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Nobel Prize in Physics 1947

Sir Edward Victor Appleton

The Nobel Prize in Physics 1947 was awarded to Edward V. Appleton *"for his investigations of the physics of the upper atmosphere especially for the discovery of the so-called Appleton layer"*.

RESEARCH INFORMATION:

On 12th December 1901, Marconi succeeded in establishing wireless communication between the Old World and the New. The way in which the wireless waves proved to follow the contour of the earth compelled the assumption that there must be an electrically conducting layer somewhere high up in the stratosphere. Thereby, it was thought, the linearly moving radio waves were thrown back towards the earth just as the rays of the sun are deviated so that its light can be observed long after the sun has passed below the horizon. According to Heaviside and Kennelly such a layer which throws back the radio waves and girdles the whole earth conceivably be due to the ionizing effects of the ultraviolet rays of the sun on the upper atmosphere. However, no conclusive proof of this was forthcoming even at the beginning of the 1920's.

At this time the rapid development of radio, especially in England and America, rendered the crowding of the ether so great that amateurs had to be relegated to wavelengths below 100 metres, while the kilometre-long waves were then considered to be most suitable for long-distance transmissions. The most immediate difficulties for the amateurs were to obtain transmitters with sufficient effect for the great distances. The competitions arranged for amateurs in radio signalling with short waves between America and Europe in the years 1921 and 1922 proved, however, that in sporadic cases communication could be obtained with surprisingly small transmitter effect.

It was here that Appleton's contributions now began to make themselves felt. By means of a brilliantly worked-out method, the so-called *frequency variation method*, in 1924 together with Barnett, he showed that there was interference between the direct radio waves along the ground and a wave reflected towards the layer in space, and that this so-called *Heaviside layer* is at about a height of 100 km. By means of a fine theoretical analysis of the penetration of the wave into the layer, Appleton was also able to investigate certain important detail phenomena which were observed in connection with these investigations. Thus the wave was refracted in the layer in the same way as a ray of light entering an optically thin medium. Consequently radio waves will either be thrown back towards the earth or, if they are strong enough to penetrate to the middle of the layer where the ionization is greatest, they will rum through it and out into space. According to the theory from the critical wavelength at which this takes place can be read off the ionization at different points of the stratosphere, often at great distances from the transmitter. During the last World War, stations with equipment for registering these conditions were established in different parts of the earth's surface. Information from these stations is of great importance for radio communication, as it affords guidance in the choice of the wavelength which should be selected in the case of radio communications between two places. But, as we shall see presently, these investigations are of considerable importance for many other things besides radio communication.

It was in the course of the study of these phenomena that Appleton found in 1927 that there must exist still another reflecting layer beyond the one mentioned previously, at a height of about 230 km. This so-called *Appleton layer* is still more exposed to the ultraviolet solar radiation than the underlying layer, or more correctly: the underlying layers, for a further couple of layers of more or less sporadic occurrence, have been proved in the course of time. Ionization is therefore more complete up there than in the underlying layers, and there is a greater power of reflection against the radio waves. Appleton has shown that during the day the new layer is divided into two components which again merge into one during the night. It is mainly the upper layer which, owing to its greater capacity of reflection, facilitates radio communications. In another respect also it differs from the lower layers. While in the latter the ionization constantly follows the changes in the ultraviolet solar radiation, the upper Appleton layer remains unchanged during the greater part of the night. This is explained by the great rarefaction prevailing at these heights, which retards the recombination of the ions of the air. The close correlation exhibited by the ionization of the lower layers with the changes in the ultraviolet solar radiation was convincingly shown by Appleton's observations between the time of the minimum of sunspots in 1934 and that of the maximum of sunspots in 1937. The increase in the ionization then amounted to 50 to 60%, corresponding to an increase in the intensity of the sun's ultraviolet radiation of 120 to 150%. This circumstance is so much the more remarkable as observations made on the surface of the earth during the same period show that the ultraviolet radiation there was practically unchanged. Thus the radio method has proved to be a means of determining the actual radiation of the sun. Through the sunspots, which must be looked upon rather as holes or windows opening into the interior of the sun, we observe some - of the mighty processes taking place there. Appleton has also found that the disturbances, which, in the form of short radio waves, emanate from these sunspots are equivalent to transmitter effects of millions of kilowatts.

It would carry us too far to give a detailed account here of all the discoveries and investigations which we have owed to Appleton during the last few years. I shall only dwell briefly upon one aspect of them. The echo methods which were developed by Appleton and his co-workers in the years before the World War must be looked upon as precursors of the *radar methods* which were so successfully employed by the Allies during the War for locating aeroplanes, submarines, etc. The ultrashort radar waves, 3-30 cm in length, will certainly be employed for many purposes in the immediate future, *inter alia* as an important auxiliary aid within *meteorology*. The direction of radar waves is not changed during their passage through ionized layers, but they are changed owing to the inhomogeneities arising owing to variations in the pressure and temperature of the air and its varying content of aqueous vapour. Thus the radar waves are reflected by showers, which can be detected at far distances and determined by the radar echo. During the World War radar methods were extensively used to locate the heat front and the cold front in distant low-pressure areas.

Finally, it may be mentioned that Appleton has carried out far-reaching investigations of the electric waves which are produced when the lightning strikes. With the help of specially equipped sounding stations, lightning discharges and thunderstorms which are 1,000 to 2,000 km away can be located, and the disturbances which affect radio reception he has found to be due to interplay between far-distant thunderstorms, especially on the equator.

Thanks to Appleton's contributions a new branch has been added to physical science, but not only that: the methods which he and his co-workers have perfected to investigate the atmosphere round the earth by means of radio waves have also become of immense importance for solving problems within other sciences, such as astronomy, geophysics and meteorology, and for radio technics.

Sir Edward Appleton. Electromagnetic waves are a subject of the greatest physical importance, and they are being increasingly applied in different fields of science. The first arguments on the existence of these waves were advanced more than a hundred years ago by your countryman Michael Faraday, who was then searching for the relations between optical and electrical phenomena. His ideas were worked out in strict mathematical equations by dames Clark Maxwell in 1873. The waves were finally discovered by the famous German physicist Heinrich Hertz in the early 1890's. Shortly afterwards their immense usefulness as radio waves was demonstrated by the Italian inventor Guglielmo Marconi.

Since then, electromagnetic waves have advanced victoriously in a multitude of sciences, giving rise, in the hands of men of genius, to scientific methods and instruments, among which I need only mention the electronic tube, based on the thermo-ionic laws, so thoroughly investigated by Sir Owen Richardson.

Now you have added a new link to this beautiful chain, applying the waves to the study of our own atmosphere. With the aid of these waves you have reached etherial regions never before attained by man. You have even taught us how to listen to the roar from eruptions in the sun and distant stars in the galaxy.

The usefulness of radar waves as applied to the solution of problems in meteorology has already been shown. The need for such a refined and instantaneous control of the unreliable and capricious conditions prevailing in the earth's atmosphere cannot be overestimated, especially in respect to the risks which still jeopardize aviation.

From Greek mythology we learn how Dacdalus fastened a pair of wings to the shoulders of his son Icarus with wax. But Icarus flew too near the sun, and the wax melted, so that he fell into the sea and was drowned. Certainly the modern Icarus also needs to strengthen his wings in his flights.

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http://www.nobelprize.org/nobel_prizes/physics/laureates/1947/press.html