Dissertation

on

ELECTRON DENSITY VARIATIONS IN THE IONOSPHERE AT LOW LATITUDES (DUE TO LUNAR TIDES)

Presented

by

RAJENDRA PRASAD SHARMA

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PHYSICAL RESEARCH LABORATORY

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P R E F A C E

Ever since systematic ionospheric soundings began, it has been found that the ionizations in the lower E and F_1 layers behave in a fairly regular manner as expected from Chapman's theory; while the F_2 layer shows anomalous behaviour in its daily, seasonal and latitudinal variations. Martyn's (1947,1948) theory based on vertical electro-dynamical drifts showed reasonable agreement with the observed variations, provided suitable values were used for the amplitude and phase of the drift. Recent studies of the variations of the H-component of the geomagnetic field and the F_2 ionization at equatorial latitudes have indicated extremely close association between the equatorial electrojet and F_2 ionization.

From the observed data of solar daily variation of F_2 ionization, the heating, ionizing and gravitational effects of the sun cannot be easily separated as their periods are identical. Thus a proper estimate of the divergence term in the continuity equation has always been difficult.

The moon does not have either a heating or ionizing effect on the ionosphere but it has a gravitational tidal effect. Therefore, a study of lunar tidal effects in the F_2 region may be expected to be of help in analysing

the drift parameters of ionization. The lunar tide at different heights in the ionosphere would enable one to estimate the height variations of the divergence term and obtain a better understanding of the relationship between equatorial ionospheric currents and F_2 ionization.

Recent rocket studies have shown remarkable changes in the composition of the atmosphere in the F-region. A study of the dynamical behaviour of the F-region at different heights could locate this particular boundary in the ionosphere and its changes with season, if any. A systematic study was undertaken to correlate the lunar variations in the geomagnetic field and in F_2-ionization at different heights and at stations near the equator, near the S_q current focus, and, to some extent, near the crest region of the equatorial F_2 anomaly. Through the kind courtesy of the former CRPL Laboratories of USA, the electron density profile data of Huancayo (an equatorial station) were available to us. This has made such studies possible. The N(h) profile data for Puerto Rico published in CRPL Ionospheric Data Bulletins (part A) were also used to get similar informations for a middle latitude station. The thesis contains six chapters:

CHAPTER - I

The salient features of ionospheric and geomagnetic variations at low latitudes; and the theories of daily variations of F_2 ionization at low latitude stations are described.

CHAPTER - II

The various methods for computing lunar tidal effects are described. The computations of the probable errors and the significance of the results are also discussed.

A brief general review of lunar tides in the geomagnetic field and in various ionospheric layers is presented.

CHAPTER - III

The correlation between lunar tide in geomagnetism and in F_2 ionization is studied at the equatorial station, Huancayo. It is found that the height of the peak ionization $h_{max}\ F_2$ varies sympathetically with the changes in the H-component of the geomagnetic field, while the variations in maximum electron density N_{max} are opposite to that in h_{max} with a delay of about 1-2 hours. The amplitude of lunar oscillation in Y_m is smaller than that for h_{max} but the phases in both are same, suggesting that the oscillations in electron density have same phase but are of increasing amplitude with increasing height.

CHAPTER - IV

The lunar variations in H and various parameters of the F_2 region for San Juan, Puerto Rico, a station close to the focus of the dynamo current systems (Sq and L), are described and compared with those obtained at the equatorial station Huancayo. It is shown that the lunar oscillations of H at

San Juan are governed by the relative positions of the Sun and Moon, while those at equatorial stations are controlled by the absolute position of the moon.

CHAPTER - V

The lunar tidal effects in electron density N(h) at different heights at the equatorial station Huancayo, at Ahmedabad which is near the peak of the Appleton anomaly and at Puerto Rico which is near S_q focus are described. The amplitude and phase of the lunar tides in electron density at fixed heights of the ionosphere and for each individual solar hour are discussed. The amplitude of the tide is shown to increase with altitude within the F-region (above 180 km). The phase of the tide at various heights are different at different latitudes.

CHAPTER - VI

An attempt is made in this chapter to interpret the various observed results in the light of the existing theoretical knowledge. It is shown that most of the observed results can be explained on the basis of vertical electromagnetic drifts produced by the interaction of dynamo (lunar) electric fields and the earth's geomagnetic field.

All the figures, equations and tables are numbered in a serially increasing order, irrespective of the chapter

in which they occur. The tables are put together in the Appendix (pp.214-258).

All the computations using an IBM 1620 computer and other works in connection with preparation of the thesis were done by the author himself. The author has also been associated with the Beacon-satellite project, for the determination of the total electron content using faraday rotation of the signals from the satellite, at the Physical Research Laboratory, Ahmedabad. However, the results of these studies are not included in this thesis.

R G Rastogi
(R.G.Rastogi)
Professor-in-charge.

R P Sharma
(R.P.Sharma)
Author.

PUBLICATIONS

The following papers based on the work described in this thesis have been published in various international journals.

(1) 'Lunar tides in noon ionization at different heights of the ionosphere over Ahmedabad during IQSY' - R.G.Rastogi and R.P.Sharma, Proc.IQSY Symp. New Delhi, p.72 (1966).

(2) 'Lunar tides at fixed real heights in the ionosphere over Ahmedabad' - R.P.Sharma and R.G.Rastogi, J.Atmos. Terr.Phys.,29,1641 (1967).

(3) 'Lunar tides in noon electron density at fixed real heights in the ionosphere over Puerto Rico and Huancayo' - R.P.Sharma and R.G.Rastogi,J.Atmos.Terr. Phys.,30,453 (1968).

(4) 'Some studies of the phase reversal of lunar semi-monthly oscillations in midday foF2' - R.P.Sharma and R.G.Rastogi, J. Inst.Telecom. Engrs.,15,581 (1969).

(5) 'Ionospheric lunar tides over the magnetic equator' - R.G.Rastogi and R.P.Sharma, Proc.Third Inter.Symp. Equat.Aeor. (Ahmedabad) Vol.II,378 (1969).

(6) 'Lunar perturbations in geomagnetic field and in the characteristics of F-region over Huancayo' - R.P.Sharma and R.G.Rastogi, Pure App. Geophys. (formerly Geofis. Pura e Appl.) Italy, 19 80(III),288(1970).

(7) 'Lunar tides in the structure of F2-region and in H at Puerto Rico' - R.P.Sharma and R.G.Rastogi, Ann. de Geophys.,25,807 (1969).

(8) 'Lunar tidal effects in horizontal magnetic field at San Juan' - R.P.Sharma and R.G.Rastogi, Ann. de Geophys.,26, 337 (1970).

(9) 'Interrelations between geomagnetic and ionospheric lunar tides at equator' - R.P.Sharma and R.G.Rastogi, Ind.J.Pure. Appl. Phys.,8,853 (1970).

(10) 'Luni-solar tides in electron density at fixed heights of the ionosphere' - R.P.Sharma and R.G.Rastogi, Planet. Space Sci., (1971) (in press).

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The entire computations presented in the thesis were carried out with the IBM 1620 computer facility at the Physical Research Laboratory. The author wishes to express his thanks to Mr.S.R.Thakore and the staff of the computing centre, in particular Mr.P.S.Shah, Mr.C.V.R.K.A.Rao, Mr.M.G. Rastogi and Mr.P.K.Shah for their kind co-operation.

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