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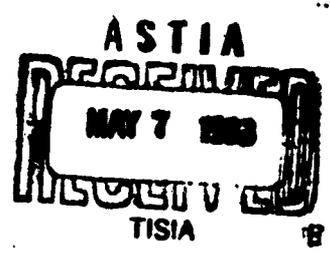
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RESEARCH ON APPLICATION OF NUCLEAR SHELL MODEL TO
CALCULATION OF ENERGIES OF GROUND STATES AND
EXCITED STATES OF NUCLEI

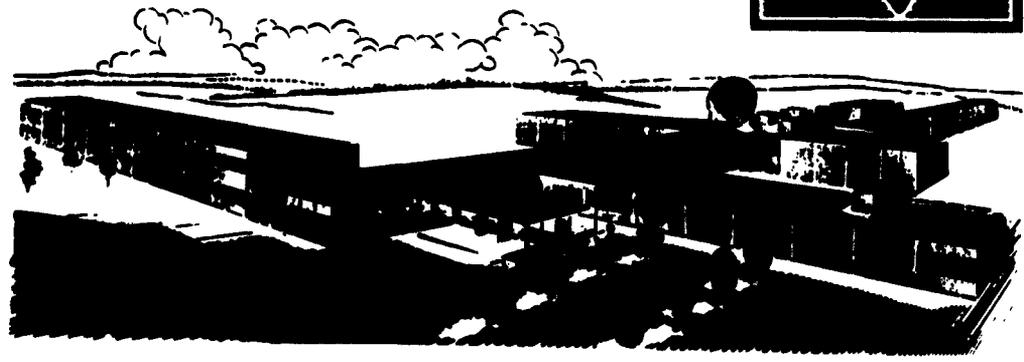
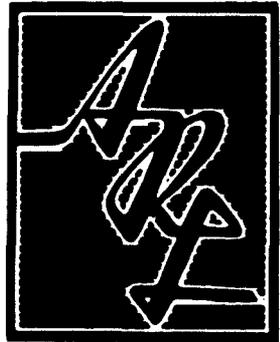
AMOS DE-SHALIT

THE WEIZMANN INSTITUTE OF SCIENCE
REHOVOTH, ISRAEL

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AERONAUTICAL RESEARCH LABORATORIES
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FINAL REPORT

Covering the period of

1st November 1961 through 31st October 1962

**"Research on Application of Nuclear Shell Model to
Calculation of Energies of Ground States and Excited
States of Nuclei".**

AF - AEOR 62 - 56

**The research reported in this document has been
sponsored in part by the**

AERONAUTICAL RESEARCH LABORATORY OAR

**Through the European Office, Aerospace Research,
United States Air Force.**

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The present grant was an extension of contract AF-61(052)-56 and grew out of it. It covered the same subject, namely that of the Application of Nuclear Shell Model to Calculation of Energies of Ground States and Excited States of Nuclei.

While trying to obtain better wave-functions for light but deformed nuclei, a method was developed which involved an extensive use of the representations of the SU₃-group (See Technical Status Report No. 13 for AF 61(052)-56). It then turned out that the same mathematical techniques could be used for the classification of some elementary particles and the clarification of their modes of decay. Together with S. Meshkov, who was holding an NSF grant at the Weizmann Institute, C.A. Levinson and H.J. Lipkin, working on the present grant, then studied the implications of their studies in nuclear spectra to the analysis of elementary particles and came out with a very simple presentation of some of the more intricate features in this field. Since this is covered in a paper published in Nuovo Cimento, 23, 236 (1962), (attached herewith), we shall not go into the details in this report. The paper on Nuclear Spectra of Oxygen Isotopes was published (Nuc. Phys. 30, 280 (1962)) during this year, but since its preparation was practically completed under the previous contract AF 61(052)-56 we shall not go into its details either, and are just attaching a copy of it here.

The major effort under the present grant was devoted to analysis of a certain mode of excitation of odd-A nuclei. This mode, the so called "Core Excitation", starts from the assumption that the even-even core of an odd-A nucleus should be treated separately from its odd particle. The resulting spectrum is then a superposition of the spectra of an even-even core and a single particle moving in a central potential. The motivation for this approach to the nucleus lies in the observation that even-even nuclei show considerably more "stable" regularities than the odd-even ones. In addition one may expect that the pairing of nucleons will lead to a super-conducting type of wave function for the even-even core with the odd particle hardly having any effect on it.

The core excitation model in a somewhat more restricted form was first suggested by Lawson and Uretsky, Phys. Rev. 108, 1300 (1957), and preliminary suggestions for the methods of searching such modes of excitations were given in a paper by A. de-Shalit in Phys. Rev. 122, 1530 (1961). Few examples were treated there, in particular those of the odd- Tl isotopes and some of the Hg isotopes. The common feature of all these nuclei was the fact that the odd nucleon was in a $j = \frac{1}{2}$ orbit - a fact which made the subsequent analysis relatively easy and straightforward.

This model was then used for the analysis of a nucleus with an odd particle in a $j = 3/2$ orbit (Au 197), and a number of new interesting features came out (see attached reprint from Phys. Lett. 1, 264 (1962)).

The success of the applications of this model led to an increasing interest in it, and the rapid accumulation of new data has kept us expanding a detailed account of the work and thus delaying its publication. It is, however, hoped that the extensive analysis will be submitted for publication soon, and we shall give here just some of its highlights.

The core excitation model predicts, in general, energies and spins of excited states, moments and transition probabilities. Strictly speaking it claims to establish only relations between moments and transitions, but taking few such pieces of data from experiment, others can of course be predicted. Predictions on moments as derived from this model have so far been tested by B.I. Deutsch of the Bartol Research Foundation (Tl 203), by L. Grodzins et al. at M.I.T. (Hg 199), and by D.A. Shirley at Berkeley (Au 197). All measurements agreed very nicely with predictions, the agreement being especially spectacular in the case of Au 197 where other models predicted a moment four times bigger.

Further work in analyzing data along the lines of this model was done by the Oak Ridge group and other groups in Europe and in the U.S.A. The Copper isotopes are under study at Oak Ridge presently, some of the light elements are under study by C. Sharp Cook at the U.S. Naval Radiological Defense Laboratory in San Francisco, a compilation of "promising cases" has been undertaken by Dr. Gove of the Nuclear Data Group at the National Academy of Sciences in Washington, additional isotopes of Au and Ir are under study by Jastrzebski in Warsaw and R. Lombard in Zurich, some light isotopes (Al and P) are being studied at Orsay, Cd 115, studied at Utrecht, may prove to be of great interest since its odd particle is in a $j = 9/2$ orbit and leads to a quintuplet; and finally the recent extension of the model to odd-odd nuclei seems to have interesting features in it which may bring out a better understanding of these nuclei.

In conclusion it is a pleasure to thank the European Office of the ARDC, with whose support and encouragement it was possible to carry out much of this work.