05627-16-P

THE UNIVERSITY OF MICHIGAN
High Altitude Engineering Laboratory
Department of Aerospace Engineering
Program in Aeronomy
Status Report
Contract No. NASr-54(05)
1 December 1966 - 28 February 1967

Abstract

A report on the effect of motion on the altitude distribution of atmospheric density was written by S. N. Ghosh. E. K. Miller continued the investigation of the behavior of cylindrical antennas in plasmas and published two reports and a paper.

The preparation of two aeronomy Aerobees to make measurements of the number densities of O, O_2, A, N_2 and particularly N to an altitude of 280 km was started. Adaptation of a multiplier to the massenfilter spectrometers formerly used on Nike-Apaches was undertaken. Other instruments on these rockets are: POGO-type massenfilter, plasma resonance relaxation probe, antenna impedance probe, rf field strength probe, Langmuir probe, magnetometers and solar aspect sensor.

Comparisons of simultaneous sphere and grenade firings resulted in significant corrections to the zonal wind magnitudes measured by grenades.

Paper by S. N. Ghosh

Effect of Motion on the Altitude Distribution of Atmospheric Density

The effect of motion on the altitude distribution of atmospheric density has been determined. It has been shown, in particular, that for vertical waves moving with increasing velocity along its direction of propagation and for $\frac{m}{kT} v^2 << 1$, the density is given by

FACILITY FORM 602

N67-85967 (ACCESSION NUMBER)

(THRU)

6 (PAGES)

None (CODE)

CR-88152 (NASA CR OR TMX OR AD NUMBER)

(CATEGORY)

$$\rho = \rho_0 \exp - \int \left[\frac{mg}{kT} + \frac{1}{T} \frac{\partial T}{\partial z} + \frac{m}{kT} \left(\frac{mg}{kT} + \frac{1}{T} \frac{\partial T}{\partial z} \right) v^2 \right] dz$$

where v is the velocity of the waves. Other terms have usual significances.

The three terms on the right hand side correspond to density variation due to gravity, temperature, and the motion in the atmosphere respectively. The relative magnitudes of the three terms at 100 km altitude has been obtained and it has been found that for v=22 m/sec the variation of density due to the above type of motion is one-tenth of that due to temperature. The vertical components of the wind, (Edwards, H. D. et al. JGR 68 3021 1963), and the dominant gravity waves, (Midgley, J. E. and H. B. Lieman JGR 71 3729 (1966) are 6 m/sec and 1 m/sec respectively and are small to affect the altitude distribution of atmospheric density at 100 km.

Electron Density Measurements

Two reports titled "Surface Current Excitation on an Inhomogeneously-Sheathed Plasma-Immersed Cylinder by Electromagnetic and Electrokinetic Waves" and "The Scattering of Electromagnetic Waves from a Plasma-Immersed Cylinder" by E. K. Miller were published in December. A paper by E. K. Miller and A. Olte, "The Excitation of Surface Currents on a Plasma-Immersed Cylinder by Electromagnetic and Electrokinetic Waves II. The Inhomogeneous Sheath" appeared in the December issue of Radio Science. A paper titled "Admittance Dependence of the Infinite Cylindrical Antenna upon Exciting Gap Thickness" by E. K. Miller was submitted to Radio Science.

Preparation of a report "The Admittance of the Infinite Cylindrical Antenna in a Lossy, Isotropic, Compressible Plasma" by E. K. Miller was

completed during the quarter; it is expected to be published during the next quarter. The results presented in this report show that the admittance of an infinite antenna in a compressible plasma may be significantly altered by the non-zero plasma temperature and sheath, below the electron plasma frequency. There is in addition, an admittance maximum below the plasma frequency, unless both the sheath thickness and electron temperature are zero. Since the finite antenna current may be thought of as multiply reflected current waves similar to the infinite antenna current, the implication of this is that the admittance of a finite antenna may be also significantly changed by the non-zero plasma temperature sheath. Consequently, the possibility exists of inferring the electron temperature and effective sheath thickness from the admittance of the plasma-immersed finite antenna, but the complexities of analyzing the finite antenna with the same rigor as the infinite antenna are very great, seeming to preclude this at the present time. The possibility of using the infinite antenna current as a first step in a solution for the finite antenna current, as has been done successfully for free space, will be looked into.

The foregoing discussion was for a plasma without a static magnetic field. Calculations have been carried out for the zero-temperature plasma with a static magnetic field parallel to the infinite antenna axis. The results will be described in a report expected to be prepared during the next quarter. A significant finding of this part of the study is that an admittance discontinuity occurs at the electron plasma frequency, a feature that has been observed experimentally and which appears to be promising for determining the plasma frequency.

A formulation of the infinite antenna in a compressible magnetoplasma has been started in this quarter, since it appears that a consideration of the non-zero temperature and magnetic field effects may give a closer relation to the actual physical situation of interest than any of the other approaches thus far used. In theory, an inhomogeneous sheath could be considered in the analysis, but the numerical computations would be very long. Some calculations are being performed for the inhomogeneous sheath and the isotropic, compressible plasma.

The selection of suitable antennas for the forthcoming Aerobee rocket firings as mentioned in the previous status report was completed and 4 units were placed on order. DeHavilland Aircraft of Canada was selected as supplier of these units on the basis of both low price and best delivery time. Each of the two antennas required for the initial electron density experiment weighs 0.6 lbs. and deploys to 15 feet in 27 seconds. Delivery is scheduled for 21 April 1967. Two sets each of flight circuit boards (regulated power supplies and the sweep generator output amplifier) were completed and tested and additional tests of the complete engineering model system continued during the quarter. Design revisions improved the resonance relaxation detector sensitivity to a satisfactory level and construction of all remaining flight circuit boards commenced except for the antenna impedance current detector. This subsystem is still in the engineering design and test stage. It is expected that two complete sets of flight circuitry plus one set of spares will be completed during the coming quarter. The telemetry-control system of the first Aerobee rocket payload which is being supplied by NASA Goddard Space Flight Center is scheduled to arrive here in April.

Massenfilter Adaptation

Electrometer. The input electrometer tube was changed to a Raytheon QV 331. Due to its rigid structure made possible by an indirectly heated cathode, zero shift due to relative mechanical motion of internal parts is virtually eliminated. Due to alternate analysis of direct ions and electron-multiplier output, it is necessary to operate with both positive and negative inputs, inserting phase reversal as necessary to maintain a constant polarity (negative) output of the electrometer. To avoid high-impedance switching problems, the input stage is common to both modes of analysis. Likewise, the output stage is common to conserve operating power. Phase reversal is accomplished, when necessary, by switching the middle stages and changing the point from which feedback is obtained.

Electron Multiplier. Due to space modulation of the massenfilter exit beam as the voltage is swept, a time history of the incident flux on any incremental area shows large fluctuations even though the integration over all elementary areas shows none. This is particularly evident in the staircase mode of analysis. The fine structure of a narrow peak is probably hidden in a narrow-band electrometer amplifier. This space modulation introduces a source of error of unknown but possibly large amplitude. To avoid the problem, completely, it was considered technically advisable to collect as close to 100% of the exit beam as possible. Accordingly, tests were undertaken to evaluate various designs for ion collection efficiency, simulating the collector mouth with a flat plate conductor of the same diameter. Attempts to bend the ion exit beam through various angles proved fruitless. An axially symmetrical design was finally developed. The ions are repelled toward the standard collector or directed toward the multiplier mouth by simply changing the potential

of a steering grid. During standard collector operation, the staircase mode quality was as good as on previous instrumentations indicating essentially 100% ion collection. Tests were then conducted with a multiplier. A gain of 100 as measured on staircase total was easily achieved. Good quality staircase data were obtained.

Data review and interpretation of previous flights was continued.

Sphere Flights

Further studies of the simultaneous grenade and sphere soundings of 1965 were continued in this period. Revised grenade data were received from Goddard for the October series of firings. The revision consisted of new surface temperature correction needed when using large microphone arrays and relatively low elevation rocket trajectories required at Wallops Island. A considerable correction to the zonal wind data resulted. The grenade wind data is now in satisfactory agreement with the falling sphere and the Hasp parachute data. The revised temperatures indicated by the grenade system were higher at most altitudes which resulted in better agreement with the Hasp and falling sphere systems. The revised sphere drag coefficient reported previously had the effect of reducing temperatures indicated by the sphere system near 50 km. The present status of the August and October 1965 data appears to be fair agreement of temperature for some soundings, in others there is a considerable difference near stratopause with the spheres indicating a higher temperature.

Respectfully submitted,

L. M. Jones

L. M. Jones

LMJ/db