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[ATOMIC PHYSICS]

Technical Progress Report
on Contract No. AT(11-1)-1674
for the Period January 1 to September 15, 1967

1. Scope of the Report. This report covers the scientific activity of the following personnel:

MASTER

- a) U. Fano, Principal Investigator: His salary was provided by this contract during July 1967 only; in addition AEC support was received for travel and supporting services.
- b) A.R.P. Rau and K.Z. Lu, graduate students, whose salary was provided beginning January 1 and March 1 respectively.
- c) D.P. Chock, graduate student, supported by ARPA SD-89 Research Assistantship from July 1, 1966 to May 31, 1967 but whose work was related to this project.

Dr. P. L. Altick, Research Associate, has reported for work supported by this contract on September 1, 1967; his activity is not yet included in this report. For the

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sake of simplicity, the activity report of Mr. Fano and Mr. Rau covers also the period beginning October 1, 1966 before the operation of this contract.

Note that two students rather than one, were supported during most of 1966 whereas a Research Associate became available for appointment only in September.

References will be made to various items of the initial "Proposal" submitted in June 1966.

2. Photoabsorption Spectra (see "Proposal" p. 4, item a).

Fano's attention was drawn back to this topic in the Fall of 1966 by new experimental and computational evidence, which emphasized the variation of these spectra along the periodic system to a degree unforeseen in his recent brief review (Ref. 107 of "Proposal"). Much of his activity was, therefore, devoted to further study of the whole field, leading to the preparation of a comprehensive article (in collaboration with J.W. Cooper of NBS) which is now in near-final stage. This activity involved extensive interplay with work of other laboratories, particularly at NBS.

This effort also yielded various by-products described in following sections. In particular we obtained a better appreciation of the critical role of the potential near the edge of atoms upon the escape probability of photoelectrons and of the sharp variations of this potential from one element to another.

3. Inelastic Form Factors. Asymptotic laws for the dependence of photoeffect upon photon energy in the high energy limit have long been known in the hydrogenic approximation and often implied to have broader validity. These laws are but a special case of laws concerning the form factors which determine the cross sections for fast charged particle collisions in the Born approximation. The whole matter was examined by Rau, leading to a detailed statement of the laws and of their underlying assumptions which is to appear in the October 2 Physical Review (Report COO-1674-1).

4. Variation of atomic properties along the periodic system.

To account for peculiar variations of photoabsorption spectra that appeared in NBS calculations, Rau investigated the characteristics of the potentials utilized in these calculations. This analysis led to the identification of properties which attain extreme values upon the completion of d or f subshells, whereas completion of the p subshell occurs at the noble gases and is usually emphasized. A report on this subject (Report COO-1674-3) which was submitted to the Physical Review Letters is now undergoing some editorial revisions and extensions and may eventually appear in the Physical Review.

5. Double excitation of helium (see "Proposal" p. 5-6). The main approach to this major problem contemplated in 1966 is being developed through numerical calculations at UKAERE by J. H. Macek. Initial results confirm the interest of the approach followed but have not yet pinpointed the origin of the remarkable phenomena that have been observed. New material by other workers has confirmed and extended the phenomenological picture.

An effort to correlate and evaluate a variety of experimental data on double excitations has been carried out by D.P. Chock. Its results have been circulated to interested laboratories as Report No. COO-1674-2.

6. Configuration Interaction. Earlier efforts to adapt the formalism of collision theory to the needs of analysis of atomic experiments have been continued by Fano. Some lecture note material has been prepared, the longer range goal being the preparation of a comprehensive article.

The extraction of information about the network of interactions among many types of excited states by suitable analysis of experimental data is being investigated by K.Z. Lu. The example under study is the perturbation of levels of 3 series of Xe by a few levels of 2 other series. The interactions between these series are the same that cause the autoionization spectra discovered by Beutler above the

first ionization potential and which determine the intensity ratio and angular distribution of different photoelectron groups above the second threshold. All these phenomena should be represented in terms of a single set of interaction parameters.

7. Cooperative activities. Much effort has been devoted by Fano, as in the past, to exchange of information with numerous other laboratories and to interpretation and discussion of their results. The students are beginning to participate in these operations. Particularly close collaboration has been maintained with the NBS Atomic Physics Division. Many examples of other collaborations are given in the Trip Report, COO-1674-5 .

Within the University of Chicago acquaintance with a view to developing actual collaboration is being developed with several groups. Of particular importance, besides the longstanding close contact between Fano and R. L. Platzman, are the contacts with Mark Inghram's experimental group and with the program of atomic and molecular calculations directed by Clemens Roethaan. Further development of the latter connection is mentioned in the Renewal Proposal.