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INTRODUCTION

We propose to continue the present program of data analysis presently being conducted under NASA Grant NGR 21-002-060. This research is concerned with the general area of ionospheric plasma utilizing flight data gathered by the Goddard Space Flight Center. The specific topics of investigation have been and will be selected on the basis of their scientific importance and their mutual interest to NASA and the University of Maryland. Some of the topics presently under investigation or planned for future investigations include (but are not restricted to) the following:

Langmuir Probe Orientation Anomaly

One of the first tasks undertaken in this program was the analysis of an anomaly observed in the ion current response of a cylindrical Langmuir Probe carried aboard Explorer 17. We found this phenomena to be an end effect which becomes important when the probe axis nears alignment with the velocity vector of the space platform. This problem has been theoretically developed and the results of this study are reported by Bettinger (1966). Chen (1966) has compared this theory with the Explorer 17 data and finds good agreement. This work has been summarized recently by Bettinger and Chen (1968).

Langmuir Probe Aspect Modulation

Miller (1967) has examined Explorer 31 electrostatic probe data and finds modulation of the electron-dominated, volt-ampere characteristics which is related to the probe orientation with respect to both the vehicle velocity vector and the magnetic field vector. These effects are largely restricted to the higher altitudes (> 500 km) and their origins are rather complex. While the electron thermal velocity is large compared to the vehicle velocity, the collection of these charges depends upon the nature and structure of the sheath. The sheath, in turn, depends upon the ion concentration and the ion concentration does depend upon vehicle velocity and probe orientation. It is through this causation chain that the electron collection characteristics are influenced by orientation of the velocity vector. While this is an important effect, it appears that this is only a part of the problem. If one assumes a negligible collisional interaction for the charged particles at a sufficient altitude,then one would develop very large asymmetries in the charge particle fluxes parallel and perpendicular to the terrestrial magnetic field. This effect is greatly modified by the gravitational potential and the neglect of collisional interactions is certainly not valid, but these effects can give rise to large asymetries. In addition, the photochemistry, charge transport, and particle/ wave interactions are probably significant. We are considering various aspects of this problem.

Ion Mass Measurements

One of the more intriguing applications of Langmuir probes to ionospheric plasma research was suggested by Brace and Reddy (1965). They examined the ion saturation region of the electrostatic probe carried aboard Explorer 17 and from its slope estimated the mean mass of the positive ions. Bettinger (1965) calculated the response of this probe to ion mass as a function of orientation on the moving satellite and concluded that it should be possible to determine the relative concentrations of the major ionic constituents from such information. A program has been undertaken to analyze data from Explorer 31 in terms of the ion masses; however, the experimental accuracy of the data heretofore available appeared inadequate to provide meaningful results. Currently, the results are more encouraging although the generating approximations appear to require review and the data may be contaminated by fluxes of energetic electrons in some cases.

Probe Analysis

A program which was preliminarily reported by Perez (1967) is a theoretical analysis of the flight data of cylindrical Langmuir probes of the type carried aboard Explorer 17, 22, and 31. We are attempting to account for all of the observed phenomena with the view to evaluating the applicability and accuracy of these probes under various conditions. It appears that we can obtain good agreement between theory and the data under consideration if we include two major effects. The first is the variation in the potential of the reference vehicle relative to the plasma and the second is the variation in reflection coefficient of the collected species as a function of particle energy. A recent report has summarized these results. (Perez 1968).

Sheath Modulations

The interaction of the space vehicle in the ionospheric plasma is one which has received considerable attention over the past several years. It is a complex problem not readily amenable to theoretical analysis. There are several important topics within this general area to which we have addressed our attention.

The sheath surrounding an earth satellite is "manufactured" by eliminating electrons from the plasma-vehicle interface for a distance efficient to accumulate the appropriate net positive charge to "shield" the vehicle potential. This results because the vehicle velocity makes the ion rigidity too high to be easily controlled by the potentials normally associated with the satellite. While the potential distribution within the sheath cannot "control" the ion motions, it does markedly affect them. This modulation of the ion trajectories by the satellite sheath is of considerable interest with regard to results obtained from ion mass spectrometers carried aboard the satellite. The response of such a detector is a function of the orientation of its aperture relative to the velocity vector of the satellite has a natural width associated with this sheath modulation and simple geometric considerations. Superimposed on top of this "natural width" is a Doppler broadening effect due to the temperature of the ions. Since a large amount of this type of effect is available, it would be useful to develop techniques which should permit us to interpret the observations in terms of the ion temperatures. We have undertaken a program which considers the motions of the ions over the forward hemisphere of the satellite. Utilizing the computer as a computational aide, we are developing programs which will permit us to calculate the flux and angular distribution of ions to an element of the surface of the satellite as a function of the ion temperature and the angle between the surface normal and the velocity vector. The first order program to this end has been completed and reported by Scott (1968).

Ion Fore to Aft Ratio

Brinton (1966) suggested that the ratio of the signal detected by an ion mass spectrometer with the normal of its aperture parallel and anti-parallel to the velocity vector may also be interpreted in terms of the ion temperature. We have undertaken a program utilizing model potential distributions about spherical bodies to calculate ion trajectories and, hence, fore to aft ratios. Preliminary results reported by Toner (1968) indicate that this data may be a sensitive indicator of ion temperature, at least for the lighter ions. While the results obtained appear reasonable, their accuracy is as yet to be determined.

Wake Structure

Since the translational velocity of the satellite is large compared with the thermal velocity of the ionospheric ions, a wake which is substantially void of ions is created by the passage of the satellite vehicle. The electrons, on the other hand, have thermal velocities which are large compared to that of the vehicle and they tend to fill this wake at a greater rate than would be predicted by simple diffusion. The accumulation of negative charge within the wake region will give rise to an ion rich outer sheath which shields this negative charge relative to the plasma at large distances. While this problem has received considerable attention over the past decade, it has yielded remarkably little information because of the theoretical difficulties. We hope to obtain some empirical information by observing the modulation of Langmuir probe data as it rotates through the wake region.

Publications Attributed To This Grant

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