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Medium Wave Propagation Modeling in the Magnetosphere

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Introduction

The portion of the Medium Frequency (MF) radio spectrum known as Medium Wave (MW) is utilized mostly for AM radio broadcasting. About 120 channels are available, albeit the sound quality isn't as good as FM stations on the FM broadcast band. Reception is typically restricted to more regional stations during the day, though this depends on the signal strength and calibre of the radio receiver being used. Since signal propagation is better at night, signals from considerably greater distances can be received (within a range of about 2,000 km or 1,200 miles). Due to the fact that numerous transmitters operate concurrently on most channels all over the world, this may result in greater interference. Amplitude Modulation (AM) is moreover frequently more susceptible to interference from other electronic devices, particularly power supply and computers.

A description is given of a model of the ionosphere and magnetosphere's medium, which includes distributions of temperatures, concentrations, collision frequencies, and magnetic field parameters. The parameters of medium radio waves in this environment were simulated using the ray-tracing method. The wave trajectories were computed using a geometric optics approximation. The parameters of the wave pathways can be determined after the level of solar and geomagnetic activity, the transmitter's location, and its frequency are all known. The importance of the magneto spheric propagation mechanism has been demonstrated by numerical modelling of the properties of experimental echo signals. The major ionospheric trough in this instance turned out to be an atypical channel. Within the trough, medium waves travel along the plasma pause.

One of the most significant issues in contemporary solar-terrestrial physics is the modelling of processes taking place in the plasma of near-Earth space. Only via intricate satellite, rocket, and ground trials was the development of this path made possible. The collection of morphological data regarding various ionosphere and magnetosphere parameters, the discovery of experimental factors influencing wave behavior, theoretical investigation and modelling of wave generation, interaction, and propagation processes, and a comparison of experimental and theoretical findings all hold a special place in the field of ionosphere and magnetosphere physics.

The distributions of concentrations and temperatures, which determine wave refraction; the collision frequencies, which determine collisional damping; and the distribution of the magnetic field, which determines how waves are contained in the magnetosphere, should all be included in the medium's model. Although the near-Earth plasma is a single, ionized region of space, it is useful to distinguish between the ionosphere and the magnetosphere in order to think about wave propagation within it. In both cases, wave propagation and the Earth's magnetic field are significantly influenced by electrons.

Ionosphere and magnetosphere properties, concentration and temperature distributions, collision frequencies, and models of the medium are all described. The MW parameters in this setting were simulated using the ray-tracing technique. The wave trajectories were computed using a geometric optics approximation. Due to its sophistication

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and popularity, the employment of this method proved to be the most appropriate. When the degree of solar and geomagnetic activity, the location of the transmitter, and the frequency are established, a specialized program can be used to determine the details of wave paths.

When the conditions of the experiment described by Blagoveshchensk and Gladky are met, numerical modelling of the signal characteristics revealed that signals can return to the transmitter in at least three situations: (a) when they are reflected in the upper ionosphere at heights both below and above $hmaxF^2$, (b) while travelling around the world, and (c) as a result of magnetospheric propagation (channelization of waves). By comparing the measured and computed values of the signal group delays and examining other properties, it was feasible to favour the magnetospheric propagation mechanism. The MIT proved to be an unexpected channel in this situation as opposed to the conventional channelling of waves through ducts.

The calculations of MW propagation are based on an analysis of a number of observations of transmitter signals at f=1.8 MHz, which is coupled with a receiver and situated close to St. Petersburg (L=3.2, where L is the shell, a parameter equal to the ratio of the distance from the Earth's center to the line of force of the magnetic field above the equator R to the Earth's radius RO, i.e. L=R/RO), in the winter. The investigations discovered echoes with low attenuation levels, almost little Doppler shift, and average delays of texp=0.280.29 s.

The channelling of MWs along the plasma pause was seen to occur under specific ionosphere and magnetosphere conditions. (a) The observations were conducted during magnetospheric sub storms; (b) the vertical sounding data of the station located close to the point for the reception of echo signals indicate that the observation point was located deep inside the main ionospheric trough, closer to its southern border; and (c) critical frequencies of the F2 lay within the receiving point at the times when the echo signals appeared.

Empirical models of the midlatitude ionosphere called Nemod were used in a range of heights from the initial ionospheric height ho to the level of 1000 km, which is the basis for the diffusion equilibrium model, to describe the distribution of the electron concentration Ne(h), or the so-called background. Ne(r) r-n is a power-law drop in concentration that represents the Ne distribution in the magnetosphere. Without altering the profile view Ne, the multiplier div was added to $NemaxF^2$ in all models to modify the background, for instance. The foF2 (or NemaxF2) values that match the experimental foF2 values can be selected using div.

It is known that the mid latitude or Main Ionospheric Trough (MIT) is a decrease in the electron concentration in the region of geomagnetic latitudes FL=50°-65° in a quiet time and FL = 35°-50°during periods of disturbances caused by convection, high-speed outflow of ions and electrons, as well as due to the difference in the positions of the geographic and magnetic poles. The MIT is a characteristic of the electron concentration's behavior in the height range from hmaxF2 up to 2000 km to 3000 km, and it is most visibly present at night during the years of minimum solar activity.