ARRD-8677.26-D

AD 744533

(1)

SEMI-ANNUAL TECHNICAL SUMMARY OF RESEARCH OF AEROPHYSICS INSTITUTE FOR STRATEGIC TECHNOLOGY

for the period ending 31 August 1971

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
ARPA Order No. 1442; Amendment 2
Program Code 9E30

PIBAL
Report 71-B

for
U. S. Army Research Office-Durham
Contract No. DAHC04-69-C-0077

D D C
RECEIVED
JUL 6 1972
A

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

U. S. ARMY RESEARCH OFFICE
DURHAM, N. C. 27706

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

MAR 22 1972

POLYTECHNIC INSTITUTE OF BROOKLYN

See AD 738563

29

SEMI-ANNUAL TECHNICAL SUMMARY OF
RESEARCH OF AEROPHYSICS INSTITUTE
FOR STRATEGIC TECHNOLOGY

for the period ending 31 August 1971

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
ARPA Order No. 1442, Amendment 2
Program Code 9E30

Date of Contract: 1 September 1969

Expiration Date: 30 June 1972

PIBAL
Report 71-B

for
U.S. Army Research Office-Durham
Contract No. DAHC04-69-C-0077

Submitted by: Martin H. Bloom
Principal Investigator
Director of Gas Dynamics
Research
Dean of Engineering

POLYTECHNIC INSTITUTE OF BROOKLYN

333 Jay Street, Brooklyn, N. Y. 11201

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Polytechnic Institute of Brooklyn 333 Jay Street Brooklyn, New York 11201	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

SEMI-ANNUAL TECHNICAL SUMMARY OF RESEARCH OF AEROPHYSICS INSTITUTE FOR STRATEGIC TECHNOLOGY

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Semi-Annual Technical Summary for period ending 31 August 1971

5. AUTHOR(S) *(First name, middle initial, last name)*

Principal Investigator: Martin H. Bloom

6. REPORT DATE	7a. TOTAL NO. OF PAGES 18	7b. NO. OF REFS 0
8a. CONTRACT OR GRANT NO. DAHC04-69-C-0077 b. PROJECT NO. ARPA Order No. 1442, Amendment 2 c. Program Code No. 9E30 d.	9a. ORIGINATOR'S REPORT NUMBER(S) PIBAL Report No. 71-B 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency and U.S. Army Research Office-Durham

13. ABSTRACT

This report contains a description of the technical problem areas and accomplishments achieved during the reporting period. In addition, a complete list of publications, presentations, lectures, etc. is included and the personnel associated with this program are listed. The research projects are in the general subject areas of fluid and plasma dynamics. The work described was carried out under an ARPA contract, Order No. 1442, Amendment 2.

DD FORM 1 NOV 65 1473

Unclassified
Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Plasmas						
Numerical methods						
Turbulence						
Raman scattering						
Liquid film cooling						
Flow diagnostics						

ic

ACKNOWLEDGMENT

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by U.S. Army Research Office-Durham, Box CM, Duke Station, Durham, North Carolina 27706, under Contract No. DAHC04-69-C-0077.

ABSTRACT

This report contains a description of the technical problem areas and accomplishments achieved during the reporting period. In addition, a complete list of publications, presentations, lectures, etc., is included and the personnel associated with this program are listed. The research projects are in the general subject areas of fluid and plasma dynamics. The work described was carried out under an ARPA contract, Order No. 1442, Amendment 2.

I. INTRODUCTION

The Polytechnic Institute of Brooklyn is conducting an interdisciplinary program involving both theoretical and experimental studies in the areas of aerodynamics, plasma dynamics, and turbulence. In particular, those aspects are dealt with which are directly applicable to the immediate and long range interests of the ARPA Strategic Technology Office. Laboratory simulations, experimental devices and comparison of results with observed flight behavior are under consideration. Generation of new ideas and the review and evaluation of research performed by others in the professional community is also a significant part of the research effort.

In addition to the research studies briefly summarized in the following section, the investigators are engaged in ARPA committees and discussions and normally participate in the various workshops and meetings pertinent to the overall program.

II. RESEARCH PROJECTS

In this section, the various technical aspects of the individual research projects are discussed. In addition to a description of the task, the investigators, including faculty and students, and the current effort and major accomplishments to date are described. The relevance to national defense is also indicated in each of the project summaries. The various research areas are listed here for reference:

A. Flow Diagnostic Development

B. Electron Beam Diagnostics of Turbulent Plasmas

C. Studies on Plasmas Produced by Microwaves

D. Turbulent Mixing

E. Liquid Film Cooling

F. Unsteady Cavity Flows

G. "Slingshot" - An Aerodynamic Test Facility

A. Flow Diagnostic Development

Investigator: Professor S. Lederman

Technical Program and Accomplishments:

As indicated in the previous semi-annual report, the aim of this phase of the program was further developments of techniques and methods of flow field diagnostics. In this phase of the work, emphasis was shifted from the electrostatic probe techniques to the electron beam density probe, and the Raman scattering techniques. While the major effort was shifted from the electrostatic probe techniques, these were not abandoned completely. On the contrary, an attempt was made to evaluate the applicability of the electrostatic probes to flow field diagnostics in different flow regimes. Both cylindrical and flush mounted probes were utilized. The results were compared with the results

obtained from an electron beam density probe, specifically built, calibrated and evaluated for that purpose in our laboratory. The results of this investigation are given in Refs. 1 and 2.

In the other aspect of this investigation, namely, the application of the Raman effect to flow field studies and concentration measurements, progress was limited to the investigation into the relation between the infrared and Raman spectra as outlined in Ref. 3, and a preliminary design of a high powered pulsed nitrogen laser, the construction of which has been initiated in our laboratory. It is believed that with this laser it would be possible to extend the concentration measurements in the flow field from several thousand to several parts per million.

In another aspect of the research program, the interaction of a shock produced electron precursor and a microwave signal was investigated. The results of this investigation are given in Ref. 4.

The breakdown of open ended microwave waveguide antennae in different gases as a function of pressure, pulse power, pulse duration and pulse rate was investigated. The results of this work in the form of a report is in preparation and should soon appear.

At present, work is in progress on the feasibility of applying the resonant Raman effect to concentration measurements and general flow field diagnostics. The necessary apparatus is being designed and constructed for the purpose of determination of the resonant frequencies of particular species of interest and their molecular invariants.

References:

1. Avidor, J.M. and Lederman, S.: Flow Field Diagnostics in Rarefied Slightly Ionized Hypersonic Flow. PIBAL Report No. 71-18, June 1971.

2. Avidor, J.M. and Lederman, S.: Flow Field Diagnostics in Rarefied

Slightly Ionized Hypersonic Flow. Paper to be presented at the 14th Israel Annual Conference on Aviation and Astronautics, Tel-Aviv and Haifa, Israel, March 1-2, 1972.

3. Lederman, S.: Molecular Spectra and the Raman Effect - A Short Review. PIBAL Report No. 71-15, June 1971.

4. Lederman, S. and Dawson, E.F.: Effect of Microwave Radiation on a Shock-Produced Electron Precursor. PIBAL Report No. 71-13, May 1971.

B. Electron Beam Diagnostics of Turbulent Plasmas

Investigators: Professors R.G.E. Hutter, H. Farber, and E. Levi; Mr. R. Eichler

Technical Program and Accomplishments:

The objective is to investigate the feasibility of using an electron beam as a diagnostic tool for plasmas. Specifically, it is expected that the electron beam may be used to determine local fluctuations or turbulence in an ionized medium. The final goal is the development of the method and the determination of its range of applicability. Theoretical studies are being conducted to derive expressions for the signals impressed on an electron beam passing through an ionized medium of various characteristics; these studies are paralleled by experimental work which is designed to approximate the theoretical model. A device has been in operation which consists of a plasma chamber through which an electron beam is passing. Before entering the plasma, the beam passes through couplers that may either be used to detect signals on the beam or to impress signals onto the beam. After leaving the plasma, the beam passes through couplers to remove signals from the beam.

The current status of the program follows: Three types of experimental plasmas were studied: 1) a thermionically heated, low-voltage arc discharge; 2) an r.f. generated discharge, using a Lisitano coupler; and 3) a P.I.G. discharge. Deliberately generated fluctuations

of the electron density in the arc- and P.I.G. discharges were detected and the mechanism explained.

It was also found that the electron beam, modulated with a microwave frequency, was a convenient tool for measuring the average density of the plasmas.

The theory of beam-plasma interaction in case of a turbulent plasma was extended to warm plasmas. This yielded more realistic dispersion relations while altering very little the growth mechanism of the fluctuations along the electron beam. It was found that waves of different transverse propagation constants k_t are being amplified differently. The work on plasmas of finite dimensions is continuing.

C. Studies on Plasmas Produced by Microwaves

Investigators: Professors E. Levi and K. Chung

Technical Program and Accomplishments:

It has been previously reported[1] that stationary striations aligned with the magnetic field can be produced in microwave generated plasmas by using slotted cylindrical couplers. These striations may be caused either by the particular mode structure of the exciting field, or by plasma waves. Both possibilities were investigated theoretically (see Refs. 2 and 3).

Recent experiments have shed some new light on the nature of these striations. It was found that the structure of the plasma depends on the ratio between the electron cyclotron frequency ω_{ce} and the microwave frequency ω, rather than on the latter. Also the onset of a particular plasma configuration exhibits an hysteresis effect, when the ω_{ce}/ω ratio is varied while maintaining ω constant. Finally, striations appear only when the coupler is located at a point where the axial magnetic field is diverging.

All these results imply that the plasma depends sensitively on the magnetic field and its gradient, rather than the coupler geometry, and

that the striations are indeed caused by plasma waves. These waves apparently break up in the "magnetic beach", as is also indicated by the presence of noise in the case that the B-field under the coupling is diverging.

A careful mapping of the density and temperature profiles reveal that the striations are indeed locations of higher density. In addition, there exists temperature discontinuities at the boundary of the striations. Since temperature discontinuities are associated with electric fields, the striations may well rotate about their axes.

Optical observations of the plasma light indicate that both neutrals and singly ionized ions are excited. Furthermore, the spectral distribution of light output is very sensitively dependent on the background gas pressure.

Attempts have also been made to control the weak turbulence associated with the electrostatic ion-cyclotron instability, both by means of dynamic and feed-back stabilization techniques. Difficulties are still encountered in the coupling of significant power into an overdense plasma column, with axial as well as with radial propagation.

References:

1. K. Chung, "Formation of Striations in an Electrodeless Plasma", J. Appl. Phys., 40, 3885, (1969).

2. A.S. Acampora, "Slotted Plasma Waveguide", M.S. Thesis, Polytechnic Institute of Brooklyn, June 1970.

3. F.T. Stone, "Parametric Interactions in Beam-Magnetoplasma Systems", PIB Doctoral Dissertation, June 1970.

D. Turbulent Mixing

Investigators: Professor P.M. Sforza and Dr. R.F. Mons

Technical Program and Accomplishments:

The problem of turbulent mixing was examined with emphasis on mass, momentum and energy transport in an axisymmetric free jet (Ref. 1).

An experimental investigation of the response of a pitot tube, a thermocouple, and a sampling probe to a known periodic fluctuating flow with variable intensity of fluctuations was performed. The results indicate that pitot tube response yields an adequate measure of the mean momentum flux in the incompressible range for any level of velocity fluctuation intensity in the direction of the probe axis. On the other hand, thermocouples and sampling probes are found to be subject to significant errors in the measurement of mean temperature and mean concentration, respectively, in the high shear regions of a turbulent free jet.

An experimental examination of the flow field of a turbulent axisymmetric free jet for non-homogeneous and non-isothermal conditions was performed. The mean fluxes of mass, momentum and total enthalpy are considered to be the dependent variables. New probes were developed specifically for measuring these flux quantities. The results indicate that, for identical initial conditions, the flux of mass and the flux of total enthalpy should behave identically and that both of these variables decay faster and have larger halfwidths than does the momentum flux. However, the radial coordinate at which the value of the flux variable is sensibly equal to zero, that is, the mean "edge" of the jet, is found to be the same for all flux variables.

An extended version of the Reichardt inductive theory of free turbulence was found to adequately describe the entire flow field for all of the conserved flux variables.

References:

1. Mons, R.F. and Sforza, P.M.: Turbulent Heat Transfer in Axisymmetric Jets. Polytechnic Institute of Brooklyn, PIBAL Report 71-14, May 1971.

E. Liquid Film Cooling

Investigators: Professor R.J. Cresci and Mr. J. Starkenberg

Technical Program and Accomplishments:

One aspect of flow-macrostructure being treated now concerns effects of film-cooling of nose-tips, and the surface downstream of the coolant injection region.

A slender, blunted cone has been tested at Mach 8.0 to determine the downstream effectiveness of a liquid injected in the nose region. Various coolant flow rates were used and the resultant surface temperature distribution was determined over a range of free stream Reynolds numbers. Computations were then performed using available analyses in an attempt to predict the measured film behavior and included the effects of film stability, vaporization, film entrainment and surface roughness.

A comparison of the analytical and experimental results indicated that the coolant mass actually required for a stable film was 5 to 10 times larger than the analyses predicted. It was originally suspected that film instabilities could have caused this behavior. As a result, a stability analysis was performed to study this problem. The results, however, have indicated that within the limitations of the theoretical assumptions, the film should remain stable under the present test conditions. Further measurements indicated that a significant amount of mass loss occurred in the blunted nose tip region, which is contrary to prior expectations. These results have been published in more detail in Ref. 2.

References:

1. Cresci, R.J.: Liquid Film Cooling. Paper presented at the Transpiration Cooling Workshop, held at Aerospace Corporation, San Bernardino, California, January 5, 1971.

2. Cresci, R.J. and Starkenberg, J.: Liquid Film Cooling on Hypersonic Slender Bodies. Paper presented at the XXII Congress of the International Astronautical Federation, Brussels, Belgium, September 20-25, 1971.

F. Unsteady Cavity Flows

Investigators: Professor P.M. Sforza and Mr. R.N. Valentine

Technical Program and Accomplishments:

The study of unsteady low Reynolds number cavity flows led to exact solutions for the flow field within circular cavities with non-axisymmetric boundary conditions (Ref. 1). Calculations indicate that such flows, which approximate the situation found in surface grooves or cavities and in the recirculation region of hypersonic vehicles at high altitudes, require a time on the order of the viscous diffusion time d^2/ν to reach a steady state.

Reference:

1. Sforza, P.M. and Valentine, R.N.: Unsteady Flow Within a Circular Cylinder. Presented at the IUTAM Symposium on Unsteady Boundary Layers, Laval University, Quebec, Canada, May 1971. Proceedings of this symposium are to be published.

G. "Slingshot" - An Aerodynamic Test Facility

Investigators: Professors M.H. Bloom and R.J. Cresci; Mr. D. Landsberg

Technical Program and Accomplishments:

The objective of this study is to develop a pilot model of an advanced design, aerodynamic test facility.[1] The concept consists of accelerating a capsule of test gas in a gun barrel, thereby achieving high Mach number flow over a stationary model. Some advantages of this concept over presently available facilities are the achievement of high Reynolds number, and complete simulation of atmospheric properties.

Using an available 2" pipe of approximately 65 feet in length, a 5" I.D. driver section has been constructed as well as a model support window and various instrumentation devices.[2] At present, velocities up to 3800 ft./sec. have been achieved and cone models have been tested, including the measurement of surface pressure and surface heat transfer. In addition, an expansion nozzle[3] has been constructed and attached to the test section end of the barrel. Tests were run on this facility to determine the feasibility of expanding the flow in the nozzle without destroying the test model. Tests have been conducted and have indicated that this is a feasible test technique. The results of this study will be presented at the AIAA 10th Aerospace Sciences Meeting.[4]

References:

1. Bloom, M.H., Cresci, R.J., Moretti, G., and Librizzi, J.: "Slingshot" - An Advanced Aerodynamic Test Facility. Polytechnic Institute of Brooklyn, PIBAL Report No. 69-24, July 1969. Paper presented at the Seventh International Shock Tube Symposium, Toronto, Canada, June 1969.

2. Librizzi, J.: "Slingshot" - Experimental and Analytical Performance. Ph.D. Thesis, Polytechnic Institute of Brooklyn, June 1970.

3. Landsberg, D.: An Examination of Performance Improvements for the Slingshot Test Facility. M.S. Thesis, Polytechnic Institute of Brooklyn, June 1971.

4. Librizzi, J., Landsberg, D., Cresci, R.J. and Bloom, M.H.: Experimental and Analytic Performance of the Slingshot Pilot Facility. Paper presented at the AIAA 10th Aerospace Sciences Meeting, San Diego, California. January 17-19, 1972 (AIAA Paper No. 72-168).

III. SUMMARY OF RESEARCH PUBLICATIONS

A. Published Articles

S. Lederman and J. Avidor, "The Application of Flush Mounted Electrostatic Probes to Flow Diagnostics", Israel Journal of Technology, Vol. 9, No. 1-2, pp. 19-28, 1971.

An experimental investigation of the behavior of flush mounted electrostatic probes operated in different flow regimes is described. Data obtained in a continuum and a free molecular regime are compared with available, but by no means complete, theoretical results. The experimental investigation was conducted in a pressure driven shock tube and a hypersonic pressure driven shock tunnel. The effect of bias, area, geometry, and position were explored. It was found within the accuracy of the experimental data, that the effect of geometry, if present, is negligible, that the collected ion current density increased with increasing bias voltage and that the current density decreases with the increase in probe area.

G. Moretti, "Initial Conditions and Imbedded Shocks in the Numerical Analysis of Transonic Flows",* Proceedings of the 2nd Conference on Numerical Methods in Fluid Dynamics, ed. by M. Holt, Springer-Verlag, N.Y., 1971.

The brief paper intends to spell out the author's general views on two basic questions: (i) Is it necessary to introduce explicit discontinuities in gas dynamical computations? and (ii) Do steady state results depend on initial conditions?

On the first point, the answer should be positive, if accuracy

*This work is partially supported under Contract Nonr 839(34).

and economy are to be satisfied. The second equation is discussed briefly on the basis of a concrete problem; it turns out that, for problems involving an infinite subsonic domain, an overall steady state does not exist and that a time dependent computational technique should be prepared taking that fact into account.

B. Presentations at Technical Meetings

S. Lederman and J. Avidor are authors of a paper entitled "The Application of Flush Mounted Electrostatic Probes to Flow Diagnostics", which was presented and published in the Proceedings of the Thirteenth Israel Annual Conference on Aviation and Astronautics, March 3-4, 1971, Tel-Aviv, Israel, Weizmann Science Press of Israel, 1971.

R.G.E. Hutter presented a talk entitled "Deflection Fields in Cathode Ray Tubes" at the Popov Society Meeting held in Moscow, U.S.S.R., May 1971.

P.M. Sforza presented a paper entitled 'Unsteady Flow Within a Circular Cavity", co-authored with R.N. Valentine, at the International Union for Theoretical and Applied Mechanics (IUTAM) Symposium on Unsteady Boundary Layers, held at Laval University, Quebec, Canada, May 24-28, 1971.

G. Moretti was invited to present a paper entitled "Numerical Solutions of Unsteady, Inviscid Flow Problems" at the Specialists' Workshop on Fluid Dynamics of Unsteady, Three-Dimensional and Separated Flows, held at the Georgia Institute of Technology, Atlanta, June 10-11, 1971.

G. Moretti presented a talk at the Workshop on Illiac IV and Other Computers of the Forthcoming Generation, held at the University of Illinois, Champaign, June 14-15, 1971.

E. Levi presented a paper entitled "Radial Particle Loss in a Hollow Cathode Plasma Column" at the 3rd Soviet Conference on the Physics of Low Temperature Plasmas in Moscow, June 21-26, 1971. He also conferred

with leading Soviet workers and workers in other countries in the area of energy sources, and furnished an account of his conferences to Dr. E. David, Jr., the President's Science Advisor.

C. P.I.B. Reports, Dissertations, and Books

S. Lederman and E.F. Dawson, "Effect of Microwave Radiation on a Shock-Produced Electron Precursor", PIBAL Report No. 71-13, May 1971.

R.F. Mons and P.M. Sforza, "Turbulent Heat and Mass Transfer in Axisymmetric Jets", PIBAL Report No. 71-14, May 1971.

S. Lederman, "Molecular Spectra and the Raman Effect - A Short Review", PIBAL Report No. 71-15, June 1971.

J.M. Avidor and S. Lederman, "Flow Field Diagnostics in Rarefied Slightly Ionized Hypersonic Flow", PIBAL Report No. 71-18, June 1971.

C.H. Shih and E.Levi, "Ion Collection by Means of Langmuir Probes",* PIBEP-71-084 , March 1971.

J. Avidor, "Flow Field Diagnostics in Rarefied Slightly Ionized Hypersonic Flow". Ph.D. Thesis, Polytechnic Institute of Brooklyn, June 1971.

E.F. Dawson "Microwave Breakdown in Shock Wave Precursors and Gases with a Low Degree of Preionization". Ph.D. Thesis, Polytechnic Institute of Brooklyn, June 1971.

R.F. Mons, "Turbulent Heat and Mass Transfer in Axisymmetric Jets". Ph.D. Thesis, Polytechnic Institute of Brooklyn, June 1971.

E. Levi and M. Panzer, "Elektromekanicheskoe Preobrazovanie Energie", Mir Publishing House, Moscow, 1970. (Russian translation of "Electromechanical Power Conversion", McGraw-Hill Book Co., New York, 1966).

---

* This work is partially supported under Contracts Nonr 839(38) and F44620-69-C-0047.

R. Eichler, R. Hutter, E. Levi and H. Farber, "Electron Beam Diagnostics of Turbulent Plasmas". Informal progress report covering period to March 31, 1971.

R. Eichler, R. Hutter, E. Levi, and H. Farber, "Electron Beam Diagnostics of Turbulent Plasmas". Informal progress report covering period to June 30, 1971.

M.H. Bloom, Coordinator, "Research of Aerophysics Institute for STRATEGIC TECHNOLOGY". Semi-Annual Technical Summary for the period ending 28 February 1971, PIBAL Report No. 71-A.

IV. ARPA-RELATED ACTIVITIES, LECTURES AND CONSULTANTS

A. ARPA-Related Activities

Dean Martin H. Bloom is a member of the Atomic and Molecular Physics Panel of the Institute for Defense Analyses (IDA); Associate Editor of the Journal of Ballistic Missile Defense Research, published by IDA for ARPA; and is a consulting member of the Plume Technology Working Group, Joint Army-Navy-Air Force.

Participation at meetings relevant to the program:

Enrico Levi attended the Symposium on Barium Releases held in Washington, D.C., April 13, 1971.

Martin H. Bloom attended the High-Altitude Nuclear Effects Symposium, sponsored by the Defense Nuclear Agency, held at the Stanford Research Institute, August 10-12, 1971; and attended the Submarine Wake Mixing Workshop held at Gulf Radiation Technology, held in San Diego, California, August 23-27, 1971.

B. Lectures

P.M. Sforza gave a seminar on "Dynamics of Non-axisymmetric Vortex Rings" at The Johns Hopkins University, Baltimore, Maryland, April 23, 1971.

G. Moretti gave a seminar on "Numerical Analysis in Gas Dynamics" at the Old Dominion University, Norfolk, Virginia, July 22, 1971.

Lectures at P.I.B.:

March 1971

Prof. S.G. Rubin Polytechnic Institute of Brooklyn	Viscous Corner Flow
Prof. J.T. LaTourrette Polytechnic Institute of Brooklyn	Review of the Spring Symposium on the Physics of Quantum Electronics

Dr. Robert Cohen NOAA Environmental Research Labs.	Ionospheric Modification Experiments
Dr. N. Solimene Polytechnic Institute of Brooklyn	Near Threshold Behavior of Self Pulsing Lasers

April 1971

Prof. R. Chevray The State University at Stony Brook	On Turbulent-Nonturbulent Interfaces
Prof. W.E. Lamb, Jr. Yale University	Non-Linear Amplification of Incoherent Radiation in an Active Medium
Prof. G. Gould Polytechnic Institute of Brooklyn	Review of Optical Society Meeting
Dr. L.L. Smith Grumman Aerospace Corporation	Planetary Observations Using I.R. Interferometer

June 1971

Dr. V.V. Shevchenko Institute of Radio Technology and Electronics Academy of Sciences of the USSR	Field Expansions in Open Waveguides
Prof. J.T. LaTourrette Polytechnic Institute of Brooklyn	Review of Conference on Laser Applications

July 1971

Dr. V.V. Shevchenko Institute of Radio Technology and Electronics Academy of Sciences of the USSR	Behavior of Eigenvalues for Guided Modes Near Cutoff in Lossy Dielectric Slab and Cylinder Configurations

Dr. Nathan Marcuvitz of New York University presented a series of seminars on plasma turbulence.

Informal seminars were held each week by Dr. KunMo Chung during the same period, covering the same topic. Dr. KunMo Chung accepted an appointment as Vice President of Academic Affairs at the newly established Korea Advanced Institute of Science (KAIS) in Seoul, Korea, and is on a leave of absence from the Polytechnic Institute of Brooklyn.

C. Consultants

Dr. Nathan Marcuvitz, Professor of Applied Physics, New York University.

V. PERSONNEL ASSOCIATED WITH THE RESEARCH PROGRAM

M.H. Bloom	Principal Investigator Director of Gas Dynamics Research Dean of Engineering
Y. Avidor	Research Assistant
R. Bushman	Research Assistant
K. Chung*	Associate Professor
R.J. Cresci	Professor
E.F. Dawson	Research Assistant
H. Farber	Professor
R.G.E. Hutter	Professor
E. Kawecki	Research Assistant
S. Lederman	Associate Professor
E. Levi	Professor
R. Mons	Research Associate
G. Moretti	Professor
C. Nardo	Research Associate
P.M. Sforza	Associate Professor

*Currently on leave of absence.

19

ADDENDUM to the
SEMI-ANNUAL TECHNICAL SUMMARY OF
RESEARCH OF AEROPHYSICS INSTITUTE
FOR STRATEGIC TECHNOLOGY

for the period ending 31 August 1971

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
ARPA Order No. 1442, Amendment 2
Program Code 9E30

Date of Contract: 1 September 1969

Expiration Date: 30 June 1972

DDC
RECEIVED
JUL 6 1972
A

PIBAL
Report 71-B

for
U.S. Army Research Office-Durham
Contract No. DAHC04-69-C-0077

Submitted by: Martin H. Bloom
Principal Investigator
Director of Gas Dynamics
Research
Dean of Engineering

POLYTECHNIC INSTITUTE OF BROOKLYN

333 Jay Street, Brooklyn, N. Y. 11201

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

POLYTECHNIC INSTITUTE OF BROOKLYN

Department of Aerospace Engineering
and Applied Mechanics

ADDENDUM

SEMI-ANNUAL TECHNICAL SUMMARY OF
RESEARCH OF AEROPHYSICS INSTITUTE
FOR STRATEGIC TECHNOLOGY

for the period ending 31 August 1971

PIBAL Report No. 71-B

II. RESEARCH PROJECTS

A. Flow Diagnostic Development

Investigator: Professor S. Lederman

Defense Significance:

The application of electrostatic probes and particularly flush mounted probes in the determination of the flow fields and degree of ionization around reentry bodies is of importance, not only for communication and control purposes, but also for the general understanding of the phenomena accompanying reentry. In this context, the precursor phenomena and the microwave interaction with the same as well as the breakdown of slot antennas as a function of the applied microwave power and pulse repetition frequency may provide valuable information on tracking, recognition, and discrimination of reentry bodies as well as communication with the same. The application of the Raman scattering technique to remote concentration measurements of given species may provide

POLYTECHNIC INSTITUTE OF BROOKLYN

Department of Aerospace Engineering
and Applied Mechanics

ADDENDUM

SEMI-ANNUAL TECHNICAL SUMMARY OF
RESEARCH OF AEROPHYSICS INSTITUTE
FOR STRATEGIC TECHNOLOGY

for the period ending 31 August 1971

PIBAL Report No. 71-B

II. RESEARCH PROJECTS

A. Flow Diagnostic Development

Investigator: Professor S. Lederman

Defense Significance:

The application of electrostatic probes and particularly flush mounted probes in the determination of the flow fields and degree of ionization around reentry bodies is of importance, not only for communication and control purposes, but also for the general understanding of the phenomena accompanying reentry. In this context, the precursor phenomena and the microwave interaction with the same as well as the breakdown of slot antennas as a function of the applied microwave power and pulse repetition frequency may provide valuable information on tracking, recognition, and discrimination of reentry bodies as well as communication with the same. The application of the Raman scattering technique to remote concentration measurements of given species may provide

a method not only of detecting enemy concentrations of well-hidden supply dumps but also movement of the same in heavily wooded or otherwise invisible terrain. While the normal Raman effect may provide signals which would permit concentration measurements of several parts per million at relatively close distances (about a thousand feet) the resonant Raman effect is capable of providing signals up to 5 orders of magnitude higher. This would permit either lower concentration to become detectable, or the same concentration could be detected from longer distances.

The Raman diagnostic technique, with its unique features, may be the only technique capable of measuring simultaneously, without interfering probes, concentration of a number of species and their temperature in inlets as well as exhausts of jet engines and combustion engines.

B. Electron Beam Diagnostics of Turbulent Plasmas

Investigators: Professors R.G.E. Hutter, H. Farber, and E. Levi
Mr. R. Eichler

Defense Significance:

Studies of the turbulence present in the aftereffects of nuclear explosions, in reentry wakes, in the ionosphere and magnetosphere, in gas dynamic lasers will greatly benefit by efforts which lead to new diagnostic tools for experimental investigations and from efforts which increase the knowledge of the range of applicability of such tools.

C. Studies on Plasmas Produced by Microwaves

Investigators: Professors E. Levi and K. Chung

Defense Significance:

Longitudinal striations have been observed in artificial plasma clouds and a close relationship has been established between the striations and the electromagnetic wave propagation properties of these clouds. The availability of similar laboratory-produced plasma striations offers considerable advantage in the search for methods of controlling the structures of the clouds.

Another area of application of such electrodeless discharges is in plasma chemistry and in energy and light sources.

D. Turbulent Mixing

Investigators: Professor F.M. Sforza and Dr. R.F. Mons

Defense Significance:

The characteristics of turbulent mixing, particularly including the effects of mass and energy transport are relevant to turbulent boundary layers and wakes of hypersonic vehicles. The results obtained indicate the errors introduced by previous diagnostic methods. New theories and experimental techniques developed in Ref. 1 will be useful in improving the accuracy of present prediction methods and experimental data for such flow situations.

E. Liquid Film Cooling

Investigators: Professor R.J. Cresci and Mr. J. Starkenberg

Defense Significance:

This problem is directly relevant to the design of low altitude, maneuvering missiles and other flight vehicles. Due to the requirement of accurately obtaining lateral forces to perform a flight maneuver, the nose tip must be protected by an active coolant system. Such passive systems as tip ablation are not satisfactory since asymmetric nose shape changes can adversely affect the desired trajectory. It is necessary, therefore, to be able to accurately predict the performance and cooling capability of a liquid film system.

F. Unsteady Cavity Flows

Investigators: Professor P.M. Sforza and Mr. R.N. Valentine

Defense Significance:

Since these characteristic times may be quite low in the flow situations mentioned above, there exists the possibility that experimental results for such flows, obtained in short duration facilities, may not truly illustrate the steady state condition. Furthermore, steady flow analyses of hypersonic vehicles undergoing rapid acceleration or high constant speed excursions through the density gradient of the atmosphere may be inaccurate.

G. "Slingshot" - An Aerodynamic Test Facility

Investigators: Professors M.H. Bloom and R.J. Cresci
Mr. D. Landsberg

Defense Significance:

This device can be used in the ground test of high speed, low altitude, intercept vehicles. The test atmosphere is readily controlled in that one can insert any mixture of gases, vapors, or solid particles into the capsule. It is anticipated that this device, in addition to its usefulness for high Reynolds number tests, can also be effective in the measurement of surface erosion in traversing an atmosphere laden with either solid particles or water vapor.