Monitoring of Atmospheric Perturbations Caused by Various Geophysical Events Using VLF Signal

ABSTRACT

Submitted for the Degree of

Doctor of Philosophy (Science)

of

Jadavpur University

By

Minu Sanfui

Department of Physics

Jadavpur University

Kolkata -700032, India

2022

ABSTRACT

The spherical shell of the atmosphere ionized by the solar X-ray and γ -ray radiation in the range of 50 – 1000 km altitude is called the ionosphere. Below this altitude medium is ionized only by highly energetic galactic cosmic rays. The ionosphere consists of different layers, viz., D-layer (60–90 km), E-layer (90–120 km), E_s -layer, F -layer (120– 500 km) and above this the topside ionosphere. The day side F -layer is sub-divided further into F_1 and F_2 layers. The space above ionosphere around the planet, where magnetic field lines are dominant is called the magnetosphere which is controlled by the planet's magnetic field. Earth surface and lower boundary of the ionosphere (50– 60 km altitude) is dielectric in nature, and eventually becomes a spherical waveguide for the low frequency radio wave.

Earth-ionsphere waveguide acts as a global circuit. Schumann resonances occur in this waveguide. It is an electromagnetic resonance phenonmenon generated by global lightning discharges within the resonator formed between the earth and the ionosphere.

Chapter 1 gives an introduction and a review of the studies reported in the literature in this field.

Chapter 2 explains the rudimentary theoretical background and the experimental techniques employed in the measurement and analyses carried out.

Chapter 3 provides the details about the severe X-ray flare occurred on 06 - 07 March 2012 followed by a solar proton event (SPE). During this event the variation in frequency of the first Schumann resonance (SR) spectra mode from the recorded data over Kolkata (22.56°N, 88.5°E) was studied. The first mode frequency enhanced (~8.14 Hz, 3.85%) during the solar X-ray bursts and immediately after its value decreased (~7.44 Hz, 5.13%) during the proton event. The influences of SPE and X-ray bursts upon the SR frequency fluctuation are

explained in terms of the changes in medium ionization, i.e., the change in dielectric property and two layer reflection height variation in the waveguide. The geomagnetic storm effect on the modification of this frequency variation occurring during that time was also considered.

Chapter 4 presents the details about earth-ionosphere waveguide. In this chapter earthquake research, meteor shower effect, solar proton event, earthquake prediction, Hiss emission etc. have been explained in detail. The space between the two spherical conducting shells, Earth surface and the lower boundary of the ionosphere, behaves as a spherical cavity in which some electromagnetic signals can propagate a long distance and is called Earth-ionosphere waveguide. Through this waveguide ultralow frequency (ULF), extremely low frequency (ELF) and very low frequency (VLF) signals can propagate efficiently with low attenuation. Resonances which occur for ELF waves due to round-the-world propagation interfering with $2n\pi$ phase difference are called Schumann resonances. Lightnings are the main sources of energy continuously producing these electromagnetic radiations from the troposphere. Some fixed frequency signals are also transmitted through the waveguide from different stations for navigation purposes. The intensity and phase of these signals at a particular position depend on the waveguide characteristics which are highly influenced by different natural events. Thus the signatures of different geophysical and extra-terrestrial events may be investigated by studying these signals through proper monitoring of the time series data using suitable techniques. In this work, we provided a review on ULF, ELF and VLF signals within the waveguide in terms of different geophysical and extra-terrestrial events like lightning, earthquakes, Leonid meteor shower, solar flares, solar eclipse, geomagnetic storms, and TLEs etc.

Chapter 5 summarizes the works presented in the thesis. It also described the scope of the future researches in this field.