegler (Technische Universität Wien, Vienna, Austria), and D.F. Parker (University of Nottingham, UK). Each of the speaker's comments seemed understandably to be an advocacy of the need to solve problems specific to his own field of specialization. One would have hoped first for a discussion of what is meant by a "complex system" and then a catalog of problems and approaches to solutions or understanding for such situations.

Felsen pleaded for "parametrization in terms of observables," which I understand to be the identification of alternate variables or combination of variables which can be most easily or efficiently determined and validated in any given problem. Test problems for which numerical solutions can be determined and compared to experimental results are to be sought after. McCoy, in his discussion relative to complex systems, talked about two frequency regimes and the different approaches to them that can be

used. In the low-frequency range, the modal approach is most useful and in this case the dependent variables are global in nature; in the high-frequency regime the solutions are local in nature and therefore most appropriately considered in terms of traveling waves.

In his discussion, Burridge stressed inverse problems. The approach that he introduced was the solution of the direct problem and then iteration to find the parameter values that yield solutions that are closest to the measurements. He also suggested that canonical problems should be attacked and if need be numerical solutions determined for problems which are intractable by analytical means. With regard to numerical solutions he mentioned "stiff systems" – i.e., those system with widely differing wave speeds. The approach he recommended was to account for the slow waves in an analytic manner and then discretize with respect to the fast waves.

Fundamental problems in seismology were discussed by F. Ziegler, with specific mention of the source characterization problem such as the "stick-slip mechanism" and wave guide transmission in anisotropic, and spatially inhomogeneous media.

While most of the previous discussions addressed linear phenomena, Parker devoted his remarks to a discussion of nonlinear wave phenomena. Since there are very few general procedures available for nonlinear problems most of the problems solved are "technique driven." He briefly discussed the generation and modulation of harmonics by nonlinearities.

There was a great deal of discussion from the audience on the subject of linear-wave versus nonlinear-wave propagation and the relative significance of each. The consensus was that linear theories should not be completely neglected in the quest for solutions to the less widely understood nonlinear models; i.e., there is still a wide spectrum of linear problems deserving of attention. Another interesting and now familiar notion arising from the audience was the idea that computational solutions can inspire new analytical developments. An example cited was that of the discovery of the "soliton."

The special session was adjourned after 6:00 p.m. in deference to the Symposium Dinner that was to be held that evening.

## Conclusion

This extremely well-organized conference demonstrated once again the continual progress being made in our understanding of wave propagation in complicated media due to anisotropies of the media, complications of the boundary surfaces, geometric and material nonlinearities, etc. I was somewhat surprised by the relatively small number of papers devoted to computational solutions, as was also the case for papers based on experimental measurements. Although many of the par-

ticipants were from the US, it was gratifying to note the wide range of countries in which significant progress in elastic wave propagation is being made.

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6/11/88

# AERONAUTICS

## Aeronautical Research at CERT – Toulouse, France

*by Daniel J. Collins. Dr. Collins was the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He has now returned to the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.*

Toulouse is the center for aeronautical research in France. My visit to the area was confined to the Centre d'Etudes et de Recherches de Toulouse (CERT), which is the research laboratory associated with l'École Nationale Supérieure de L'Aéronautique et de l'Espace (ENSAE), commonly called SUP'AERO. CERT is also a part of Office National d'Etude et de Recherches Aérospatiales (ONERA). In 1968, under the direction of Dr. M. Pelegrin, SUP'AERO was transferred to Toulouse, from Paris and, at the same time, CERT was established as its research laboratory. Pelegrin stated that he modeled the institutional relationships between the school and research laboratory on what he had seen in the Boston area when he worked there in the early part of the 1960's. At one time Pelegrin directed both the SUP'AERO and CERT but now he is director of CERT. There is strong emphasis on the school-laboratory relationship, and many of the researchers at CERT also teach as part of their duties at SUP'AERO. This type of relationship produces superior research wherever it is found. About one-third of the support of CERT is in the form of direct funding from the government and the other two thirds comes from government and industry contracts.

The instructional program at SUP'AERO, which has a yearly input of about 170 students, consists of the last 3 years of a 5-year program leading to a degree of Diploma Engineer. A further year of speciality can lead to a diploma of specialization or M.S., while still a further year—matched with 2 to 4 years of research—leads to a Ph.D. CERT has each year some 60 "Docteur-Ingenieur" students who are accepted at the center in order to carry out a research program which lasts 2 to 3 years. In addition, third-year students of ENSAE perform end-of-study projects of 3-month duration. Since the staff of CERT numbers a total of over 350 (with about 210 engineers and

technicians) it can be seen that the student researchers are an important part of the research effort. CERT is divided into seven technical departments (acronyms in parentheses):

- Aerothermodynamics (DERAT)
- Automatic Control (DERA)
- Computer Science (DERI)
- Mechanics and System Energetic (DERMES)
- Microwaves (DERMO)
- Optics (DERO)
- Space Technology (DERTS).

I will give a detailed account of what I observed at the first four departments listed but will give only brief comments on the activities of the last three.

### DERAT

The aerothermodynamics department is directed by Dr. J. Cousteix and has about 30 members, of whom 18 are engineers and seven are engineering students. Research activities are divided into two main areas: fundamental research into viscous and turbulent shear flows, and techniques and test methods in transonic flows.

**Viscous and turbulent shear flows.** In the problem of laminar transition there have been four areas of investigation. One effort has been directed at the stability of compressible boundary-layer flows (Arnal and Vignau, 1987). This approach is based on the method of small perturbations as applied to the Navier-Stokes equations. Recent analysis has been directed at the study of the effect of a cold wall on boundary-layer flow at a high Mach number. By introduction of the notion of a generalized inflection point the lack of sensitivity of the stability of the boundary-layer to a cold wall at high Mach number is explained.

The effect of different types of three-dimensional disturbances (vertical cylinders) on transition on a flat plate at various angles of attack and over a Mach number range of 4 to 10 have been experimentally studied. Theoretical analysis has been made of Gortler instabilities with the construction of stability diagrams as a function of pressure gradient. In a series of experiments in the F2 subsonic tunnel at Fauga-Mauzac, measurements have been made of incompressible transition on swept wings. These experiments are intended to verify transition criteria developed at DERAT and involve the consideration of an intermittence factor. Further transition measurements have been made on large models in flight using temperature-sensitive films and infrared cameras placed on either side of the model.

Three-dimensional calculations and measurements have been made on strongly swept wings at large angles of attack, on flow around helicopter fuselages, and on a special test wing of the Groups for Aeronautical R&D in Europe (GARTEUR). This latter airfoil has been used by GARTEUR to test different calculation codes throughout Europe. Since one measure of the effectiveness of DERAT is their ability to transfer numerical codes developed in the center to industrial concerns, there is heavy emphasis on the publication of the numerical code work and its verification. Cousteix (1986) has reported on three-dimensional and unsteady boundary-layer calculations. Further work has concerned the calculation of the full Navier-Stokes flow about airfoil profiles and the detached flow in a canal with a descending step.

Real gas effects on hypersonic boundary-layers are being calculated for the Hermes aircraft. In the case of two-dimensional calculations, 11 different gas species are included in the calculations. For perfect gas calculations using the Navier-Stokes equations, comparisons have been made of the location of the shock wave and the boundary-layer in hypersonic flow.

Two other areas of investigation concerning boundary-layer are being investigated. The first involves unsteady boundary-layers which have been experimentally studied in pulsed flow over a flat plate, on an oscillating flat plate, and on an airfoil with an oscillating flap. In the second area the reduction of friction drag has been investigated by means of riblets applied to the entire 1/38 model of the A300 Airbus fuselage. Finally, there is a program on the effect of external manipulators on the boundary-layer.

Should there be further interest in any of the topics previously discussed I have an extensive bibliography on the work, although a good deal of it is in French.

**Techniques in Transonic Flows.** Experimental techniques in transonic flows that have been investigated have included laser velocimetry, adaptation and correction of wall configurations, study of boundary-layer growth, and

vibration of models in transonic flow. Most of these investigations have been in the department's cryogenic transonic wind tunnel, T2. T2 is an induction wind tunnel with an operating flow temperature from 100 to 120 K which is pressurized up to 5 bars and can reach Mach 1.1 in the test section. The cryogenic temperatures permit an augmentation of a factor of four to five in the Reynolds number. The tunnel has been recently fitted with computer-controlled adaptive walls but only in the vertical direction. In the most current experiment the wall and correction effects have been obtained for a half fuselage and swept wing model of the A310. The wall adaptation is based on a numerical simulation using three-dimensional singularities in a panel method.

Laser velocimeter measurements have been made in the transonic tunnel of the oscillations of a shock wave on a profile at Mach 0.72 and an angle of attack of 2 degrees. The output of a pressure transducer was used to partition the data into cycles of oscillation. The evolution of the boundary layer as a function of shock position was also obtained. As perhaps a continuation of this work there has also been an extensive investigation of flow-induced vibrations in transonic flow. In particular, the effect of Reynolds number on flow with vibrations has been investigated with a semifuselage swept model in the T2 tunnel.

## DERA

DERA's Automatic Control Department, directed by M. Labarrie, has a permanent staff of 32 and about 22 doctoral students. Foundation support represents 20 percent of the effort and the remaining 80 percent comes from contracts. There are three main axes for research in the department: control of vehicles and engines, robotics and the automation of production, and fundamental research and development of control methods and tools.

**Control of Vehicles and Engines.** DERA, in conjunction with l'Aérospatiale, has been working on the active control of the wing loading of the Airbus. Such a control would permit a lighter structural load for the aircraft and, thus, improved fuel consumption. A more detailed description of the nature of the work that DERA does with respect to the Airbus with some artificial intelligence overtones is given in a recent article by Pelegrin and Ziegler (1987). Pelegrin gives a nice review of current control methods such as flutter suppression, stability augmentation, and buffeting reduction as they apply to the A320 and future A330/340 models. With respect to the Gazelle SA 349 helicopter, DERA has developed a multicycle command system for vibration reduction. This work is now being extended to a global optimization of the rotor motion. Finally, in this area DERA is also engaged in an optimal analysis of aircraft traffic control.

Control activities are not limited to aircraft. For space systems DERA has developed a computer code – SMASP, presently being used in industry – which is used in the simulation of robotic and telemanipulators in space. There is also a project which is concerned with the complete automatization of space systems. At the request of the French Service Technique, the department has a large program in the modeling and control of marine engines. Similar to the air traffic control project there is a project on terrestrial vehicle control and traffic control in a large city – in this case Toulouse.

#### **Robotics and the Automation of Production.**

Through the Ministère de la Recherche, DERA has a global contract under the national robotics program, ARA (Automatization et Robotique Avancée). The program is effectively centered at DERA so that the department has contract lines with all the principal industries in robotics in France. Thus DERA is a center of excellence in robotics in France. As a result of this activity a new industrial concern has been created – MIDI-ROBOTS. Earlier work at DERA resulted in the creation of a painting robot for the Société AKR. Current robotic activity has been oriented toward the creation of machine-assembly robots with complex adaptive tasks involving multiprocessors and proximity sensors based on scanning laser beams. A new position-force grasping sensor has been developed which will be commercially used in a SCARA robot. The robot considers the task to be performed in terms of displacements and forces. Large displacements are decoupled from fine positioning which would be needed for precision assembling.

One can prescribe any force along with any displacement during fine positioning. This type of grasper has not previously been available, and the system is now being commercialized through a company in Toulouse. A further program with the Centre National d'Etudes Spatiales (CNES) has been started on the control of robots for flexible structures in space. Industrial projects include a feasibility study of a jet engine heat exchanger for MICROTURBO. Further industrial projects are the design of an assembly cell for Aérospatiale and the design of an end effector to learn deburring trajectories for the Dassault company.

In the area of automation of production, DERA has had a project with Renault since 1978 to develop a flexible automatic factory. Scheduling is a central problem in a flexible automatic factory, and a scheduling system computer code developed by DERA is now in industrial use by l'Aérospatiale de Bourges in one of its missile workshops where its use has given a significant increase in productivity. The computer code is particularly easy to use and can be implemented on a personnel computer (PC). This is one stage in the automatization of factories and is part of the European program EUREKA in

flexible manufacturing (the PARADI Project). As part of the development of flexible manufacturing computer codes DERA has found that artificial intelligence (AI) methods permit specialists in different areas of the production to modify and influence the chain of production. AI methods also permit a more general approach to different types of factories, automatic adaptation to changing configurations, and the characterization of the factory environment. Among the computer codes developed by DERA for production applications are PARSIFAL and OASYS, which are specific and object-oriented simulation software. OPAL, based on AI methods, is a computer code which is a knowledge-based provisional scheduling system. The simulation and scheduling of a paper factory for Papétères de CONDAT is a recent industrial application of such computer codes.

**Fundamental Research.** In the area of fundamental research and the development of analytic tools, DERA is investigating the use of AI methods in the obtaining of control-problem solutions. Since the command of flexible structures poses particular problems for control techniques DERA has developed a test facility, called SECAFLEX, where it can experimentally investigate effects caused by such variables as the location of sensors, location of actuators, imperfection of models, etc. on the control of flexible structures. More generally DERA is investigating eigenvector methods, command of non-linear systems, and robustness of complex systems. With respect to eigenvector methods, a computer code, EVAS (eigenvalues/eigenvectors assignment), has been developed, and recent application of the code has been to the design of a remotely piloted vehicle (Bsalis, 1987). From a theoretical viewpoint a recent series of papers on exact pole assignment using output feedback are quite interesting (Magni, 1987). Necessary and sufficient conditions are developed for the pole assignment using output feedback in which the number of inputs and outputs exceed the number of states. Several recent French books on the control of multivariable system, on numerical control, and on filtering and its application are the result of activity in this area.

#### **DERI**

DERI, the Computer Science Department, led by D. Vallette, has 60 people, of whom 37 engineers are engaged in research and 13 are doctoral students. Research is organized around five principal themes: information security, architecture of parallel computers, treatment of data bases, numerical analysis, and development of computer codes. The department also runs the central computer for CERT and SUP'AERO.

**Information Security.** Information security is a difficult problem, particularly with large network systems.

In France, for example, there is a single CRAY II in Paris which can be accessed by all the national laboratories in France. This type of system creates several security problems. Perhaps the first and by no means trivial problem is to insure that only authorized personnel use the system. (The gaining of access to a computer in the Pentagon by a hacker underlines the problem.) Within the system there can be a multilevel gradation in the security levels, with some calculations being on highly classified subjects and others on fairly mundane topics. At the lowest level there is, in any case, a desire to respect the mutual confidentiality of the users and to protect the users' files. DERI is considering a system approach to security with multilevel security considerations introduced at all levels. DERI will use AI methods to have the user prove his access authorization to the system and to the different security levels. Since an actual security system is being created rather than just studied there is little information now available on the details of the system.

**Parallel Computers.** Parallel computer architecture is being studied both from a hardware and a software viewpoint. One of what I considered the more interesting projects was that concerned with a European project on the development of supercomputer called MILORD (multiprocess interaction liaison optical reconfigurable dynamic). In most parallel systems there is a strong interaction between the hardware configuration and the corresponding software. Programming a transputer network is thus done in a special language called OCCAM (discussed fully in *ESN* 40-11/12:306-309 [1986]). A specific software language for each new hardware configuration is awkward to say the least. DERI and other parts of ONERA are studying a relatively massive (100 CPU's) parallel computer in which the connections of the system are reconfigurable dynamically by programization. Interconnections are by optical cable, thus the term, "liaison optic." The hardware realization of a reconfigurable computer is one problem, but an even more difficult problem is the appropriate programming of such a computer where the meaning of programming in this context extends to the language used. What is exciting about the project is that it focuses attention on the general concept of parallelism and thus could be a fertile source of new ideas not keyed into a specific hardware system. A prototype computer in VLSI is expected this year. The programming language for the system will be a functional language similar to LISP. DERI is working with industrial companies such as BULL and Thompson on this and other projects.

**Research for Data Base Management.** Work on the treatment of data bases has two aspects – those of deductive data bases and of AI data bases. One of DERI's projects concerned with deductive data bases is an ESPRIT project, called ESTIME, which is being done in cooperation with the Netherlands. A typical question of

this project is how to select from the data what is needed in response to a query. The response to a query could be a formula or maybe many formulae, rather than a list of objects. Many of the questions of this type are tested on a relational data base called SYNTEX.

**Expert Systems.** The first expert system developed in 1979 at DERI and written in PROLOG was called PEACE. Since then, emphasis has been on the development of tools to create expert systems quickly and efficiently. A complete software system for the development of expert systems, called SYLOG, has been developed and has been available since 1987. The program is written in a language which is combination of LISP and PROLOG and permits the development of knowledge bases and rules for expert systems. As with any program such as this it is difficult to judge the effectiveness of the software without having used it. I was told that several expert systems have been created, using elements of the system, for such industries as Aérospatiale, CNES, and Matra.

**Other Interests.** I will consider the last two directions of research together. With respect to numerical analysis, the major effort is in the application of the finite element method. Interestingly enough, although some analysis is being done with the Euler equations it appears that most of the effort is directed at Maxwell's equations with the practical application to radar signals. In the development of computer codes there are two interesting ESPRIT projects. The first, TOOLUSE, is a code devoted to the computer direction of projects with the use of a knowledge base formed from previous projects; the latter part of this is where the difficulty lies. A somewhat similar project beginning this year is called Replay, where, again, previous knowledge and computer codes will be used in project direction.

Local computer facilities are quite adequate and include a DPS 8-70 biprocessor, vectorial processor FPS 164, a multiprocessor consisting of nine transputers, a Vax 11/750, and several Sun work stations and PC's.

## DERMES

DERMES, the Department of Mechanics and Energetics of Systems, is directed by M. Labarrie; it has a staff of 35 with 18 research engineers and an additional 10 doctoral students. The research activity is oriented around three axes mechanics of unsteady fluids, systems of measurement, and visualization of fluids and energetics.

**Mechanics of Fluids.** In the area of the mechanics of fluids, experimental studies have been made of both two- and three-dimensional wakes, laminar and turbulent flows, particle trajectories and liquid interfaces. DERMES has developed one of the most effective experimental arrangements for digitally treating flow field images that I have seen in Europe. A very impressive real-time

image treatment system in false color permits highlighting of different aspects of complex flow patterns (Berger et al., 1987). Image storage allows replays of the same flow pattern with different emphasis introduced by variation of the false color. The information and understanding that one can obtain by this treatment from, for example, a wake pattern, is fascinating. The system can also take images from infrared cameras as an input so that temperature change in the fluids can be distinguished. Some practical applications of the image treatment techniques include validation of codes involving the law of the wall in flows over helicopters, modelization of combustion chambers in turbomachinery, and studies of combustion instability.

Coupled with the experimental measurements are several theoretical methods used to predict the flow. These include modelization of wakes by extension of the method of singularities, modelization of turbulence based on the random vortex method, and numerical simulation of turbulence using large eddy simulation. The comparisons of predicted shear wake patterns with the images obtained from the flow are excellent. It is a combination of such work as this with sophisticated image treatment and advanced numerical analysis and graphics that will create a deeper understanding of complex flows. Flow-field imaging is an important technique that is used in all three research axes.

**Sensors and Systems of Measurement.** DERMES has developed a series of patented sensors for measurement of temperature, pressure, velocity, and composition of gaseous mixtures and fluids. Most of the sensors are based on small thermometric elements such as thin wires and thermistors used in a pulsed or periodic mode. These small sensors have a response of the order of microseconds and can measure, for example, temperature to one-thousandth of a degree centigrade. The sensor investigations are not limited to thermometric elements, and, in the case of vortex gas flow sensors, DERMES, by means of flow-field visualization and analysis, has improved the precision of the sensor. The specialization in localized or point measurements combined with the excellent digital image processing capability creates an exciting experimental capability in the department.

Some of the activity in the area of systems of measurement and visualization of fluids I have already described. A major part of the research in this area is in acoustics. In the case of combustion instability (in this discipline there is a defense agreement with the US), a study is underway of the coupling of acoustic energy and flow energy as it is affected by pulverization (Hebrard and Lavergne, 1987). Previous work has investigated the acoustic signatures of helicopters. The anechoic chamber is used to study acoustic imagery. One doctoral

project for the French Navy which I witnessed was a study of the transmission of sound through metallic structures.

**Energetics.** In the energetics area there are two activities. The first is a study of injection and vaporization processes. Different types of injectors, effects of acoustic and vibration, impact on walls, and pressure and velocity effects are being studied. In the second activity, transparent combustion chambers with novel geometries are being investigated through flow-field visualization. This latter activity has some overlap with the combustion instability studies and is part of a national program to develop a combustion chamber for a turboreactor.

## DERMO, DERO, and DERTS

I will briefly mention the research areas of the other three departments. DERMOM, the Microwave Department, is militarily oriented and has research on antennas, integrated devices, composite materials, and detection devices. DERO, the Optical Department, has four research areas—application of optical methods to aerodynamic and atmospheric phenomena, use of optics in space, optical communications, and the use of optics in computers. DERTS, the Department of Space Technology, is concerned with the space environment, characterization of structural materials in space, and the effect of the space environment on electronics in space.

## Conclusion

CERT is one of the top research laboratories in France. Dr. Pelegrin has created an outstanding institutional arrangement of world class in SUP'AERO and CERT. Each of the departments that I visited has a particular speciality which makes it unique in France. DERAT has a sound experimental and theoretical expertise in shear flows and boundary layer flows. DERA is a center of excellence in robotics and automation of production. DERI is strong in artificial intelligence and has an exciting program in parallel computer architecture. DERMES' treatment of image systems is a fundamental tool which can lead to deeper understanding of complex flows.

I have previously found ONERA (and its associated laboratories) to be an impressive research institution. CERT is a research laboratory that combines elements of some of the top NASA laboratories and some of the top research schools in the US. I can't help thinking that except for the language CERT would be very much at home in Boston or Pasadena.

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3/9/88

## BEHAVIORAL SCIENCES

### The First Joint Meeting of Portuguese and Spanish Social Psychology: a Conference Sponsored by the Office of Naval Research, London

by William Crano. Dr. Crano is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until August 1988 from Texas A&M University, where he is a Professor of Psychology.

#### Recent History

More than 20 years ago, the European Association of Experimental Social Psychology (EAESP) was born. Social psychology in Europe at that time was fragmented, its rate of growth retarded relative to other areas of scientific endeavor, both within and outside of psychology. There was relatively little contact among European social researchers, in part because there was no commonly recognized medium of organized scientific exchange. With the formation of the Association, things began to change. First, membership in EAESP provided a point of contact for scientists who might otherwise have had difficulty in identifying and communicating with one another. The establishment of the *European Journal of Social Psychology* gave researchers a common forum within which to discuss issues of importance. Indeed, in some ways, the journal set the research agenda for many, highlighting issues of concern and importance, and by omission, identifying those that were seen by the leaders of the field to be of perhaps less pressing importance.

Today, the Association's secretary publishes a quarterly newsletter to keep members informed of what other members are studying, and publishing. EAESP sponsors a monograph series which has resulted in important books on intercultural differences, attitudes toward the European Economic Community, and levels of explanation in psychology. It also sponsors small

workshops, at which issues of a specific, narrow focus are discussed. This allows interested scientists from all European countries to meet, discuss common interests and (in the best of all possible worlds) to collaborate and come to grips empirically with theoretical and methodological differences that might exist between them. This program was designed to be, and often proves, a very positive force for progress.

Too, the organization has made use of a peculiarly European innovation—every 4 years, it sponsors a summer school program for recent graduates, a type of intensive postdoctoral training session, in which leading European and American psychologists serve as directors for a 6-week program of research and study. In addition to expanding the methodological and substantive horizons of the new Ph.D.'s, the summer school also lays a foundation of social and scientific contacts that can and do have important implications for the development of the students. At this time, membership in the EAESP numbers more than 500. There is no psychological organization in Europe comparable to this one in terms of scientific muscle or activity level, and the strength and importance of the organization is reflected in the vibrant state of social psychology in Europe. Although under financial pressure in many countries, the scientific discipline of social psychology is thriving in Europe. Much credit must be given to the organizational support structure laid by the EAESP.

It would be egregious for ONRL to claim credit for all of this, but there is no doubt that ONRL was there at the beginning and provided the financial backing necessary to help launch the fledgling association. Even without ONRL support, EAESP would have been born, but it might have been stillborn, and there can be little doubt its development would have been retarded.

The focus and membership of the Association is primarily Western European, but recently it has made strong and successful efforts to integrate Eastern-block psychologists as well. If there is a weakness in the representativeness of the EAESP, it occurs in the Iberian peninsula. Although strenuous efforts have been made on the part of EAESP organizers to integrate Spanish and Portuguese social psychologists into the more wide ranging European research community, these efforts have been less than completely successful. In part, this results from Iberian research traditions that are somewhat different from those of the main line Western European countries.

Another, more difficult, problem concerns the lack of a "critical mass." In short, there simply are not enough social psychologists in these countries. A critical mass is necessary for a number of reasons. It provides an audience for the scientist's work. It allows for the formation of a network of interpersonal contacts that can serve to stimulate, invigorate, develop, and refine the scientist's ideas. It provides a lobbying base that can help secure research support. Indeed, without relatively well-developed systems of this type, research funding can become extremely problematic. But even more importantly, without a group of interested peers, the engine of the creative process, so necessary in the production of good science, oftentimes runs out of gas. It is my impression that a lack of critical mass is the central retardant to the progress in social psychology in Spain, and in Portugal.

However, a critical mass is not lacking in Spain and Portugal combined, and it was with this fact in mind that ONRL sponsored the first joint meeting of Portuguese and Spanish social psychologists. The manner in which the meeting was organized by the Portuguese hosts is interesting, and illustrates well the ways in which the established organization (EAESP) was used to facilitate further development in Iberian psychology.

As a first step, all Portuguese and Spanish members of the organization were contacted, and polled on the advisability of a joint conference, with the clear implication that this was to be the first of an annual series. After receiving overwhelming and unanimous support, the Portuguese then set the task of Iberian EAESP members to nominate up to three other social psychologists, whose work they respected, to attend the conference. Again, the response was massively encouraging. The organizers then solicited funds from the EEC to help support

delegates' travel, and from the Gulbenkian Foundation to subsidize the publication of a book of papers selected from those presented at the meeting.

With these funds in hand, along with support from ONRL, the first joint meeting was held in the beautiful town of Tomar, Portugal, from 13 through 15 November 1987. The conference was organized by two of Portugal's outstanding social researchers, Professors Orlindo Gouveia Pereira (Faculdade de Economia da Universidade Nova de Lisboa) and Jorge Correia Jesuino (Instituto Superior de Ciencias do Trabalho e da Empresa, Lisbon).

At the meeting, participants were given 20 minutes to present their ideas. The ambience of the sessions was friendly and informal, but the seriousness and intensity of the participants clearly indicated that they recognized the potential importance of this first organized encounter of Spanish and Portuguese social psychology. Participants were free to discuss any aspect of their research, the antecedents of their current interests, the progress they had made, the evolution of their ideas. Many took the opportunity to pinpoint specific areas in which intercultural collaboration would be possible and desirable.

Participants spoke in their native language, and it was encouraging to see the surprise on the faces of speakers and listeners when they realized that they could understand one another! Of course, there were some misunderstandings: One young Portuguese researcher told me, "I thought everything was going very well. We discussed a study, and planned some collaborative research. I hope to visit Spain next month to begin work on the project. However, it took 20 minutes before my new Spanish friend understood my university address, so maybe not everything came through as clearly as I thought."

The range of topics surveyed in the meeting was impressive. The entire conference was organized along three general themes: epistemological questions, basic processes, and applications (see Table 1, page 16).

A number of more specific areas were organized within the sessions encapsulated within these three themes. At the completion of each session, a commentator offered his observations on the works discussed, and highlighted possibilities for collaboration between scholars. In almost every case, researchers from both countries participated in all sessions.

Given the range of research interests represented at the conference, it is impossible to present a comprehensive discussion of each of the papers. The works will speak for themselves in the monograph to be published in the coming year. However, some flavor of the meeting can be gained from a very brief description of the works, which follows. In addition, formal titles of the various presentations and the authors and their institutional affiliations are summarized in Table 1. I will be happy to

provide details on these works should the reader wish to learn more about any of these lines of research.

### Session 1. Epistemological Questions

Two of the four presentations in this session dealt with the scientific status of the discipline of social psychology. In his paper, Caparros described the evolution of social psychology within the broader context of the development of psychology in general. He opposed the traditional positivistic paradigm with the intentional models inspired by phenomenological philosophy. Munne discussed the historical development of the epistemological assumptions which underlie some of the major theories in contemporary social psychology, and explained how these variations lead to the diversities that are evident in the field. The two remaining speakers discussed more personal scientific itineraries by describing how their social thinking and research had evolved over the years. For Ibanez, trained in the French tradition, research began with the study of power relationships, then proceeded to the study of social knowledge and the construction of social reality, in short, to the study of social representations (see *ESNIB* 88-01:8-9). For Miranda Santos, trained in the German school of cultural anthropology, early studies on acculturation led later to the investigation of intuition, and from there to considerations of projective techniques and imagination.

### Session 2. Basic Processes

**Attitudes and Social Judgment.** The two papers presented in this session were an interesting combination of theory and research. In the first, Marques discussed his research on social categorization and influence in a pedagogical context. As a demonstration, he asked his students in a class on research methodology to conduct a number of studies relating these two central variables of social psychology. Then, he used the results of these efforts in a meta analysis which combined the results of all of the studies to allow for an estimate of the general effect of social categorization on attitude change. In terms of both pedagogy and research, this approach has much to recommend it.

In her presentation, Gonzalez discussed the application of Lewinian principles of group influence on cognitive change and creativity. She demonstrated that a group can exert influence not only on the beliefs of its members, but also on their creativity.

### Social Identity and Sexual Stereotypes

In this session, Amancio reviewed the theoretical status of prejudice and stereotyping, with special focus on sexual stereotypes. She suggested that social identity theory could provide the means by which the social and

individual functions of stereotyping might be integrated. Gonzalez and Rueda discussed research in which more than 600 adolescents were given the "Who am I" test. In this test, subjects give up to 20 responses to the question, Who am I? These answers were content analyzed, and the authors found very strong sex-role identification in the sample. They plan to use more sophisticated content analytic systems in future research to identify clusters of traits that appear central to subjects' self-definition.

A related paper by Clemente Diaz and Pozo Delgado investigated the popular image of young delinquents by a thoroughgoing content analysis of (Spanish) popular newspaper accounts of juvenile delinquents. Their research is based on the hypothesis that the press might operate as an instrument of self-fulfilling prophecies, and thus help to create delinquent "careers" by fostering expectations on the part of young malcreants as to how they should (mis)behave. The importance of this research, should its implications be borne out, is impressive.

A fourth paper presented in this session, by Paez and Martinez, investigated the role of public and private self-consciousness and the expression of emotion. The study, a large questionnaire investigation making use of self-report instruments tapping self-consciousness and emotionality, disclosed a number of interesting differences between groups split in terms of sex and self-consciousness. However, the discovered differences were not predicted in advance, and thus, it remains to be seen if these findings will replicate and whether they will lead to further refinement of the concept of self-consciousness. Considerable previous research that has made use of personality scales of the self-consciousness variety have simply identified differences between groups differentiated on this trait. The absence of prior theory and hypotheses resulted in a relative inability to structure and organize the data in a coherent fashion. That research of this type does not contribute much should not prove surprising, and one hopes that the Spanish investigators will not fall into this trap.

### Decisions and Social Representations

The presentation of Lopez and his colleagues, which dealt with social perception and information processing, was the only research at the conference that combined the rigorous approach of the experimental cognitive laboratory with principles of social cognition. A central theme of this research is that social perception is influenced by information that might not be readily accessible in the memory of the perceiver. In this presentation, the investigators disclosed some preliminary evidence that abstract representations can be activated automatically by information presented subliminally. The findings at this point are tentative, but an interesting start has been made.

Another presentation that related to the concerns of cognitive psychology was presented by Rueda in his discussion of the social psychology of time. Time perception has been a topic of active interest in cognitive psychology, and is now coming under the scrutiny of social psychologists. The central theme of Rueda's work is that the representation of time is dependent upon the regulating mechanisms the people use to plan and execute their assigned tasks. As such, social factors can influence strongly the perception of time, and it is his plan to investigate the dynamics of such influence – to attempt to identify classes of social variables that have the greatest effect on time perception.

### Session 3. Applied Social Psychology

By far the great majority of presentations fall under the general rubric of applied social psychology. This is reasonably representative of the state of social psychological research in Portugal and Spain, where application is much more stressed than in the United States. The reasons for, and implications of, this imbalance are discussed in the final section of this report.

**Organizational Psychology.** In his presentation, Miguez dismissed the sometimes vehement differentiation between proponents of social psychology and those who study organizational behavior. He decried this state of affairs, by pointing to the sterile antagonisms of the past, between psychology and sociology, basic and applied research, quantitative and qualitative methods, and suggested that "scientific imperialism" in the study of organizational behavior will prove as fruitless as previous attempts to maintain the pristine nature of one field in opposition to another. There is much to recommend Miguez's view. It is obvious that the Ph.D. is not equivalent to receiving holy orders – that high priests have no role either in psychology or organizational development. To preclude consideration of a scientific finding because the researcher was anointed with the wrong oil is not only foolish but anti-scientific as well.

In the discussion that followed, Piero and his associates described the central research activities on organizational behavior and socialization being undertaken at the University of Valencia. This talk was primarily an attempt to describe ongoing research – what was being studied, rather than what was being discovered. Research was focused on the distinction between behavior in organizations and behavior of organizations; organizational structure and the environment; organizational stress, and socialization processes in organizations.

A. Pereira followed this presentation with a discussion of the mechanisms that conflicting groups employ to select leaders, and the manner in which organizations

control the decisions that leaders make. Discussion was interesting but speculative, since few data were reported.

In an intriguing presentation, Torregrosa discussed results which suggested that the traditional values placed on work were not shared by the newest members of the (Spanish) work force. It is as if Weber's Protestant ethic no longer operates (if it ever did in Catholic Spain). The implications of this change, not only for the Spanish economy, but also for the social identity of the young workers, was discussed. Torregrosa identified the change as a consequence of the diffusion of fundamentally narcissistic, hedonistic values, which have replaced more traditional ones.

In the final paper of this session, Jesuino and Szoka discussed the different social representations of work held by men and women in a large sample of Portuguese respondents. Their work involved the use of a questionnaire regarding perceptions of work that has been administered in a number of other cultures, worldwide. The research is part of a very large cross-cultural research effort to compare and contrast workers' attitudes toward the concept of work. The central finding reported in this discussion was that female respondents appeared to hold much more favorable attitudes toward work, even though the conditions of their work (e.g., pay, likelihood of promotion, etc.) generally were not nearly as good as those of men. The research procedures employed in this study do not allow for a clear specification of the processes that underlie this apparently contradictory state of affairs, but the data certainly provide considerable grist for the mill of speculation.

**Organizational Culture.** An extended session was then devoted to the study of organizational culture. In this session three papers were presented, all of which focused strongly on the analysis of organizational culture. Lopes presented a case study of a cooperative social group in Portugal, and analyzed the contribution of research on organizational culture to its investigation. Gomes proposed that the content analysis of communications within an organization could provide useful insights into organizational culture.

Lima and colleagues proposed a novel means of dissecting organizational culture, in which five dimensions were to be considered: members' perception of the organization, dynamic explanations (i.e., causal attributions of how things are accomplished organizationally), values, group identity (or cohesiveness), and the implicit strategic vision that represents the ideal endpoint of the organization at any specific point in time. Based on this theoretical orientation, Lima and her coworkers developed a questionnaire which they administered to the managers of a large bus company in Lisbon. Managers' responses did appear to be organized by the five hypothesized dimensions. Subsequent analyses disclosed three distinct styles of management, which the re-

searchers termed conservative, technocratic, and passive opposition.

Lima et al. have developed an interesting approach which appears to have some validity. It will be interesting to see if their work can be extended to other organizational frameworks, in different work settings. Their methods of analysis are quite sophisticated, and they have made very good use of data to shed light on their theoretical ideas.

### Environmental Psychology

In this session, an interesting theoretical analysis of environmental psychology was presented by Oliveira, who argued that the growth of this field was dependent upon the systematic application of theories and models of social cognition. To this end, he proposed a set of conceptual principles that he felt might be used to order the majority of environmental research, concentrating particularly on studies of environmental cognition.

The other participants in this session, Aragonés and Corralisa, focused on current research activities in environmental psychology in their university in Madrid. In general, it appears that a strongly cognitive focus dominates Spanish environmental research, with considerable emphasis placed on problems of a practical nature — pollution, quality of life, etc.

### Economic Psychology

All the papers on economic psychology were presented by members of the faculty of economics and business of the New University of Lisbon. In this set of papers, Raposo presented her results of an investigation of people's reaction to the imposition of special taxes introduced in Portugal in the aftermath of the economic crisis caused by the revolution of 1974. Raposo demonstrated that respondents' negative reactions to the taxes generalized to the policies and programs that the government used to justify their imposition.

Riberio discussed research focused on the adaptation of managers to economic catastrophes. His computer simulation of an economic crunch, and his measures of respondents' reactions, was greeted with considerable interest. One of the useful aspects of Riberio's model is its capability for modification and expansion. New parameters can be built into the predictive machinery without the need for completely redeveloping the structure of the simulation.

The final report of this session, delivered by Pereira, was focused on bargaining behavior. In his discussion, Pereira proposed that an analysis of the language behavior of interactants would provide important insights into the nature of the bargaining encounter, and could be used to predict the outcome of the negotiation. A predic-

tive pragmatic model of bargaining was discussed, and it is reasonable to hope that empirical results reflecting on its validity will be soon forthcoming.

The focus on language is an interesting innovation in light of considerable bargaining research conducted within the framework of the popular social dilemma game. (A social dilemma presents a choice situation that sets in conflict one's immediate self-interest with that of the collective good. Examples of social dilemmas occur in most zero-sum situations; i.e., those in which there exists a finite pool from which to draw desirable resources.) In most such research, almost no communication occurs between participants, other than that which indicates the pro- or antisocial decisions that each has made. By focusing research attention forcefully on communication processes, Pereira has prodded investigators in this area to move in a direction of greater ecological validity. In addition, he has highlighted a probably important source of systematic variance.

### Health Psychology

Much of the work on health psychology in the Iberian peninsula reflects the historic link in Spain and Portugal between psychology and psychiatry. For example, Barriga, a psychiatrist, described his work in community psychology, and discussed the relevance of social psychology in his work. Pereira and Jesuino, both trained in psychology and psychiatry, presented a detailed account of their work on stress and leadership in the Portuguese Marine Corps, which was reminiscent of some of the work they conducted earlier for the Portuguese Navy (see ONRL Report 7-033-C, 30 December 1987). Their research demonstrated that through the thoughtful manipulation of leadership practices, much of the negative effects of stress reactions could be avoided.

Ridruejo's work was concerned with the relationship between biorhythms and social behavior. His observations were interesting and creative, if somewhat more speculative than was usual for earlier presentations in the conference. One of his central positions is that there exist sociorhythms which, like biorhythms, are cyclical in character. Sociorhythms, however, are thought to influence people's interactions with one another. Ridruejo called for a more intensive study of such rhythms, and for the construction of an alternative clinical/social psychology to study the impact of these rhythms on all aspects of normal and abnormal behavior.

The final presentation in this session was Gameiro's discussion of drug-addicted adolescents and the means that might be used to attack this problem. He argued that some of the currently popular methods of treatment, which involve the substitution of one drug for another, were not likely to succeed. Likewise, he dismissed cognitive therapy models as ineffective. He suggested instead

an approach in which addicts, parents, former addicts, and health workers are brought together in an intensive group therapy interaction. Of course, this approach has been tried with some degree of success in other settings. The relative novelty of drug addiction in Portugal, however, made Gameiro's remarks especially relevant, even if his ideas were not entirely new.

### Political Psychology

The last set of papers was concerned with social/political psychology. In the first presentation, Vala and his colleagues investigated the relationship between materialistic values and social identity. The results of this research suggest that social identity theory can have important implications for understanding social-political values, and consequent behaviors. The social group with which one identifies is predictive of a host of work-related values and behaviors.

Martin's work also concentrated on values, but in this particular instance on the apparent political values of Spanish presidents, as inferred from the content analysis of their speeches. Martin could determine no differences in the political values of presidents, despite the fact that they ranged across the political spectrum; however, there were differences between the political parties to which the presidents belonged, and these could serve to reverse the drift toward the homogenization of political thought that many political scientists have decried.

Also employing the method of content analysis, Burillo and Aragonés presented a political and psychological analysis of the ecologist movement in Spain. Based on their content analysis of the statements of spokespersons of the movement, the researchers concluded that ideology rather than science guided much of what was proposed. Although not comforting, it is not altogether surprising to learn that even people with whom we agree can be demagogues.

In a realistic application of social identity theory, Echabe used members of the various political factions in the Basque sections of Spain to study in-group/out-group bias effects. Consistent with much previous laboratory research, Echabe found evidence for an in-group favoritism effect, and corresponding out-group discrimination. Being a member of a group that is important to one's self-identity has a powerful effect on attributions regarding the causes of events, and on evaluations of members of the in-group and the out-group.

In a presentation related to that of Echabe, Javeloy discussed his explorations into the psychology of fanaticism. There is, unfortunately, no small number of real-world examples from which he could draw in making his points. Javeloy's intent is to determine the process through which a person who initially merely sympathizes

with an idea or social movement is transformed into a fanatic.

Study of the development of intolerance and closed-mindedness is a worthy pursuit, and one that promises to produce some very interesting and potentially useful findings. In a study of clear relevance for Javeloy's work, Valencia and Villareal discussed the utility of a theory of motivation that could be used to predict variations in political participation and of collective action. Certainly it is from among the group of participants in social movements that the fanatic arises.

Dorado and Torregrosa turned the attention of the meeting to a consideration of nationalism, a sentiment which they viewed as on the rise in Spain, if not worldwide. This work, too, is potentially related to Javeloy's research on fanaticism, for while nationalism does not always lead to fanatic beliefs and actions, it can and does with some frequency. In their work, Dorado and Torregrosa attempted to translate social identity theory from the individual to the wider social system in providing an explanation of this phenomenon. Admittedly they were not completely successful, but they observed that their approach held greater promise than those currently used to explain the irrational behaviors that people sometimes undertake in the name of God and country.

The final paper to be discussed at the conference was read by Ribas, and focused on unemployment and social alienation. His research reinforced a syndrome of effects that are the apparent outcomes of unemployment. The cognitive and behavioral responses exhibited by Ribas's unemployed subjects were perhaps as could be expected—they were more depressed than their employed peers, less active politically, less assertive, and had lower self-esteem. As Ribas observed, this is precisely the syndrome of traits that helps to guarantee that the unemployed remain unemployed.

### Concluding Observations

**Similarities and Differences.** This conference disclosed that there was considerable communality between the interests and approaches of Spanish and Portuguese psychologists. In general, it seems fair to say that the orientation of the participants was more inclined toward Europe than the US. This is probably so because the majority of psychologists represented in Tomar received their training in Europe, or from mentors who had. This state is somewhat less in evidence in the youngest generation of social psychologists, but it is clear that the great preponderance of Iberian psychologists, even those of the youngest generation, have received their training in Europe. This European view is in evidence in the research themes that formed the backbone of the conference. While not unknown in the US, the study of social identity, social representations, and intergroup relations

are far more commonly encountered in the pages of European, as opposed to American, social psychological journals.

Methodologically, the European inclination is also evident. Research discussed at the conference was much more likely to make use of correlational than parametric (analysis of variance) statistics. This reflects two facts: first, the Iberian research was less likely than American studies to take place in a psychological laboratory. Second, Iberian research is much more likely to be problem oriented, rather than focused on basic processes. This is especially true in the case of the Spanish, whose research oftentimes was directed toward the unraveling of one or another of the vexing social problems with which that country currently must contend.

One area in which these observations do not hold is that of organizational behavior and economic social psychology. In these fields, which were primarily the concern of the Portuguese, there was heavy reliance upon the conceptualizations, and the findings, of American research. In part, this trend reflects the fact that there is a greater proportion of American-trained Portuguese, as opposed to Spanish, social psychologists. This training also is reflected in the somewhat greater reliance of the Portuguese on standard (and often elaborate) analysis of variance models in the design and analysis of their research, and the somewhat greater emphasis, relative to the Spanish, on basic research, rather than on applications to current social problems.

## Value

Ultimately, judgment of the success of this endeavor lies in the future. Will the Portuguese and Spanish continue to communicate and cooperate and, if so, will this cooperation make for a more complete integration of the Iberians into the main line of contemporary European social psychology? There are positive signs that these questions will be answered in the affirmative. For example, almost all participants came away from the meeting with plans for collaboration with colleagues from the other country. And, plans were laid by the leading Spanish and Portuguese social psychologists to meet at the forthcoming convention of the Spanish Psychological Association to organize the Second Joint Meeting of Spanish and Portuguese Social Psychology, this time in Spain. It is a good bet that this second meeting will materialize, and that Spanish hospitality will prove equal to its vaunted reputation. If the quality of the presentations at the second meeting mirrors that of the first, then in 20 years' time I fully expect that the ONRL liaison scientist for psychology will be able to copy, almost verbatim, the first three paragraphs of this report merely by substituting "Spanish and Portuguese Association of Experimental Social Psychology" (SPAESP) for EAESP. If this occurs, then ONRL will have made another important contribution to the science of psychology in Europe.

**Table 1. Summary of Papers Presented at the First Joint Meeting of Spanish and Portuguese Social Psychology.**

### Session 1. Epistemological Questions

- Social psychology and the history of psychology (Antonio Caparros, U. Barcelona, SP)
- Social psychology as politics (Tomaz Ibanez, U. Autonoma Barcelona, SP)
- The construction of social psychology as a science (Frederico Munne, U. Barcelona, SP)
- Projective techniques in social psychology (Miranda Santos, U. Coimbra, POR)

### Session 2. Basic Social Psychological Processes

#### Attitudes and Social Judgment

- Social categorization and social influence (Leonel G. Marques, U. Lisboa, POR)
- Groups and attitude change (Maria Pilar Gonzalez, U. Barcelona, SP)

#### Social Identity and Sexual Stereotypes

- Social functions of stereotypes and social identity (Ligia Amancio, Instituto Superior de Ciencias do Trabalho e da Empresa, Lisbon, POR)
- Self-identity in adolescents (H. L. Martinez Gonzales and Iniguez Rueda, U. Barcelona, SP)
- A content analysis of the image of juvenile delinquents in the press (M. Clemente Diaz and M. Pilar del Pozo Delgado, U. Complutense, Madrid, SP)

- Self-consciousness and emotion (Dario Paez and Beatriz Martinez, U. Pais Vasco, SP)

#### Decisions and Social Representations

- Social perception and automatic information processing (J. Lopez, B. Sierra, M. Froufe, and M. D. Izquierdo (Autonomous University, Madrid, SP)
- The social psychology of time (Iniguez Rueda, U. Barcelona, SP)

### Session 3. Applied Social Psychology

#### Organizational Psychology

- Intervention in organizations: what practices and what models (Jose Miguez, U. Oporto, POR)
- Organizational behavior, role setting, and socialization (Jose M. Peiro, Vicente Gonzalez Rovira, Jose L. Melia, and Fernando Prieto, U. Valencia, SP)
- Decision making (Artur Parreira, Portuguese Catholic University, Lisbon, POR)
- The social meaning of work: Male and female representations (Jorge Correia Jesuino and Luis Soczka, Instituto Superior de Ciencias do Trabalho e da Empresa, Lisbon, POR)

Youth attitudes toward work (Jose Ramon Torregrosa, U. Complutense Madrid, SP)

Organizational Culture

The culture of organization (Albino Lopes, Instituto Superior de Ciencias do Trabalho e da Empresa, Lisbon, POR)

Communication and organization (Adelino Gomes, U. Coimbra, POR)

Organizational culture: A psychosociological approach (Maria Lima, Jorge Vala, Maria Benedita Monteiro, Instituto Superior de Ciencias do Trabalho e da Empresa, Lisbon, POR)

Environmental Psychology

Toward a social psychology of the environment (Jose M. Palma Oliveira, U. Lisbon, POR)

Notes on environmental psychology in Spain (J. Ignacio Aragonés and J. Antonio Corralisa, U. Madrid, SP)

Economic Psychology

The social psychology of taxation (Elsa Raposo, New University, Lisbon, POR)

Organizational psychology in a depressed economy (Jorge Ribeiro, New University, Lisbon, POR)

Pragmatic social psychology (Orlindo G. Pereira, New University, Lisbon, POR)

Health Psychology

Social psychology and health (Silverio Barriga, U. Seville, SP)

Stress and leadership (O. G. Pereira, New University, Lisbon, POR, and J. C. Jesuino, Instituto Superior de Ciencias do Trabalho e da Empresa, Lisbon, POR)

Families with drug-addicted children (Aires Gameiro, Portuguese Catholic University, Lisbon, POR)

Political Psychology

Political culture in urban Portugal (Jorge Vala and Leite Viegas, Instituto Superior de Ciencias do Trabalho e da Empresa, Lisbon, POR)

Three classes of political ideologies: An empirical confirmation (Eugenio Garrido Martin, U. Salamanca, SP)

Political significance of ecological attitudes (Florencio Jimenez Burillo, Juan Ignacio Aragonés, U. Complutense, Madrid, SP)

Social identity, social cognition, and ideology of nationalistic social movements: The case of the Basques (Agustin Echebarria Echabe, U. Pais Vasco, SP)

The psychology of fanaticism (Federico Javaloy, U. Barcelona, SP)

Representation, motivation, and collective action (Jose Valencia and Mikel Villareal, U. Pais Vasco, SP)

Towards a social psychology of nationalism (J. Ramairez Dorado and Jose Ramon Torregrosa, U. Complutense Madrid, SP)

Unemployment and social alienation (J. Blanch Ribas, U. Barcelona, SP)

3/31/88

## Management of Combat Stress: Recent Developments in Israel and England

by William Crano.

Shell shock, battle fatigue, combat stress – these phrases, drawn from different wars, different times, and different places, all depict a common psychological state. Combat stress reaction (CSR), the currently popular phraseology, represents a breakdown in battle, a psychological state of partial or complete mental disorganization, in which the soldier has ceased to function as a soldier. The manifestations of CSR are varied: the afflicted individual may freeze in his tracks or run amok; he may burst into hysterical laughter or weep disconsolately; he may lose the ability to attend to anything, including his basic bodily functions. In the field, the CSR-stricken soldier is a danger to himself and his brothers in arms.

The problem of stress in combat is ubiquitous. Indeed, it is not unreasonable to expect that CSR will be observed in any prolonged combat situation. In US research on our soldiers in World War II and Korea, findings suggested that at least some of the debilitating symptoms of

combat stress were almost inevitable for those involved in intense fighting for more than 200 days. Statistics drawn from these times suggested approximately 23 percent of American soldiers in the Second World War experienced some degree of debilitating combat stress; in Korea, the figure was only 6 percent. These differences may reflect a number of factors, including differences in the definition of CSR, variations in battlefield conditions, and so on.

It is an unfortunate fact that one of the most fertile cultures for the nurturing of CSR is Israel, whose recent history has been scarred by a series of major and minor wars with its Arab neighbors. Despite the vaunted – and well deserved – reputation of the Israeli fighting man (and woman), this country, too, has had its share of combat stress victims. Indeed, given the frequency with which this country finds itself involved in armed conflict, and its relatively limited population, it is not uncommon that

soldiers find themselves involved in a succession of wars. A series of important practical and theoretical questions arise in such circumstances. For example:

- What is the likelihood of CSR in soldiers who have already fought in an earlier war (or wars)
- How does this probability compare with that of untested men
- Does previous evidence of CSR presage problems in future wars, or future battles
- Are veterans who have demonstrated no prior CSR more or less resistant to CSR in future fights.

Issues of this type were the focus of a longitudinal study of Major Zahava Solomon, a University of Pittsburgh-trained clinical psychologist, who is head of the research branch of the Medical Corps of the Israeli Defense Forces (IDF) Mental Health Department. She has been concerned for many years with the problems of treatment of CSR, and with a study of its implications for the future fighting trim of the Israeli soldier. Recently, she reported the results of a study of more than 700 men who had been in the front lines in Israel's war in Lebanon.

As will be recalled, the IDF withdrew most of its forces from Lebanon in 1985. Shortly thereafter, Solomon began a study of 380 men who had been diagnosed as suffering from CSR by experienced clinical psychologists and psychiatrists, after having been referred by Army physicians. To form a comparison group, Solomon constituted a group of 320 soldiers whose members matched the CSR group in terms of age, rank, education, and military assignment.

In this study, Solomon obtained the records of all 700 men in order to study their prior experiences in the IDF, and to assess the relationship between previous and current reactions to the stress of battle. Some of the men in the sample had served in previous wars, some had not; some had suffered previous bouts of CSR, some had not. This division of veteran and novice, CSR and non-CSR sufferer, allowed the investigator to address the questions presented earlier in this report. Highlights of the results of Solomon's research are:

- First, it is painfully evident that those who in previous wars had suffered from CSR were much more likely than unscathed veterans to experience CSR problems when fighting in Lebanon. Indeed, the results suggest that nearly two-thirds of the prior-afflicted group succumbed to CSR in the Lebanon conflict.
- The relapse rate of the veterans who had experienced CSR in wars prior to Lebanon was higher even than that experienced by novice soldiers engaged in their first armed conflict
- Veterans who had not experienced CSR in earlier fights were less likely than either the novices or the prior-afflicted group to experience CSR in Lebanon.

Exact percentages of IDF-wide CSR-affliction and relapse are difficult to determine from Solomon's research, since these data are considered confidential.

However, from my reading of her findings, it is clear that CSR is a very major problem for any force in which there is a likelihood either of prolonged fighting or successive battles, even if the battles are separated in terms of years, rather than days or weeks.

## Treatment

Current practice calls for immediate treatment of CSR casualties, and a return to the front as rapidly as possible. The "get back on the horse as soon as you fall off" philosophy exemplified by this approach might be questioned in light of Solomon's research. To return a battle-shaken soldier to the front in the full knowledge that there is a much greater than even chance that he will experience even more severe problems must be viewed as less than completely reasonable. There seems to be an element of punitiveness in such a practice, which harkens back to an earlier time when the "mad" were consigned to chains in dark and dingy dungeons to pay for whatever unspeakable sins they had committed to bring themselves to the catastrophic state of mental collapse.

## Field Psychiatric Teams in Great Britain

Israel is not alone in recognizing the importance of dealing with CSR. For example, since the end of the Second World War, the Norwegians have operated a center devoted to the psychological study and treatment of victims of catastrophic events (see *ESN* 41-4:175-178 [1987] and *ESN* 41-5:227-230 [1987]). Recent developments in Great Britain suggest that the treatment of combat fatigue also looms as an important issue in British military thinking. Apparently as a consequence of experiences in the Falklands Islands conflict, the British Army has instituted a policy in which field psychiatric teams (FPT's) will be assigned to all battlefield settings in the future. The FPT's consist of a psychiatrist, two nursing officers, and four nursing NCO's. These teams are in addition to the more standard medical evacuation groups that have long played so valuable a part in the treatment of combat casualties. According to Manners (1988), the FPT's are based with each armored division, in the corps rear area, and in the rear combat zone. Only one or two of the FPT's that have been mandated have yet to be manned. The remainder are operational, and will remain operational even during peace time.

This is a worthwhile and overdue development. Unless we cling to the outdated and erroneous notions that combat stress is an indication of moral weakness, a failure of courage, treatment for the very real problems of CSR must be provided. Medical help must be made available to the injured soldier, whether his injuries are physical or psychological in origin. In addition to the humanitarian aspects of the FPT concept, some have attempted to

justify it on pragmatic grounds as well. These pragmatic rationalizations, however, call for close scrutiny in light of Solomon's research on the IDF soldier. In the paragraphs that follow, I will examine briefly the manpower-based arguments, the logic of which seems to me to be problematic.

As noted earlier, current medical practice calls for the immediate treatment of the afflicted soldier, near the front, and his rapid return to his combat unit. The manpower implications of such practices, especially in situations in which CSR rates approximate those observed in the Second World War, are staggering. Let us propose a conservative example. Suppose that 12 percent of the debilitating injuries experienced by troops in a specific combat situation are CSR-related. If effective treatment can be brought to bear, and the soldiers returned more-or-less intact to their units, this addition in manpower could well mean the difference between victory and defeat. There is no arguing with the arithmetic. However, one might have some second thoughts about the assumptions that underlie the conclusions drawn from the calculations.

The central question concerns the resilience of the soldier who has suffered CSR. Will he prove capable of standing up to repeated combat exposure? What proportion of returnees will suffer relapse? And what is the prognosis of those who do? These questions are difficult to answer, but they must not be avoided, for to do so would be to foster a set of unrealistic expectations on the manpower implications of the FPT's. Unfortunately, it seems to me that the hopes pinned on the FPT's by some in the upper echelons of the British Army are bordering on the unrealistic. In his discussion of the remanning opportunities presented by the successfully treated CSR victim, for example, the Director of Army Psychiatry in Britain, Brigadier General Peter Abraham, observed:

"Where else could one get such massive reinforcements?... The pay-off is enormous in the sense that you improve a chap's chances of getting better, but it is also the biggest single source of reinforcements...because what you are getting back is somebody who is physically fit, who already belongs to a unit, already at that unit and already trained....This is in contrast with other reinforcements who have to be transported there, who are often less well

trained than the regulars, and who are not integrated into the unit already. Those three factors make them less satisfactory as reinforcement troops....Those returning from battle stress are a bonus in a war which has heavy casualties." (Cited in Manners, 1988, p. 70).

### Solomon vs Abraham

On the basis of the Israeli research, it is clear that the manpower benefits implied in Abraham's assessment should be rethought. Solomon's research has demonstrated that even after years of treatment, a good proportion of CSR victims are unable to stand up to the rigors of combat. The stress-suffering soldier, having received "first aid" psychiatric treatment in the near combat zone, would seem even less likely to be able to withstand the pressures involved in his reintroduction to combat. To be sure, some will persevere, but there will be a considerable proportion who fall victim again to CSR. The question for the scientist is who is likely or unlikely to relapse. Can we, on the basis of the host of physical and psychological data collected during the course of training of all soldiers, predict a priori those who will, and who will not, be able to tolerate the stress of combat.

Lacking a definitive answer to this question introduces a question for the manpower analyst, namely, are the gains in troop strength obtained by the rapid reintroduction of CSR-treated soldiers to front line combat offset by the dislocations caused when a goodly proportion of these same troops fall victim again to the problem of battle fatigue. There is no answer now available to this question, but on the basis of Solomon's research, it is difficult for me to envision a situation in which a battlefield commander would place a newly returned CSR victim in a position on which the lives of many others depended. This lack of confidence would not necessarily be the result of unreasoned prejudice: it well could represent a logical assessment of risk.

### Reference

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4/16/88

# BIOLOGICAL SCIENCES

## Biochemistry Conference: Ion Channels as Drug Targets

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1989 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

### Introduction

This 1-day focused conference was recently held at the Royal College of Physicians building, London, UK. The conference was sponsored by the Society of Chemical Industry of London. There were 175 participants at the meeting with 69 percent from industrial organizations and the balance from academia. Although the majority of the delegates were from the UK, seven West European countries were also represented as well as the US.

The format of the scientific sessions was as follows:

- Ionic channels as targets for drug action
- Potassium channel blockers and neuronal function
- Smooth muscle potassium channel openers
- Ligand interactions at the calcium channel
- Electrostatic models of ion channels and pumps
- Molecular approaches towards the understanding of the GABA receptor, a chemically gated ion channel
- Role of membranes in cataracts of the lens.

This report summarizes the presentation given on those topics.

### Ionic Channels as Targets for Drug Action

This topic was discussed by M. Lazdunski (Center of Biochemistry of the CNRS, Nice, France), who surveyed the present status of channel pharmacology and the recently acquired information on ion channel structures.

Lazdunski said that the voltage-dependent  $\text{Na}^+$  channel protein (molecular weight of about 270 kilodaltons [kDa]) is the target of numerous natural compounds which appear to associate with six different classes of receptors: (1) the tetrodotoxin/saxitoxin receptor; (2) the receptor for batrachotoxin, veratridine, grayanotoxins, and parent compounds; (3) the receptor for scorpion neurotoxins and sea anemone toxins; (4) the receptor for  $\beta$ -scorpion neurotoxins; (5) the receptor for brevetoxins and ciguatoxin; and (6) the pyrethroid receptor. Lazdunski briefly described the properties of these different receptors as well as those of receptors of new non-natural cardiotoxic molecules such as DPI-201-106 (Sandoz Pharmaceutical Co., Basel, Switzerland).

Apical  $\text{Na}^+$  channels present in epithelia, primarily in the kidney and bladder were also discussed by Lazdunski. These channels are the target of the diuretic, amiloride. Properties of the interaction of amiloride and more potent amiloride derivatives with this channel were mentioned briefly.

Calcium channels are the target of 1,4-dihydropyridines such as nitrendipine or PN 200-110, phenylalkylamines such as D<sub>600</sub> and verapamil, diltiazem, bepridril or of peptides such as  $\omega$ -conotoxin. Lazdunski discussed the main molecular properties of interaction of these channels with their ligands such as: (1) number of different sites, (2) biochemical nature of the calcium channel protein, (3) new calcium channel blockers, and (4) receptors for calcium channel blockers in plant membranes and neuronal insect systems.

Lazdunski also said that there are numerous types of potassium ( $\text{K}^+$ ) channels. He spoke about three types of  $\text{K}^+$  channels: (1) voltage-dependent  $\text{K}^+$  channels that are the target of polypeptide toxins such as dendrotoxin and MCD peptide, (2)  $\text{Ca}^{2+}$ -activated  $\text{K}^+$  channels that are the target of polypeptide toxins such as apamin and charybdotoxin, and (3) ATP-sensitive  $\text{K}^+$  channels which are the target of sulfonylureas.

### Potassium Channels and Neuronal Function

This subject was addressed by A.L. Harvey (University of Strathclyde, Glasgow, UK). He said that transmembrane channels that are selective for potassium ions regulate the excitability of neurons. Compounds blocking neuronal potassium channels can cause repetitive firing and enhancement of neurotransmitter release. Such compounds include simple organic molecules (for example, aminopyridines, tetraethylammonium, tetrahydroaminoacridine) and protein toxins such as apamin, charybdotoxin, dendrotoxins, and mast cell degranulating peptide.

According to Harvey, aminopyridines have been used or tested for anticurare effects; for Lambert-Eaton myasthenic syndrome, myasthenia gravis, and botulism; to

reverse antibiotic-induced muscle paralysis and verapamil toxicity; in multiple sclerosis; and as respiratory stimulants after general anesthesia. Tetrahydroaminoacridine and 4-aminopyridine have been tested in Alzheimer's-type senile dementia.

Harvey said that a major difficulty associated with the use of aminopyridines is that they tend to block most forms of potassium channels, and hence, their effects are widespread. The protein toxins are more specific for particular subtypes of potassium channels, according to Harvey. He thinks that as these toxins provide detailed structural information, they provide the starting points for the design of new potassium channel blocking drugs with a greater selectivity of action.

Harvey mentioned that a new institute has been recently set up at the University of Strathclyde, called the Strathclyde Institute for Drug Research.

### Smooth Muscle Potassium Channel Openers

A report of research on this topic was given by A.H. Weston (Smooth Muscle Research Group, Department of Physiological Sciences, University of Manchester Medical School, UK), who, with his group, has carried out extensive studies in this area. He said that cromakalim (Beecham) and pinacidil (Leo) are smooth muscle relaxants which can be classified as potassium channel openers. *In vitro* studies have shown that these substances raise smooth muscle membrane potential towards  $E_k$ , an effect which is accompanied by an increase in  $^{86}\text{Rb}$  or  $^{42}\text{K}$  efflux from tissues preloaded with these isotopes. Furthermore, Weston said that the mechano-inhibitory effects of these agents are prevented in the presence of high potassium concentrations ( $\geq 80$  mM). He also said that these results combine to suggest that the effects of cromakalim and pinacidil result from potassium channel opening of L-type calcium channels with consequent relaxation. Nicorandil (Chugai) also exhibits potassium channel opening properties but, in addition, it activates soluble guanylate cyclase as shown by Weston and coworkers.

*In vivo*, both cromakalim and pinacidil lower blood pressure, an effect which has recently been assumed to result, according to Weston, from the indirect closure of calcium channels in resistance vessels. However, both agents relax bronchial smooth muscle (Allen et al., 1986; Bray et al., 1987). According to Weston, this suggests that other mechanisms are also involved, and recent evidence suggests that hyperpolarization also inhibits the refilling of intracellular calcium stores in smooth muscle as shown by Weston and coworkers. Furthermore, the possibility that hyperpolarization additionally lowers intracellular calcium concentrations by stimulating sodium-calcium exchange in the direction of calcium extrusion must also be considered, according to Weston.

### Ligand Interactions at the Calcium Channel

This topic was presented by D.J. Triggle (State University of New York, Buffalo). Triggle said that  $\text{Ca}^{2+}$  channel antagonists, including diltiazem, nifedipine, and verapamil, constitute chemically, pharmacologically, and therapeutically heterogeneous groups of compounds that exert their effects at an allosterically linked set of specific binding sites on a major protein of voltage-dependent  $\text{Ca}^{2+}$  channels. It is likely that additional binding sites for other structurally unrelated compounds also exist, according to Triggle. These binding sites also appear to be capable of mediating activator effects – prominently so at the 1,4-dihydropyridine site.

According to Triggle, the definition of structure/activity relationships, including stereospecificity, has been of major import to the designation of specificity of action of  $\text{Ca}^{2+}$  channel ligands. The state-dependent behavior of ligand interactions, observed in biochemical, electrophysiologic and pharmacologic systems, indicates that structure/activity relationships will be differentially expressed, qualitatively and quantitatively, according to channel state. Triggle also discussed some aspects of 1,4-dihydropyridine pharmacology in terms of state-dependent interaction and their implications for tissue selectivity.

### Electrostatic Models of Ion Channels and Pumps

A different approach to the study of ion channels and pumps, namely, model building, was presented by D.T. Edmonds (The Clarendon Laboratory, University of Oxford, UK). Edmonds said that if models of biological systems are to advance our understanding of the underlying mechanisms they must be based upon plausible components acting in a physically realistic manner. He said that too often, published kinetic models of channels and pumps consist of blocks of undefined states connected by arbitrarily assigned rate constants in which no attempt is made to relate the assumed "states" to real physical entities.

Edmonds presented arguments to support his hypothesis that at a molecular level, the dominant forces controlling ionic flow in gated channels or pumps will be electric rather than, for example, mechanical. As an example, Edmonds showed that the apparently complicated kinetics of gating of the sodium channel in excitable tissue may be modeled using a purely electrostatic threshold model in which the underlying kinetics are close to simply exponential. He also showed that the same model can explain the very different sodium channel kinetics measured in different preparations.

As an example of active transport, Edmonds described a model of an ionic counterpart which consists

of two passive ion channels each selective for a different ion, that are sufficiently close neighbors to interact electrostatically. This model is presented in detail in the *Proceedings of the Royal Society*, 1986, listed in the reference section.

### Molecular Approaches towards the Understanding of the GABA<sub>A</sub> Receptor

Gamma-aminobutyric acid (GABA) is the major inhibitory neurotransmitter in the vertebrate central nervous system (CNS). GABA mediates its effects via the specific binding to an integral membrane glycoprotein, the GABA receptor which results in an increase of the chloride ion permeability of the recipient cell. F.A. Stephenson (MRC Molecular Biology Unit, MRC Center, Cambridge, UK) said that GABA receptor function can be allosterically regulated by several classes of pharmacologically active compounds. These include the anxiolytic benzodiazepines, the barbiturate drugs, the anthelmintic avermectins, and some steroids.

The coexistence of benzodiazepine and GABA binding sites within a single oligomeric complex enabled Stephenson and her coworkers to purify and characterize the receptor protein. Stephenson showed that the receptor had a molecular weight of 230 kDa and was heterologous, consisting of two polypeptide chains,  $\alpha$  of 53 kDa and  $\beta$  of 57 kDa molecular weights. More recently, Stephenson and her group have deduced the primary structure of the GABA receptor from the respective complementary DNA's (cDNA) of the  $\alpha$  and  $\beta$  subunits. Stephenson discussed the above-mentioned biochemical studies together with those derived from recombinant DNA experiments with respect to the fine structure of the GABA<sub>A</sub> receptor.

### Role of Membrane Channels in Cataract of the Lens

G. Duncan (School of Biological Sciences, University of East Anglia, Norwich, UK), who presented the subject, said that cataract of the lens is the major cause of blindness throughout the world and in the majority of cataracts loss of transparency is accompanied by severe disruption of the normal internal ionic balance. This type of cataract, he said, affects mainly the cortical regions of the lens and can be reproduced in animal lenses *in vivo* by a wide range of insults: for example, by exposure to x-rays or by induction of diabetes. Cortical cataracts can be similarly induced *in vitro* by the same techniques or by exposure to ouabain or digoxin. In all cases the lens membrane potential is greatly depolarized. Duncan said that *in vitro* studies have shown that changes in internal calcium produce the most dramatic loss in transparency and that this is probably due to a combination of two prin-

ciple mechanisms: proteolysis induced by calpain and protein aggregation following protein modification.

According to Duncan, the optical quality of the human lens in fact often begins to decline at the age of 40 and the incidence of cataract increases dramatically beyond 50 years of age. He said that the lens membrane potential measured in clear donor lenses remains constant at about -45 mV until 40 years when it begins to decline to reach about -25 mV at 60 years. The internal free calcium concentration measured by ion-sensitive microelectrodes, also remains low until 40 years (< 10  $\mu$ M) but thereafter the free level increases. Duncan thinks that both the loss in membrane potential and increase in calcium associated with age and cataract may be mediated by nonspecific cation channels in the lens membrane. These channels can be activated by oxidative stress, membrane deformation, and a reduction in external calcium.

### Conclusion

The high proportion of delegates from industry attending this conference on ionic channels attests to the great interest of pharmaceutical companies in developing drugs that affect ion channel function. It is evident from some of the presentations that several drugs are already on the market but that there is a need for drugs with more specific action than those available at present. The basic research in the area of ion channels as presented by scientists from academia at this conference is necessary to provide the information required for the development of drugs acting on ion channels. The speakers covered a range of topics from functions of the various types of ionic channels, molecular biological approaches as well as the development of mathematical and physical models to obtain additional information on this subject. Although much has already been learned about ion channel function, there is still a need for a greater understanding of the exact mechanisms involved. It was evident that European researchers are making major contributions in this area.

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# CHEMISTRY

## Seventh International Biodeterioration Symposium

by John D. Bultman. Dr. Bultman is a Research Chemist in the Chemistry Division, Naval Research Laboratory, Washington, DC.

### Introduction

The Seventh International Biodeterioration Symposium was held at Emmanuel College, Cambridge, UK. The well-attended Symposium (about 300 registrants) was cosponsored by the Biodeterioration Society and the Pan-American Biodeterioration Society and was cochaired by Drs. H.O.W. Eggins (Bioquest, Ltd., Birmingham, UK) and R.N. Smith (Hatfield Polytechnic, Hatfield, Herts, UK). The Symposium covered all aspects of biodeterioration of materials of economic importance and the biodegradation of effluents and solid wastes.

The scientific program consisted of 56 sessions (232 papers) devoted to 22 subject areas:

- Biocides
- Biodeterioration mechanisms
- Biofilms
- Concrete/stone
- Computers
- Cosmetics/pharmaceuticals
- Effluents
- Hydrocarbons
- Insects
- Marine structures
- Metals
- Museums/archives
- Packaging
- Paper packaging
- Physical control methods
- Plastics/rubber
- Postharvest decay
- Rapid test methods
- Rodents/birds
- Solid waste
- Textiles
- Timber/cellulosics.

Obviously, it is not possible to discuss all of the papers presented at these sessions. Thus, a brief review of a random selection of papers from the various subject areas will serve as the substance for this article. Dr. David Houghton (227 Devonshire Avenue, Southsea, Hants, PO4 9EE, UK) is editing and supervising the preparation of the Proceedings, which should appear during 1988.

### Postharvest Decay

**Aflatoxins.** Many of the 24 papers relating to post-harvest decay addressed the subject of contamination of grain, peanuts, cottonseed, and other agricultural products by aflatoxins and tricothecenes and the concomitant economic and potential health problems associated with these mycotoxins. These very toxic substances are secondary metabolites of species of *Aspergillus*, *Fusarium*, *Myrothecium*, and *Candida*; they can also be heptacarcinogenic, mutagenic and teratogenic. G. Llewellyn and coworkers (Virginia Department of Health [VDH], Richmond) reported that Aflatoxin B<sub>1</sub> may reduce feed consumption by acting on the central nervous system of male Sprague-Dawley rats, but it did not affect plasma glucose levels. T. Kimbrough (director of VDH) and Llewellyn measured the intestinal motility (composite motility, peak amplitude, and contraction frequency) of CD-1 mice in response to *Fusarium*-produced T-2 tricothecene and found that this toxin caused toxigenic response in the digestive tracts of these mice. J. Smith, et al. (University of Strathclyde, Glasgow, Scotland) showed a marked stimulation of aflatoxin formation by *Aspergillus flavus* when growing on maize extract agar or on sterilized maize seeds in the presence of *Hypopichia burtonii* and *Bacillus amyloliquefaciens*.

**Fruits and Vegetables.** Several papers were devoted to the postharvest deterioration of fruits and vegetables. Deterioration of these fragile commodities may take many forms, according to A. Snowden (University of Cambridge, UK). These include commodity, cultivar, and growth conditions and how the crops are harvested, handled, and stored. Molds, fungi, and bacteria take their toll, and certain microorganisms can be rather specific for certain crops. For example, citrus fruits are decayed by *Penicillium* molds; bananas and mangos are susceptible to the anthracnose fungus *Glomerella cingulata*; and cucurbits, solanaceous fruits, and legumes are decayed by species of *Alternaria*, *Cladosporium*, *Botrytis*, and *Sclerotinia*. The storage environment is crucial. In a 15-year study it was found that 39 percent of cargo deterioration resulted from adverse preshipment factors, 42 percent from adverse shipboard factors, and 19 percent from both preshipment and shipboard factors. J. Gesson (AFRC Institute of Food Research, Norwich, UK), in

discussing control of fungal spoilage, indicates that even low-temperature storage (0-5°C) is not sufficient to prevent fungal activity. In addition, while many storage diseases can be effectively controlled by the application of postharvest fungicides, the chemical control of these diseases may be limited in the future by legislative fiat.

## Timber and Cellulosics

The biodegradation of timber and its prevention was the subject matter of 17 papers. Of these, three were review papers covering recent trends in wood preservation research (J. Butcher, Forest Research Institute, Rotorua, New Zealand), termite control (J. La Fage, Louisiana State University Agricultural Center, Baton Rouge, Louisiana), and ground line decay of treated hardwood in Australia (L. Leightley, Queensland Department of Forestry, Indooroopilly, Queensland, Australia).

**Fungi.** Among the many microfungi causing wood degradation, soft rot organisms, particularly of the genus *Phialophora*, are considered to be the most important, and these organisms severely damage wood products over a wide range of terrestrial and marine environments. Soft rot fungi may even have a very high preservative tolerance and be able to attack treated timber, particularly that in ground contact such as utility poles, piles, and fence posts. Preservative concentration decreases rapidly from the wood surfaces, and such attack often occurs in the fibers adjacent to preservative-filled ray cells. This is demonstrated by M. Hale (University College of North Wales, Bangor, UK) and R. Eaton (Portsmouth Polytechnic, UK) for the attack by *Lecythophora mutabilis* of cell walls on hardwoods treated with copper-chrome-arsenic.

**Bacteria.** The importance of bacteria in degrading wood is not as well understood (B. Henningson, The Swedish University of Agricultural Sciences, Uppsala, Sweden) although several morphological types of bacterial attack on wood are described based upon the appearance of the decay pattern produced. This attack is confined mainly to the surface layers of the wood. Beside untreated and treated soft- and hardwoods, bacterial attack has been reported as occurring on preservative-treated, chemically modified, and naturally resistant wood in a variety of terrestrial, marine, and aquatic environments, world-wide. T. Nilsson and A. Daniel (Swedish University of Agricultural Sciences, Uppsala, Sweden) cite three types of bacterial attack. One (erosion) causes a cell wall thinning from the lumen surface inward; the second (tunnelling), an active penetration and continuous degradation within and throughout the cell walls; and the third (cavitation) is characterized by the formation of discrete cavities within the cell walls. Studies also suggest that bacteria may possess ligninolytic as well as cellulolytic activity which make them well suited to perform their

degradative role and to possess the faculty of overcoming the preservative effects of toxic metals.

**Natural Resistance.** Of 28 species of Indonesian hardwoods evaluated for natural termite resistance, *Dalbergia latifolia*, *Eusideroxylon zwageri*, *Intsia bijuga*, and *Tectona grandis* were shown by N. Supriana (Forestry Research Institute, Pematung, North Sumatra, Indonesia) to be naturally resistant to the dry-wood termite *Cryptotermes cynocephalus* and the subterranean termites *Coptotermes curvignathus* and *Reticulitermes lucifugus*. These results were based upon wood weight loss and termite feeding activity. And extracts of these woods were also shown to be repellent to the termites. Of the 28 species, *Agathis alba* and species of *Diptocarpus* and *Mangifera* sp. were the most termite susceptible.

**Marine Borers.** Utilization of wood as food by teredinids was first postulated in the early 1700's, but the method used by the animals to digest cellulose and how their nitrogen requirement was met were unknown. Since then, however, bacteria have been isolated from the gills (gland of Deshayes) of several *Bankia*, *Teredo*, and *Lyrodus* species, and these bacteria have been shown to possess the ability to digest cellulose and fix nitrogen. Bacterial isolates have now been made by R. Turner, Harvard University, Cambridge, Massachusetts, (with colleagues Waterbury and Mann) from 23 of 68 known species of teredinids, representing nine of the 15 general. All of these isolates are similar and probably represent a single species of bacterium, and the measurement of acetylene reduction rates for intact teredinids shows that nitrogen is fixed on demand. Experiments also show that teredinids are very nitrogen conservative and that nitrogenous products excreted into the epibranchial cavity are quickly recycled. *Lyrodus* and *Bankia* take up and metabolize free amino acids.

## Biofilms

About half of the 15 papers presented on biofilms addressed the subject of biofilm formation in aqueous systems of metalworking fluids; the remainder described fungal adhesion in the development of marine microfouling communities. Papers by J. Costerton (University of Calgary, Alberta, Canada), P. Cook (City of London Polytechnic, UK), E. Jones (Portsmouth Polytechnic, UK), and others state that bacteria growing in industrial systems have a strong tendency to adhere to available surfaces, building up thick, coherent biofilms at solid/liquid or liquid/liquid interfaces (E. Prince and L. Morton, Lancashire Polytechnic, UK), and that the organisms in these films may be more important than the fluid's planktonic organisms in degrading the coolant and the metal surfaces exposed to it. This matrix concentrates nutrients and excludes many antibacterial agents which are unable to penetrate it (Costerton). Eventually a multispecies,

structural consortium of cells develops in which the structured biofilm serves to favorably juxtapose the cellular components. Many physiological activities, such as cellulose digestion, require this complex film structure to be present. An understanding of these complex film structures can lead to more effective control.

**Fouling.** As the means to control the deposition of a macrofouling community has become more effective, microfouling of antifouling paints on surfaces in marine service has become more important. D. Woods, et al. (Portsmouth Polytechnic, UK) found that biofilm thickness and surface roughness were related to the floristic composition on the films. *Amphora coffeaeformis* and *Navicula corymbosa* dominated fine diatom slimes while thicker, mixed diatom/reduced macroalgal biofilms were dominated by the diatom species *Achnanthes parvula*, *A. coffeaeformis*, *N. corymbosa*, and *Synedra* sp., and the alga *Ectocarpus siliculosus*. The effect of biofouling on seawater condenser tubing fabricated from 90/10 cupronickel or titanium was discussed (N. Gunn and E. Jones, Portsmouth Polytechnic, UK) in terms of pressure differentials, heat transfer, and overall thermal resistance.

The fouling of nonbiocidal coatings of hydrophobic, low-energy silicone elastomers was also reported by M. Callow and R. Pitchers (University of Birmingham, Birmingham, UK). Laboratory exposure of surfaces to the diatom *Amphora coffeaeformis* and to field exposures showed that the lowest bioadhesion occurs on room-temperature vulcanizing of silicone elastomers cured by tin catalysts and modified by phenylethyl silicone oil. A review of the adhesion of micro-organisms to surfaces was made by Jones. This review, in four parts, considered: substrata and habitats available for colonization, organisms that form part of the biofilm, mechanisms of attachment to surfaces, and methods of preventing the formation of biofilms.

## Hydrocarbons

Thirteen papers covering hydrocarbons and fuels were presented, including two review papers on the biodegradation of hydrocarbons. One by D. Hopper (University college of Wales, Aberystwyth, Dyfed, UK) concerned the aerobic and anaerobic bacterial metabolism of several simple aromatic hydrocarbons, such as benzene and toluene, and reviews the pathways for both aerobic and anaerobic processes and the associated enzymatic steps. The other, by C. Ratledge (University of Hull, UK) discussed the occurrence of biosurfactants present in micro-organisms and how they may function in conjunction with amphipatic receptor molecules which may act as channels for conveying the hydrocarbons into the cell membrane. Dissociation of the hydrocarbon from the surfactant possibly occurs within these molecules, and the surfactant is returned to the outside of the cell.

G. Lloyd-Jones and P. Trudgill (University College of Wales) used a consortium consisting of *Rhodococcus* sp., a strain of *Flavobacterium* and *Pseudomonas cepacia* with a wide variety of substituted cycloalkane substrates, a flexibility not displayed by these organisms, individually. Studies with cell extracts and purified enzymes from the methylcyclohexane-grown consortium have shown that metabolic flexibility arises from the broad substrate specificity of a limited number of key enzymes. These allow the simultaneous use of a number of different, but related, catabolic pathways.

**Surface Films.** In a study of the distribution of hydrocarbons in marine surface films, O. Floodgate (University College of North Wales, Anglesey, Owyneidd, Wales) showed that in the western Irish Sea there was little seasonal variation of carbon tetrachloride-soluble material in these films and that its concentration was not greatly affected by the formation of a thermally induced front in the summer. Film bacterial numbers were not greatly different on either side of the front. GLO signatures indicated both anthropogenic and biogenic inputs into the oil: the biogenic substances being alkanes or possibly alkenes. Although there was an increase in inorganic nitrogen concentration in the surface films, there was little evidence of bacterial degradation of the film-contained oil.

**Fuels.** Middle distillate fuels can be spoiled by certain bacteria by the formation of a solid surfactant membranous material, possible polysaccharide or lipopoly-saccharide, at the oil/water interface. Bacteria attach to this skin. R. Smith (Hatfield Polytechnic, UK) states that this slime layer may extend into the overlying oil and is very lipophilic; it is also very hydrated and contains a large amount of water which gets carried into the fuel. This material causes blockage of fuel filters, turbidity, unacceptably high water content in the fuel, and some low-temperature increase in viscosity. Attempts have been made to control the development of such microbiological growth in stored fuel by the application of biocides.

G. Hettige (ICI New Zealand, Ltd. Lower Hutt, New Zealand) and Sheridan (Victor University of Wellington, New Zealand) found that commercially available biocides (EGME, DEGME, and Biobor JF) suppressed *Cladosporium resinae* in the field but were neither biostatic nor biocidal in the laboratory; experimental DML-7 and Proxel AS were inhibitory; and benomyl, imazalil, and Kathon 886 (all experimental) gave total control of the predominant micro-organisms, including *C. resinae*. All of the biocides passed engine performance and corrosion tests.

## Plastics and Rubber

About 12 papers were dedicated to the degradation of natural and synthetic polymers. Cameron and Huang

(University of Connecticut, Storrs) studied the biodegradability of the polyester polycaprolactone by a yeast (*Cryptococcus laurentii*), a filamentous fungus (*Fusarium moniliforme*), and a coryneform bacterium. The yeast extracellular enzyme system consisted of a constitutive enzyme of 23,000 daltons and a low molecular weight cofactor. The end products of substrate degradation were primarily trimers. The fungal enzyme was approximately the same size as the yeast enzyme, and the degradation products were also trimers—no cofactor needed. The bacterial enzyme was also about the same size as the yeast enzyme—a cofactor required. Most of their bacterial isolates required a cofactor; the filamentous fungi did not. G. Griffin (Brunel University, Egham, UK) studied the degradation of polyethylene packaging material by considering the mechanics of its reduction to tolerable physical states rather than by its biodissipation as carbon dioxide. Griffin considered the development of low-density polyethylene systems which degrade by embrittlement and subsequent fracture rather than by metabolic mechanisms. These systems depend upon biologically originated composting temperatures rather than on direct microbiological interaction.

Degradation of natural rubber was addressed by K.E. Simpson (Malaysian Rubber Bureau, Brickendonbury, UK). Rubber vulcanisates are subject to deterioration on long-term exposure to soil or water. Oxidation seems to be an essential prerequisite for microbial attack, and oxidation catalyzed by transition metal (from water) is a significant factor in the mechanism of attack. By careful choice of compounding ingredients, natural rubber vulcanisates can be prepared which develop negligible deterioration. This is achieved by incorporating a sufficient amount of an aqueous-insoluble antioxidant and by avoiding the use of extractable or readily degradable ingredients in the compounding. Papers by A. Kaplan (US Army, Natick Research, Development, and Engineering Center, Natick, Massachusetts) and J. Kelley (CAB International Mycological Institute, Kew, Surrey, UK) discuss the rationale behind the selection of methodologies in the investigation of microbiological deterioration of materials, particularly test methods for plastics, including the selection of suitable challenge organisms and the interpretation of the results.

### Marine Structures

Biological deterioration of marine structures was covered by eight papers. This included a review on the role of marine algae in biodeterioration (R. Fletcher, Portsmouth Polytechnic, UK), and a second review (G. Relini, University of Genoa, Italy) on the protection of marine structures from biodeterioration. With regard to algae, these organisms seriously reduce the efficiency of structures through skin frictional resistance, increased

hydrodynamic loading, obstruction of water flow through intake pipes and cooling systems, enhanced corrosion of metal, and the physical disruption of protective coatings. The second review covered the principal methods of controlling foulers and borers with special attention to ships, offshore platforms, piling, intakes, and condensers. Only a few methods are applied successfully in practice. And since protectants are toxic by design, they become a source of environmental pollution. A biological approach to control of foulers and borers is in its infancy; consequently, this means of materials protection in the marine environment is not widely used at the moment.

Mihm and Loeb (NSRDC, Annapolis, Maryland) discussed the relationship between biofilms and the release of organotin from antifouling paints containing this ingredient. Results showed that bacterial films decreased the release rate of, but did not degrade, the tributyltin in films. Conversely, algal films showed an increase in release rate, with the degradation of the organotin to di- and monobutyltin. Removal of the biofilm caused a significant increase in release rate.

### Museums and Archives

Two sessions were devoted to problems associated with the preservation of museum materials and ancient monuments. Deterioration of paper written on with iron-gull inks is a well-known phenomenon. Causes of this deterioration could be substances of microbiological origin (cellulases, acids, hydrogen peroxide) excreted into the ink before its use or through a chemical reaction of iron sulfate in the ink with the paper (cellulose). K. Messner et al. (Institute for Biological Technology and Microbiology, Vienna, Austria) found that while fungi developed in the inks, their cellulase activity and acid and hydrogen peroxide production were weak or nonexistent. The reduction of the tensile strength of paper strips caused by biological factors was negligible compared to the reduction caused by the iron sulfate in the ink; biological factors are not relevant to ink eating. High temperature and humidity aggravate the deterioration of books in libraries.

Sixteen fungal species embracing nine genera were isolated by S. Chingduang (Bangkok, Thailand) from books from eight Bangkok libraries. Of these, *Aspergillus niger*, *A. flavus*, *A. fumigatus*, and *Curvularia lunata* predominated in all samples. Deterioration generally occurred on the covers of the books, the inside pages being damaged only under humid conditions. In nonairconditioned libraries, serious damage occurred due to cellulose decomposition by the fungi *Memnoniella echinata* and *Chaetomium globosum*. M. Seaward et al. (University of Bradford, UK) made a critical appraisal of the part played by lichens in the deterioration of a wide range of archaeological materials in central Italy. An assessment

was made of the relationships between specific lichen species and the chemical and physical nature of the substrata to determine the relative importance of these organisms in the biodeterioration process and to establish those species responsible for disfigurement and those responsible for actual destruction.

### Conclusions

To reiterate, the foregoing material represents only a brief overview of about a quarter of the total number of

presented papers which, collectively, covered a wide spectrum of problems in bioteriation of materials. Those papers that have not been mentioned are not less important, and I suggest that readers interested in other subject areas of this symposium consult the Proceedings, when available.

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## CONTROL SYSTEMS

### Nonlinear System Theory at France's Laboratoire des Signaux et Systems

*by Daniel J. Collins. Dr. Collins was the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He has now returned to the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.*

Recent advances in nonlinear system theory motivated my visit to the Laboratoire des Signaux et Systems (L2S) at Gif-Sur-Yvette, which is near Paris, France. L2S is both a Centre National de la Recherche (CNRS) laboratory and a laboratory of l'Ecole Supérieure d'Electricité (ESE) associated with l'Université Paris-Sud. I also made a brief visit to the Control Department (Service Automatique) of ESE. L2S has a staff of 65, of whom 55 are engaged in research. The laboratory has three divisions: Signal, Systems, and Waves (electromagnetic and acoustical). The Signal Division is concerned with the modeling and treatment of signals, communication in general, optical communications, and inverse problems. The Wave Division is concerned with wave/structure interaction where the structure characteristic dimension is the same size as the wave. My visit was to the Systems Division.

#### Systems Division

The System Division, with a research staff of about 16, is divided into two equal groups. One group, called Nonlinear Systems, is directed by Dr. M. Fliess while the other group, called Modeling and Control, is directed by Dr. E. Walter. Each group has one of its people presently studying in the US — one at the University of Phoenix (Arizona) and the other at the University of California at San Diego. In a recent year, seven doctoral students graduated under the guidance of the division.

**Nonlinear Systems Group.** Fliess has recently made a fundamental advance in the study of nonlinear system theory. To be specific, Fliess has introduced a new approach to nonlinear control theory based on differential algebra. With this approach he has solved the long-standing input-output inversion problem for multivariable nonlinear systems (Fliess, 1986). What is exciting about this approach is that the differential algebra viewpoint permits great simplification of a series of questions in nonlinear system theory — such as the distinction between inputs and outputs — that previously appeared quite complex. Differential algebra is related to differential equations as commutative algebra is to algebraic equations and is a well-defined mathematical discipline developed some 60 years ago by the American mathematician, J. F. Ritt. Thus, an ordinary differential ring is a commutative ring equipped with one derivative operating on the reals. The theory includes algebraic equations in the concept of differential equations of zero order. Questions of right or left invariability in input-output systems are based on the well-defined concept of the differential output rank. Without going into the details of the theory, it is possible to get some idea of the elegance of the approach in the theorem on feedback linearization (Fliess, 1987) by stating it here:

**The Fliess Theorem.** An input-output system can be feedback linearized if, and only if, the components of the output are differentially  $k$ -linearly related.

This is the weakest possible condition according to Fliess for feedback linearization. He is now applying the

concepts of differential algebra to input-output decoupling, state space realization of nonlinear systems, perturbation rejection, and, in general, fundamental ideas in system and control theory.

Another aspect of the research of the group – optimal feedback control of nonlinear systems – is being pursued by Dr. H. Siguerdidjane. The method proposed for computing the optimal control shows that the feedback loop satisfies a system of quasi-linear partial equations (Siguerdidjane and Fliess, 1987). When the dimensions of the state and of the control vector are the same, the partial equations are of first order. Further is the case that where the performance index does not depend on the control these partial equations degenerate into a set of algebraic equations. Connections with the Volterra series and the Hamilton-Jacobi-Bellman equations are given as well as some illustrative examples.

Other recent work has been in the area of nonlinear discrete systems, particularly with respect to identification problems. Problems similar to those previously discussed – such as decoupling, rejection of perturbation, optimal control, and pole placement – are being studied. A new approach selected by Fliess, is to base the description of the system on a difference algebra analogous to that of the differential algebra for continuous systems. The methods used here can involve the development of computer codes and have some industrial applications as, for example, to electric power plants.

**Modeling and Control Group.** The two directions of the Modeling and Control Group are, as its name implies, in modeling and in control. The modeling is by nature parametric and requires the selection of one or more structures for the system with some criterion of quality which permits comparison between models. From measured data one then optimizes the parameters of the system and determines the effect of errors in the measurements on the uncertainties in the model. The proper selection of the type of data measured is important in the optimization, verification, and robustness of the model. There are two aspects to the modeling research of the group: one is the development of industrial models (catalytic methanation, pharmacokinetics of Betaxolol) and the second is concerned with the theory of modeling and identification (Piet-Lahanier, et al., 1986). A computer code has been developed which obtains a global optimization of a cost function not necessarily differentiable in the parameter space. The key feature here is the fact that a global optimization is obtained and not a local minimum. This code has been used with some success in the development of the industrial models.

The control of complex systems has been approached through model reduction by means of aggregation. Work has also been done on a distributed processor control which includes component selection, component location, and control law synthesis with a cost index that is sensitive

to both reliability and performance (Mariton and Bertrand, 1987). This latter work can be taken as a global approach to the design of a reliable flight control system. Included in the analysis is an application of jump linear quadratic (JLQ) systems which has been a control system design under study by the group for a number of years. Essentially, random discontinuities in the system due to component failure are represented by a Markov chain, which causes transitions in the system matrices (ABCD). The JQL approach provides a mathematical framework to form reliable control law synthesis with random component failures. Although an actual flight control system was not designed in the referenced paper a sample problem was given which indicated all aspects of the design. Further work on stochastic linear jump systems has examined observability, controllability, pole placement, and frequency and state space method of linear systems.

### ESE Control Department

I briefly visited the ESE Control Department, which has a staff of 15 directed by Professor D. Vialat. Our discussion was oriented towards teaching, and it was interesting to see the heavy emphasis on computing in the department and the ready availability of software and computers for the students. Their computer laboratory is the equal of many that I have seen in the US. Research directions include control of robots as well as more straightforward application of linear control theory. I had the impression that the robotics work was in its early stages.

### Conclusion

The new approach of differential algebra introduced by Fliess into nonlinear system and control theory is a major advance that should lead to a renovation of the entire field. The nonlinear optimal control work should also be quite significant. The work in the model and control group on the reliable design of flight control systems may have significance with respect of reconfiguration algorithms for modern aircraft. The systems design group has strong ties with the US which, in this case, is of considerable benefit to the US.

### References

- Fliess, M., "A Note on the Invertibility of Nonlinear Input-Output Differential Systems," *System Control Letters*, Vol. 8 (1986), 147-151.
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3/10/88

## MATERIALS SCIENCE

### Materials Meeting in Bordeaux: EXPERMAT '87

by Louis Cartz. Dr. Cartz was the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He has now returned to Marquette University, College of Engineering, Milwaukee, Wisconsin, where he is a Professor of Materials Science.

#### Introduction

The important, and wide-ranging conference, "Materials with Exceptional Properties, EXPERMAT '87," was held at the conference center at Bordeaux-Lac, a suburb of Bordeaux, France. The conference was sponsored by a great many organizations, almost all of them from France.

Sessions were held on a large number of aspects of new materials and their developments: ceramics, non-destructive testing, electronic materials, polymers, fibers and optoelectronics, metals and alloys, chemical sensors, superconductivity, and crystal growth. Other sessions dealt with the organizations of programs of research, both national and European, as well as discussions of materials for the future. Considerable effort had been made to develop an international conference. However, more than 400 of the 500 participants were from France; about 15 came from the UK, a handful of persons from the other European countries, about four from the US and a similar number from Israel.

There was an extensive exhibition of scientific equipment, new industrial products, publications, and materials; almost all the industries represented were French.

This report covers the sessions dealing with hard materials, containerless crystal growth, and the electrical properties of some crystal structure. The sessions on ceramics are reported in the article following, page 32. A complete set of abstracts of all the sessions were available at the time of the meeting, and simultaneous translations (English/French) were provided. There are no plans to publish the proceedings of the conference.

#### Hard Materials

K.H. Jack (University of Newcastle-upon-Tyne, UK) discussed the development of hard materials based on crystal structures with no easy-glide and high interatomic

bond strength. The  $\beta$ - $M_2Mo_3N$  phases, of  $\beta$ -Mn crystal structure, with  $M = Fe, Co, Ni$ , were selected. In this structure, the N atom is situated at the approximate center of six Mo atoms, similar to that of C in WC.

The  $\beta$ - $Ni_2Mo_3N$  phase was studied. This phase is prepared by nitriding mixed Ni and Mo metal powders for 4 hours at 1000°C in cracked ammonia ( $25N_2:75H_2$ ). Pressureless sintering in  $N_2:H_2$  atmospheres with a Ni binder at 1250°C gives a high density and hardness approaching that of Co-cemented WC. The free energy of reaction showed the compound  $\beta$ - $Ni_2Mo_3N$  to be very stable.

Jack found  $\beta$ - $Ni_2Mo_3N$  to be resistant to high-temperature oxidation as well as resistant to corrosion in acid and in alkali. The Ni can be replaced by Fe and Co, and the Mo can be partially replaced by V, Nb, Ta, and Cr. The N can be partially replaced by C by heating Ni-Mo-C in  $N_2$  at 1200°C. These studies are continuing.

Hard coatings of Cr and Mo prepared by magnetron sputtering, which have considerable advantage over coatings prepared by electroplating, were discussed by J. Danroc (Centre d'Etudes Nucléaires Grenoble, France). Cathodic magnetron sputtering is carried out on targets of pure Cr, of targets Cr-Cr<sub>3</sub>C<sub>2</sub> (8.5 weight percent), Cr-Cr<sub>2</sub>N (18.5 weight percent), or pure Mo. Analyses were carried out by x-ray diffraction, transmission electron microscopy (TEM), and microprobe analysis. The C and N are introduced directly by the use of composite targets, or by reactive sputtering by the gas phase. The coatings are supersaturated solid solutions of C and N with concentrations up to several weight percent. The Cr and Mo carbide and nitride coatings have hardnesses up to 30 GPa. The hardness, wear, and corrosion results are considerably better than those of electrolytic coatings.

#### Containerless Crystal Growth

The interest in containerless processing of materials arises from the need to produce ultrapure and fault-free

specimens. A. Rialhe (Centre d'Etudes Nucléaires Grenoble) described the preparation of glass for lasers by containerless processing (for other work in containerless processing, see *ESN* 41-5:249-253[1987] and *ESNIB* 87-01:61-63). Rialhe's levitation furnace is shown schematically in Figure 1 (see Granier and Potard, 1987). Cold-pressed pellets (from 1 to 15 g) are levitated by Ar gas flowing through porous graphite. Heating is carried out by HF induction. On melting, the pellets form a concave sessile drop. Heating is carried out at 1450°C for 4 hours to homogenize the specimen and to allow for outgassing. Cooling rates are greater than  $20 \text{ K s}^{-1}$ . The glass crystallization has been studied by microscopy, differential scanning calorimetry (DSC), differential thermal analysis (DTA), and x-ray diffraction. Glasses studied were of composition  $\text{SiO}_2$  39.7  $\text{CaO}$  29.8  $\text{Li}_2\text{O}$  27.3  $\text{Al}_2\text{O}_3$  2.5  $\text{Nd}_2\text{O}_3$  0.5  $\text{CeO}_2$  0.2 (volume percent). The glass prepared under levitation has been compared to one prepared in a Pt crucible. In the levitated specimen, nucleation is predominantly homogeneous with a maximum rate of  $3.6 \times 10^7 \text{ cm}^{-3}$  at 500°C. Crystallization of  $\text{LiSi}_2\text{O}_3$  and  $\text{Li}_2\text{Al}_2\text{Si}_3\text{O}_{10}$  between 530° and 640°C is a diffusion-controlled process with activation energy 280 kJ/mole. There is a recrystallization with the formation of  $\text{Li}_2\text{Ca}_2\text{Si}_2\text{O}_7$ . The oxide glass-ceramics prepared by containerless processing are homogeneous, and do not suffer from heterogeneities associated with the surfaces.

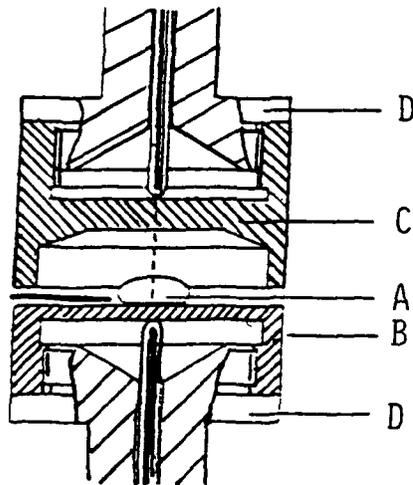


Figure 1. Levitator-Furnace Assembly. A-Levitated sample; B-Graphite porous diffusing part; C-upper tip; D-support parts.

D. Camel (Centre d'Etudes Nucléaires Grenoble, France) presented a theoretical study of crystal growth under microgravity, and of the effects of convection, micro- and macrosegregation, morphological instability of the solidification front, and of the resulting microstructures. He discussed the gravity,  $g$ , levels necessary to give convection free solidification; at normal levels of  $g$ , dendritic growth occurs, while at lower values of  $g$ , a planar solidification front is attained. Experimental

results were shown for a Ge containing  $10 \text{ atom/cm}^3$  of Ga, comparing the microstructure of crystals grown under gravity and under microgravity conditions. Electrical resistance methods show the microgravity crystals to be very uniform, which is not the case for gravity specimens. Experiments on Al-Cu alloys and gravity and microgravity show the interdendritic spacings to be much smaller under gravity.

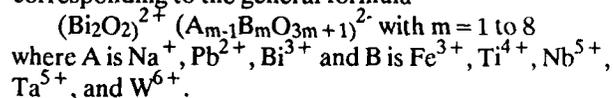
J.C. Launay (University of Bordeaux I, Talence, France) compared gravity and microgravity epitaxy, by chemical vapor transport in a closed tube, in the  $\text{GeI}_2/\text{GeI}_4$  system.

### Ionic Conductivity of Lamellar Structures

The ionic conductivity of lamellar structures is being studied by A. DeRoy (Université Blaise Pascal, Aubiere, France), who presented his findings. The lamellar compound  $\text{M}^{11}_2\text{M}^{11}(\text{OH})_6\text{X.nH}_2\text{O}$ , where  $\text{M}^{11}$  is a divalent metal,  $\text{M}^{11}$  a trivalent metal, and X an anion, has a structure related to hydrocalcite, characterized by  $\text{M}_3(\text{OH})^+_6$  brucite-like sheets. The lamellar structure has a low level of crystallinity, with hexagonal lattice parameters  $a = 0.3 \text{ nm}$  and  $c = 2.3 \text{ nm}$ , which correspond to three interlayer distances.

DeRoy also studied the effect of hydration on the ionic conductivity of  $\text{Zn}_2\text{Cr}(\text{OH})_6\text{Cl.nH}_2\text{O}$ . Cylindrical pellets were pressed at 750 MPa, at which point hard pellets can be formed in the presence of some humidity. The ionic conductivity was found to depend on the hydration of the specimen. This conductivity is stable to thermal cycling between  $-30^\circ\text{C}$  and  $-90^\circ\text{C}$  if protected from dehydration. DeRoy said that the activation energy measurements are very variable, revealing complex conduction mechanisms.

**Ferroelectric Bismuth Compounds.** J.P. Mercurio (Université de Limoges, France) has reported his studies of the phase transitions in a large number of bismuth compounds with layer structure, known to be ferroelectric, corresponding to the general formula



Mercurio said that ceramics prepared from these oxides are characterized by (1) low dielectric constants, (2) high Curie points, (3) low temperature coefficient of the resonant frequency, (4) small aging rate, and (5) a larger anisotropy of the electromechanical coupling factor with respect to the conventional PZT ( $\text{PbZrO}_3$ - $\text{PbTiO}_3$ ) ceramics, making them suitable for high-temperature and high-frequency devices. These compounds have high coercive fields so that poling is difficult compared to perovskite materials.

Mercurio also studied the ferroelectric properties of solid solutions derived from  $\text{Bi}_4\text{Ti}_3\text{O}_{12}$  by cationic

substitution of  $\text{Pb}^{2+}$  for  $\text{Bi}^{3+}$  and  $\text{Nb}^{5+}$  for giving  $\text{Bi}_{4-x}\text{Pb}_x\text{Ti}_{3-x}\text{Nb}_x\text{O}_{12}$ . He synthesized these compounds from oxides at 1123 K for 15 hours, followed by grinding and thermal treatment at 1373 K for 2 hours. X-ray powder patterns showed that solid solution continues from  $\text{Bi}_4\text{Ti}_3\text{O}_{12}$  to  $\text{Bi}_3\text{PbTi}_2\text{NbO}_{12}$ . As  $x$  increases, the  $a$  and  $b$  parameters of the orthorhombic (pseudo-tetragonal) unit cell increase and attain the same value at  $x=0.7$ —that is, become tetragonal.

Mercurio measured the dielectric properties between room temperature and 1023 K at 10 kHz under weak a.c. fields on disc-shaped ceramics coated with silver electrodes. All the solid solutions showed dielectric anomalies as a function of temperature, characteristic of ferroelectric phase transitions. The transition temperatures decreased linearly with increasing  $x$  from 948 K ( $x=9$ ) to 523 K ( $x=1$ ), the transition becoming more and more diffuse, typical of disordered ferroelectric solid solutions. Along with the decrease of the transition temperature, the maximum of the dielectric constant dramatically decreased from  $20 \times 10^3$  for  $\text{Bi}_4\text{Ti}_3\text{O}_{12}$  to about  $10^3$  for  $x=1$ .

M. Manier (Université de Limoges, France) described the dielectric properties of  $\text{Bi}_3\text{Pb}_4\text{Sb}_5\text{O}_{21}$  substituted with Cd or Nb, a new oxide in the  $\text{Bi}_2\text{O}_3$ - $\text{PbO}$ - $\text{Sb}_2\text{O}_5$  system. This compound crystallizes in the trigonal system (space group  $P3m1$ ) with lattice parameters being  $a=0.7345(2)\text{nm}$  and  $c=1.0015(3)\text{nm}$ .

The dielectric characteristics of this phase,  $\epsilon \approx 30$ ,  $\text{tg}\sigma = 10 \times 10^{-4}$ ,  $\tau_E = -40 \times 10^{-6}\text{K}^{-1}$  at 10 kHz, made it suitable for microwave dielectric resonators. Manier is carrying out investigations on  $\text{Bi}_3\text{Pb}_{4-x}\text{Cd}_x\text{Sb}_5\text{O}_{21}$  ( $0 \leq x \leq 1$ ), and  $\text{Bi}_3\text{Pb}_4\text{Sb}_{5-x}\text{Nb}_x\text{O}_{21}$  ( $0 \leq x \leq 3$ ).

These compounds have been synthesized from oxides at 873 K for 24 hours in open alumina crucibles followed by subsequent thermal treatments (1073 K for 6 hours and 1223 K for 5 hours). X-ray powder data have shown that the limits of the solid solutions are reached for  $x=0.6$  and  $x=3$  for Cd and Nb substitution respectively. The dielectric properties are being determined.

J. Grannec (University of Bordeaux I, Talence, France) reported on his studies of the ferroelastic and ferroelectric properties of Ti-oxyfluorides between  $\text{Na}_5\text{Ti}_3\text{O}_3\text{F}_{11}$  and  $\text{Na}_5\text{W}_3\text{O}_9\text{F}_5$  compositions, using x-ray diffraction, microcalorimetry, optical, and dielectric measurements. Many oxyfluorotungstates are

monoclinic, being distorted chiolite ( $\text{Na}_5\text{Al}_3\text{F}_{14}$ )-related structures and are expected to have ferroelastic-ferroelectric properties.

The compounds were prepared by solid-state reactions between NaF,  $\text{TiOF}_2$ , and  $\text{WO}_3$ . The reactions were followed by quenching procedures. Crystals of  $\text{Na}_5\text{Ti}_3\text{O}_3\text{F}_{11}$  for optical studies were obtained by slow cooling in Pt-sealed tubes. The structural details for  $\text{Na}_5\text{Ti}_3\text{O}_3\text{F}_{11}$  and  $\text{Na}_5\text{W}_3\text{O}_9\text{F}_5$ , both monoclinic, are given in Table 1. The ferroelectric and ferroelastic properties are coupled since they have identical Curie temperatures ( $770 \pm 10\text{K}$ ). Various solid solution compositions are under examination.

Table 1. Lattice Parameters.

| Compound  | a<br>( $\pm 0.005 \text{ \AA}$ ) | b<br>( $\pm 0.005 \text{ \AA}$ ) | c<br>( $\pm 0.005 \text{ \AA}$ ) | ( $\pm 0.05^\circ$ ) |
|---|----------------------------------|----------------------------------|----------------------------------|----------------------|
| $\text{Na}_5\text{Ti}_3\text{O}_3\text{F}_{11}$ | 7.399                            | 10.247                           | 7.399                            | 90.86                |
| $\text{Na}_5\text{W}_3\text{O}_9\text{F}_5$     | 7.360                            | 10.635                           | 7.360                            | 90.77                |

## Comments

The meeting at Bordeaux was organized into nearly 30 sessions, many parallel. There was wide coverage by French industry, French scientists, and French scientific organizations. Participation from outside France was severely limited, even though extensive effort had been made to provide English translations of all talks and abstracts. The subjects covered the whole range of scientific endeavor, including such specialized topics as high-pressure materials, materials for mass memory storage, and materials for offshore structures—for which, several speakers were present from Norway.

The ferroelectrical properties of a range of crystal structures are under study, with several of these studies reported by workers at the University of Limoges, France, under the direction of M. Frit; their work was described in *ESN 40-10:360* [1986].

## Reference

- Granier, J., and C. Potard, *Proceedings of the 6th European Symposium Materials Sciences under Microgravity*, ESA SP-256, Feb. (1987), 421-425. [See also *ESN 41-5:249-253* (1987).]

4/29/88

# Ceramics at Expermat '87

by Louis Cartz

## Introduction

The ceramics session at EXPERMAT '87 was only one of many topics presented at this conference – as discussed in the preceding article. I have chosen to discuss ceramics separately because of the current as well as my own interest in ceramics. Although the session formed only a small part of the conference programs, and had no special theme, some of the papers presented on non-oxide ceramics, sol-gel processing, and Ti-silicide films were important. These are reported in the paragraphs following.

## Non-Oxide Ceramics Oxidation and Corrosion

The oxidation of  $\text{Si}_3\text{N}_4$ ,  $\text{SiC}$ ,  $\text{ZrN}$ , and  $\text{ZrC}$  in the presence of  $\text{H}_2\text{O}$  was reviewed by M. Yoshimura (Institute of Technology, Tokyo, Japan). His group carried out hydrothermal studies at pressures up to 100 MPa, for 24 hours over a range of temperatures. They examined the powders by x-ray diffraction, transmission and scanning electron microscopy (TEM and SEM), mass spectroscopy, gas analysis, and gas chromatography. An amorphous layer of  $\text{SiO}_2$  is formed about the ceramic particles, giving a passive protection, where further oxidation depends on oxygen diffusing through the  $\text{SiO}_2$  layer. At low oxygen pressure, gaseous  $\text{SiO}$  is formed, leading to active oxidation. In the presence of  $\text{H}_2\text{O}$ , oxidation of all powders is observed at temperatures as low as  $200^\circ\text{C}$ . Above  $400^\circ\text{C}$ , cristobalite and keatite crystallize from the amorphous  $\text{SiO}_2$ . Activation energies were derived for the oxidation processes, and these range from  $77 \pm 5$  kJ/mol for the oxidation of  $\text{Si}_3\text{N}_4$  between  $200$ - $400^\circ\text{C}$ , and  $135$  kJ/mol between  $700$ - $800^\circ\text{C}$ . For  $\text{SiC}$ , the activation energy of oxidation were found to be  $180 \pm 12$  kJ/mol. The values are lower than those reported in the absence of  $\text{H}_2\text{O}$ . The activation energy of diffusion of  $\text{H}_2\text{O}$  in amorphous  $\text{SiO}_2$  was reported to be  $80 \pm 25$  kJ/mol, so that these investigators believe that  $\text{H}_2\text{O}$  diffusing through the amorphous  $\text{SiO}_2$  is the controlling mechanism. The oxidation in the presence of  $\text{H}_2\text{O}$  of  $\text{ZrC}$  and  $\text{ZrN}$  is by a different mechanism.  $\text{ZrO}_2$  fine particles are produced and since these are of lower density, there is a large volume increase, so that a protective coating is not formed.

C. Weber (Joint Research Center, Petten, Holland) discussed his examination of the mechanical properties

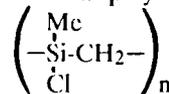
at high temperatures of a  $\text{Si}_3\text{N}_4$ , hot pressed with 9-vol-percent  $\text{Y}_2\text{O}_3$ . He said that there is no glass phase at the grain boundaries (GB), but a crystalline Y-Siliconoxynitride with an apatite structure. The strength of 600 MPa is retained at  $1400^\circ\text{C}$  with good oxidation resistance at  $1450^\circ\text{C}$ , and a low creep rate. The studies of time-temperature-strength were carried out under load, when stress-assisted growth of subcritical cracks is believed to occur. The crack velocity,  $V$ , is related to the applied stress intensity factor,  $K_I$ , by  $V = AK_I^N$ , where  $A$  and  $N$  are determined experimentally. A high value of  $N$  is desired and the  $\text{Si}_3\text{N}_4$  hot pressed HPSN with 9-weight-percent  $\text{Y}_2\text{O}_3$  has a high value of  $N \sim 22$ . In preparing this ceramic, it is necessary to control the composition carefully to avoid glass formation at the GB. It is not possible at present to predict the high-temperature properties of these ceramics. These studies are continuing.

J.B. Veynet (Joint Research Center, Petten, the Netherlands) reported his studies of the high-temperature corrosion of  $\text{Si}_3\text{N}_4$  in  $\text{SO}_2$ /air mixtures, at temperatures from  $800$ - $1400^\circ\text{C}$ , for up to 100 hours with 1- to 5-vol-percent  $\text{SO}_2$  in dry air. The Si used contained 9-weight-percent  $\text{Y}_2\text{O}_3$ , 1.2-weight-percent  $\text{MgO}$ , or 10-weight-percent  $\text{Y}_2\text{O}_3 + 1.2$ -weight-percent  $\text{MgO}$ . At high partial pressures of  $\text{O}_2$ , a silica layer was formed, limiting the reaction. At lower  $p(\text{O}_2)$ ,  $\text{SiO}(\text{g})$  was formed, resulting in a loss of weight without the formation of a protective layer. Weight losses were observed starting at approximately  $1100^\circ\text{C}$ , after 100 hours. X-ray diffraction studies were not able to identify any S-containing phases. Electron spectroscopy chemical analysis (ESCA) studies identified " $\text{SO}_4$ " at the specimen surface. Veynet is continuing these studies.

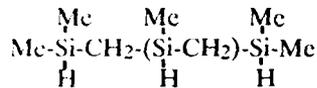
## Precursors Si-C Fibers

Precursors of Si-C fibers have been examined by J.P. Pillot (Université de Bordeaux I, Talence, France), who described the synthesis of linear polycarbosilanes, polymethylchlorosilimethylene, and polysilapropylene. These are of interest as precursors of silica carbide fibers.

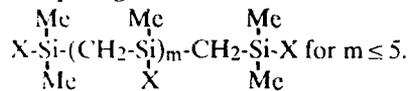
Pillot said that the action of excess  $(\text{Me})_3\text{SiCl}$  with  $\text{AlCl}_3$  as catalyst on linear polydimethylsilimethylene gives the linear polymer



This could be converted into



(or deuteride form) by refluxing in Et<sub>2</sub>O for 24 hours in an inert atmosphere. The <sup>1</sup>H, <sup>13</sup>C, and <sup>29</sup>Si structures are identified by nuclear magnetic resonance (NMR) by comparing with short-chain molecules of

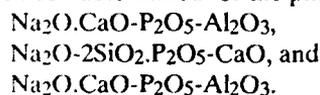


These linear polycarbosilane chains provide accurate precursors for studying the mechanism of conversion to Si-C fibrous materials.

### Sol-Gel Processing

P. Colombari (Ecole Polytechnique, Palaiseau, France) reported his work on the sol-gel preparation of mullite, and the effect of hydrolysis rate, water excess, pH, nature, and length of the alkoxide organic chain, Ti, Zr additives, and Si/Ge substitutions. Gel examination was carried out by weight loss measurements, x-ray diffraction, differential scanning calorimetry, and Raman spectroscopy. A gel powder was obtained by drying the gel at room temperature after rapid hydrolysis of a propanol solution of Al butoxide with Si alkoxide with a large excess of H<sub>2</sub>O. The gel powder was compacted to give densities up to 2.3. Translucent amorphous materials were obtained, and only on heating to about 1400°C were mullite phase x-ray diffraction peaks observed. The mullites are of interest for their IR transmission and dielectric properties.

Sol-gel monolithic (optically clear) compositions of the SiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub>-P<sub>2</sub>O<sub>5</sub>-Na<sub>2</sub>O-CaO-H<sub>2</sub>O system, which is of interest as a bioceramic, were reported by N. Blanchard (Ecole Polytechnique, Palaiseau, France). He carried out slow hydrolysis of the alkoxides. Low-temperature sintering below 650°C produces a porous glass. A glass-ceramic is obtained at higher temperatures of about 1000°C. The optically clear monolithic regions have been determined for the phase diagrams



The order of mixing the reactants is very important. Blanchard said that this can be related to the Al solubility gap; the Ca and P compounds must react together to prevent the total hydrolysis of the Al derivative when adding the Na alkoxide.

A.M. Elias (Lisbon University, Lisbon, Portugal) described optical fibers obtained by the densification of polymerized Si tetra-alkoxide. The transmission losses of prepared fibers are 5.5 dB/km at 840 nm due to residual hydroxyl content.

A review of the sol-gel synthesis of ceramics was given by A.C. Pierre (Aérospatiale, St. Médard-en-Jalles, France). The precursors can be metal salts or metal alkoxides M(OR)<sub>n</sub>. The postgelatin process depends on the type of three-dimensional gel network at the gel point, the limit of the elasticity region. The diameter, d, of the aggregate increases with mass, m, by  $d = m^{1/f}$  where the exponent, f, is the fractal dimension. The final structure depends on the drying process, by osmosis, and then by capillarity. Dried gels have typically high specific areas (about 10<sup>3</sup> m<sup>2</sup>/g), and require high-temperature treatment to densify or crystallize. Pierre said that thin film coatings, and fine powders have been successfully prepared.

J. Ravez (Université de Bordeaux I) discussed the dielectric properties of LiTaO<sub>3</sub> ceramics obtained by sol-gel, which avoids the high-temperature sintering otherwise required, and which results in the loss of Li by volatilization of Li<sub>2</sub>O. The LiTaO<sub>3</sub> was prepared when Ta(OEt)<sub>5</sub> was added to LiOEt in ethanol, followed by hydrolysis in H<sub>2</sub>O, when a homogeneous gel is obtained. Excess solvent is driven off at 100°C. On heating above 450°C, the x-ray diffraction lines of LiTaO<sub>3</sub> are observed. A powder is obtained of grain size ~10 μm. Ceramic specimens are obtained by sintering pressed pellets at 1150°C for 1 hour when a weight loss of about 15 percent occurs. Ravez compared the sol-gel sintering with solid-state reaction sintering of Li<sub>2</sub>CO<sub>3</sub> and Ta<sub>2</sub>O<sub>5</sub>; a higher shrinkage coefficient (about 20 percent) occurs at a lower sintering temperature (1150°C) for the sol-gel than for the solid-state reaction (about 15 percent shrinkage at 1200-1400°C). Ravez's dielectric measurements at 1 kHz gave a ferroelectric-paraelectric transition of Curie temperature below 600°C, lower than that of pure LiTaO<sub>3</sub> (685°C). He said that this diminution is related to the nonstoichiometry with Li/Ta ≤ 1.

### Ti-Silicide Films

TiSi<sub>2</sub> has a very low resistance and is a prime candidate for very large scale integration (VLSI) technology interconnecting material. J.F. Million-Brodaz (Institut National Polytechnique de Grenoble, St. Martin-d'Hères, France) has prepared high-quality thin films of TiSi<sub>2</sub> by CVD on single crystal Si and sapphire at 650-800°C. He said that adhesion is improved by a first coating of polycrystalline Si. He conducted surface studies by x-ray diffraction, microscopy, Auger electron spectroscopy (AES), and Rutherford backscattering (RBS).

I. Lombaert (Université de Bordeaux I) has prepared TiSi<sub>2</sub> films by several methods: co-sputtering from Ti and Si targets, from composite targets, and by Ti evaporation. Rapid thermal annealing is performed under Ar. Lombaert studied the film composition by RBS, secondary ion mass spectroscopy (SIMS), AES, x-ray diffraction, and

TEM. Best film quality (resistivity, grain size, impurity concentration) were obtained for co-sputtered films from Ti and Si targets. Films from composite targets are under investigation.

### Discussion

This session on ceramics formed a small part of the wide-ranging conference, Expermat '87, and as such may have suffered from not having a defined theme of its own. Nevertheless, the presentations covered several interesting topics. These included the behavior of nonoxide

ceramics; oxidation in the presence of  $H_2O$  of  $Si_3N_4$ ,  $SiC$ ,  $ZrN$ , and  $ZrC$ ; mechanical properties of  $Si_3N_4$  hot pressed with 9-volume-percent  $Y_2O_3$ ; and precursors of  $SiC$  fibers. Various papers dealt with the sol-gel process, or wet chemistry formation of ceramic green bodies, considering the application to complex silicate and phosphate systems, the formation of optical fibers, and  $LiTaO_3$  ceramics. The use of  $TiSi_2$  thin films in VLSI circuitry is interesting as a possible connection material, and several detailed studies were reported.

4/29/88

## MECHANICS

### Fluid Mechanics Research at IMST, Marseille, France

*by Daniel J. Collins. Dr. Collins was the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He has now returned to the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.*

The Institut de Mécanique Statistique de la Turbulence (IMST), directed by Professor M. Coantic, is a laboratory of the Centre National de Recherche Scientifique (CNRS) and also of the University of Aix-Marseille. The staff of researchers numbers 45, of whom 15 are CNRS personnel and 25 are engineers and technicians. IMST has a laboratory on the St. Charles campus with a research interest in turbulent supersonic and subsonic flows and another laboratory on the Luminy campus where the research is directed at the study of atmosphere/ocean interactions. Teaching activities involve fluid mechanics in the second and third cycles at the university and also preparation of doctoral candidates in fluid mechanics.

#### St. Charles Laboratory

My host for the visit at the St. Charles campus was Dr. M. Elena, whose primary research interest concerns compressible turbulent flows. The St. Charles Laboratory's supersonic wind tunnel (built in 1960), which has two test sections, was designed with special reference to low turbulence and noise levels. The test sections (Mach 2.3, 1.8) are isolated from the flow generation equipment (400 kw) by a massive sound-insulated wall. The investigations have a strong aerodynamic slant, with experimental studies of shock/boundary layer interaction as one of the principal activities. A recent experimental program involved measurements of the

mixing layer between two supersonic flows of different Mach numbers. The effect on turbulence models of compressibility effects is one of the emphases of the research. There is further emphasis on improvement in measurement techniques in supersonic flow through hot-wire and laser Doppler equipment.

In a different activity but still connected with compressibility effects on turbulence, there are experimental and theoretical investigations of turbulence in internal combustion engines. A linear analysis is being used to calculate the spectrum of the turbulence which will be compared with the experimental evolution of the turbulence flux.

In the research group concerned with subsonic turbulence both heat transfer and mass transfer effects as well as unsteady aerodynamics effects and numerical modeling of turbulence are being studied. Dr. R. Schiestel, in cooperation with B. E. Launder, is developing a new approach to turbulence analysis based on multiple scales for rapidly evolving flows in which there is a disequilibrium between production and dissipation mechanisms. Other more classical point closure methods are being applied to industrial problems in which gravitational and rotational effects may be present. A comparison is also being made between large-scale eddy simulation and the multiscale approach, with an extension to inhomogeneous turbulence envisioned. In perhaps a more practical investigation, turbulent effects on problems in the atmosphere and ocean such as flows due

to pollution are being analyzed in two and three dimensions by Dr. I. Dekeyser.

Unsteady aerodynamics is principally concerned with wind energy machines. This work, in cooperation with Canada, includes experiments conducted in the laboratory's subsonic wind tunnel. There is also a prototype Darrieus wind machine of 1 kW on the campus. My impression was that this work was in process of termination.

The subsonic experimental measurements are concerned with boundary layers, wakes, and jets. The jet work has included two aspects. In one experiment a vertical axisymmetric jet was strongly heated by a flame. Both temperature and velocity were measured. This work has combustion applications and, of course, the modelization of heated jets. In a second experiment the dilution of a hot jet from a helicopter engine was modeled and experimentally measured. The latter experiment, which involves strong turbulence and recirculation effects, was used to verify the modeling and theoretical calculations developed at IMST.

Wake measurements were made in a hydrodynamic tunnel of a slightly warmed cylinder by means of flow visualization and laser Doppler anemometry. Favorable comparisons were made with similar experiments made in air at the University of Newcastle, Australia. The aim of the boundary layer work is control and modification. Studies of wall suction with riblets have been made. Modification of the boundary layer and the coherent structure by means of external manipulators is also being studied.

Finally, a project by M. P. Chauve and G. Tavera is concerned with instabilities and transition due to turbulence. The approach here is from chaos theory, and attempts to describe transition by means of a small number of equations ( $\sim 5$ ). The experimental program is a favorite one that I have found in Europe – that of transition on an airfoil.

### Luminy Laboratory

My host for the visit to the Luminy laboratory was Dr. A. Ramamonjariisoa, who indicated that the staff consists of six researchers and of seven students working on their doctorates. In a unique facility – a marriage of a wind tunnel and a water canal – air/ocean interactions are investigated. These interactions can be grouped into three areas: turbulence effects in the atmospheric boundary layer due to wind, gravity effects due to waves and currents, and capillarity-gravity effects. Ninety percent of the support for the laboratory comes from contracts, 10 percent from foundations.

In the first area of interaction, the effect of turbulence in the atmospheric boundary layer near the ocean surface is studied. Essentially, wind affects the dynamic

and thermic fields near the surface. By proper selection of conditions in the wind-wave facility the researchers can simulate the atmospheric boundary layer in the laboratory. In fact, current work in the facility is directed at preparation for an international experiment in humidity exchange over the sea (HEXOS). Dr. Messtayer, whose research interest is in the atmospheric boundary layer and who is involved with HEXOS, told me that one of the participants in this experiment is Ken Davidson, of the Naval Postgraduate School. Other people from the US, as well as people from Norway, West Germany, and France, are engaged in the project. The experiments in the wind-wave facility have the acronym HEXIST and will focus on the fine structure in the temperature and humidity field of the turbulence field. One instrumentation aspect of this study has been the development of a sensor that will permit the laboratory to determine the humidity field over the ocean.

Under gravity effects one is concerned primarily with the generation of waves on the ocean surface. The research of Dr. C. Kharif is directed at the numerical simulation of the surface of the ocean. In particular, Kharif is interested in the breaking of waves and the formation of air bubbles in the water. Numerical calculations can simulate the wave to the breaking point. The evolution of air bubbles is obtained experimentally by flow visualization and the numerical treatment of digitally recorded images. Ramamonjariisoa and Kharif are also interested in the sub- and superharmonics of very strong waves. Modeling based on the classical equations of surface waves is being compared with specific experiments in the wind-wave facility. This work has application in the imagery of the sea surface by synthetic aperture radar. In another somewhat related project, Ramamonjariisoa is investigating the interaction of electromagnetic waves and surface waves. He is studying the retrodiffusion of 1-cm waves by the surface waves. Actual experimental radar data obtained by the French Space Agency (CNES) is being analyzed with the purpose of determining the sea movement and the velocity of the wind.

Mr. J. P. Giovanangeli is also concerned with waves, but in his case, with wind-generated waves. An important application of this work is the prediction of the sea state. Giovanangeli has developed a very interesting hot-wire/pitot-tube sensor that can be used to simultaneously measure unsteady pressures and velocity fluctuations near the surface of the sea. With some reasonable theoretical assumptions the sensor can obtain the shear stress in the boundary layer. Commercial development of the sensor is now being considered. Giovanangeli has also been involved in a NASA project on rain effects on sea state and its effect on scattering measurements.

Capillarity-gravity effects are being studied by Dr. G. Caulliez. In what I found to be a very interesting experi-

ment, Caulliez (1987) used a laser Doppler velocimeter to measure water motions near the surface. Measurements were made within up to about 0.8 mm of the surface in forward scatter with a tilted optical system below the water surface in a 1/5-scale model of the wind-wave facility. Wave action and particle seeding became greater problems as one neared the surface. This experiment was a well-designed and innovative application of laser Doppler velocimetry. Further theoretical results of Caulliez's doctoral thesis on capillary waves will shortly be available in the open literature. The structure of capillary waves has an important effect on material transfer at the air/sea interface and on teledetection. The effect on CO<sub>2</sub> transfer and thus the global balance of CO<sub>2</sub> is particularly important.

### Conclusion

I found the work at Luminy with its unique wind-wave facility particularly relevant to US Navy application. Perhaps due to their heavy emphasis on contract work I found

the people at Luminy quite dynamic and, indeed, excited by their work. The capillary-gravity work and the new sensor developments are particularly important. Several of the people have worked and studied in the US and there is presently strong contact with American programs. Some of the facilities at the St. Charles campus had recently undergone renovation, which created, perhaps falsely for a single-time visitor such as myself, an impression of less activity than one would expect. The program at St. Charles is a well-conceived program of investigation of turbulence both from an experimental and theoretical viewpoint.

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4/25/88

## Turbulence and Fluid Mechanic Calculations at the University of Paris SUD

by Daniel J. Collins.

The Laboratoire d'Analysis Numérique (LAN) is a laboratory associated with the Centre National des Recherches Scientifiques (CNRS) and with the University of Paris-Sud, where LAN is located. Professor R. Temam directs LAN, which, together with a group concerned with partial differential equations, constitutes a "complete" CNRS laboratory. As with most associated CNRS laboratories, LAN has both teaching and research activities. For the DEA degree (Diplome D'Etudes Approfondies) in numerical analysis and application there are some 30 students; about five students a year obtain their doctorates. There are five permanent staff in research/teaching. I would like to highlight two aspects of the research, one connected with fundamental aspects of turbulence and the other with numerical calculations of complex flows.

### Turbulence

Temam identifies turbulence with chaotic motion of a dynamic system. The key idea in this approach is that for a dissipative set of nonlinear partial equations the chaotic motion is confined to a bounded region of the phase space. A perhaps surprising result of analysis based on the chaotic approach is that the bounded region can be of finite dimension, even for infinite-dimension systems. I

think the simplicity and elegance of the mathematical and physical ideas involved merit further explanation. My presentation will follow that of Temam (1988).

Consider a general system given by the equations

$$\frac{du}{dt} = F(u(t)) \quad (1)$$

$$u(0) = u_0$$

This set of equations may also be considered as representing a set of partial differential equations, in which case one has

$$u = u(x,t), \text{ where } x \text{ is a vector.}$$

For the finite dimensional case one takes

$$u \text{ as an element of } H = \mathbb{R}^n$$

and for the infinite dimensional case one has

$$u \text{ as an element of } H, \text{ a Hilbert space.}$$

Associated with the equations (1) is a semigroup  $S(t)$  — i.e., a set of possibly nonlinear operators such that  $u(t) = S(t)u_0$  where  $u(t)$  is the solution to the set of equations (1). Thus the semigroup  $S$  carries the initial conditions of the system into the solution, or maps the initial conditions into the solutions space. In a steady-state problem, where one might not know the initial conditions, one would be interested into what part of the phase space are all possible initial conditions mapped. With this background it is now fairly straightforward to describe the na-

ture of the steady-state motion and chaotic motion of a system — i.e., the solution as  $t$  goes to infinity.

In steady-state motion as  $t$  goes to infinity in a given system one has  $u(t) \rightarrow X$  where  $X$  is an invariant subspace of the phase space  $H$ . All motion thus ends up in a subspace  $X$  of the original phase space  $H$ . The subspace  $X$  has the further property that it is invariant with respect to the semigroup; i.e.,

$$S(t)X = X \text{ for all } t \geq 0.$$

The invariant subspace  $X$  can be trivial in that it involves stationary solutions (fixed points) or an orbit of time-periodic solutions. In the case of chaotic motion or turbulence the set  $X$  is convoluted and may be a fractal set. From a dynamic viewpoint it is the wandering of  $u(t)$  in this complex set  $X$  for large values of  $t$  that creates turbulence. Temam's recent work has been directed at the characterization of the invariant set  $X$ , which he has variously called "global attractor," "universal attractor," and "maximal attractor."

For a series of equations Temam and his coworkers have found that the the universal attractor is compact and of finite dimension, although large. For the Navier-Stokes equations the bound on the dimension of the attractor in terms of Reynolds number is of order 3. Although this is more pessimistic than the classical result of order  $9/4$ , it must be remembered that no a priori knowledge of the spectrum of the flow is used. In a recent paper (Foias et al., 1987) the condition under which one obtains the  $9/4$  value were developed. Further connections between the classical approach to turbulence and the attractor approach have been developed in a series of papers by the same authors as well as the extension of the analysis to connective problems. Further work on characterization of universal attractors by Dr. J. Ghidaglia has extended the analysis to a series of important equations, among which are the nonlinear Schrodinger equation, the Kortweg-De Vries equations, and the Ginzburg-Landau equation. The attractor methodology is thus being applied to a wide range of dissipative equations with the important result that the attractors are all of finite dimension.

### Numerical Analysis

Computational work by Dr. J. Lamine has been primarily directed at the Euler analysis of two- and three-dimensional (2- and 3-D) flows using the method of finite elements. The analysis in 3-D has been conducted on supercomputers both in France and at the University of Min-

nesota Supercomputer Institute in the US. In the fine mesh calculations, 50,000 nodes were used to characterize the flow. The number of nodes in the calculation would be typical of similar calculations in the US and indicate that the European community is beginning to overcome its previous handicap in supercomputers. Calculations were made of vortex flows past a flat plate at high angle of attack. Despite the fact there was no artificial viscosity and that the Kutta condition was not used, the calculations showed how vortices developed spontaneously around the tip of the plate and propagated into the wake. These calculations have been for both subsonic, supersonic, and hypersonic flows (Bruneau et al., 1988). Lemine indicated that future work would be directed at the Navier-Stokes equations.

In a perhaps more exciting extension, Lemam indicated that he would like to begin numerical calculation based on the attractor approach to turbulence. A typical problem might need some 30,000 equations to characterize the turbulence field, and there is further the question of how to develop the set of equations even if one can show that the universal attractor has a dimension of 30,000.

### Conclusions

Very innovative work in turbulence is being conducted by Professor R. Temam and his group at LAN. Nice connection with more classical methods and the attractor method have been made for the theory of turbulence. Attractors form an elegant and in some sense simple approach to the understanding of turbulence. The laboratory is also conducting innovative numerical analysis of vortex flow. There is also the exciting although difficult prospect of developing methods based on attractors for the numerical analysis of turbulence.

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5/4/88

## The Combustion Research Laboratory at Marseille

by Daniel J. Collins.

The Combustion Research Laboratory (LRC) under the direction of Professor P. Clavin was established at Marseille, France, in 1985. LRC is associated with the Centre National des Recherche Scientifique (CNRS) and the University of Provence at Aix-Marseille. The laboratory has 24 research personnel of whom 15 are permanent staff. Since five doctoral students graduated in 1987 it can be seen that they form an important part of the Centre's research combustion effort. From 1984 to the present there have been 125 publications (50 in scientific journals) produced by LRC people. Contracts provide about 45 percent of the support of the staff. Three EEC contracts provide fairly extensive contacts with European research institutes, and there are important cooperative programs with American research laboratories such as those at Los Alamos, the Lawrence Livermore Laboratory at Berkeley, Princeton University, and the University of Chicago.

The main research theme of LRC is the study of the topology and dynamics of unstable flame fronts in turbulent flows of premixed gases. The three groups into which the laboratory is divided correspond roughly to the three research directions of the study (the director of each group is noted in parentheses):

- Analytical methods (Professor P. Clavin)
- Experimental methods (Professor L. Boyer)
- Numerical methods (Dr. P. Haldenwang)

My review considers each of the research directions in turn. Although I list only an occasional reference I have a detailed reference list to all the items discussed.

### Analytical Methods

Singular perturbation analysis and the method of multiple scales have permitted a theoretical description of the internal structure and propagation of wrinkled flames (Clavin and Joulin, 1987). This analysis also throws light on the nonlinear interaction of the flame with the gas flow that regulates the dynamics of the flame front. As a result of this analysis a better understanding of extinction, and of curvature and stretching effects on the flame front due to flow inhomogeneities is obtained. Further analysis has been made of strongly curved flame fronts, of cellular flame fronts, and of turbulent combustion. Applications of the theory to cool flames and to flames in porous media have also been considered.

### Experimental Methods

Most of the phenomena discussed under analytical methods are subject to experimental investigation. There

is thus a close relationship between theory and experiment. One of the principle experimental tools used in the laboratory is laser tomographic techniques in which the local velocity and position of the dynamically stabilized flame front is obtained (Boyer, 1987). The experimental arrangement is well conceived, with particular consideration to the elimination of wall curvature distortions of the container. Pulsed lasers with 50-ns pulsed durations are used with computer-controlled experiments. Although some digital "image" processing is now being done, future work will emphasize digital acquisition and processing of images of the flame.

A variety of different flame fronts including cellular flames, flames stabilized in the wake of holders, and bubble-shaped flames in tubes (Pelice-Savorin, 1987) are being studied. The bubble-shaped flames research, as well as most of the other experiments, form part of a doctoral thesis investigation. Experimental measurements are also being made in natural convection flow, as in Rayleigh-Benard flow. The experimental natural convection work fits in with the numerical analysis in this area.

### Numerical Methods

Spectral methods are one of the principle analysis tools used at LRC. There has also been extensive use of self-adaptive grids to convective flows, a cooperative effort with France's national institute for research in informatics and control (INRIA) at Sophia Antipolis. Random vortex methods have also been developed with the University of California at Berkeley. In what I considered to be a very interesting investigation, work is going on in the simulation of gases on lattice networks (Searby 1987). These simulations, which involve a joint project with the University of Ulm in Germany, can be done with high computer efficiency and speed and represent another method of analyzing complex gas flows.

Applications of the numerical analysis have been to the problem of the extinction of flames at walls, the dynamics of unstable thermal diffusion fronts, and the study of singularities on strongly unstable flame fronts. A recent doctoral thesis included calculation on the Rayleigh-Benard problem.

### Conclusion

A large part of the research of the Combustion Laboratory is narrowly focused on turbulent flame fronts. This focused is a strong point of the laboratory in that analytical, experimental, and numerical methods can be applied to the problem. There is a healthy interaction be-

tween the laboratory groups. I was particularly impressed by the innovative application of laser methods to combustion measurements in the laboratory. LRC also has strong ties with research in the US.

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5/10/88

# PHYSICS

## Photon-Localization, Detection, Amplification, and Antibunching: an ONRL-Supported Workshop

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1988.

In early 1988, a NATO-ARW Institute on Squeezed and Nonclassical Light was held at the conference center near Cortina d'Ampezzo, Italy. The Institute was preceded by a workshop entitled Photon Localization, Detection, Amplification, and Antibunching. This workshop was sponsored by the Office of Naval Research, Branch Office, London.

The director of the workshop was the UK's Professor E.R. Pike, FRS (King's College, London, and Royal Signals and Radar Establishment, Malvern). There were nine selected European speakers (and one unsupported American), and a substantial (but restricted) number of participants in the subsequent NATO institute came to attend the workshop too.

The purpose of the workshop was to facilitate in-depth discussion of production and properties of antibunched light, and of related subjects such as conditions and meaning of photon localization, theoretical mechanisms of photon detection, and aspects of photon amplification. Brief reviews of the European opening addresses follow.

### The Presentations

**Basic Aspects of Nonclassical Light.** The first speaker, I. Abram (Centre National d'Etudes des Telecommunications, Bagneux, France), gave a fine

general review of nonclassical light propagation. He demonstrated that the inadequacy of traditional quantum optics in the description of propagation of nonclassical states of light hinges on the circumstance that this theory addresses the temporal evolution rather than the spatial progression of the field. This is so because the traditional quantum theory is based on the Hamiltonian of the radiation modes, where interaction between modes can occur only through the medium's polarization (if any). There is no interaction term in the Hamiltonian that can describe the modification of the spatial progression due to refraction.

Abram then proceeded to elucidate his new quantum mechanical formalism that permits the treatment of both temporal and spatial features of light propagation, thus allowing for a complete description of the propagation of nonclassical states of light in linear or nonlinear media and across medium interfaces. The crux of the new formalism is that, in addition to the Hamiltonian, it also uses the momentum operator of the field for the description of its spatial progression.

F. Haake and M. Wilkens (University of Essen, West Germany) presented research results which generalize quasi-probabilities based on coherent states to quasi-probabilities based on squeezed states. It was shown that the representation of an operator as a diagonal mixture of squeezed states defines an analogue of the Glauber-Sudarshan P-function. The usefulness of the new for-

malism was illustrated on a linearized model of subharmonic generation.

**Some Selected Nonclassical Phenomena.** The now familiar experiments on radiation from a single-atom maser formed the basis of the talk by H. Walther (Max Planck Institute for Quantumoptics, Garching, West Germany.) He reviewed the circumstances in single-atom maser experiments which have the result that the system approaches the idealized case of a two-level-atom interacting with a single quantized mode of a radiation field. It is therefore possible to perform experiments on the dynamics of the atom/field interaction predicted by the Jaynes-Cummings theory. The statistical and discrete nature of the photon field leads to new dynamical characteristics, such as the collapses and subsequent revivals in the Rabi mutation. Experiments were described which directly test the statistics of the photons in the cavity. The nonclassical nature of the radiation was analyzed in detail.

S. Sarkar (Royal Signals and Radar Establishment, Malvern, UK) gave a theoretical analysis of a related problem. He calculated the spectrum of photons in a vacuum cavity, assuming that one mirror of the cavity has undergone some smooth motion (starting from rest and returning to rest). He demonstrated that the spectrum is not consistent with either the thermal- or the Poisson-distribution of light.

The Royal Signals and Radar Establishment was the source of a second, very beautiful paper in this area. J.G. Rarity and P.R. Tapster discussed nonclassical effects in parametric down-conversion. The authors demonstrated that using nondegenerate type-I phase matching, two identical trains of photons (obeying momentum and energy conservation in the down-conversion process) can be selected by apertures; the detection of photons in one train can then be used to modify the quantum statistics of the other train. In this way, antibunched and/or sub-Poissonian light is produced. A further property of the down-converted photon pairs is their high degree of temporal coincidence. Recent theory and experiment has shown that recombining indistinguishable photon pairs in a beam splitter leads to a fourth-order interference effect which allows a direct measurement of the photon overlap. Such experiments allow measurement of sub-picosecond time delays at the single photon level. Furthermore, the detailed shape of the effect can be related to the bandwidth of the photons, which is eventually limited by the bandwidth of the crystal nonlinearity and the fundamental theory of parametric down-conversion.

The last paper in the subarea of nonclassical phenomena came from the Laboratoire de Spectroscopie Hertzienne de l'École Normale Supérieure, Paris, France; it was presented by E. Giacobino. The interesting research of this Parisian group concerns questions quite closely related to the topic of the preceding talk.

The scientists reported on the observation of an appreciable reduction of noise (to below the shot-noise level) in an experiment where high-intensity coherent beams were generated by parametric down-conversion. The nonlinear crystal was inserted into an optical cavity which was designed to resonate at the frequencies of both daughter photons. The photons, emitted in pairs, were then stored in the cavity during a random time-interval of the order of the inverse of the cavity linewidth  $\Lambda$ . Therefore, by counting the photons on a timescale long compared to  $\Lambda^{-1}$ , one can expect to measure exactly the same intensity in both beams, so that the noise attached to the intensity difference is strongly reduced for frequencies smaller than  $\Lambda$ . A detailed calculation allows also the prediction of the fluctuation spectra of the amplitudes and of the phases. In the actual experiment (where a KTP crystal emitted two, orthogonally polarized beams at wavelengths 1.046  $\mu\text{m}$  and 1.065  $\mu\text{m}$ , with an intensity of a few milliwatts) it was found that the total noise power was reduced by 30 percent below the shot noise limit (the "vacuum value"). (The experimental setup monitored the noise spectrum of the intensity difference between the two beams.) In fact, noise reduction was large over a broad range of frequencies: more than 15 percent from 3 to 13 MHz. The presentation ended with the discussion of possible applications.

**Localization, Detection, Amplification.** The workshop's director, Pike, contributed a report (coauthored with Sarkar) in which a full multimode-theory for parametric down-conversion was used to calculate the two-photon detection amplitude. (Thus, in a sense, this paper tied in neatly with the preceding two talks' subject matter.) Based on the structure of this amplitude, the Malvern researchers proceeded to develop a heuristic argument for the estimation of the configuration-space extent of single photons involved in the process. It appears that these single photons have a configuration space localization consistent with an asymptotic fall-off  $r^{-5/4}$  with distance in the radial direction.

The talk by M. LeBerre (University of Paris-South, Orsay, France) was largely a careful survey of previous work on the connection of photodetection and photon statistics. Various models were given regarding the probability  $p(n,T)$  of counting  $n$  photoelectrons in a counter, within a given time interval  $(t, t+T)$ . LaBerre emphasized that the classical and first-order-approximation quantum theoretical models fail for large  $T$ , but a complete quantum theoretical treatment of photodetection overcomes the difficulties. In particular, it can be shown that  $p(n,T)$  tends to the photon distribution as  $T$  tends to infinity. LaBerre mentioned that, while all theories agree for small values of  $T$ , it is possible to devise a test to distinguish classical fields from pure quantum fields; the proposed experiment is based upon the observation of in-

tensity modulation. Finally, the speaker described a pure quantum effect which arises in cooperative quantum fluorescence. He predicted antibunching of photons in a conical shell around the propagation axis. He also described the temporal aspects of the predicted effect.

In a paper authored by G. Mander, R. Loudon and T.J. Shepherd, the Optics Group at the University of Essex (Colchester, UK) put the finishing touch on the workshop. This work presented models for phase-insensitive linear quantum amplification. The researchers pointed out that the operation of a laser amplifier (biased just below threshold) is most easily described in quantum theory by using a model of a phase-insensitive system, where gain is obtained through an atomic population inversion. The basic model for the inverted atomic population system in a closed cavity was described. Then, more sophisticated systems were analyzed, where the internal electromagnetic mode is coupled to explicit external

input- and output-fields. In particular, the scientists analyzed the degree of degradation of the amplification process as a function of the signal-to-noise ratio of the injected field. In addition, they examined the limitations of the system regarding its ability to support nonclassical properties of the amplified field.

### Concluding Note

I have one-page abstracts of the talks reviewed above. The complete texts will appear toward the end of 1988 in a special volume *Photon Localization, Detection, Amplification, and Antibunching*, to be published by Adam Hilger, Bristol. The editor will be Professor E.R. Pike, to whom all further enquiries should be addressed (Royal Signals and Radar Establishment, St. Andrews Road, Great Malvern, Worcester WR14 3PC, UK.)

## Young British Scientist Proposes Sophisticated Research in Molecular Physics

by Paul Roman.

Jeffery H. Williams is a "theoretical chemist," whom I met while he was doing advanced experimental molecular physics research in the University Chemical Laboratory at the University of Cambridge, UK. Williams received his degree about a decade ago from the distinguished scientist, A.D. Buckingham (the director of the Department of Theoretical Chemistry at the same Laboratory), whose ideas and predictions influenced Williams very strongly. At first, he used molecular beam methods to study the fascinating world of van der Waals molecules. Currently his research uses the static Kerr effect, with the aim of both doing extremely high-resolution and high-sensitivity molecular spectroscopy, and to determine characteristic molecular constants in unusual molecular states.

### Current experiments

Williams just concluded a series of careful dispersion study experiments in the Kerr effect of molecular oxygen. Essentially, he measured the birefringence induced by application of an intense uniform electric field to a sample of gaseous oxygen. The experimental setup is rather simple (see Figure 1). The light source was a commercial tunable dye laser, pumped by a commercial argon ion laser. (CW operation was maintained.) The 80-mW output of the laser was centered at 630-nm. The frequency was scanned, using a birefringent filter, which was controlled with a (home-built) stepping motor interface. The

apparatus gave tunable radiation over the area of interest with a linewidth of about 40 GHz. The nearly vertically polarized laser output radiation is further polarization-selected by a Glan polarizer; then it passes through a home-built Kerr cell which has in it a 46-cm-long electrode assembly (with plate separation 0.476 cm.)

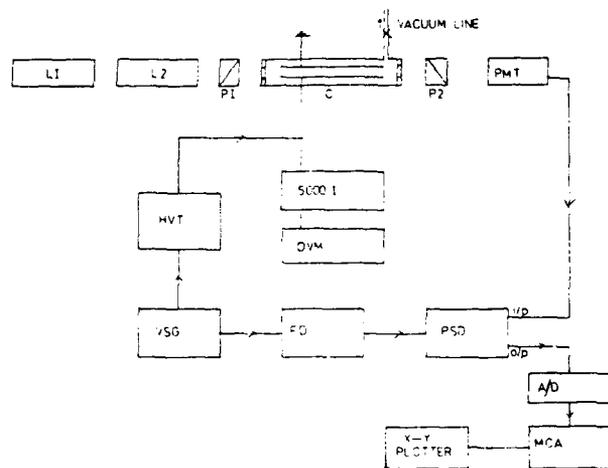


Figure 1. Schematic of experiment. L1: Ar ion laser; L2: dye laser; P1 and P2: Glan polarizers; C: Kerr cell; PMT: photo-multiplier tube; PSD: phase-sensitive detector; MCA: multichannel analyzer; DVM: digital voltmeter; VSG: variable signal generator; HVT: high-voltage transformer; FD: frequency doubler; A/D: analog-digital converter.

Typical operating voltages amounted to fields of the order of a few million  $V\text{ cm}^{-1}$ . The gas pressure was, typically, around 1 atm. The essential feature of the experiment consisted in the application to the electrodes of a high-voltage sinusoidal signal at approximately 590-Hz: this produces (via the second-order Kerr effect) a birefringence in the oxygen that has an alternating component with twice as high frequency. The transmitted light was then made to pass through an analyzing Glan polarizer, and was fed to a phase-sensitive detector for demodulation. (The reference signal came from the oscillator that drives the high-voltage transformer, via a frequency doubler.) Clearly, the use of phase-sensitive detection is the clever "trick" in the experiment. The output from the detector was digitized and collected by a multichannel analyzer. The output could also be recorded by an X-Y plotter.

Using the quantum theory of the Kerr effect, the observed phase retardation between the electric vector components parallel and perpendicular to the electric field in the laser beam propagating along the axis of the cell, one can determine the anisotropic polarizability of particular states which are probed while the laser beam is scanned through the corresponding molecular transitions. Williams obtained excellent Kerr spectra; part of a typical low-resolution scan of the (2,0) band of the  $^1\Sigma_g^+ \leftarrow ^3\Sigma_g^-$  transition is shown in Figure 2, clearly exhibiting the start of the  $^P_P$ ,  $^P_Q$  and  $^R_R$ ,  $^R_Q$  branches. Figure 3 is a higher resolution scan of part of the (2,0) band. Calculation then yielded the ratios of the polarizability-anisotropy for the  $v'=2$  and  $v'=3$  levels of the  $^1\Sigma_g^+$  state to that of the  $v'=0$  level of the groundstate of  $^3\Sigma_g^-$ .

To appreciate the "cleverness" of the experiments, one must realize that the triplet-singlet transitions are electric-dipole-forbidden, very weak transitions. Previous work, with classical spectroscopic methods, required a several-kilometers-long path-absorption experiment (using sunlight passing through the atmosphere). In

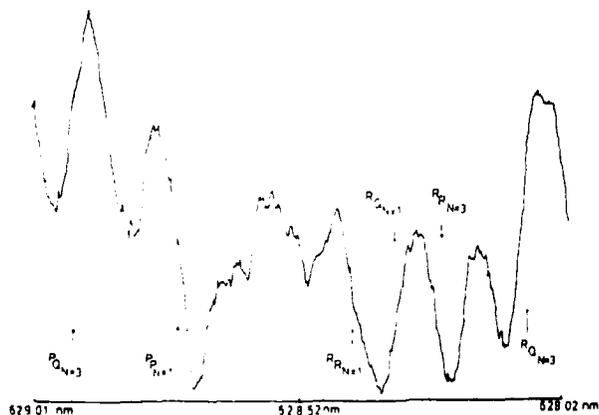


Figure 2. Part of a low-resolution spectrum.

addition, Williams' experiment gave an improved sensitivity by a factor of  $10^4$ . The signal-to-noise ratio was 50:1. By using better bandwidth lasers and by placing the Kerr cell inside the laser cavity, a further order of magnitude improvement in sensitivity can be expected.

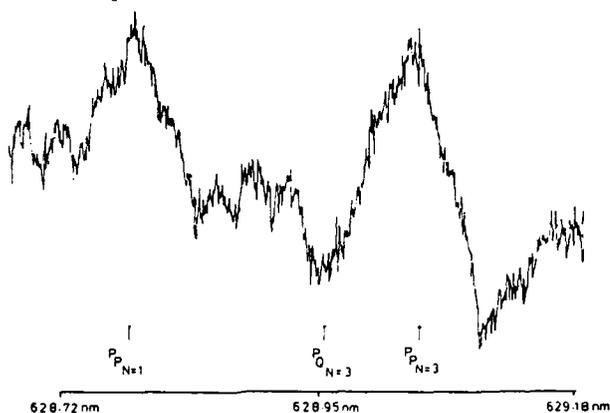


Figure 3. A high-resolution spectrum sector.

### Planned Work With Static Kerr Spectroscopy

Encouraged by his initial results (a copy of the preprint can be obtained from me), Williams now plans several extensions of techniques, and also new applications. First of all, he wants to observe some of the oxygen isotopomers (such as  $^{16}\text{O}^{18}\text{O}$ ), so as to obtain information on the vibrational potential high up in the  $^1\Sigma_g^+$  state. Alternatively, he intends to use his technique for the accurate measurement of very small oscillator-strengths. More generally, the experiments could be extended to study other molecules (e.g.,  $\text{Na}_2$ ,  $\text{NaK}$ , or  $\text{NO}_2$ ) as well; in particular, one will measure accurately electronic properties, such as dipole moments and polarizabilities of molecules in excited states, and also transition moments. To improve the technique, it will be necessary to use a Fabry-Perot etalon (to give higher resolution in the dye laser) and to employ an improved phase-sensitive detector.

### Optical Kerr Effect Plans

But Williams is not restricting his plans to the use of the static Kerr effect: to the contrary, he has already initiated successful studies using the optical Kerr effect. This fourth-order nonlinear effect can be characterized by saying that an intense beam of light passing through, say, a fluid, gives rise to an induced optical anisotropy. The optical field exerts a torque on an anisotropically polarizable molecule; and the observed signal is proportional to the mean-square anisotropy (MSA) in the polarizability. In preliminary experiments Williams demonstrated that it is possible to measure the optical Kerr effect using a powerful CW argon laser to induce the

anisotropy, and a weak He-Ne laser to probe it. With a path-length of only 10 cm, a chopped argon laser beam, and a rotating cell (rotation allows overcoming thermal lensing), changes in the index of refraction of the order as small as  $10^{-16}$  could be detected. Williams now tends to apply the technique to the study of aqueous solutions. (Conductivity of such solutions prevents normal electro-optic studies.) It is easy to understand that from the observed MSA and a knowledge of the polarizabilities of the constituents of the solution, one will be able to make sound deductions about the structure in the solution. Optical Kerr effect studies would complement recent successful neutron diffraction experiments about the structure of aqueous solutions; in fact, Kerr experiments would have higher selectivity since one can vary the frequency of the orientating and/or the probe laser.

### Molecular Beam Resonance Spectroscopy Plans

Williams spoke also of an unrelated research project. He wishes to use the techniques of molecular beam resonance spectroscopy—that is, molecular beam electric resonance spectroscopy (MBERS) and molecular beam magnetic resonance spectroscopy (MBMRS)—to probe both the structure and the electromagnetic properties of small clusters of metal atoms, and of small clusters of metal-nonmetal atoms. Regarding methodology, he thinks that MBMRS has been neglected in the past two decades, in all aspects of molecular beam spectroscopy. He advocates the use of modern cold beam sources and computer-controlled signal averaging techniques to restore MBMRS in general,

and for the investigation of clusters in particular. But for these specific studies, he would also use MBERS. In any case, a beam of atom clusters would be produced by laser evaporation of a suitable target over which an appropriate carrier gas is flowing into a nozzle. The internal energy of the clusters would be controlled simply by controlling the backing pressure. The beam will be then studied by analyzing the induced dipole moments in suitable electric or magnetic fields. For example, a vibrational spectrum of a metal-nonmetal cluster could be obtained from a MBERS spectrometer, provided a suitable light source were available. Williams thinks that an optoparametric oscillator pumped by a YAG laser would be ideal. Williams put together a long list of experiments with the clusters in question which, he thinks, could be successfully accomplished with MBERS and MBMRS techniques. (Enticingly, the list includes the study of magnetic properties in systems which are related to high-temperature superconductors.)

### Epilogue to William's Work

It is by no means clear when and where Williams will be able to pursue his innovative ideas. Because of funding difficulties in the UK, Williams recently assumed a staff physicist position in Grenoble (France), at the von Laue-Langevin Institute. (This institute is cosponsored by France, West Germany, the United Kingdom, and to lesser extent, by a few additional West European countries.) Here Williams will turn to a new enterprise: neutron spectroscopy. But he intends to apply his acquired system-oriented approach to this area as well.

## "Optronic 88" in Hannover

by Paul Roman.

In connection with the annual Hannover Industry Fair, 20 through 27 April 1988, and supported by the Ministry of Lower Saxony for Economy, Technology and Transportation, West German industrial and commercial institutions organized a fine international laser congress.

On the opening day, six invited speakers gave broad overall reviews of various areas, ranging from aspects and trends in laser technology in Germany, Japan, and the US to the review of some research at the Lebedev Physical Institute, Moscow. The impressive opening address was given by Nobel Laureate J.C. Polanyi (University of Toronto, Canada), who talked about new directions in laser chemistry.

The second day was devoted to presentations on laser methods. It had the following sessions:

1. Laser methods in materials processing
2. Laser methods in microprocessing of materials
3. Laser methods in metrology and analysis.

The third day focused on laser applications and was divided into the following sessions:

4. Laser applications in manufacturing
5. Laser applications in communication
6. Laser applications in metrology and analysis.

All talks were substantial (lasting 40 minutes) and 10-minute discussion time was provided after each. The three sessions, each day, ran parallel to each other, but

this caused little overlap and allowed for more intense participation.

In this note, I very briefly review a few selected papers taken from areas 3 and 5.

### Laser Metrology

Laser-Doppler-anemometry was discussed in a talk by M. Faber and colleagues (PTB, Braunschweig, West Germany). In particular, recent progress in the miniaturization of laser-Doppler anemometers and optical velocimeters was emphasized. Apparently, such progress was made possible through the use of high-performance diode lasers. Applications of diode-laser techniques in the field were expounded.

In a very interesting talk, H. Endert (Academy of Sciences, East Berlin, East Germany) discussed new focal points of laser-technology applications in metrology. He concentrated on automatized picosecond CW dye lasers, sub-nanosecond N<sub>2</sub> lasers, and picosecond streak camera research; he also described complete laser metrology analytical systems.

### Lasers in Communication and Computing

Laser technology in space was the topic of the informed talk given by P. Hartl on behalf of the Institut for Navigation (Stuttgart University, West Germany). He explained that, in the area of civilian space travel, laser tech-

nology will play an important role in remote sensing, communications, navigation, and high-precision surveying. He described very interesting possibilities for communication between earth and spacecrafts, for intersatellite transmission, and for survey in space.

C. Hanke (Siemens A.G., Munich) discussed the use of semiconductor diode lasers in fiber-optic systems. The tutorial part of the talk presented the state of art of semiconductor lasers in terms of typical laser structures. The second part of the presentation discussed requirements on the characteristics of semiconductor lasers for use in the planned coherent transmission systems (hetero- or homodyne reception), and for high-bit-rate systems in general.

Digital optical computers of the future were discussed by K.H. Brenner (University of Erlangen-Nuremberg, West Germany). After a general review he focused on the new features (such as constant connection lengths, and reduced "fan-in" or "fan-out" of the gates) which will ensue from the transition to higher synchronization frequencies. Brenner then discussed ideas for the logic, architecture, and implementation of optical computers.

### Concluding Remarks

Abstracts of all contributed presentations can be obtained from me. For additional material, please contact directly the chief organizer, *Laser Magazin*, Magazin Verlag, Friedrichstr. 71, D-6342 Kronberg, West Germany.

## Optimal Structures and Slaving: an ONRL-Supported Seminar Session

by Paul Roman.

The 8th Winterseminar of the Institute for Applied and Physical Chemistry of the Universität Bremen (West Germany) was held from 27 February through 6 March 1988 at the ideally isolated mountain hamlet, Zeinisjoch (Tirol, Austria). The organizer and director of the seminar was Professor P.J. Plath, Department of Chemistry, Universität Bremen. The general topic was "Structures and Dynamics in Heterogeneous Chemical Systems." There were 28 participants. The Office of Naval Research undertook the full sponsorship of a special session entitled "Optimal Structures and Slaving of Chemical Reaction Systems." A brief review of the talks presented at this session follows.

### Papers Presented

The paper by A. Kuhn and A. Wunderlin (Stuttgart University, West Germany) served as keynote address. It

expounded the slaving principle of synergetics. Starting from the description of complex systems far from thermal equilibrium on the level of their subsystems, a systematic mathematical method can be developed which leads to establishing order parameter equations determining the macroscopic behavior of the complex system. The method starts with determining stationary states on the level of subsystems, which are then analyzed in regard to their stability under changes of external influences. Possible instabilities are determined from linear stability analysis. In the vicinity of an instability one then finds the collective modes of the system. These can be divided into stable and unstable ones. It can be demonstrated that, under suitable conditions, the behavior of the stable modes is completely determined by the motion of the unstable modes ("slaving principle"). This fact allows one to systematically eliminate the stable modes from the equations for the unstable modes. Thus, one obtains a few

nonlinear equations for the order parameters – these are generalized Ginzburg-Landau equations. Their solutions can be identified with a description of the macroscopic coherent behavior of the system. The paper concluded with outlining new ideas leading to macroscopic and phenomenological descriptions in synergetic situations, and presented a few examples.

The talk by O.E. Rossler (University of Tübingen, West Germany) also dealt with a basic subject. He talked about the Leibnitz effect, by which he meant the possible reduction of information (or collapse of information) induced by certain symmetries. In particular, he illustrated this on the example of Gibb's theorem on the reduction of phase space. Then Rossler tried to show that the Pauli exclusion principle is a "direct implication" of the Leibnitz effect. In addition he discussed other symmetry-related "quantum-like" effects, such as exchange tunneling across macroscopic distances and fractional charge/multiple-h effects in plasmas or two-dimensional electron gases. Rossler's arguments to reduce these cooperative phenomena to a non quantum-mechanical explanation appear confused.

Chaotic patterns in systems far from equilibrium were the subject of the talk by R. Friedrich (University of Stuttgart, West Germany). He applied the method of generalized Ginzburg-Landau equations for the description of pattern formation in synergetic systems, applying it to several problems in hydrodynamics. To begin with, he focused on the emergence of chaotic temporal behavior due to the nonlinear interaction of several critical modes. For the special case of the onset of convection in a spherical fluid shell, Friedrich demonstrated the existence of wavelike as well as chaotic dynamical behavior. He emphasized that the spherical symmetry plays here a crucial role, so that similar phenomena may be expected to occur in quite different systems too. In the second half of his presentation Friedrich concentrated on the formation of traveling waves due to an oscillatory instability in systems with large aspect-ratios. In particular, he considered the onset of convection in binary fluid mixtures. He showed that the instability may give rise to a variety of interesting spatio-temporal behavior, such as periodic traveling waves, quasi-periodic traveling waves with several independent frequencies, and also wave trains evolving chaotically in time.

P. Schuster (University of Vienna, Austria) talked about the optimization of complex systems and its role in molecular evolution. Thus, this contribution gave the second focal point of the special session. In the opening part of his talk, Schuster reviewed novel optimization methods: simulated annealing, neural network methods, and genetic algorithms. Subsequently, he concentrated on a particular "evolutionary optimization" procedure relevant to the molecular mechanisms of polynucleotide

replication and mutation. The background in which this method (in the class of genetic algorithms) operates, is the underlying dynamical theory of molecular evolution, conceived by M. Eigen. Replicating ensembles are considered at different replication accuracies. It turns out that speed and efficiency of optimization increase with increasing error rates; but there is a sharp error threshold beyond which one observes a breakdown of "inheritance," and the optimization algorithm ceases to work. The optimization procedure was implemented by computer, and applied to the "traveling salesman problem" as well as to the optimization of secondary structures of RNA molecules.

A rather special topic paper, on bifurcation in the heterogeneous oxidation of ethanol, illustrated the current work of the seminar director (Plath) and coworkers at Bremen; it was coauthored by H. Engel-Herbert (Humboldt-University, East Berlin, East Germany). The background to this presentation is rather general. Heterogeneous catalytic reaction systems (such as the oxidation of ethanol) have been shown to produce a richness of complex dynamic features (including multiple steady state, and also oscillatory behavior). It proved fruitless to describe these systems by the classical approach, which would set up kinetic equations from postulated chemical mechanisms. Instead, the inspection of the system's bifurcation behavior may enable one to construct a mathematical model which accounts for the observed sequence of states represented in the phase plane diagram. In fact, earlier experimental research at Bremen showed that the palladium-catalyzed oxidation of ethanol produces all bifurcation patterns, which should be observable in fully developed two-variable systems. Based on these experimental results, the current research concerns the formulation and study of the corresponding system of differential equations. The "semantic" correlation between the terms of these equations and actual physical observables was discussed in the presentation.

### Concluding Remarks

I have one-page abstracts (some with references) of the above-reviewed special-session presentations, and will be glad to share them with interested colleagues. There will be no proceedings published, but the presentations of *all* contributions to the seminar will be included in a forthcoming volume in the Springer Series on Synergetics, dedicated entirely to the dynamics of heterogeneous systems. Further information may be obtained from the seminar's director, Professor Dr. P.J. Plath, Angewandte und Physikalische Chemie, Universität Bremen, Postfach 330-440, D-28 Bremen 33, West Germany.

# SUPERCONDUCTIVITY

## HTSC M<sup>2</sup>S: The First Post-1988 Nobel Prize Award Conference on Superconductivity

by Alan Clark. Dr. Clark is the Liaison Scientist for Superconducting Materials and Electromagnetics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until March 1989 from the National Bureau of Standards in Boulder, Colorado, where he is Group Leader of the Superconductor and Magnetic Measurements Group.

The conference represented by the long acronym, HTSC M<sup>2</sup>S, had major impact on European science and sent ripples throughout the superconductivity world as well. It stands for High Temperature Superconductors and Materials and Mechanisms of Superconductivity, and the combined conference was a focal point for all the latest developments in superconductivity. Held at Interlaken, Switzerland, from 29 February through 4 March 1988 it not only celebrated the recent award of the Nobel Prize in Physics to two Swiss scientists for research on superconductivity (see *ESNIB* 88-03:1-3 [1988]) but celebrated the first real snows of winter in this beautiful city and the surrounding Alps. The fresh snow only enhanced the fresh enthusiasm for further advances of the critical temperature ( $T_c$ ) in a BiCaSrCuO compound to 106 K and in a BaTlCaCuO compound to 125 K. The former had been generally known for only 4 weeks, and literally dozens of papers representing many laboratories confirmed and presented results on the bismuth compound. Less than a week old, the thallium compound results were confirmed by several respected laboratories, and thus strongly emphasized the need for repeatability by other independent scientists as an additional necessary criterion for advances in any scientific breakthrough.

### General Description

This conference was an *ad hoc* continuation of a series of primarily fundamental conferences held on such disparate aspects of superconductivity as d and f band, ternary, organic, and, most recently, materials and mechanisms, and held in equally disparate locations as Rochester, New York, LaJolla, California, Karlsruhe, West Germany, and Ames, Iowa.

More than 800 papers were presented, 755 of them on the new high  $T_c$  superconductors (i.e.,  $T_c > 5$  K). The conference organizers wisely chose to have only about 100 oral presentations in no more than two parallel sessions. Even this required several evening sessions. The poster session of about 250 papers each day was generally available most of the day, which helped the attendees con-

siderably. The planning was extraordinarily well done and even included a break during a sunny spell in the daily snowfall.

Since the organization was begun and Switzerland was selected long before the recent breakthrough and resulting Nobel Prize, many candidates were eager to host the next one, which will be held in 1989 in the San Francisco Bay area. It was noted that the number of attendees (1200) was approximately 10 times  $T_c$ , as it was for the last one in Ames with 230 attendees and the then upper limit of  $T_c = 23$  K. We all hope that the next conference will require a hall for more than 3000!

### Highlights of the Conference

Most of the new results were in the high  $T_c$  superconductors, but there were several significant advances in the more classical superconductors that should not be eclipsed. Some *organic* superconductors, (BED-TTF)<sub>2</sub>X, where X = I<sub>3</sub>, IBr<sub>2</sub>, or Cu(NCS)<sub>2</sub>, have very strong interstack coupling, and the latter has a  $T_c = 10.4$  K and  $H_{c2} = 20$  T at ambient pressure. This is a dramatic increase in  $T_c$ —a factor of more than 20 in the last few years.

In the *heavy fermion* superconductors, magnetic ordering has been shown in the superconducting state, and antiferromagnetic ordering was shown to be induced by impurities. In *multilayered* superconductors evidence for two different  $T_c$ 's was given where the net effect was to increase the value rather than average it.

In the *high critical temperature* superconductors there were many highlights leading to some general conclusions about their properties, especially when comparing the new YBaCuO with the newest BiCaSrCuO. Orthorhombicity and the effect of oxygen deficiency on the *structure* are no longer unique, and ordering at the 2 to 5 unit cell lengths must be accounted for. Twinning is no longer shown to be required and, in fact, shows some time dependence even at 4 K. In the *electronic properties*, anisotropy is strongly evident, electron energy loss spectra define a clear role for the oxygen 2p states, and

positron annihilation shows a simple Fermi surface half filled at the 2d band. The jump in the *specific heat* looks BCS-like and indicates strong coupling, small fluctuations, and the possibility of a linear term at low temperatures. The role of *chains* versus *planes* is still not clear and nuclear magnetic resonance (NMR) and nuclear quadrupole resonance (NQR) results leave sites unassigned. The small effect of substituting the rare earths and even iron for copper leaves the role of *magnetism* very cloudy indeed. Antiferromagnetic behavior with reduced oxygen is also not understood. Good success with *thin films* was reported, with film growth right to the tetragonal structure so that only one anneal is necessary, some single crystal films with  $T_c$ 's of 90 K, and some critical currents of  $4 \times 10^6$  A/cm<sup>2</sup>. *Tunneling* data remain an enigma but the break junction technique is beginning to show consistent results and an anisotropic energy gap. As to *theory*, most investigators agree that phonons contribute but are not sufficient, strong electron correlations establish some limits to the pairing but do not imply unconventional pairing, and the 2d Hubbard model appears to provide the most agreement with present results. The most newsworthy results were the new materials, with the Bi-based compounds having  $T_c$ 's of  $10^5$  to  $10^8$  K, and the (highly toxic) thallium-based compounds with  $T_c$ 's of 118 to 125 K.

### Review of Selected Papers

K. Kitazawa of the University of Tokyo gave an excellent review of all the disparities observed in the electronic properties of the new high  $T_c$  superconductors. Pointing out that the shape of the Fermi surface is important and that if it is a half-filled,  $3d^9$  band, as has been proposed, then there would be no energy gap, but tunneling and infrared experiments give good indications for one. If electron phonon coupling is strong, then electrons should be stabilized by charge density waves; if spin-spin coupling is strong, then they are stabilized by spin density waves. Electrical conductivity behavior at higher temperatures indicates weak phonon coupling, but thermal conductivity indicates the inverse. The normal state resistivity along the c axis is semiconducting in one experiment and metallic in another, while that along the a,b axis is metallic. However, the Seebeck coefficient is flat and should be linear if it behaves like a metal, and the thermopower is flat with a magnetic field which is inconsistent with the observed anisotropy. There are also many observed inconsistencies in the specific heat data. Kitazawa did observe, however, that both XPAS and electron energy loss spectroscopy (EELS) indicate oxygen 2p carriers at the Fermi level. He summarized by stressing the desperate need for carefully prepared, well characterized single crystal samples!

R. Schrieffer of the University of California, Santa Barbara, took a hard look at the theories trying to explain the new superconductivity, especially BCS theory. He indicated that the only two inputs to BCS theory were the existence of Landau quasi-particles of normal phase and an unidentified pairing interaction, which for conventional superconductors is the electron phonon interaction. The questions for relevancy to the high  $T_c$  materials are then, is the framework still valid and what is the pairing interaction? He felt that the first answer is "yes" and that there are several possibilities for the second; phonon or lattice fluctuations, charge fluctuations, or spin fluctuations all still have experimental bases for at least not discarding them. That many theories are created, and that some are more fully developed and few are forbidden, led him to conclude that the key will be understanding the interaction potential.

J. Clem of Iowa State University, Ames, applied Ginzburg-Landau theory to a granular array of Josephson junctions and was successful in explaining the field and time dependence of the magnetization. Understanding experimental results requires a careful distinction between inter- and intragranular properties.

J.M. Tarascon of Bellcore, Red Bank, New Jersey, related success in using the solution technique for making both bulk and thin films of both the YBCO and the new Bi-based compounds, stressing the easy and inexpensive nature of the process. Both single-phase and single-crystal BCSCO of the 85 K type were *insensitive to the environment*. From x-ray, etching and magnetization measurements Tarascon concluded that the 110 K phase existed as an amorphous coating on platelike cores of the 85 K material.

R.J. Cava of AT&T, Murray Hill, New Jersey, indicated that Pb stabilizes a 102 K phase but does not create single-phase material, and concluded that the proper spacing between the copper oxygen planes is what is necessary for superconductivity, not the orthorhombic phase.

A. Kapitulnik of Stanford University, California, reported considerable success in manufacturing thin films of the 90 K superconductors including well-oriented grains, clean grain boundaries, sharp transitions, and good critical currents but still with bad surfaces. Using BaF as the Ba source was key, and Ba-rich deposition yields grains with the c axis perpendicular to the surface and Y-, CU-rich with the a,b axes. They could also make films with an extra glide plane so the unit cell was 28.3 Å long, much like the Bi compounds with 30.5 Å.

B. Batlogg of AT&T, Murray Hill, calmed the initial flurry of excitement caused by an unusually large isotope effect reported by the Los Alamos Laboratory in specimens carefully prepared with  $O^{18}$  oxides. He noted that there was a self-consistency between the lattice

parameters and an oxygen deficiency concluding a 60 K phase.

J.S. Tsai of NEC, Tokyo, Japan using a modified break junction technique, observed an anisotropic energy gap in oriented thin films with a  $2\Delta/kT$  of 5.9 and 3.6 parallel and perpendicular, respectively, to the CuO planes. The energy gap, however, extrapolated to zero at about 40 K—consistent with observations by Moreland, (National Bureau of Standards) Goldman (University of Minnesota), and others.

Finally, for progress in devices, N.V. Zavaritsky of the Institute for Physical Problems Moscow (USSR), C.E. Gough of the University of Birmingham (UK), and others reported reasonably good superconducting quantum interference device (SQUID) operations at 77 K, and I. Kirschner of Eötvös University, Budapest, Hungary, constructed two magnets that yielded 32 and 207 Oe at 77 K.

### Summary

This conference, now being referred to as the "Interlaken Conference," rekindled the excitement and enthusiasm that had begun to wane after a year's worth of study on the YBaCuO material. The steps upward in  $T_c$  from 92 K to 110 K to 125 K are very significant in two ways in addition to regenerating interest. First, other

structures and compounds have been shown to be superconducting. This not only gives hope for further increases in  $T_c$ , but after further study compared to the first two compounds, should yield guidance in the pursuit of understanding the fundamental mechanism—i.e., four points on the curve instead of two. Second, and perhaps more important for rapid development in applications, devices can now be operated in liquid nitrogen at a much smaller fraction of  $T_c$ , 0.6 instead of 0.9, where the superconducting properties are better optimized and the stability margin much larger. It also permits optimizing the material development at something other than maximum  $T_c$ .

The Interlaken Conference also reemphasized the truly international nature of the development of the new superconductivity. First discovered in Europe, the upward steps in  $T_c$  have come successively from the US, Japan, and the US again, but all based on an open international sharing of results and ideas. Many of the results presented at the conference were based on materials made in one laboratory, structurally analyzed in a second, and characterized in a third, frequently crossing national boundaries (as do the authors). Thirty-six nations were represented and all contributed.

5/4/88

## New Magnetic Materials

by Alan Clark..

In a one-day conference on New Magnetic Materials held in London on 21 April 1988, invited experts from England, Germany, and the Netherlands outlined recent progress in magnetic materials developments. The new materials and their properties were described along with potential applications and expected further developments. Categories included soft magnetostrictive, fine particle, thin film magneto-optic, ferrofluidic, and permanent magnet materials. The success of the conference was greatly indebted to, and thus appropriately dedicated to the memory of, the recently deceased Professor E.P. Wohlfarth, a long-established leader in the field.

After an excellent introduction to magnetic materials by Professor D. Melville of Lancashire Polytechnic, Preston, UK, Dr. H. Warlimont from Vacuumschmelze, Hanou, West Germany, summarized the recent developments in soft magnetic materials. These materials generally have a low Curie temperature, high electrical resistivity and thus low losses. A good example is the recently developed amorphous, cobalt-based CoFe alloys with very low coercivity and hysteresis loops which can be

shaped to match the application. These materials compete very favorably with the ferrites for low inductive loss components, for example. If in crystalline form, they are more corrosion resistant, and when started from powder form can be readily shaped.

Dr. D. G. Lord, from the University of Salford, UK, outlined the useful properties of magnetostrictive materials for transducers, sensors, and actuators. These are mostly the rare earth iron compounds and a few new amorphous compounds. By balancing the magnetostrictive and the crystalline magnetic energy anisotropy, materials can be designed for specific applications and most efficient conversion of magnetic to elastic energy or vice versa. A good example is Terfenol with  $Tb_{0.27}Dy_{0.73}Fe_2$  with a large positive magnetostriction along the  $\langle 111 \rangle$  axis and yet a compensated magnetic anisotropy near 0°C. More recently an amorphous alloy ribbon has been made with transverse domains resulting in a strain gauge with four orders of magnitude improvement in sensitivity.

Dr. R.W. Chantrell of Lancashire Polytechnic, Preston, UK, explained the application of very fine particles to recording media and ferrofluids. The principle advantage of very fine particles is the reduced energy requirement in producing domain walls in these single-domain particles. Barium ferrite is a good example with a high coercivity and a high crystalline anisotropy. Fine dispersions are being designed for the new perpendicular recording media. Ferrofluids also require very fine particle suspensions and already have applications in magnetic fluid seals and magnetic suspension of both magnetic and nonmagnetic components.

Thin film magneto-optic materials were covered by Dr. K.H.J. Buschow of Philips Research Laboratories, Eindhoven, the Netherlands. Magneto-optic materials have the big advantage over other optical recording media in the ease of reversibility – i.e., to write and erase. The rare earth cobalt or iron alloys have the necessary properties – i.e., magnetically hard at room temperature but soft at about 150°C – which is easily achievable with a laser pulse because these materials also have a low thermal diffusivity. The Kerr rotation can also be enhanced

by sublayers. Amorphous materials have the advantages of no domain walls, a wider choice of compositions for optimizing the optical properties, and low thermal conductivity, but they also are less stable.

Finally, Dr. D. Hadfield, BNF Metals Technology Center, Wantage, UK, described recent permanent magnet developments which, of course, have been highlighted by the properties of SmCo and NdBF<sub>6</sub>. The increase in coercivity in these materials by much more than an order of magnitude and their production in amorphous form have opened the doors to many new applications.

All of the lecturers also outlined key problem areas for future research and discussed limitations to the materials properties, which added immeasurably to the usefulness of the course. A few of the research opportunities identified were recrystallization of amorphous materials, particle and layer interaction, property optimization and stabilization, and, of course, the continued search for even better new materials.

6/3/88

## NEWS, NOTES, AND ABSTRACTS

### Staff Changes at ONRL

With this issue we say goodbye to Drs. Louis Cartz and Daniel J. Collins, who have completed their tours at ONR London.

Dr. Cartz is resuming his post as a Professor of Materials Science at Marquette University in Milwaukee, and Dr. Collins, at the Naval Postgraduate School in Monterey, California, as a Professor of Aeronautical Engineering.

Also with this issue we welcome Dr. Henry A. Resing, a senior research chemist who comes to us from the Polymeric Branch of the Naval Research Laboratory's Chemistry Division. His most recent work has included the execution of theoretical and experimental research on magnetic resonance as applied to electroactive materials.

C.J. Fox  
6/21/88

### Update of ESNIB Report on the NATO Workshop on Surface-Generated Noise

The NATO Advanced Research Workshop on Natural Mechanisms of Surface-Generated Noise in the Ocean was organized by Dr. Bryan Kerman, not B. Keman, as reported in ESNIB 88-03. Also, since publication, we have learned that the proceedings, edited by Dr. Kerman and published by Reidel, has been given the title *Sea Surface Sound*.

C.J. Fox  
6/23/88

### Update of the EUREKA Program

The EUREKA program was discussed in two earlier issues of the *European Science Notes* (ESN 40-4:141-142 [1986] and ESN 41-1:12-15 [1987]).

Since its launch during the first ministerial meeting in Paris in July 1985 four further ministerial meetings have been held at which projects were approved. The approval of 58 new projects during the Madrid meeting of 15 September 1987 brought the total to 165. The dominant fields of technology in the adopted projects are information systems, production technology, and biotechnology. The cost of the development effort in the 165 projects is about 4 billion ECU (\$4.8 billion) over the lifetime of the projects. Many more projects are in preparation, some of which will receive approval at the forthcoming Sixth Ministerial Conference, to be held in Copenhagen in June 1988.

The 58 new projects approved in Madrid are divided between high technology as follows:

|                            |    |
|----------------------------|----|
| ● Information technology   | 15 |
| ● Robots and manufacturing | 15 |
| ● Biotechnology            | 12 |
| ● New material             | 2  |
| ● Environment              | 2  |
| ● Telecommunications       | 0  |

- Transport 1
- Energy 2
- Lasers 9

As in the entire list of approved projects, the dominant fields of technology in the latest 58 projects are information technology, production technology, and biotechnology.

Brief descriptions of all the approved EUREKA projects are given in ONRL Report 8-009-R.

The EUREKA Program continues to attract participation despite the absence of central funding and central management. The attraction seems to be mainly international cooperation that includes sharing of expenses and talent.

As mentioned in my previous EUREKA reports, central coordination appears to be a weak link in the program. Only a very small coordination group located in Brussels will assist in this respect. And there is no centralized financing, as is the case in ESPRIT, RACE, and BRITE. Most of the financing will come from participating companies, with some support from their own national governments.

J.F. Blackburn  
4/26/88

## New Technology at the Hannover Industrial Fair

The "Fair of Fairs," as the proud and successful organizers refer to the annual Industry Fair of Hannover (West Germany), took place this year from 20 through 27 April. As is always the case, it attracted nearly 500,000 visitors, including 100,000 from over 100 foreign countries. Twenty-three halls (and an open-air site), occupying 130,000 square meters, housed stalls and displays for some 5,600 exhibitors from over 40 countries. The major themes of the exhibition were the following (in order of apparent emphasis):

- Microtonics (i.e., microelectronics, electronic components, assemblies, systems, automated processing, optoelectronics, microcomputer, CAD/CAE/CAM, software)
- Electronics and electrical engineering (including electric automation and electric energy)

- Energy and environmental technology
- Optec (i.e., optical components, devices, measuring equipment, high-power laser systems)
- New materials (metals, ceramics, polymers, elastomers, composite materials)
- Innovative research and technology market.

The Optec section was an innovation and, for the first time, made it possible to exhibit in one systematic show components, devices, and systems in technical optics as well as laser technology. There were about 150 exhibitors from 14 countries in this section. (In comparison, the "old" favorite section, Microtonics, attracted some 200 exhibitors from 15 countries.) Optec was supplemented by a laser conference (see page 43, preceding).

I have the lists of exhibitors (with addresses) for the Optec, the Microtonics, and the Innovative Research and Technology sections, which I will be glad to share with qualified enquirers.

## The UK Moves to Strengthen Information Technology Research

In May, new plans were announced for closer working ties between the UK's Science and Engineering Research Council (SERC) and the Department of Trade and Industry (DTI) in Information Technology (IT) R&D and training. The arrangements cover proposed expenditure of £90 million (about \$163 million) in 1988/89.

The objective is to establish a unified framework for the support by the SERC and DTI across the whole spectrum of IT research, ranging from fundamental work in higher education institutes through collaborative LINK programs to industry-led activities, often in collaboration with the academic sector.

A new advisory structure will be set up, drawn from the academic sector and industry in roughly equal numbers, and headed by a single advisory body, advising both SERC and DTI on research programs and resource allocation, and on individual applications for support. Both

SERC and DTI will use their normal procedures for the award of grants.

The new advisory arrangements will be supported by a new management structure which will provide greater coordination between the various components of the overall programs, and between national and European Community activities. There will be new arrangements for financial management, although both SERC and DTI will retain responsibility for their own funds.

In a clear statement of British intent and their view of their own strength, Lord Young, Secretary of State for Trade and Industry, said:

"This decision brings together into one coordinated research effort all the work DTI and SERC have been undertaking on IT. IT is one of the key areas for future industrial growth and one where British research has proved itself time and again to be at least equal with the rest of the world. The Government is committed to helping the transfer of advanced technology from the laboratory to the factory, a process that was outlined in my recent DTI policy white paper. This reorganization will further strengthen the links between industrial and academic researchers and provide the coordination that will be necessary for the successful future development of advanced technologies in this field."

C.J. Fox  
6/17/88

## List of German Optics Firms Available

I have a rather comprehensive, 30-page list of West German companies that develop and market optical and optoelectronic components and systems (including mechanical components, coatings, fiber optics). The listing is divided, very professionally, into areas and subareas. Unfortunately, however, addresses of the companies are not given. I will be glad to supply copies to interested colleagues on a "need to know" basis.

Paul Roman

## Heat Flash Lights Up the Flaws

The UK's Atomic Energy Authority Harwell Laboratory has announced an agreement with Rank Taylor Hobson Ltd. for the exploitation of its novel inspection technique known as Pulse Video Thermography (PVT).

PVT rapidly locates hidden defects and structural flaws in a wide variety of materials by utilizing a pulsed heat source and thermal imaging and recording equipment.

Powerful xenon flash tubes subject the item under inspection to a pulse of thermal energy that rapidly dissipates into the material. Defects in the sample cause the heat to diffuse at different rates from that of the bulk material and, when viewed by a thermal imager, show up as contrasting images. A video recorder stores these images in real time for subsequent frame-by-frame analysis and interpretation.

The system, developed by the National Nondestructive Testing Centre at Harwell, uses a thermal imager from

Rank Taylor Hobson for thermographic analysis of metals and advanced composite materials. Because there is no physical contact and inspection times last only seconds, PVT has great potential for process inspection on manufacturing lines in the automotive and aerospace industries or in any process requiring quality control of fabricated items.

C.J. Fox  
6/17/88

## Improved Sensors for Underwater Electric Field Detection

Subspection Ltd., a British firm, has developed over the last few years a robust silver/silver-chloride electrode based on new (proprietary) techniques. The manufacturer has stated that the electrodes have properties which far outweigh those of other types of electrodes, from dc to a few kilohertz. They exhibit excellent long- and short-term stability and allow offset voltage errors (dc) be-

tween pairs of electrodes as low as 1-5 microvolts. The low-frequency noise levels are also extremely small. The voltage differences at the electrodes are fed into the electronic data acquisition circuitry, which is contained in a watertight pressure-housing. They are amplified and filtered, then fed into analogue to digital converters. A microprocessor controls the operation by selecting the channels in sequence, and by adjusting the amplifier gain to suit the signal levels. The digital signal is then sent over a fiber-optic link to the data computer. In this way, wide-band signals can be sent over a long cable. According to Subspection Ltd. officials, the resulting system shows a 10,000-fold increase in sensitivity over systems of just a few years ago. This would imply that electric field detection must now be a strong competitor with other detection methods, in contrast to its relatively poor performance in the past.

CDR J.P. Simpson  
4/27/88

## ONRL REPORTS AND MAS BULLETINS

### Reports

To request reports, indicate the report number (in parentheses after the title and author's name) on the self-addressed mailer and return it to ONR, London.

### Biological Sciences

*Biotechnology Conference: Diagnostics '87*, by Claire E. Zomzely-Neurath. (8-006-C) A detailed review is given of selected topics presented at this conference held in December 1987 at Cambridge, UK. Topics include thin-layer technology, single-step immunoassays, rapid microbial assays, diagnostic applications of DNA probes, DNA probe *in situ* hybridization assays, new amperometric biosensors, and application of electrochemical methods to immunoassays.

*Biotechnology Conference: Drug Delivery and Drug Targeting Systems*, by Claire E. Zomzely-Neurath. (8-007-C) Presentations given at this conference, held in December 1987 in London, UK,

are reviewed in detail. Topics include development of new dosage forms; controlled release (including dosage forms, implants, and transdermal systems); the possibilities and limitations of greater selectivity in targeted delivery of currently available systems such as liposomes, macromolecules, monoclonal antibodies, and prodrugs; and delivery of peptides and proteins via the gastrointestinal and nasal routes.

### Computational Physics

*16th International Symposium on Shock Tubes and Waves*, by David L. Book. (8-008-C) Selected presentations given at this symposium held at Aachen, West Germany, are discussed. Topics are: shock experiments, Mach reflection, and computational methods.

### MAS Bulletins

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during June. The *MAS Bul-*

*letin* is an account of accomplishments in European naval research, development, test, and evaluation. Request copies of the *Bulletins*, by number, from ONR, London.

- 34-88 MIROS Wave Radar (Up-date)
- 35-88 Miniature Solid-State Underwater Television Camera
- 36-88 Automatic *In-Situ* Pumphotometer
- 37-88 Improved Sensors for Electronic Field Detection Underwater
- 38-88 New Hydro-Survey Hovercraft
- 39-88 French Center for Marine Meteorology
- 40-88 Norwegian Underwater Inspection and Survey Sensor
- 41-88 Underwater Magnetic Particle Inspection
- 42-88 Calendar of AGARD Technical Meetings in 1988
- 43-88 Guidance and Control Systems for Tactical Weapons Symposium
- 44-88 Merlin - Terminally-Guided 81mm Anti-Armour Weapon for the Infantry

# REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

## Reports

Information on the reports listed below was furnished by the activity identified by its abbreviation. Report numbers are given in brackets after the titles. Requests for copies of or information about these reports should be addressed to the appropriate office:

USARDSG – US Army Research Development and Standardization Group, Box 15/65, FPO New York, 09510-1500

EOARD – European Office of Aerospace Research and Development, Box 14, FPO, New York 09510

## Biological Sciences

*Research in Life Sciences at Ben Gurion University*, by MAJ Jim McDougal, EOARD. (4 pp) [EOARD-LR-88-11]

Research at Ben Gurion University related to chemical-induced nephrototoxicity, effects of exercise and heat exposure on drug pharmacokinetics, human gonadotoxicity of dibromochloropropane, effects of magnetic fields and radio frequency radiation on chick fibroblasts, effects of forced water loading on dehydrated desert dwellers, and cognitive psychology are discussed.

*Neurobiology, Visual Perception, and Robotics*, by MAJ Jim McDougal, EOARD. (5 pp) [EOARD-LR-88-10]

The Weizmann Institute, Israel, has several interesting projects underway. Dr. Segal has been using tissue grafting into the brain of laboratory animals as a tool to pharmacologically manipulate the serotonergic transmitter system which has been implicated in sleep/wakefulness and long-term potentiation. Professor Ullman and Dr. Sagi are investigating parallel and serial processes in the brain. They suggest that short-distance motion, location, and detection of target are processed through a parallel mechanism, and that long-distance motion, orientation, and color are processed by serial

mechanisms. Dr. Flash is interested in object manipulation by robots and humans and is attempting to develop a mathematical model of human motor control.

## Electronics

*Proceedings of the 17th European Solid-State Device Research Conference – ESSDERC 87*, eds. P.U. Calzolari and G. Soncini. [Send inquiries to USARDSG]

An international conference was held during 14 through 17 September 1987 in Bologna, Italy, which provides a forum for scientists and engineers to discuss recent developments in solid-state electronic devices. Various topics relating to reliability and processing of solid-state devices and electronic materials were covered at this meeting. These topics included novel, submicron devices, analog and digital GaAs devices, integrated optoelectronics, and process/device modeling. The proceedings contains the extended abstracts of papers presented at this meeting.

## Lasers

*Laser Research at Trinity College*, by Dr. Stacey Lazdinis. (4 pp) [EOARD-LR-88-33]

This report summarizes the work of the Laser Physics Group at the Department of Pure and Applied Physics at Trinity College in Dublin, Ireland. The research of Professor W. Blau concerning the nonlinear, high CHI(3), optoelectronic properties of certain infrared dyes and polydiacetylene, using degenerate four-wave mixing, is discussed in detail.

## Material Sciences

*Ion Implantation Work*, by LTC LaRell Smith, EOARD. (30 pp) [EOARD-LR-88-18]

The research group of Dr. Ian Wilson at the University of Surrey is one of the biggest groups in the UK doing ion implantation work. They have recently been working mostly on oxygen and nitrogen implantation in silicon although there are

numerous other projects ranging from synthesis of films to attempts to use ion implantation in forming the new High  $T_c$  superconductors. This report provides a very brief description of their work and includes reprints of publications on films synthesis, defects in Si from ion bombardment, and computer simulation of surface damage and cascades.

*A Stable Cold-Cathode Source of High Brightness*, by LTC LaRell Smith, EOARD. (40 pp) [EOARD-LR-80-19]

The Solid-State Research Group at Aston University (Birmingham, UK) under the leadership of Dr. R.V. Latham has an outstanding capability in the area of field emission. Together with the company, Oxford Applied Research, they have proposed a scheme for producing a stable cold-cathode source of high brightness that could replace traditional thermionic cathodes in devices such as CRT's, electron microscopes, klystrons, etc. The device would be based on needle cathodes (angstrom size) coated with liquid metal. It is hoped the device will be stable in the dc mode and also reversible to provide ions as well as electrons. This report provides more information on the two groups and reprints from recent research of both.

*Optical Metrology at the Institute für Technische Optik*, by Dr. Stacey Lazdinis. (3 pp) [EOARD-LR-88-37]

Professor Hans Tiziani of the Institut at the University of Stuttgart heads one of Europe's major optical metrology and nondestructive testing research establishments. In addition to conducting research to refine, extend, and find new applications for standard metrology techniques, such as interferometry, holography, and Speckle interferometry, the institute's staff also develops measurement techniques and equipment for outside customers. Its modern and well-equipped laboratories are also used to perform contract testing for German industry, German governmental laboratories, and industrial concerns and laboratories within the European Community (EC). (It has been made Western

Europe's Testing Center for Aspheric Surfaces.) The activities of Professor Tiziani and his colleagues in optical metrology are summarized.

*Ceramic Preforms for Metal Matrix Composites*, by LTC Jim Hansen, EOARD. (3 pp) [EOARD-LR-88-38]

Ceramic preforms for metal matrix composites include a region with alumina short fibers (ICI Saffil) adjacent to a porous ceramic insulating layer (infiltrated with 10 percent metal). The technique eliminates the need for bonding a totally ceramic insulating layer to metal. This industrial product has been developed by the German company Didier for the German automobile industry, for use in such parts as piston heads.

*Advanced Composites and Information Technology at Devtech*, by LTC Jim Hansen, EOARD. (11 pp) [EOARD-LR-88-31]

The Devtech company in Heerlen, Netherlands, uses a strong mathematical basis founded in topology to solve, with the aid of artificial intelligence, complex materials, engineering, and information technology problems. Materials developed include *in situ* ceramic-ceramic composites, claimed cheaper to produce than cast iron. Intelligent manufacturing of thermoplastic composites is being scaled to large size. In the information technology area, data compression of 10,000:1 has been demonstrated.

*Concrete Reinforced with Melt Spun Ribbons*, by LTC Jim Hansen, EOARD. (3 pp) [EOARD-LR-88-29]

Amorphous melt spun ribbons made by rapid solidification are used as fibers in fiber-reinforced cement. The main advantages of these ribbons versus other reinforcing fibers are the ease of mixing and corrosion resistance. Improved mixing could lead to better properties for materials produced on the construction site. Research on these materials is conducted at a university in Lausanne, Switzerland and a research center in Pon-a-Moussan, France.

## Physics

*Hot Electron Emission in Semiconductors*, by Professor Dr. Erich Gornik and Dr. Mag. K. Unterrainer, Institut für Experimentalphysik, Innsbruck, Austria. This is a final technical report under contract DAJA 45-84-C-0052. [USARDSG, cite title and authors]

The spectrum of the stimulated far infrared emission from p-Germanium in crossed electric and magnetic fields is studied by means of a tunable narrow-band GaAs-detector. The problem of the electron distribution in crossed electric and quantizing magnetic fields is treated for free electrons in a parabolic band. It is shown that population inversion between Landau levels can be achieved if scattering by optical phonons and a quasi-elastic scattering process are taken into account. The energy relaxation of 2D electrons in GaAs/GaAlAs structures has been investigated by analyzing the electric field dependence of Shubnikov-de Haas oscillations, the far infrared emission, and photoluminescence spectra.

*Gallium Arsenide and Related Compounds 1987*, Proceedings of the Fourteenth International Symposium held in September/October 1987 in Heraklion, Crete; eds. A. Christou and H.S. Rupprecht; Institute of Physics Conference Series Number 91, Institute of Physics, Bristol and Philadelphia. [Send inquiries to USARDSG]

The Fourteenth International Symposium on Gallium Arsenide and Related Compounds was held in Heraklion, Crete, Greece, from 28 September to 1 October 1987. Two hundred research papers were presented at the Symposium in three plenary sessions, the regular sessions, and poster sessions. The symposium papers were selected from over 275 abstracts submitted to the Technical Program Committee for evaluation. The symposium was highlighted by 11 invited speakers in the areas of: DX centers, advanced MOCVD optoelectronic devices, electronic states in superlattices, polar-nonpolar epitaxy, delta doping, integrated

guided wave optics on III-V semiconductors, wave function engineering, rare earth injection lasers, below bandgap photoresponse of undoped GaAs, Raman scattering of superlattices, and stable ohmic contacts.

## Semiconductors

*The "DX Center" of Madrid, Spain*, by Dr. Ewing Davies, EOARD. (2 pp) [EOARD-LR-88-20]

Interesting studies on the "DX Center" in gallium aluminum arsenide are being conducted by Professor E. Munoz's group in Madrid. This so-called "center" can impose restrictions on the design and ultimate performance of advanced transistor structures such as MODFETS. New pressure-related measurements help clarify how the center is not a defect but a manifestation of a more complex doping behavior that may be characteristic of wide bandgap alloys.

*Monte Carlo Analysis of Quantum Transport and Fluctuations in Semiconductors II*, by Professor Carlo Jacoboni et al., University of Modena, Italy. This is a final technical report under US Army Contract DAJA 45-86-C-0004. [USARDSG, cite title and author]

The first topic treated is quantum transport. Two major lines of research have been investigated: the first is based on the introduction of the joint spectral density into a traditional Monte Carlo simulation; the second regards the formulation of a fully quantum mechanical approach for electron transport based on the density matrix approach. The second topic deals with noise, diffusion, and autocorrelation functions both from a theoretical and a simulative point of view. Results have been obtained for both bulk systems and quantum wells. The third topic concerns an analysis of the effect of phonon populations in excess with respect to their thermal equilibrium values. Numerical Monte Carlo simulations have been performed both for GaAs and for GaAs-AlGaAs quantum wells.

## THE EMBASSIES: TECHNOLOGY ROUNDUP

### France

For further information on French items, contact Dr. Allen Sessoms, Office of the Science Counselor, American Embassy, APO New York 09777.

**Magnetism Research in France: the Louis Neel Laboratory.** The proximate center of magnetism research in France is the Laboratoire Louis Neel in Grenoble. The laboratory is named after its founder, and the father of the Polygone Scientifique in Grenoble, who was also a Nobel Laureate. The laboratory, which consists of about 70 people, concentrates on metals (50 percent of effort), rare earths, three-dimensional magnetism, and theory (heavy fermions). This type of research takes on added significance in a world of vast data recording and management systems since all of these systems rely on magnetic properties of matter for their operation (from magnetic tapes to magnetic bubble arrays). Also, all motor systems contain permanent magnets. The laboratory also has significant work ongoing in magnetism and superconductivity, thin metallic films, and the application of permanent magnets. The laboratory's budget in US terms is about \$8 million, a misleading sum when one considers the free access by researchers to colocated facilities in Grenoble such as the high-intensity neutron flux reactor at the Institut Laue-Langevin. The laboratory is engaged in extensive international collaborations with institutions in Ireland, Italy, the Netherlands, Spain, Japan, Austria, West Germany, the US, Portugal, Israel, the UK and Poland. It has recently established an exchange program with the Soviet Academy of Sciences.

The Laboratory's work is highly technical and appears to be first rate. There are few laboratories in the world outside of industry (such as 3M in the US) that focus exclusively on magnetism from basic research to advanced applications. Given the scope and quality of work done here, and the strong interest expressed in building up European capabilities in this area, this "center" is probably the one to watch in Europe.

**The French Crystallography Laboratory in Grenoble.** The Laboratoire de Cristallographie in

Grenoble, a classic, but progressive physics research establishment, is directed by US-trained crystallographer Massimo Marezio. The laboratory consists of about 40 senior researchers, 15 students, 12 technicians, and a small administrative staff of 3. The major research groups are in the following areas:

- Magnetic materials
- Fluorides
- Physical crystallography
- Phosphates
- New materials
- Superconductivity
- Theoretical molecular crystallography.

The major research topics in the laboratory are:

- Materials synthesis and structural characterization
- Elucidating the relationship between the structures and the physical properties
- Physical crystallography Instrumentation.

In laboratory studies researchers use only diffraction techniques utilizing primarily x-rays, but also electrons and neutrons. The wave of the future is in the area of surface physics utilizing the European Synchrotron Radiation Facility (ESRF) presently under construction in Grenoble. The laboratory excels in studies using grazing x-ray diffraction, magnetic x-ray diffraction (which is scattering from spins instead of charge), and in taking into account diffuse scattering in reconstructing physical crystalline lattices which has proven especially important for HT<sub>c</sub> superconductors.

The laboratory is well equipped and appears to be doing excellent work in classical crystallography. Their work in elucidating on short notice the structure of the HT<sub>c</sub> superconductor B<sub>12</sub>SR<sub>2</sub>CaCuO<sub>8</sub>, taking into account diffuse scattering — which was presented at the 1 March 1988 meeting at Interlaken — highlights their analytic strengths. With the advent of ESRF, this laboratory will probably become a world leader in crystallographic research.

**The High Field Magnet Laboratory in Grenoble.** The high field magnet in Grenoble (Le Service National de Champs Intenses [SNCI]) is an international (French/German) center for research on, and for the use of, ultrahigh

magnetic fields. SNCI holds the current world record for magnetic field strength, 31.35 tesla, set 3 November 1987 with a hybrid superconducting magnet. The laboratory plans to double the power available for magnets to 20 MW dc by 1992 at a cost of about \$15 million. This will keep it 3 to 5 years ahead of the US program centered at the Francis Bitter National Magnet Laboratory at the Massachusetts Institute of Technology (MIT). SNCI is also known for the quality of research conducted there. It is a user facility, such as many US national laboratories, and thus hosts experiments from laboratories all over France and West Germany. Also, there is participation by researchers from several other countries. It was at SNCI that, on 5 February 1980, Klaus Von Klitzing conducted the experiment in which he discovered the quantized Hall effect. Von Klitzing was awarded the 1985 Nobel Prize in Physics.

The staff of SNCI is about 100. The budget (equally contributed by France and West Germany, without salaries, major equipment expenses, etc., is F15 million (about \$2.6 million [to get a rough US budgetary normalization multiply this number by a factor of 10 to 15]). More than 100 refereed papers per year are published on work done at the facility.

Scientific work at the lab is conducted in the following areas:

#### Semiconductor Physics

- Magnet optical experiments of two-dimensional semiconductor structures
- Magnetotransport
- Theory of two-dimensional structures
- Optical properties of bulk semiconductors
- Transport properties of bulk semiconductors.

#### Metal Physics

- Heavy fermion metals
- Quasi two-dimensional metals
- Metallic point contacts in high magnetic fields
- High T<sub>c</sub> superconductors.

#### Molecular Physics

- Anticrossing spectroscopy of gasphase polyatomic molecules
- Nuclear magnetic resonance.

#### Physics in Gases and Fluids

- Dielectric breakdown in gases in magnetic field

- Self diffusion in solutions of wormlike polymers
- Multiple light scattering from disordered media
- Rayleigh Benard convection in paramagnetic fluids
- Ferroelectric liquid crystals
- Polarized atomic hydrogen.

SNCI owes much of its success to the fact that it is extremely user friendly. Once an experiment is approved for magnet time the lab support is superb. In fact, experiments are designed and fabricated so that they can be mounted into the magnet and demounted in an hour, an extraordinary feat for such complex and delicate systems. This is aided by the fact that all magnet bores are standardized to 50 mm and there are a very large number of instrumentation cryostats, cylinders, and ports.

**European Coordinated Research on New Magnetic Materials.** Of interest, in relation to the preceding item on SCNI is that the European Community has a coordinated research program on new magnetic materials. The project, called Concerted European Action on Magnets (CEAM), is a cooperative project financed from the community's stimulation action and implemented with the help of EURAM, the commission's research program on new materials. The activities, involving 58 European laboratories and more than 120 scientists and engineers, span every aspect of new iron-based high-performance magnets, from theoretical modeling of their intrinsic magnetic properties to the design and construction of novel electrical machines and devices. This project is considered to be a unique experiment in interdisciplinary collaborative research and development. Of the 58 laboratories, those of industrial companies make up about one-third, the others being university and national laboratories. The project receives funding of 2.5 million ECU (about \$3 million) from the stimulation program for research covering a period of 30 months. That support covers the costs of coordination, communication, meetings, and minimal equipment costs. Thus, it is clear that the actual research costs are much larger for the project as a whole. Depending on the level of instrumentation usage, the full cost of the research could be at least 2.5 times the stimulation award. With very costly instrument use, it could go to 10 times the award for research. The motivation for this activity stems

from a belief among members of the European community that Japan and the US are actively carrying out ambitious materials research and development with long-term aims in view.

**STRIDE: Advanced Microelectronics Research in France.** The Laboratory for Solid State Physics and Solar Energy (Laboratoire de Physique du Solide et Energie Solaire [LPSES]) at Sophia Antipolis near Nice is devoted exclusively to research on advanced, high-performance, photo voltaics for space applications and studies of the electronic properties of semiconductors. The focus of attention is GaAs (III-V) and its derivatives. The laboratory excels at molecular beam epitaxy and metallo-organic vapor phase epitaxy. It is the only laboratory in Europe which can produce GaAs thin films on silicon substrates by both methods and make quantitative and qualitative comparisons between the two techniques. LPSES is the head of a European consortium, including EIM, EC (Belgium), Marconi (UK), Fraunhofer (West Germany), and an Italian company charged with working on GaAs and related materials for space applications. In the area of GaAs thin films deposited on silicon substrates, LPSES may be the best laboratory in the world.

LPSES consists of 25 full-time Ph.D. scientists and 13 support staff of engineers, technicians, and administrators. Excluding major expenditures such as large equipment purchases but including salaries, the LPSES budget is about F10 million (about \$1.8 million) per year.

LPSES possesses state-of-the-art equipment in both molecular beam epitaxy and metallo-organic vapor phase epitaxy. C. Verie, the Director, argues convincingly that it is easily the best lab in Europe in this regard. It is the only lab in Europe that has the capability to compare thin films produced by the two techniques. Using these techniques, attention is focused on GaAs (and related materials) thin films on silicon substrates, taking advantage of the properties of both media. The aim is to produce reasonably sized photovoltaic systems for space applications that can produce tens of kilowatts as compared to the hundreds of watts currently available. (The Soviet MIR Space Station uses 13 kW supplied by 100 square meters of GaAs solar cells, but these are not thin films. The Japanese satellite GS-III uses 1 kW derived from 10 square meters of GaAs thin films on a silicon sub-

strate.) In this area LPSES has collaborative efforts underway with the universities of Delaware and North Carolina and with Stanford University and the Jet Propulsion Laboratory at the California Institute of Technology. It also works with Varian Corporation and the Hughes Company. In the area of III-V systems (including GaAs and GaInAs), LPSES heads a European consortium consisting of 25 LPSES researchers and 35 researchers from the industrial firms EMIEC (Belgium), Marconi (UK), Fraunhofer (West Germany), and an Italian company which was not identified.

LPSES is also the only French laboratory which conducts research on ultrahigh-purity germanium vapor. The work, funded by the French space agency CNES, includes epitaxy studies. Ultrahigh-purity germanium thin films with impurities on the order of  $2 \times 10^{-12}$  have been achieved. The laboratory also studies impurities in semiconductor single crystals under high pressures (40 kilobar) using photoluminescence. Work is in the planning stage on high temperature superconductivity in organometallic materials.

**Superconductivity Research in France.** Research on high temperature superconductors carried out at the Centre de Recherches sur Les Tres Basses Temperatures (CRTBT—Center for Research at very low temperatures) and the Laboratoire de Cristallographie (Crystallography Laboratory), both in Grenoble, is world class. An extended but loosely aggregated scientific group effort (Groupement Scientifique), which includes industrial as well as academic researchers, has been organized under the leadership of R. Tournier of CRTBT. This collaboration includes scientist from these two labs, the group of J. Etourneau at the Laboratoire de Chimie du Solide in Bordeaux, the group of B. Raveau in Caen (who prepared the first ceramics which led to the discovery of high temperature superconductivity) and groups from the industrial firms Rhone-Poulenc, CGE, and Thomson. The Centre Nationale de la Recherche Scientifique (CNRS) has committed, exclusive of salaries and overhead, F1 million per year for 4 years to this group effort which has been matched by the industrial participants. In US budgeting terms, the resources available amount to about \$1 million per year. The number of researchers involved is about 40. Major recent developments have

been the achievement at CRTBT of current densities of 4000 amps/cm<sup>2</sup> in silver-doped YBaCuO, the discovery at Caen simultaneously with IBM of the TlBa<sub>2</sub>Ca<sub>2</sub>Cu<sub>3</sub>O<sub>9</sub> HT<sub>c</sub> superconductor and the measurement on a powder sample of this material (with large grains) of 70 percent diamagnetism at about 100 K. (This extrapolates to 100 percent diamagnetism in a solid.) In the facilities available in the scientific park at Grenoble, including the international Institut Laue-Langevin (ILL) with the highest neutron fluxes in the world and the International (French/German) High Field Magnet Laboratory, the "groupement" can do most things of interest in HTC superconductivity research except, perhaps, thin films and optical measurements, although capabilities in these areas are actively being developed.

**The Laboratory for Condensed Matter Physics at the University of Nice.** The laboratory for condensed matter physics at the University of Nice focuses on five major research areas. These are: liquids and suspensions, interfaces, transport and propagation in porous materials, liquid crystal polymers, and fiber and nonlinear optics. The laboratory consists of 33 Ph.D. researchers (of whom 23 belong to the Centre Nationale de la Recherche Scientifique [CNRS]) and 16 engineers, technicians, and administrative staff. The laboratory is headed by Dr. Nicole Ostrowsky. A major new project is the first university-based production facility for producing fiber optics from preformed glass. The laboratory will be moving in September from its somewhat cramped quarters in several university buildings to a new, dedicated building. The efforts in the liquid crystal area appear particularly strong as does work on helium 3/helium 4 interfaces and optically controlled Josephson junctions.

**A French Technopole—The International Science Park in Sophia Antipolis.** The "International Science Park" in Sophia Antipolis near Nice on the Cote D'Azur has progressed in just a few years from a struggling, and somewhat sleepy industrial development to a fast-expanding technological center. Located in or near the park are research centers and also, in some cases production facilities of: Dow Chemical (US), Digital Equipment Corporation (US), IBM (US), Texas Instruments (US), G.D. Searle, Thomson CSF, and Air France, to name just a few. Many small high-tech firms are

located there. In addition, the Centre Nationale de La Recherche Scientifique (CNRS) and the Institut Nationale de La Recherche en Informatique et en Automatique (INRIA), among others, have major research facilities in the park. This, coupled with the significant scientific laboratories at the University of Nice, Aerospatiale, Villefranche Sur Mer (oceanography) and, generally, those in the Alpes-Maritime Region, make technological research and development a major growth sector.

There are a number of French government-supported basic research laboratories at Sophia. These include the Laboratory for Solid State Physics and Solar Energy, the Laboratory for Informatics of Sophia and Nice, The Center for Materials Forming (of the Ecole Nationale Supérieure des Mines de Paris), the Thermal Economics Laboratory (Solar energy and materials), the Center for Archeological Research, the International Center for Dermatological Research, the Scientific and Technical Center for Buildings, and one of the four major research centers of INRIA. A large biochemistry facility is under construction.

The development of the Alpes Maritimes Region into a Center for Scientific and Technological Development, a *Technopole*, is clearly being given a high priority by both the central and regional governments. The Technopole model is being copied with varying success by other communities in France, elsewhere in Europe, and in the US and Asia. In fact, Technopole has become a catch-all term for regional development in many cases. There are some who argue that, given its exceptional natural setting and burgeoning technological resources, Nice and its region will shortly overtake Toulouse as a site of choice for high-tech firms. This is not obvious at least in the near term given the extraordinary concentration of aerospace activity in the Toulouse area; aerospace remains a growth industry in France. However, it is clear that the Alpes-Maritime Region is on to something.

## Israel

*For further information on Israeli items, contact Mr. Rock (Bud) Anthony, Office of the Science Counselor, American Embassy, APO New York 09672-9700.*

**Israeli Industrial Research and Development Statistics.** Dr. Shmuel

Ofri, representative of the Office of the Chief Scientist (OCS), Ministry of Industry and Trade (MOIT), recently discussed Israel's current directions in industrial research and development.

According to OCS, the gross domestic expenditure on civilian R&D in Israel is \$599 million, of which \$415 million (67 percent) is spent by the government. This total represents roughly 2.76 percent of Israeli gross domestic product (GDP). (Open literature estimates of Israeli defense R&D expenditure ranges from \$600 million to \$1.5 billion/year.) The total volume of R&D in the private sector in Israel is about \$366 million. MOIT hopes that, by 1995, exports of civilian R&D-based industry will total \$8.5 to \$9.0 billion. Last year, however, this figure was only \$2.5 billion.

Some in Israel argue that expectations from high-technology industry vastly exceed realistic proportions. In fact, roughly 4 percent of the 700 R&D-based industries are responsible for 75 percent of high-tech profits. Venture capital has been limited and the country struggles to encourage joint ventures as a means of injecting its R&D expertise into the global marketplace. Israeli R&D industries have difficulty making the leap from small high-potential start-up firms to medium-sized established institutions. One reason for this phenomenon could be that many of these new firms are established by new immigrants or retired military personnel who have advanced technological expertise but insufficient business management experience or capital to support their ideas. In addition, many of the high-technology industries in Israel devote a disproportionate amount of budget to R&D at the expense of much needed marketing. In general, the successful firms have developed niche products that have little competition from other industrialized nations in the global marketplace.

Even as Israeli industries are recovering from the inflationary spirals of past years, civilian R&D industry still must compete for funds with the overwhelming economic emphasis on defense. OFRI quotes Israeli defense industry exports (1985) as about \$1.148 billion with the aim of \$1.67 billion by 1995.

In 1986 (most recent MOIT official statistics), civilian R&D industry exports by subject area were:

- Medicine—\$6.7 million
- Telecommunications—\$117 million

- Aeronautics-\$526 million
- Metals-\$339 million
- Electronics-\$480 million
- Manufacturing/workshop devices-\$71 million
- Chemistry-\$429 million
- Machinery for industry and agriculture-\$135 million
- Insecticides-\$122 million
- Specialized high-precision machinery-\$87 million
- Optics and photography-\$62 million.

These figures do not vary significantly from MOIT statistics of the previous several years.

## Italy

*For further information on Italian items, contact Dr. Gerald Whitman, Office of the Science Counselor, American Embassy, APO New York 09794-0007.*

**Ansaldo Successfully Tests Superconducting Magnet at CERN.** A record 9-tesla superconducting magnet built by Ansaldo was successfully tested at CERN laboratories. The Ansaldo magnet is a prototype for the 4700 superconducting magnets to be used in the LEP Project.

**Aeritalia Studies Robot System for Space Station Servicing.** Aeritalia's Space Systems Group is studying a manned robot capsule (Capsula Robotica Abitata - CRAB), for the in-orbit maintenance and servicing of components and vehicles of the space station. The project is derived from the manufacturing and maintenance module developed in 1988 and the assembly and servicing manned vehicle developed in 1985. The CRAB project is under consideration as a line item for the Italian national space program.

**Italian Milestones for Ariane 5.** Fiat has completed assembling the prototype of the liquid oxygen turbopump for the Ariane 5 motor. The Fiat turbopump is part of the project to develop very low temperature components and was built in cooperation with the Swedish firm Volvo. Elsewhere, SNIA BPD is investing 100 billion lire (about \$80 million) to enlarge its Colleferro factory, where it is building the Ariane 5 strap-on boosters.

**Italian Government Approves Law to Hire Foreign and Italian Emigrant Scientists.** The Italian parliament approved at the end of April a special law that will enable the National Research Council and the National Institute of

Nuclear Physics to hire prominent scientists working abroad under a 5-year contract at internationally competitive salaries. The GOI hopes to attract foreign scientists and Italian emigrants to Italy to manage advanced research centers.

**Minister of Research Creates Committee for Advanced Materials.** The minister of scientific research has created a committee of experts to manage research in advanced materials. The committee has the task of developing an advanced materials research program and of coordinating existing programs. Present efforts include the finalized projects of the national research council, some projects carried out by the National Agency for Nuclear and Renewable Energies (ENEA) and the "Material Physics Projects" of the Interuniversity Consortium for the Physics of Matter. The committee will also pursue initiative to develop professional training among young scientists and experts.

**University of Milan Establishes New Degree in Pharmaceutical Biotechnology.** The Faculty of Pharmacy of the University of Milan is establishing a new 5-year graduate program for pharmaceutical biotechnology, sponsored by a consortium of Italian industries active in the biotechnology area. The purpose of the program, open only to about 40 students, is to create qualified personnel for Italy's biotechnology industries.

**Trento's Institute for Scientific and Technological Research.** The city of Trento's Institute for Scientific and Technological Research spent 18 billion lire (about \$14.4 million) in 1987 for research in artificial intelligence and materials science. The institute will spend 22 billion lire on research in 1988 and will double its scientific personnel (100 scientists at present) by 1991. In addition the institute is negotiating with the Association of Industrialists (CONFINDUSTRIA), for the creation in Trento of a center for the development of environmental technologies.

**Trieste Develops Its Research Area.** The Trieste research area spent about 5.5 billion lire (1 billion lire = about \$0.8 million) for research and another 10 billion lire for building and infrastructures in 1987. The number personnel, about 200 today, is expected to increase to 2000 by 1992. The consortium managing the research area plans to spend 55 billion lire through 1992 for the Synchrotron Light

Facility, 28 billion lire for the International Center of Genetic Engineering and Biotechnology, 10 billion lire for equipment, 5.5 billion lire for general research, and 60 billion lire for buildings and infrastructure.

**Turin and Moscow Sign Agreement to Study Impact of New Technologies.** Last April in Turin the Fiat foundation "Giovanni Agnelli" and the Institute of World Economy and International Relations of the Soviet Academy of Sciences (IMEMO) signed a scientific cooperation agreement on The Social Aspects and Impact of New Technologies and Innovation. The agreement will provide for three seminars, two in Moscow in 1989 and 1991 and one in Turin in 1990. The agreement also provides for four to five fellowships from each side for experts to spend a month in Turin or Moscow. During the April seminar in Turin, it was noted that in 1987 Italy exported to the Soviet Union goods worth 1,686 million rubles (\$1=0.60 Rubles), 70 percent of which was represented by machine tools and technologies and 5 percent strictly technology. On the other hand of the 1800 million rubles of Italian imports, only 20 million rubles were technology related. During the seminar the Soviet participants called for removing obstacles impeding the transfer of advanced technologies, many of which are protected by Cocom-Nato agreements.

## West Germany

*For further information on West German items, contact Edward M. Malloy, Office of the Science Counselor, American Embassy, APO New York 09080.*

**West German Report on Research and Technology Policy.** The Federal Minister for Research and Technology released the 1988 federal report on research and technology policy. The promotion of basic research has gained considerable weight in the BMFT budget. A second priority has been the promotion of health, ecological environment technology, and climate research. Funding in these areas is up 72 percent since 1982. The BMFT has focused on promoting industry-oriented technologies such as information technology, materials research, biotechnology, and Airbus development as well as selected physical technologies. Research promotion for medium-sized industries in 1987 reached DM780 million (about \$460 million). West Germany in-

tensified its international cooperation efforts, particularly in Europe: the EUREKA Program grew to a total volume of DM9 billion, and a new framework for research and development was established in the EC setting; Germany initiated efforts toward technology standardization in Europe, committed to participation in the new high energy accelerator (LEPO at CERN) and an expanded European space program. West Germany will also participate in the international space station.

Industrial enterprises have increased their R&D expenditures by 57 percent since 1981. German R&D activities continue to be internationally competitive.

**European Cooperation on Superconductivity Research.** The German Research Society (Deutsche Forschungsgemeinschaft [DFG]) announced that European cooperation in the field of high temperature superconductivity will be intensified. For that purpose, representatives of the DFG, the Max Planck Gesellschaft, the French Research Center (CNRS), the Italian Research Council, and the British Science and Engineering Research Council recently met to decide on measure for cooperation in this field.

Cooperation efforts will include:

1. The exchange of information on national research programs, their financial framework, scientific staff, and equipment.

- The establishment of regular scientific symposia
- The provision of travel funds and financial means for scholarships abroad.

2. The exchange of research results before their publication.

- Joint evaluation of proposed large research projects by European scientists

3. The realization of the cooperation measures agreed upon at the meeting will be pursued by a "Standing Committee" consisting of representatives of Germany, France, Italy, and Great Britain. Participation by Dutch and Swiss Research establishments on this committee is likely.

## Spain

*For further information on Spanish items, contact Ishmael Lara, Office of the Science Counselor, American Embassy, APO New York 09285-8500.*

**Spanish Participation in EC Technology Development Programs.** Spain's involvement in the EC technology effort began in earnest in September 1987, when Spanish Minister of Industry Luis Croisier chaired the annual meeting of participants in the EUREKA program.

EUREKA is the program where Spanish participation has been greatest. For example, Spain is participating in 17 of the 58 projects approved at the September 1987 EUREKA Ministerial meeting. Those 17 account for 17.2 percent of EUREKA's overall budget. At present, Spanish companies are involved in 40 EUREKA projects worth \$270.7 million (7 percent of the total program budget). Indicating the kind of project that has been attractive to the Spanish companies, is a breakdown of the 40 projects by sectorial interest:

- Biotechnology, medicine, and agriculture (10)
- Communications (2)

- Energy (1)
- Information technologies (7)
- Laser (2)
- Advanced new materials (6)
- Robotics and industrial automation (12).

In terms of other EC programs, such as European Nuclear Research Organization (CERN) and the European Space Agency (ESA), ESPRIT, and RACE, Spain is in the unfortunate dilemma of paying more into these programs than they have been able to get out. For example, in the case of the CERN, from 1983 through 1987 Spain contributed \$83 million while receiving only \$75.7 million in contracts. Spanish policy makers are quite determined to reverse this situation.

Perhaps the most important impact of these programs to date has been on Spain's priorities and projects in the industrial/technological development area. CDTI, the principal Spanish agency in the industrial technological development area, was reorganized in 1986 and early 1987 principally to better take advantage of EC programs. Senior staff at CDTI directly reported that 100 percent of CDTI's efforts were now focused on EC programs.

Similar phenomena have occurred at the regional autonomous government where the CDTI-equivalent agency, CIDEM, has been required to devote 100 percent of staff time and promotion resources to EC programs.

In summary, Spanish public and private sector attention is devoted almost exclusively to work on EC technology development programs.

## OVERSEAS TRAVELERS

Notes on trip reports to locations in Europe and the Middle East which have been received by ONRL are reported below. For details, contact the traveler directly.

### Biosciences

*Traveler: Dr. Paul Nachtigall, Research Branch of the Biosciences Division, Naval Ocean Systems Center,*

*Hawaii Laboratory, Kailua, Hawaii 96734-0997*

Dr. Nachtigall attended the meeting of the European Association for Aquatic Mammals, which was held in March 1988. The society is a very interesting mix of scientists, trainers, veterinarians, and managers of dolphinariums and zoos in Europe. The unifying problem facing the group is the steady encroachment of the

European animal rights activists on their ability to maintain animals in captivity for research and public display.

Nachtigall reports that the program included a good variety of papers on: (1) captive environments, (2) population biology, (3) medicine and pathology, (4) care of newborns, (5) sound and sensory physiology, and (6) human/wildlife interactions. Summaries of each of the ses-

sions will be provided in an upcoming edition of *Aquatic Mammals*, the society's journal. If the group remains true to form, a high percentage of the papers will be collected by the editor, V.J. Manton, and published in that journal.

### Oceanography

*Traveler: Dr. Thomas H. Kinder, Physical Oceanography Program, Office of Naval Research, Arlington, Virginia 22217-5000.*

Dr. Kinder attended the 20th annual colloquium on ocean hydrodynamics, held in May 1988 in Liège, Belgium. He reports that the topic of this year's colloquium was "Mesoscale/Synoptic Coherent Structures in Geophysical Turbulence." The organizing committee consisted of Benoit Cushman-Roisin (Florida State University), K.N. Federov (Institute of Oceanology, Moscow), J.C.J. Nihoul (University of Liège), and Allan Robinson (Harvard). About 50 lectures and about 10 posters were presented. The talks ranged from anecdotal evidence of the forcing of the Kuroshio Current to highly idealized numerical experiments of the interactions of eddy-pairs and topog-

raphy. Nearly 100 scientists were in attendance.

Included with the report is the program of the colloquium, the list of attendees, and a list all 11 of the International Liège Colloquium Series books (published by Elsevier). Kinder says that these books have proved popular because each concerns a particular topic, they all contain a number of important overviews that are unavailable elsewhere, and include a number of original research results.

### Plasma Physics

*Traveler: Dr. A.E. Robson, Plasma Physics Division, Naval Research Laboratory, Washington, DC 20375-5000.*

Dr. Robson attended a meeting on Fiber and Large Current Experiments held at the University of Stuttgart, West Germany, and afterwards visited colleagues at Imperial College, London, to discuss progress in z-pinch research.

Robson says that the meeting in Stuttgart was one of a series of meetings, held about every 6 months, to discuss progress on z-pinch research being carried out by a group of European universities. This

work is sponsored in part by the EEC under a program to encourage scientific collaboration across national boundaries. The universities involved are: Imperial College, London; Ecole Polytechnique, Paris; University of Düsseldorf; and University of Stuttgart. For this meeting, representatives of Swedish, American, and Polish groups involved in z-pinch work had also been invited.

In summarizing the meeting, Robson notes there is a lot of z-pinch work going on in Europe, particularly in theory. Much of the effort has been stimulated by recent experimental results, and particularly by the NRL *idiot* hypothesis. No theory can yet account for the observed stability, but as the theory becomes more refined (Vlasov-fluid, CGL, etc.) the predicted growth rates become significantly less than given by ideal MHD. There is a trend in Europe away from the plasma focus and towards fiber pinches, although gas-embedded and compressional pinches are also being studied.

Robson's report includes the program of the meeting and the list of attendees.

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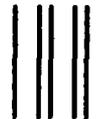
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