The Ionosphere

The Ionosphere is the ionized part of the Atmosphere, it is ionized by solar radiation. It plays an important part in Atmospheric electricity and forms the inner edge of the Magnetosphere. It has practical importance because, among other functions, it influences radio propagation to distant places on the Earth. It is located in the Thermosphere. At heights of above 80 km, in the thermosphere, the free electrons can exist for short periods of time before they are captured by a nearby positive ion. The number of these free electrons is sufficient to affect radio propagation. This portion of the atmosphere is ionized and contains a plasma which is referred to as the ionosphere. In a plasma, the negative free electrons and the positive ions are attracted to each other by the electromagnetic force, but they are too energetic to stay fixed together in an electrically neutral molecule. Solar radiation at ultraviolet (UV) and shorter X-Ray wavelengths is considered to be ionizing, since photons at these frequencies are capable of dislodging an electron from a neutral gas atom or molecule during a collision. At the same time, an opposing process called recombination begins to take place in which a free electron is "captured" by a positive ion if it moves close enough to it. As the gas density increases at lower altitudes, the recombination process accelerates since the gas molecules and ions are closer together. The point of balance between these two processes determines the degree of ionization presents at any given time.

The ionization depends primarily on the Sun and its activity. The amount of ionization in the Ionosphere varies greatly with the amount of radiation received from the Sun. Thus there is a diurnal (time of day) effect and a seasonal effect. The local winter hemisphere is tipped away from the Sun, thus there is less received solar radiation. The activity of the Sun is associated with the sunspot cycle, with more radiation occurring with more sunspots appear. The received Radiation also varies with geographical location (polar, auroral zones, mid-latitudes, and equatorial regions). There are some other processes that disturb the Ionosphere and decrease the ionization. There are disturbances such as solar flares and the associated release of charged particles into the solar wind which reaches the Earth and interacts with its geomagnetic field.

Ionospheric Layers

The Ionosphere is classified according to the electron density of three distinct layers, designated from lowest level to highest level (D, E, and F), as shown in Figure (1.2). In addition, the F layer is divided into two layers, designated F1 (the lower level) and F2 (the higher level). The presence or absence of these layers in the ionosphere and their height above the Earth vary with the position of the Sun. At high noon, radiation in the ionosphere above a given point is greatest, while at night it is minimum. When the radiation is removed, many of the ionized particles recombine. During the time between these two conditions, the position and number of ionized layers within the ionosphere change. Since the position of the Sun varies daily, monthly, and yearly with respect to a specific point on Earth, the exact number of present layers is extremely difficult to determine. A generalized profile of the electron density with altitude in the ionosphere would look similar to that shown on Figure (1.2). The peaks in the profile are labeled D, E and F layers.

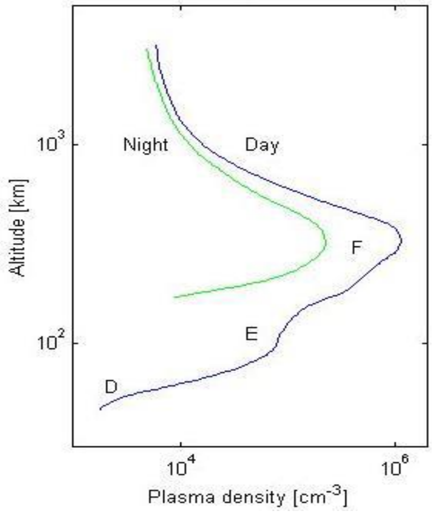

Figure (1.2): A generalized profile of electron density.

Three ionized layers constructed the structure of the ionosphere, starting from D-layer to F-layer which splits in daytime hours into two layers F1 and F2 layers.

D-LAYER:

•The D-layer ranges from about 38 to 88 Km above the Earth. Ionization in the D-layer is low because less ultraviolet light penetrates to this level.

• The dominant ions are NO^+ and O_2^+.

• Ionization here is due to Lyman series-alpha hydrogen radiation at a wavelength of 121.5 nanometer (nm) ionizing nitric oxide (NO).

• The D layer is mainly responsible for absorption of HF radio waves, particularly at 10 MHz and below, with progressively smaller absorption as the frequency gets higher.

• The absorption is small at night and greatest about midday.

• The layer reduces greatly after sunset, but remains due to galactic cosmic rays. A common example of the D layer in action is the disappearance of distant AM broadcast band stations in the daytime.

E-Layer:

• The E-layer ranges from approximately 89 to 140 Km above the Earth.
• The dominant ions are NO^+ and O_2^+.
• Ionization is due to soft X-ray (1-10 nm) and far ultraviolet (UV) solar radiation ionization of molecular oxygen (O_2).
• This layer can only reflect radio waves having frequencies less than about 10 MHz .
• At night the E layer begins to disappear because the primary source of ionization is no longer present.
• The increase in the height of the E layer maximum increases the range to which radio waves can travel by reflection from the layer.
• The E region peaks at about 105 km.

ES-LAYER

• ES or Sporadic E propagation is characterized by small clouds of intense ionization, which can support radio wave reflections from 25 – 225 MHz .
• Sporadic-E events may last for just a few minutes to several hours and make radio amateurs very excited, as propagation paths which are generally unreachable, can open up.
• This propagation occurs most frequently during the summer months with major occurrences during the summer, and minor occurrences during the winter.
• During the summer, this mode is popular due to its high signal levels.

F-Layer:

• The F-layer exists from about 140 to 380 Km above the Earth.
• In the F region O^+ ion dominates.
• Above the F region is a region of exponentially decreasing density known as the "topside ionosphere." This region extends to an altitude of a few thousand kilometers.
• Here extreme ultraviolet (UV) (10-100 nm) solar radiation ionizes atomic oxygen (O).
• The F region is the most important part of the ionosphere in terms of HF communications.
• During daytime, it divides into two layers, the F1 and F2.
• The F layers are thickest and most reflective of radio on the side of the Earth facing the sun.

The maximum frequency that the F-layer will return depends on the degree of sunspot activity. During maximum sunspot activity, the F-layer can return signals at frequencies as high as 100 MHz . During minimum sunspot activity, the Maximum Usable Frequency can drop to as low as 10 MHz .
On a more practical note, the D and E regions reflect AM radio waves back to Earth. Visible light, television and FM wavelengths are all too short to be reflected by the ionosphere. So your tv. stations are made possible by satellite transmissions.

Aurora

When protons and electrons from the Sun travel along the Earth's magnetic field lines above the north and south poles there is an oval region charged particles can enter the ionosphere and excite its neutral atoms and molecules, giving off light , just like fluorescent lighting (fig. 2.2) .

Fig. (2.2) **Aurora**

This all happens in the ionosphere, 60-200 km up. We are talking major-league energy, much more than the power of lightning: 20 million amps at 50,000 volts is channeled into the auroral oval. The aurora is also known as the northern and southern lights. Sometimes, when the Sun is active, the northern auroral oval expands and the aurora can be seen much farther south.