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FINAL REPORT

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SPACE PLASMA RESEARCH

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by

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and

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Work under this contract has covered four basic areas: (i) development of analysis techniques and software and numerical simulations; (ii) data analysis and interpretation; (iii) spacecraft sheath studies; and (iv) laboratory studies. The important details of this work have been documented in terms of either appropriate software documentation or publication in refereed publications, conference proceedings and technical reports. Progress reports have been issued to the scientific community in a timely manner by means of paper presentations to national and international meetings, and additionally to the contracting agency by means of quarterly progress reports. For these reasons, this report consists of a brief summary of major accomplishments in the four primary areas noted above, followed by a chronological listing of the publications and presentations which have resulted from the research supported under this contract.

DEVELOPMENT OF DATA ANALYSIS TECHNIQUES AND SOFTWARE AND NUMERICAL SIMULATION SOFTWARE

Several major developments were completed under this contract. Among these were the derivation of the thin sheath analytical model for ion flux into an RPA and its use in a computational procedure for analyzing temperatures and densities. This model was extended semi- empirically to incorporate spin modulation, which was likewise included in the analysis software. These models have been included in software for simulating RPA and spin curves for different plasma conditions. Methods were also developed for determining flow velocities within the plasmasphere for the different ion species. Software incorporating all these techniques was combined with automated decision-making and included in the program which generates the data base for the empirical model now under development.

Several numerical simulation programs have also been developed or modified. A two-dimensional ion trajectory code was developed for high latitude studies. Besides going through several evolutionary improvements and applications to different regions of the magnetosphere, it is now being extended to three dimensions. A three-dimensional numerical model of the polar electrostatic field is also under development for high latitude studies. A previously developed sheath simulation program and a one-dimensional plasmasphere model have also been modified and employed in appropriate investigations.

In addition to these, a number of small, special-purpose programs have been prepared for carrying out different investigations.

DATA ANALYSIS AND THEORETICAL STUDIES

In terms of scientific studies, we have been involved in a wide variety of investigations; this is reflected in the titles of the papers and presentations in the references. A primary thrust of this research has been to delineate the properties and behavior of thermal or core plasma in the magnetosphere. Coupling between the ionosphere and the plasmasphere or other parts of the magnetosphere has been another area of importance. Interactions between spacecraft and plasmas have also received considerable attention. Topics of general interest in space plasma physics, such plasma expansion into a vacuum phenomena have also been treated. These topics have been studied both theoretically, observationally, using RIMS and other instruments' data, and experimentally, with laboratory plasma flow studies. In carrying out these studies, we have collaborated at all levels: locally, nationally, and internationally. During this period, our research has resulted in the publication of 67 papers in refereed journals or conference proceedings, with 21 more either submitted or in press. We have also presented reports to our colleagues at national and international meetings in more than 114 scientific papers. These are all listed in the references.

SPACECRAFT SHEATH STUDIES

The primary focus of our efforts in this area has been the effects of spacecraft charging on low-energy particle measurements. Thermal plasma in the plasmapause region is typically repelled by the positive satellite potentials characteristic for conditions there. When the satellite is eclipsed by the Earth, these "hidden" ions become visible, as demonstrated for the ATS-6, SCATHA, and DE-1 satellites. Aperture bias experiments on DE-1 were moderately successful in overcoming positive potentials, but were limited by potential barrier effects. One major success achieved with this technique was the measurement of the polar wind. The concern with large negative satellite potentials was addressed with examinations of the charging behavior of the ATS and SCATHA satellites.

Experiments in charge control showed that electron emitters were largely ineffective, while plasma sources could control both mainframe and differential charging effects.

LABORATORY PLASMA FLOW STUDIES

In addition to participating in the laboratory calibration of flight instruments, we have used laboratory chambers to perform plasma flow simulation experiments. The thrust of this research has been to examine experimentally the wakes of conducting bodies immersed in collisionless, supersonic plasma flows. The results for the filling-in of the near wake were examined in the context of the theoretical predictions of phenomena associated with the expansion of a plasma into a vacuum. Specifically, we observed the acceleration of ions to speeds above the ion acoustic speed. Preparations have been made to extend these experiments to two ion species plasmas, which are characteristic of conditions in many space plasmas.

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FINANCIAL STATUS REPORT

CONTRACT NAS8-33982

Total Cumulative Costs incurred as of 9/30/86 $1,327,885.40

Estimate of cost to complete: $22,112.60

Estimated Percentage of Physical Completion 98%

Statement relating the Cumulative cost to the percentage of physical completion with explanation of any significant variance: