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Scientific Article

Relevance of F Region of the Ionosphere

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The ionized part of the Earth's atmosphere is known as the ionosphere. Ultraviolet light from the sun interacts with atoms in this region knocking out outer electrons thereby creating ions. This is what gives the Ionosphere its name and it is free electrons that cause the reflection and absorption of radio waves. In fact, the ionosphere is the shell containing electrons and ions surrounding the earth stretching from a height about 50 km to around 1000 km. Thermosphere, one of the layers of the atmosphere is at the heights of above 50 km and in the thermosphere, the atmosphere is so thin that free electrons can exist for short periods of time before they are captured by a nearby positive ion. Though the density of these free electrons is low, it is sufficient to affect radio propagation. It is Ultraviolet, X-ray and shorter wavelengths of solar radiation which are responsible for ionization as these photons contain sufficient energy to remove an electron from a neutral gas atom or molecule upon interaction; the ionosphere, in turn, protects the earth from these harmful radiations leading to sustenance of life on the earth. As the ionization depends on the activity of sun, there is diurnal i.e., day effect and also seasonal effect on the ionization. The activity of the sun is associated with the sun spot cycle as well, when more radiations are produced with more sunspots. At the same time, there are factors such as solar flares and release of charged particles into the solar wind and its interaction with the geomagnetic field with lead to the decrease in the ionization.

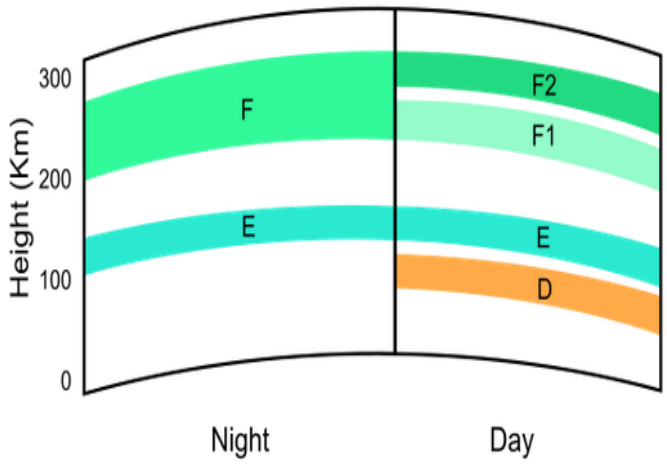

Figure 1: Schematic of ionospheric layers.

It is found that the intensity of ionization determines the quality of radio propagation and based on the density of ionization the ionosphere has. The ionosphere is divided into different layers as shown in Figure 1. Only the F layer with significant ionization is present during the night time, while ionization in the E and D layers is extremely low as the radiation intensity of the sun is low during the night time. During the day, the D and E layers become much more heavily ionized, as does the F layer which develops an additional, weaker region of ionization known as the F1 layer. The F2 layer persists by day and night and is the region mainly responsible for the refraction of radio waves.

The theory of electromagnetic waves given by Clark Maxwell, became the first step in using electromagnetic radiation in space for radio communication. According to Maxwell electromagnetic waves, just as light, can be subjected to reflection, refraction and absorption. These studies were the base for Marconi to conduct experiments with wireless telegraphy using Morse code which is now history. Marconi successfully transmitted and received transatlantic signals using a kite aerial at Signal Hill in Cornwall, England. But it was Edward Appleton [who received Nobel prize in Physics in the year 1947 for the discovery] who first discovered that radio waves can be broadcast around the world after they are reflected back from the upper layer ionosphere i.e., F layer, one of the highest electrified layers of the atmosphere that contains large concentrations of charged particles (ions) and free electrons. The property of ionized layers of the atmosphere to refract high frequency (HF) or shortwave (SW) radio waves , can be utilized to bounce a transmitted signal down to ground. The electric field of radio wave when reaches ionosphere, forces the electrons in the ionosphere to oscillate at the same frequency as that of radio wave. Some of the radio-frequency energy is used for this resonant oscillation. The oscillating electrons will then either be lost to recombination or will re-radiate the original wave energy. Total refraction is maximum when the oscillation frequency of electrons in the ionosphere matches with radio frequency, and if the electron density in the ionosphere is high. This is the mechanism of refraction of radio waves from the ionosphere which is used in the radio wave propagation. For very high frequency (VHF), ultra high frequency (UHF) and for microwaves, the radiation passes through the ionosphere, and hence, line-of-sight communication is used.

As the presence of F layer varies with time, it affects quality of radio wave propagation. The interaction between the ionized and neutral air, the electric fields, and ionospheric storms are responsible for F region stability. The problem of radio wave propagation through the ionosphere was of great practical importance during the first half of the 20^{th} century, because, during that period, long-wave radio waves were the principal means of military communication. During the last few decades however, the communication technology has vastly improved with introduction of microwaves based on advanced devices and communication satellites. Today, low-loss fibre optic cables (with repeaters) carry bulk of the high speed data transmission.

References

[1] Source : Internet