The Sun and HF radio propagation

A summary of the way in which the Sun affects ionospheric propagation (HF radio propagation) for two way radio communications, mobile radio communications, broadcasting, etc.

Solar effects on propagation includes:

Solar effects on radio propagation   Sunspots   Solar disturbances   SID sudden ionospheric disturbance

As electromagnetic waves, and in this case, radio signals travel, they interact with objects and the media in which they travel. As they do this the radio signals can be reflected, refracted or diffracted. These interactions cause the radio signals to change direction, and to reach areas which would not be possible if the radio signals travelled in a direct line.

The Sun has an enormous impact on HF radio propagation because it affects the ionosphere which gives rise to most of the long distance effects that enable long distance radio communications on the HF bands. As a result is greatly affects many forms of radio communications from the typically two way radio communications systems that are used by many organisations, and various forms of mobile radio communications using the HF bands to radio broadcasting, point to point radio communications and radio amateur transmissions. As a result, a knowledge of how the conditions on the Sun affect radio signal propagation is essential for radio planning and prediction HF propagation conditions. Radio propagation prediction software also takes the state of the Sun into consideration when it calculates its estimates of the propagation conditions.

To look at the way the Sun affects the ionosphere and radio propagation conditions, it is necessary to take a quick look at the various areas in the atmosphere to see which areas influence radio propagation and how the sun affects them. These factors are important in being able to predict propagation conditions and when using radio propagation prediction programmes.

The ionosphere

For many years it has been known that there are ionised layers in the upper reaches of the atmosphere that affect various forms of radio communications. This region is known as the ionosphere, although the existence of the an ionised region was first proposed just after the turn of the century, separately by two scientists, namely Kennelly in the USA and Heaviside in the UK. Since then far more has been learned about these layers, especially since the first rockets managed to pass through the ionosphere to collect data.

In most regions of the atmosphere it is found that the gases are in a stable molecular form. However in certain areas of the atmosphere some of them start to become ionised, splitting into free electrons and positive ions. Of these it is the free electrons that affect the radio signals, although the layer where these ions and electrons are found is still called the ionosphere. This generally starts to happen at an altitude of around 30 km, although at this height the levels of ionisation are very small and they do not have an effect on radio signals. However as the altitude increases the number of ions rises.

FOLLOW

18 APRIL 2019

Fact of the day: It was in this month in 191 that Lucien Levy in France made the fir receiver using the superheterodyne principl for the elimination of atmospherics. It used variable IF stage and not the fixed frequenc IF normally used. It was also the day on whic Albert Einstein, the famous physicist died i 1955.

Quote: *Life is priceless, peace is a blessin* Ancient Chinese saying

Fact: Professor Sir Ambrose Fleming th inventor of the diode valve was an eccentri He was often heard whistling the letter "V" i Morse code through his teeth as this was th was the letter he used for his radi transmitter test messages.

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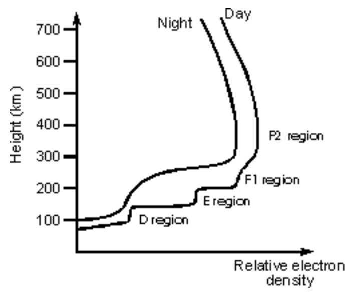
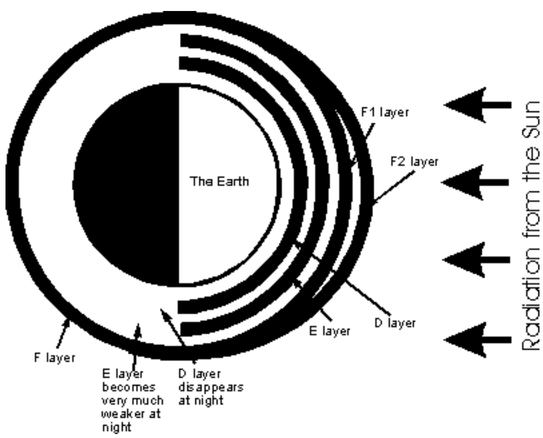
The ionosphere is traditionally thought of as having a number of distinct layers. While it is often convenient to think of the ionosphere in this way, it is not strictly true. The whole of the ionosphere contains ions and free electrons, although there are a number of peaks, and which may be considered as the different layers. These layers are given the designations D, E, and F. A diagram of the approximate levels of ionisation is shown below. This can only be very approximate because the levels of ionisation vary as a result of a number of factors.



The approximate levels of ionisation in the ionosphere

The lowest of the layers is the D layer. This is found at altitudes between 60 and 90 km. It only exists during the daytime when it is in view of the sun. Above this is the E layer at around 110 km. This exists during the day, and then at night when it is not in sunlight it becomes very much weaker. Finally there is the F layer. This varies considerably, normally existing as two layers during the day. These are designated the F1 and F2 layers. They are found at altitudes of around 300 and 400 km in summer, and then during the winter they may fall to around 200 and 300 km. At night the two layers generally combine to form a single layer and this is generally around an altitude of 250 to 300 km. It should be remembered that these figures are only a rough guide because they change quite considerably according to the time of year and the state of the sun.



Variations of the ionosphere over the day

Formation of ions

The ionisation in the ionosphere is generated when radiation from the sun strikes the gas molecules in the upper atmosphere. The radiation is of sufficient intensity that it gives the electron in some molecules sufficient energy to leave the molecular structure. This leaves a free electron and the gas molecule, having one electron too few becomes a positive ion.

At very high altitudes the atmosphere is very thin, and as a result the levels of ionisation are very low. As the atmosphere become denser, so the level of ionisation starts to rise. However the ionisation process uses up the energy of the radiation, and after a certain distance the energy of the radiation is such that it does not ionise as many gas molecules as before and the level of ionisation begins to fall.

It is also found that for the higher layers including the F and E layers most of the ionisation results from ultra violet light. The D layer being at a lower altitude results mainly from X-rays that are able to penetrate further into the atmosphere.

It is also found that the free electrons and positive ions slowly recombine. In other words the radiation is causing them to ionise, and then they slowly recombine afterwards. In chemistry this state of affairs is called a dynamic equilibrium. It means that if the source of radiation is removed, then the levels of ionisation will fall. As a result the D layer disappears after nightfall, and the E layer is greatly reduced in intensity. In view of the high levels of ionisation in the F layers and the fact that the air density is so much less, it takes longer for the recombination process to take place and consequently it remains over night, although its level is reduced. This can be seen in the way that radio communications vary over the course of a day.

Effect of the ionosphere

The different layers of the ionosphere affect radio ways in slightly different ways. When a signal enters the D layer it sets the free electrons vibrating. As they vibrate they collide with nearby molecules, and after each collision some energy is lost. As a result radio signals entering the D layer are attenuated. It is found that the level of attenuation is inversely proportional to the square of the frequency. In other words doubling the frequency reduces the attenuation by a factor of four. It is found that low frequency radio signals are completely absorbed by it. This can be shown by the fact that radio stations on the medium wave broadcast band can only be heard over short distances during the day, and then at night when the D layer disappears they can be heard over much greater distances.

The effect is slightly different for the higher layers. Being higher in altitude the gas density is much less. As a result a different effect predominates. Again the electrons are set in motion, but as fewer collisions take place they act on the signal to bend it away from the area of highest ionisation. In other words the signal is refracted back towards the earth. It is also found that the effect decreases with frequency and as a result the signal will eventually pass through one layer and on to the next.

Variations in the ionosphere

The effect of the ionosphere is greatly linked to the amount of radiation it receives. This varies over the period of a day. At night when the ionosphere receives no radiation from the sun, the level of ionisation falls and communication may not be possible over some paths or different frequencies may have to be used.

Other changes also affect the ionosphere. In just the same way that winters are colder because that part of the earth receives less warm from the sun, so the ionosphere receives less radiation, and the levels of ionisation in the ionosphere fall.

Sunspots

Changes on the sun itself also affect the ionosphere. One of the major changes occurs as the result of the sunspots that appear on the surface of the sun.

If the sun is viewed by projecting its image onto a screen, then a number of dark areas may be seen from time to time. These spots may last from anywhere between a few hours to days or even weeks. The spots are areas where the surface of the sun is cooler than the surrounding areas. The temperature of the spots is only about 3000 C. This is quite cool when compared to the temperature of the rest of the surface that is around 6000 C! However it is very much hotter under the surface where temperatures reach in excess of a million degrees.

The sunspots are areas of intense magnetic activity. The magnetic fields in these areas are enormous and as a result the surface of the sun is disrupted. This causes the surface temperature to fall in these areas causing a darker area to be perceived.

Around the sunspot itself there is an area that is known as a plage. This is slightly brighter than the surrounding area and is a large radiator of ultra-violet radiation and X-rays. The amount of radiation emanating from the plage means that there is an overall increase in the level of radiation from the sun. In fact it is noticed that the level of radiation from the sun can be estimated from a knowledge of the number of sunspots that appear on the surface.

As sunspots often appear in groups, a method of trying to estimate their effect has been devised. A figure known as the sunspot number is used. This number does not represent the number of spots themselves, but the level of activity on the sun and the sunspot number is very closely related to the amount of radiation received from the sun.

The daily readings of the sunspot numbers fluctuate considerably. To overcome this, the readings are smoothed mathematically to take out the erratic nature of the readings and so that the underlying trend can be seen. This number, called the Smoothed Sunspot Number (SSN) is often quoted in association with propagation reports.

The sunspot cycle

The number of sunspots on the Sun's surface varies. On some days very few, or even none may be seen, whereas at other times there are very many. The daily number varies considerably over a short period of time as the sun rotates, but if the smoothed sunspot number is used it can be seen that there is a much longer-term trend. This trend shows that the number of sunspots rises and falls over a period of approximately eleven years. This number is only an approximate guide because there is a considerable amount of variation on this.

Records of the sunspot numbers have been kept since the mid-eighteenth century, and by referring to these records it has been possible to track the cycles since then. Cycle 22 started in September 1986 with a number of 12. It rose rapidly over the next 33 months to reach a peak of 158. From then it fell slightly and rose again to give a second smaller peak before ending in 1996. Now cycle 23 has started and the numbers are rising.

The effect of the sunspot cycle

The increased numbers of sunspots mean increased levels of radiation. In turn this means that there are greater levels of ionisation in the ionosphere. Accordingly this affects propagation on the HF bands. It is found that the maximum frequencies that can be reflected are increased.

At the sunspot minimum frequencies of around 15 to 20 MHz are normally supported during the day. However at the maximum, frequencies in excess of 60MHz may be affected. This means that popular ham bands like 24 and 28 MHz may not support communications via normal ionosphere modes in the sunspot minima. Often 28 MHz appears dead with no stations audible. However during periods of around the maximum it is an excellent band. Low power stations or those with poorer antennas find it particularly good. As the D layer attenuation is much less, even low power stations can make excellent contacts.

The sunspot number can be used to give a very rough guide to what conditions may be like. The figure tends to vary from about 65 at the minimum of the cycle to over 300 at the maximum. For good conditions on the higher frequency bands it is found that a figure of in excess of about 100 is required. Up to date figures can be accessed from a variety of web sites including http://www.sunspotcycle.com

A word of warning

> Under no circumstances should the sun be viewed directly, even though dark glasses. In the past many people have had their sight damaged by doing this.

By Ian Poole

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