STUDIES OF ELECTRON CONTENT AT LOW LATITUDES

A THESIS

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BY

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INDIA

Dedicated

to

my uncle

LATE SHREE MULTAN MAL SETHIA

and

my father

LATE SHREE GHEWAR CHAND SETHIA

CERTIFICATE

I hereby declare that the work presented in this thesis is original and has not formed the basis for award of any degree of any university or institution.

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(R.G. Rastogi) (H. Chandra)
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PREFACE

In the present investigations an attempt has been made to study some of the physical properties of the low latitude ionosphere and the plasmasphere. The study is based on the (a) ionosphere electron content derived from Faraday rotation measurements, made at a chain of stations covering almost entire Indian sub-continent during the period October 1975 - August 1976 using radio beacons from the geostationary satellite ATS-6 and (b) the plasmasphere electron content derived from simultaneous Faraday rotation and the group delay measurements made at a low latitude station Ahmedabad (23.0°N, 72.6°E, dip. lat. 18.6°N) during June, July 1976 and at a near equatorial station Ootacamund (11.4°N, 76.7°E, dip. lat. 3°N). It is worthwhile to note that the ionosphere electron content measurements using a geostationary satellite were made for the first time, at a chain of stations at low latitudes from magnetic equator to about 25°N dip lat. In addition the plasmasphere electron content measurements at low latitudes were not available so far; hence the current investigations on the plasmasphere form a new contribution to the subject. Various ionospheric and geophysical data have also been studied and used for interpretation, wherever necessary.

The total electron content (TEC) defined broadly as the number of free electrons in a column of unit cross-section extending through the ionosphere and above, can be measured by a number of techniques out of which the Faraday rotation and ~~the group delay techniques are of present interest.~~ In the Faraday rotation technique, the angle of rotation of the plane of polarization of the radio wave is measured as it passes through the ionosphere whereas in the group delay technique, the difference in transit times of two radio waves, with different frequencies, across the medium is measured. It is important to note that the Faraday rotation angle is strongly dependent upon the longitudinal component of the earth's magnetic field whereas the dependence of the group delay on the earth's magnetic field is insignificant. The Faraday rotation technique, therefore, gives the ionosphere electron content N_F, upto an altitude of h_F (which is about 2000 km for low and mid-latitude stations and is about 1500 km for near equatorial station like Ootacamund) whereas the group delay technique gives the electron content N_T upto the satellite height. The difference in electron content measured by these two techniques i.e. N_T-N_F gives the electron content above h_F, upto the satellite height along the ray-path. The electron content so obtained is usually termed as plasmasphere electron content (N_P). Keeping in view the errors involved in deriving N_F, for Ootacamund to ATS-6 geometry due to uncertainties in geomagnetic field models, the plasmasphere electron content has not been studied for this station. However, the difference of the N_T and N_F termed as the 'residual component' (N_R) for the Ootacamund measurements has been studied and may be considered as a rough estimate of the plasmasphere content. The importance of the eadio beacon studies of the plasmasphere has been realised only recently and not much work has undergone in this direction.

The lay-out of the thesis is as follows:-

The general introduction to the low and equatorial latitude ionosphere and the plasmasphere is given in the first chapter. Previous work about TEC studies at low latitudes and the plasmaspheric studies using in-situ and whistler measurements have been reviewed.

The second chapter describes the group delay and Faraday rotation techniques of electron content measurements. The calibration factors for these measurements, for the present satellite geometry have been described. Using actual electron density profiles over Kodaikanal and Jicamarca, the calculations of magnetic field factor calibration for Ootacamund to ATS-6 ray-path have been undertaken, and are described in detail. Lastly a description of the computations of elevation, azimuth, range, sub-ionospheric points and magnetic field factors, is given in the same chapter.

In the third chapter, the morphological studies like diurnal, seasonal, latitudinal and day to day variations of TEC at low latitudes has been described. A comparison has been made between electron contents N_F and N_T, obtained from Faraday rotation and the group delay techniques respectively. The quiet time variations of the residual electron content (N_R) at Ootacamund and the plasmasphere electron content (N_P) at Ahmedabad, have been described and discussed in the same chapter.

The fourth chapter deals with the electron content studies in conjunction with the bottomside ionosonde data. The daily variation of equatorial TEC has been compared with the variations of many different parameters like equatorial N_mF_2, crest region TEC, topside electron content N_a, bottomside electron content N_b, slab-thickness τ, semi-thickness y_m, and the height of the peak F-region electron density h_m, etc. A detailed study of the slab-thickness of the equatorial ionosphere using both N_F and N_T data has also been undertaken and **is** described in this chapter.

The fifth chapter describes the **influence** of electrojet on the low latitude ionosphere. The role of electrojet in latitudinal distribution of TEC under different geomagnetic conditions and also in the anomalous semi-annual variation of TEC at low latitudes has been studied and discussed. Lastly the day to day variability of the low latitude ionosphere in conjunction with electrojet strength has been discussed.

The lunar tidal effects in the low latitude TEC and in the equatorial N_mF_2 and slab-thickness have been separated and studied in the sixth chapter. A brief summary of the previous work on lunar tidal effects in the F-region of the low latitude ionosphere is also given in the same chapter.

The storm time effects on the low and equatorial latitude TEC and equatorial N_m have been described in the seventh chapter of the thesis. In addition the storm time effects on the residual electron content (N_R) at Ootacamund has been studied and discussed in terms of solar wind velocity and geomagnetic activity dependence of N_R.

The eighth chapter describes the numerical model for low latitude ionosphere TEC for different solar activity conditions. Its applications to satellite tracking systems have been described.

The conclusions of the present investigations are summarised in the last i.e. in ninth chapter. Some suggestions for the future work have also been included in this chapter.

It is sincerely hoped that the present work has made some contribution in the better understanding of the complex ionospheric and plasmaspheric processes; though it is being wished, keeping in view the Einstein's remark which says:

> "Onething I have learned in a long life:
> that all our science, measured against
> reality; is primitive and childlike - and
> yet it is the most precious thing we have".

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