SPACE RESEARCH X – NORTH-HOLLAND PUBLISHING COMPANY, AMSTERDAM (1970)

ROCKET BASED IONOSPHERIC MEASUREMENTS AT THUMBA WITH HIGH-FREQUENCY CAPACITANCE PROBE

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Abstract: A high-frequency capacitance probe was flown during the afternoon on 26 February 1969 from the Thumba equatorial rocket launching station in India. Before noon on the same day a major solar flare occurred and an intense magnetic crochet was observed at the ground. The preliminary results of the flight show a maximum electron density of 1.5×10^5 cm^{-3} at 110 km and a vertical stratification of electron density with a scale length of about 8 km.

1. Introduction

A Centaure rocket carrying a high-frequency capacitance probe was launched from the Thumba equatorial rocket launching station, India (geog. long. 76°51′E, geog. lat. 8°32′N) at 1530 hours Indian Standard Time (1000 UT) on 26 February 1969. The rocket reached a peak altitude of 148 km. In this paper we present only the preliminary results of the experiment. The detailed analysis and a description of the instrumentation will be published elsewhere (Degaonkar et al. [1]).

The principle and the advantages of the high-frequency capacitance probe for the measurement of ionospheric parameters are well known (Heikkila et al. [2]). The tip of the rocket, which formed the capacitance probe sensor, was used as a capacitance in series with one or other of two inductances in the tank circuit of a Clapp-type oscillator. The oscillator frequency in free space was chosen to be nominally 5 MHz and 10 MHz for the two inductance coils. An onboard programmer was used to switch alternately between the two coils, the switching period being 0.125 sec. The programmer arranged that after three switching cycles a negative potential (−100 V) was applied to the probe during the fourth cycle. The application of this negative potential to the probe provided the inflight calibration, giving the free-space frequency of the oscillator, so that any systematic drift in the oscillator frequencies due to environmental changes could be adequately corrected. Although each coil was switched on for 0.125 sec, the oscillator frequency was sampled for only 0.1 sec, care being taken to avoid the beginning and the end of each cycle which otherwise might introduce errors. The frequency of the oscillator was directly transmitted as binary bits using three VCO channels, thus achieving the maximum possible accuracy. The programming period was derived from a multivibrator and the jitter introduced by this circuit imposed the lower limit of accuracy in the calculation of frequency, which was less than 100 Hz.

2. Results

In fig. 1 is shown the frequency variation of the 10 MHz oscillator with time. The frequency does not show any appreciable change for the first 85 sec, during which time the rocket reached an altitude of about 80 km. Thereafter the frequency increased due to the presence of ionospheric plasma, reaching a maximum at about 115 sec which corresponded to an altitude of about 110 km. Beyond this E-layer maximum, the presence of cyclic variations in the data is evident. The very short period variations of about 1 sec duration can be attributed to the programmer cycling. The larger periodic variations having periods of about 8 sec are quite genuine.

The change in oscillator frequency is linearly related to the electron density. After allowing for the sheath and stray capacitance effects, the electron density has been derived as a function of altitude. In figs. 2 and 3 are shown the distributions of electron density with altitude derived from the 5 MHz and 10 MHz oscillator measurements, respectively. Each distribution indicates a maximum electron density of approximately 1.5×10^5 cm^{-3} at about 110 km altitude.

The most important finding of the present experiment was the presence of vertical irregularities in the region of 110–150 km. Fig. 4 shows the change in frequency of the 10 MHz oscillator plotted on a linear scale as a function of altitude. Three cycles of variation with wavelengths of about 8 km are quite evident from the figure. A similar result

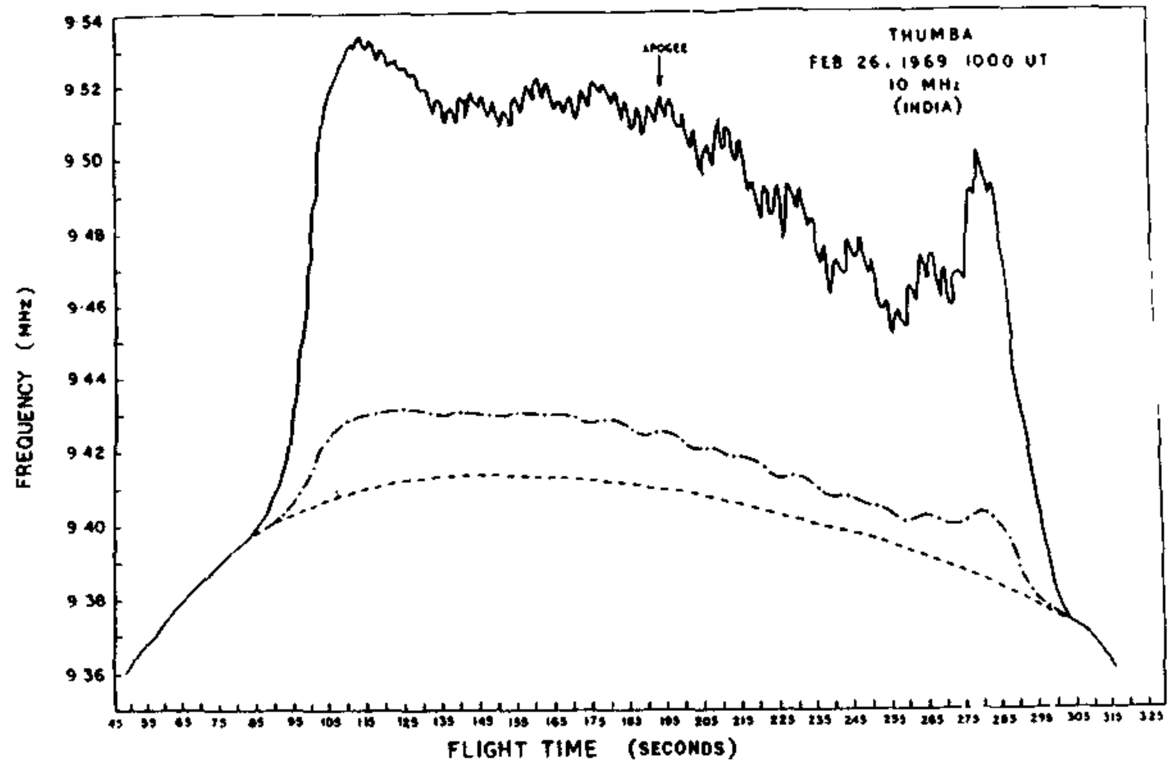

Fig. 1. Variation in frequency of the 10 MHz oscillator with time of flight. The free-space frequency derived from the onboard calibration is also shown.

—— Plasma frequency

–·– Frequency during –100 V

– – – Assumed curve of oscillator frequency in free space (neglecting the effect of the ionosphere). Frequency during –100 V increased by 16.5% of the change in frequency.

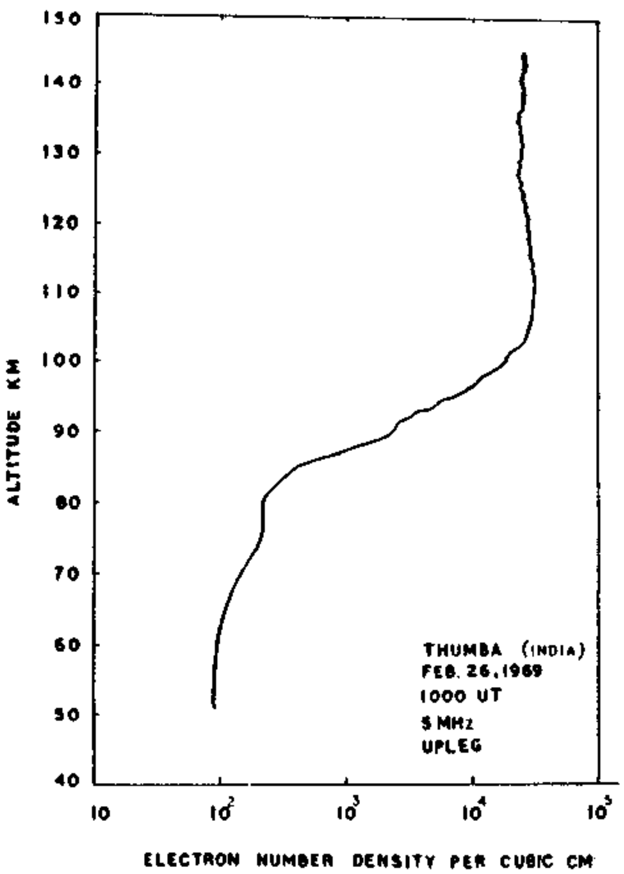

Fig. 2. Altitude variation of electron density derived from the 5 MHz oscillator measurements.

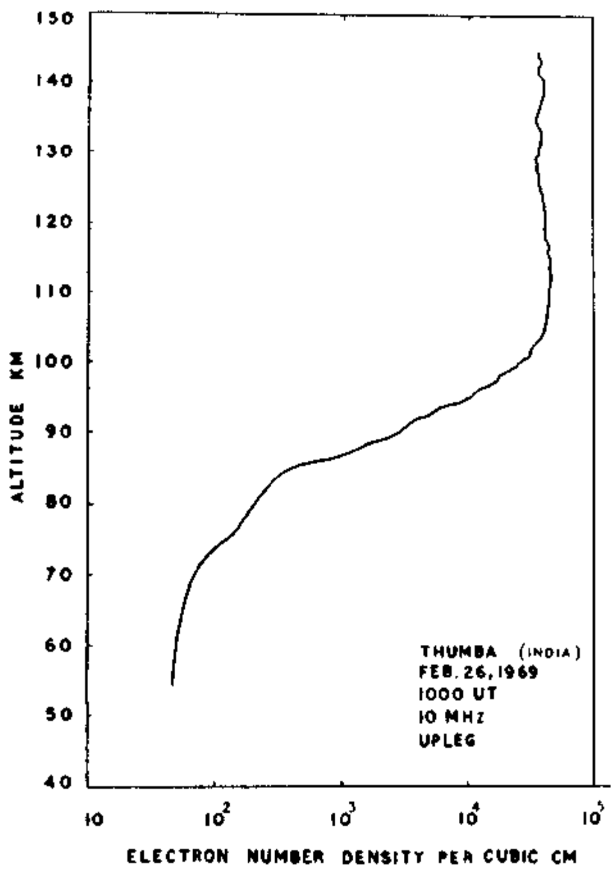

Fig. 3. Altitude variation of electron density derived from the 10 MHz oscillator measurements.

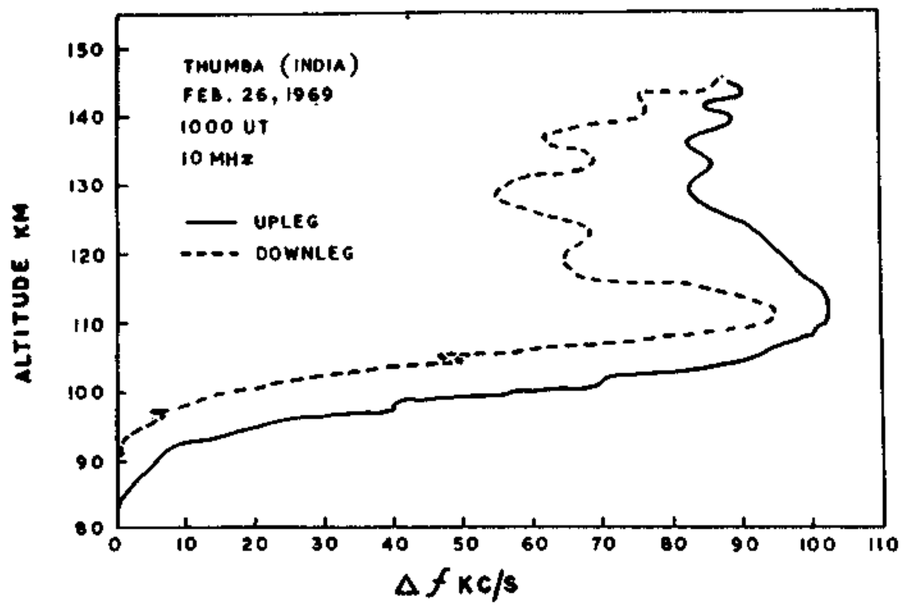

Fig. 4. Change in frequency of the 10 MHz oscillator with altitude.

rate of about 6 revs sec^{-1}, and the precession half-cone angle, as derived from on board sensors, was less than 2 deg, the characteristic wavelength of 8 km which corresponded to the 8 sec periodicity was undoubtedly a property of the ambient medium observed in our flight.

Such vertical stratification in E-region ionization has been noted before at middle latitudes (Ellyett and Watts [3]). The presence of distinct layers with a remarkably uniform spacing of 7 to 8 km at equatorial latitudes is reported here for the first time. It may be pointed out that the wavelength of 7 to 8 km is to be expected if the gravity-wave mechanism is the dominant factor in causing the irregularities (Hines [4]). The gravity-wave oscillations induce density variations in the neutral atmosphere which, in the presence of ionizing radiation, give rise to variations in the distribution of ionization, with successive maxima separated by a wavelength. The wind shears produced by the gravity waves, in association with the geomagnetic field, can also produce the observed stratification of ionization. We want to emphasize that our observation cannot be taken as a proof for the existence or absence of gravity waves. We wish to simply point out that our observations can be explained by the gravity-wave mechanism. Since 26 February 1969 was a particularly disturbed day characterized by a major flare and an intense cröchet in the ground-based magnetogram, we are unable to say whether the presence of stratified ionization is a feature of the quiet-day ionosphere without more observations.

Acknowledgment

The authors are grateful to Mr. H.G.S.Murthy and his colleagues for their help in launching the rocket. The above research has been carried out with the aid of funds from the Department of Atomic Energy, Government of India.

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