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FINAL REPORT

Contract Nonr-393(04)

With the Department of the Navy
Office of Naval Research

Project Title: Physics of the Solar Corona

Project Director: Dr. Donald E. Billings

18 August 1964

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GENERAL SUMMARY OF ACHIEVEMENTS

The research carried out under Contract Nonr-393(04) constituted a continuing ten-year program of coronal study. The only other research program comparably directed toward the corona throughout this period of time was that by Waldmeier in Arosa, Switzerland. In addition, however, many other solar programs, notably radio, rocket, and satellite astronomy, have contributed to our knowledge of the corona. These various studies have interacted with each other to the point that it is impossible to clearly identify the contribution of any one program. In this report, nevertheless, we will attempt to indicate how work under this contract contributed to progress in coronal science during the past decade.

Our current concepts of the corona were already formulated in a general way at the beginning of the contract period a decade ago. A temperature of approximately one million degrees was recognized, and characteristic density structures had been studied in some detail. Questions remaining unanswered were:

(1) Was the corona characterized by a single temperature in all parts and at all times in a solar cycle, or were ranges of temperature present?

(2) If a single temperature described the corona, where, between a few hundred thousand degrees to several million degrees, did this temperature lie?

(3) If various temperatures were present in the corona, which temperatures best represented which features?

(4) What are the dynamic properties of the corona?

(5) How is the corona heated?

(6) What is the relation of the corona to flares and prominences?

(7) What, precisely, is the role of a magnetic field in the corona?

We feel that our work under this contract has made significant contributions toward answering these questions.

An achievement early in the contract period was to present evidence in favor of the tentative identification by Elden of the coronal yellow line with Ca XV. Our work stimulated a new evaluation of the problem by Rohrlich, Glazer, and Elden, with the result that the identification is now generally accepted. The high ionization potential of Ca XV clearly indicated very high temperatures in active regions of the corona -- a conclusion that was first confirmed by our measurements of the width of line profiles in these regions.

Several years after rocket and satellite astronomers rediscovered the high-temperature characteristics of coronal condensations. Furthermore, the close association that we found between hot coronal condensations and flares and loop prominences provided a basis for understanding the enhancements of shorter wave length X-ray flux observed in satellite observations during flares.

Our studies indicated the existence of a rather wide range of coronal temperatures within even small structures, and persistently indicated that the temperatures were a factor of two or more higher than those being given by ionization theory. Our own attempts to explain this discrepancy were unsuccessful, but they stimulated Seaton and his co-workers at University College, London to spend several years on the problem. Their study resulted in discovering the overwhelming importance of dielectronic recombination in the corona, to the extent that when this process is taken into account, the ionization theory temperatures are in good agreement with the line profile temperatures. Finally, because of the successful application of dielectronic recombination to the corona, it is currently being applied to problems of the photosphere and chromosphere, and even to the terrestrial aurora.

Our studies further indicate that the macroscopic motion of the corona is remarkably small. This realization has placed severe limits on theories of the heating of the corona, and is currently providing criteria for discrimination between one theory and another.

Our continued interest in the physics of the corona, fostered by this contract, was primarily responsible for our suggestion to officials of the International Astronomical Union that a symposium on the solar corona [illegible] in 1961. It is also responsible for our participation in the recent "Cloudcroft Symposium" as co-hosts with Sacramento Peak Observatory, [illegible] Dr. Roberts as chairman and Dr. Billings as secretary of the [illegible] Committee. The symposium revealed the rapid evolution underway in concepts of the corona, particularly under the stimulus of radio, radar and rocket astronomy. The resulting "Proceedings" provides a rather inadequate documentation of the symposium, since the most stimulating ideas were [illegible] in the informal discussion groups which were reported in the "Proceedings" only in a summary form.

No detailed survey of coronal science incorporating the [illegible] recent years has been written. Consequently, we have undertaken the [illegible] of a comprehensive book on this subject as a final project [illegible]. The rough draft of the book is essentially complete. Editing [illegible] preparation are being carried out under Grant Nonr-[illegible]-35.

Respectfully submitted,

John W. Firor

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Director

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