## TECHNICAL PAPERS

# ELECTRICAL DISTURBANCES APPARENTLY OF EXTRATERRESTRIAL ORIGIN* 

## By

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Summary-Electromagnetic waves of an unknown origin were detected during a series of experiments on atmospherics at high frequencies. Directional records have been taken of these waves for a period of over a year. The data obtained from these records show that the horizontal component of the direction of arrival changes ap-

zontai an uponent of the direction of arrival of these waves changed nearly 360 degrees in 24 hours, and at that time this horizontal component' was approximatery the same as the azimuth of the sun. These facts led to the assumption that the source of these waves was somehow associated with the sun.

Records of these waves have now been taken at frequent intervals for a period of more than a year. The data obtained from these records,
 tions made above relative to the source of the waves, but indicate that


Fig. 1-Sample record of waves of extraterrestrial origin
the direction of the phenomenon remains fixed in space, that is to say, its right ascension and declination remain constant.

## Apparatus

The apparatus used and the type of records obtained were described in detail in a former paper. ${ }^{1}$ Briefly, however, the apparatus consists of a rotating antenna array, a short-wave measuring set, and an auto-
 plane and is rotated about a vertical axis so that data obtained with the system, like that obtained with a loop rotating on a vertical axis, give the horizontal component of the direction of arrival of signals, but tell nothing directly about the angle the direction of arrival makes with the horizontal plane. The operation of the recorder is synchronized with that of the rotating array so that the records show directly the
horizontal component of the direction of arrival of signals as well as their intensity. The apparatus was tuned to a wavelength of 14.6 meters during all the experiments.

## Results

Fig. 1 shows a sample record of the waves of unknown origin obtained with this apparatus. The time at which the array was pointed in the direction from which the unknown waves come is clearly indicated on the record by the humps in the curve. The direction of the waves at those times can be determined from the scale along the top of the record.


Fig. 2-Direction of arrival of waves of extraterrestrial origin.

1. Jan. 21, 1932
2. May 8, 1932
3. Aug. 21, 1932
4. Feb. 24, 1932
5. June 11, 1932
6. Sept. 17, 1932
7. March 4, 1932
8. April 9, 1932
9. July 15, 1932
10. Oct. 8, 1932
11. Dec. 4, 1932

If, now, the horizontal component of the direction of arrival is plotted against the time of day a curve similar to one of those of Fig. 2 is obtained. Thus, data from the record just mentioned constituted part of that from which curve 9 of this figure was obtained. The figure shows curves for eleven different days spaced approximately one month apart during the year 1932. There is no curve for the month of November. These curves were obtained by averaging the data taken over several consecutive days so as to eliminate the errors made in measuring the records. The day assigned to a given curve is the middle day of the group over which the data for that curve were obtained. The curve at the right in the figure shows the variation in intensity of the waves plotted against the direction of arrival.

This figure shows: first, that the horizontal component of the direc-

around the circle $A B C D$ eastward from the line $O A$ as reference. The line $O A$ is determined by the direction of the sun from the earth at the time it crosses the equator on the first day of spring. Thus the line $O A$ lies at 0 hours, $O B$ at 6 hours, $O C$ at 12 hours, and $O D$ at 18 hours; 24 hours of right ascension being equal to 360 degrees. Declination is measured in degrees above or below the equatorial plane, plus, if it is above the plane and minus, if below. The positions of the earth with

direction of arrival
of WAVES IN SPACE
Fig. 4-The effect of the daily rotation of the earth on the direction of arrival as measured at the receiving location.
respect to the sun for the first day of each season are shown. Since the diameter of the earth's orbit is so small with respect to the distances to the stars, it is assumed that the earth is always at the center of the sphere at 0 and the rest of this discussion is based on that assumption. Accordingly, the plane of the celestial equator coincides with that of the earth's equator and the axis of the celestial sphere coincides with the earth's axis.

Now, if there were radio waves coming from a direction fixed in space and from a source so far removed from the sun that the direc-
tions of propagation throughout the whole solar system were substantially parallel, if there were no distortion in direction suffered by the waves during their passage through the ionized layers of the earth, if these waves had the ability to bend around the earth, and if there were no other unexplained phenomena taking place, then, for this idealized case, the horizontal component of the direction of arrival as measured at the receiving location would change 360 degrees during one complete rotation of the earth. Let us assume for the sake of argument that the right ascension of the direction of arrival of these idealized waves is 18 hours and its declination 0 degrees, that direction


Fig. 5-Theoretical curve of the direction of arrival of idealized waves having a right ascension of 18 hours and a declination of 0 degrees.
represented by the line $D O$ in Fig. 3. Then at midnight on the first day of winter, the relation between the direction of arrival and the location of the receiver will be as shown at $A$ in Fig. 4. Since the receiver lies in north latitude 40 degrees 22 minutes and the declination of the direction or arrival of the waves is 0 degrees, then at the instant represented the horizontal component of the direction of arrival would be north as shown by the broken arrow. Six hours later the condition shown at $B$ would exist and the horizontal component of the direction of arrival would coincide with the true direction and would be east. After another six hours, the direction of arrival would coincide with
direction of arrival were plotted against time of day, a curve like that shown in Fig. 5 would be obtained. The curve is dotted for that portion of the time during which the earth. would be hetwoen the source of the waves and the receiver. As will be seen from, the figura, the horizantal, component of the direction of arrival changes 360 degrees in about 24 hours, or in exactly 23 hours and 56.06 minutes since that is the time required for the earth to make one complete revolution with re-


Fig. 6-The effect of the earth's orbital motion on the direction of arrival as measured at the receiving location.
spect to the stars. It is this difference between the length of the sidereal day and the mean solar day ( 3.54 minutes of solar time) that accounts for the uniformly progressive shift of the curves of Fig. 2 to the left.

Fig. 6 will illustrate just how this shift takes place. This figure shows the earth in its orbit around the sun as seen from above. If, as has been assumed, the direction of arrival of the waves has a right ascension of 18 hours, they can be represented by some such group of arrows as shown at the left in the figure. When the earth is in the position shown for June 21 then, regardless of the declination of the direc-
tion of arrival of the waves, the time at which this direction of arrival will coincide with the meridian of the receiver will be at midnight. On September 23 this time of coincidence will occur six hours earlier at 6:00 p.m. On December 22 it will occur another six hours earlier or at 12:00 noon and on March 20 it will occur at 6:00 A.m. Consequently if a curve like the one of Fig. 5 is plotted for every month of the year a family of curves like that of Fig. 7 will be obtained where each curve occurs approximately two hours earlier than the one for the preceding month. Note the similarity between this family of curves and that of Fig. 2.


It will be shown later that the declination of the direction of arrival of the waves detected by the measuring equipment is between the values of -40 degrees, 22 minutes and +40 degrees, 22 minutes. Consequently, if the right ascension remains constant then points obtained from Fig. 2 in a manner exactly similar to that just explained should fall on a straight line the slope of which should be $365.25 / 24$ days per hour. It was in this manner that the points of Fig. 8 were obtained. The


Fig. 8-Time of coincidence of the direction of arrival and the meridian of the receiver for the different days of the year.
correspondence of the points with the heavy line, the slope of which is $365.25 / 24$ days per hour, cannot be accidental and proves that the right ascension of the direction of arrival of the waves is constant. The position of this heavy line on the graph is determined by the value of the right ascension. Thus the position of the curves corresponding to a right ascension of 0 hours, 6 hours, 12 hours, and 18 hours are shown by the light diagonal lines on the figure.

[^0]From the relative positions of the heavy line and the light lines it will be seen that the measured direction of arrival occurs at a right ascension of approximately 18 hours, 30 minutes; however, because the mechanism of the recorder takes a finite time to record the field strength values, the directions measured on these records lag behind the true directions by a value varying from 4 degrees to 9 degrees. If the measured values are corrected for this error the right ascension of the direction of arrival becomes approximately 18 hours. ${ }^{4}$

Referring to Fig. 3, if the direction of arrival has a right ascension of 18 hours then it must lie in that half of the plane $P D P^{\prime} B$ to the left of $P P^{\prime}$. One such direction is represented by the line $X O$ in the figure.


Fig. 9-Comparison between the actual curve of the horizontal component of the direction of arrival and the theoretical curves for different declinations.

The curve of Fig. 5 was drawn for the idealized waves having a declination of 0 degrees. Obviously, the shape of the curves would be considerably different for waves having different declinations. Fig. 9 shows the theoretical curves for several different declinations. In this figure the horizontal component of the direction of arrival is plotted against time, but here the time is given not in terms of the hours of the day but in terms of the time interval before and after the direction of arrival coincides with the meridian of the receiver. The values of declination used for the different curves are given in the figure. As before, the curves are dotted for that portion of the time during which

[^1]the earth would be between the source of the waves and the receiver. F-
measured would be the direction of the center of activity, and as before, the value of the right ascension would be accurate in spite of the bending of the rays in the ionized layers, and the declination would be in error by an amount equal to that for a single source at the center of activity.

From a consideration of the data and the method of interpretation it is believed that, in spite of the possible errors mentioned in the above cases, the declination of the source or center of activity, if there is more than one source, as measured would be accurate within an error not greater than $\pm 30$ degrees.

The apparent direction of arrival of the waves has not as yet been definitely associated with any region fixed in space; however, there are two such regions that should be seriously considered. The point on the celestial sphere of right ascension 18 hours and declination -10 degrees, the direction from which the waves seem to come, is very near the point where the line drawn from the sun through the center of the huge galaxy of stars and nebulae of which the sun is a member would strike the celestial sphere. The coördinates of that point are approximately right ascension of 17 hours, 30 minutes, declination -30 degrees (in the Milky Way in the direction of Saggitarius ${ }^{5}$ ). It is also very near that point in space towards which the solar system is moving with respect to the other stars. The coördinates of this point are right ascension 18 hours and declination +28 degrees. ${ }^{6}$ Whether or not the actual direction of arrival of the primary rays coincides with either of these directions cannot be determined definitely until some method of accuratelv measuring their denlination is devised and the measure-


[^0]:    is not uniform. However, the effects are all so small that the greatest deviation would be scarcely perceptible on the curve so they will not be considered in this discussion.

[^1]:    ${ }^{4}$ The limit of error has not been exactly determined but is certainly not greater than $\pm 7.5$ degrees, which is equivalent to $\pm 30$ minutes of right ascension.

