PLANAR ION TRAP (RETARDING POTENTIAL ANALYZER) EXPERIMENT

FOR

ATMOSPHERE EXPLORER

FINAL REPORT

For Contract No. NAS5-11407

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CENTER FOR SPACE SCIENCES

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The Atmosphere Explorer program consisted of the study of data from three satellites to further our understanding of the aeronomy of the earth's upper atmosphere. Included in the satellites' payload was the capability to measure the constituent composition and temperature of the neutral and ionized gas as well as the motion of these atmospheric components. These data together with measurements of the electron temperature, the energetic particle input and the atmosphere airglow emissions have provided the foundation upon which giant strides in the understanding of our environment have been made.

The retarding potential analyzer and drift meter were carried aboard all three Atmosphere Explorer spacecraft. These instruments measure the total thermal ion concentration and temperature, the bulk thermal ion velocity vector and some limited properties of the relative abundance of H^+, He^+, O^+ and molecular ions. These instruments functioned with no internal failures on all the spacecraft. On AE-E there existed some evidence for external surface contamination that damaged the integrity of the RPA sweep grids. This led to some difficulties in data reduction and interpretation that did not prove to be a disastrous problem. The AE-D spacecraft functioned for only a few months before it re-entered. During this time the satellite suffered from a nutation about the spin axis of about ± 2°. This 2° modulation was superimposed upon the ion drift meter horizontal ion arrival angle output requiring the employment

of filtering techniques to retrieve the real data. This function proved to be quite difficult in highly structured high latitude regions but, nevertheless, high quality data was retrieved in most cases. The AE-C spacecraft functioned without major incidents for about seven years. During that time a large data base from the RPA/Drift Meter has been accumulated. The data have been of high quality and data reduction algorithms have functioned smoothly throughout the mission.

A great deal of fundamental and more detailed science has been performed using the RPA/Drift Meter data. Data from all three spacecraft have contributed in different fields, the highlights of which are described below.

The Ionosphere as a Plasma Laboratory

The elliptical orbit of the AE-C satellite allowed a number of measurements to be made in a confined latitude and local time region but with varying neutral and ionized gas concentrations by virtue of a changing altitude. Under such conditions the details of many chemical reactions can be studied. In particular, reaction rates for species that are extremely hard to produce in a laboratory can be studied. The AE data base has been put to good use in this area with the magnetic spectrometer and RPA providing details of the ionic constituents, the airglow instrument providing information on excited neutral and ion species and the bulk neutral gas densities provided by mass spectrometers. New information on fundamental ion recombination rates has been returned as well as an improved understanding of chemistry of minor ions such as O^{++} and N^{++}.

In the plasma laboratory environment we have also learned more about the conditions under which thermal equilibrium between the ion and neutral gases is established and made use of a unique opportunity to examine the neutral hydrogen envelope of the earth.

Ionospheric Irregularities

In addition to providing ion composition, velocity and temperature data the RPA also functions in a mode that allowed the properties of ion concentration irregularities to be determined down to scale sizes of about 125 meters. Spectral analysis of this data has produced information about the dominant scale sizes of ionospheric irregularities as a function of position. In addition the combination of high resolution measurements from the magnetic spectrometer has allowed an investigation of the constituent ions in regions of high and low density and a measure of their chemical lifetimes. Such data has also been combined with measurements of the bulk ion velocity so that the motion of ionospheric irregularities can be determined. Many different characteristics have been discovered, some of which can be understood in terms of current theoretical models and others which are a stimulus for future theoretical work in plasma physics.

High Latitude Ionospheric Dynamics

The contribution of AE to ionosphere magnetosphere coupling studies and our understanding of magnetospheric energy inputs to the atmosphere may not have been anticipated initially but has turned out to be a significant legacy left by AE. The combination of ion composition measurements, ion velocity measurements, and energetic particle measurements has led to a significant advance in our understanding of the impact of each of these parameters on the other. The data have led to new thinking on the geometry of the high latitude convection pattern, to new ideas about the location of electric field and particle sources in the magnetosphere and to a new generation of sophisticated ionospheric models to include the effects of high latitude ionospheric

dynamics. Significant advances have been made in our understanding of the formation of ion concentration depletions, in the electric field structure around auroral arcs and in the distribution and magnitude of ionospheric conductivity.

There is no doubt that the AE mission has left us with unanswered questions. However, most of these questions are new ones requiring new and more specialized data. As a result the AE mission has been a huge success that can be easily recognized by the large and significant amount of published material that it has generated. Attached to this report is a list of those publications either fully or partially supported by this contract.

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