TABLE 3. GEMINID METEORS, DEC. 11–13, 1947

Range (km.)	$(k/p)_{\text{mean}} \times 10^{-2}$	$\frac{k}{p}\sqrt{R}$	Velocity (km./sec.)
460	7·85	1·68	33·7
470	7·90	1·71	34·3
170	13·60	1·77	35·6
370	8·95	1·72	34·6
370	8·84	1·69	34·1
420	8·32	1·71	34·2
400	8·74	1·75	35·1
440	7·90	1·66	33·2
220	11·32	1·68	33·8
490	8·30	1·83	36·9
400	8·07	1·61	32·4

The mean value for the geocentric velocity, U, of the Geminid meteors is 34·4 km./sec. (standard deviation 2·8 km./sec.), in excellent agreement with the velocity of 34·7 km./sec. obtained by Whipple[7] from photographic measurements of visible Geminid meteors.

The Quadrantid results indicate the existence of hree velocity groups. The only existing measurements with which these results can be compared appear to be the visual estimates collected by Fisher[8], which gave Quadrantid velocities of 32–46 km./sec., with a mean value of 38 km./sec. The Quadrantid results also contain a group of meteors with a very low mean velocity of 22·4 ± 1·8 km./sec. These were obtained using a non-directional aerial system at the beginning of the shower, and may not be associated with the Quadrantid radiant.

In the present experiments the range was measured visually on a cathode ray tube display and the maximum range error is estimated as ± 20 km. This introduces a mean error of 5 per cent in the range measurements, or 2·5 per cent (± 0·8 km./sec.) in velocity.

Amplitude fluctuations with a frequency of the order of 15 per second have also been found and are being investigated.

This work was carried out at the Jodrell Bank Experimental Station of the University of Manchester. We are indebted to Mr. N. Herlofson for suggesting the possibility that Fresnel zones could be measured[6], and to Dr. A. C. B. Lovell for constant interest and advice.

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[1] Hey, J. S., and Stewart, G. S., *Proc. Phys. Soc.*, **59**, 858 (1947).
[2] Prentice, J. P. M., Lovell, A. C. B., and Banwell, C. J., *Mon. Not. Roy. Ast. Soc.*, **107**, 155 (1947).
[3] Lovell, A. C. B., Banwell, C. J., and Clegg, J. A., *Mon. Not. Roy. Ast. Soc.*, **107**, 164 (1947).
[4] Lovell, A. C. B., *Nature*, **160**, 670 (1947).
[5] Hey, J. S., Parsons, S. J., and Stewart, G. S., *Mon. Not. Roy. Ast. Soc.*, **107**, 176 (1947).
[6] Herlofson, N., *Rep. Progress in Phys.*, **11**, 1948 (in the press).
[7] Whipple, F. L., *Proc. Amer. Philos. Soc.*, **91**, 189 (1947).
[8] Fisher, W., *Harvard College Observ. Circ.*, No. 346 (1930).

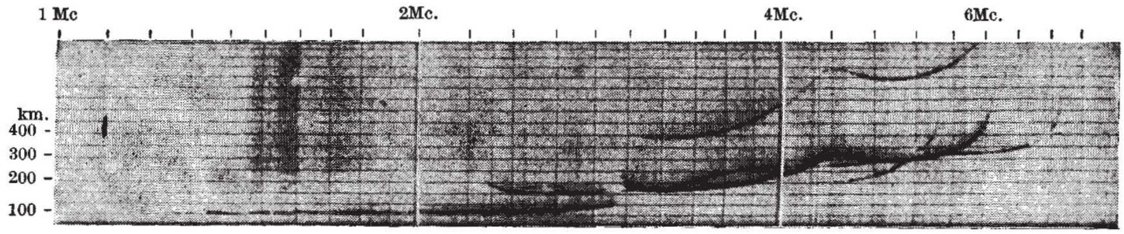
Triple Splitting of Ionospheric Rays

THE well-known theory of the ionosphere indicates the existence in polar regions of a third split in vertical incidence measurements of medium- and high-frequency radio wave reflexions from the ionosphere, its presence being due to the nearly vertical magnetic field of the earth. Its presence was first observed by Harang[1], and since then by others.

It was first seen in Canada in 1943 when the Churchill ionosphere station commenced operation. Since then the phenomenon has been observed frequently at other Canadian stations as well.

To date, observers have noted its presence only in the F_2 region; however, in Canada a complete trace is often seen extending from the E region through the F_1 region to the F_2 region.

The accompanying sample record was made with the National Research Council's automatic ionosphere recorder at The Pas, Manitoba (54·0° N., 101·0° W.). May 16, 1946, at 17.00 C.S.T. and illustrates some of the observed characteristics of the third split (z trace).



The following points may be noted:

(1) The z trace follows through from f^zE to f^zF_2.

(2) The down sweep on the left-hand side of the z trace indicates the presence of f^zE (2·3 Mc.), and on the original record there is evidence of retardation of the E region z trace to this point.

(3) $f^zF_2 = 5{\cdot}45$. $f^xFz - f^zF_2 = 1{\cdot}5$ Mc.
$f^oF_2 = 6{\cdot}10$. $f^xF_2 - F^oF_2 = 0{\cdot}85$ Mc.
$f^xF_2 = 6{\cdot}95$.

(4) The F_1^z trace disappears at f^oE; this is a normal occurrence.

(5) Retardation at f^oF_1 is greater than at f^zF_1 and f^xF_1.

(6) The minimum virtual heights of the F region traces increase from z trace to o trace to x trace.

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[1] Harang, L., *Terr. Mag. and Atmos. Elect.*, **41**, 143 (1936).

MR. GORDON NEWSTEAD, of Hobart, Tasmania, has observed a triple splitting of the rays reflected from the F region[1]. The occurrence of such triplets had already been observed in 1933, when they were described at a meeting of the Royal Society[2]. The signals were received on a polarimeter, so that the polarization of the triplets was known. These were always of the type of two ordinary rays and one extraordinary ray. The mechanism of the triplet was therefore known, and although no explanation was given in the paper, it had been discussed by Millington and myself.

If these triplets were due to the coupling between the ordinary and extraordinary rays, they would be expected to have one extraordinary and two ordinary characteristics—as, in fact, they have. That such coupling exists is without doubt, so that the explanation that it is the direct cause of the triplets observed is, I think, correct.

The frequency of the occurrence of these triplets is small. We received only five in five months. At Hobart, thirty-nine cases in fifty thousand records have been obtained. This is rather greater than we observed, but the explanation is, I think, quite correct.

The photograph shown is a very clear instance of this triple splitting, which has also been observed by Harang[3].

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[1] *Nature*, **161**, 312 (1948).
[2] *Proc. Roy. Soc.*, A, **141**, 710 (1933).
[3] Harang, *Terr. Mag. and Atmos. Elect.*, **41**, 160 (1936).

Blackett's Hypothesis of the Magnetic Field of Rotating Bodies

PROF. P. M. S. BLACKETT[1] has recently directed attention to the well-known, but forgotten, fact that the ratio of magnetic moment $\vec{P}$ and angular momentum $\vec{U}$ is roughly the same for the sun and for the earth and can be written in the form,

$$\vec{P} = -\beta \frac{G^{1/2}}{2c} \vec{U}. \quad . \quad . \quad . \quad (1)$$

Here G is the gravitational constant, c the velocity of light and β a dimensionless constant of the order of unity, which Blackett estimates to be 0·30 for the earth and 1·14 for the sun. Furthermore, from Babcock's measurements Blackett deduces the value $\beta = 1{\cdot}16$ for the star 78 Virginis, but since the mass, radius and angular velocity are all deduced statistically in this last case and the sign is unknown, only little weight can be attached to it.

Next, Blackett urges that (1) may be generally true for all rotating, electrically neutral bodies and thus give a clue to a possible connexion between electromagnetic and gravitational phenomena. Quite apart from the secular variation, the fact that $\vec{P}$ and $\vec{U}$ are not parallel either for the earth or for the sun, and the fact that an eccentric dipole field gives a better description of the main field of the earth than does a centered dipole field, the relation (1) meets with the following difficulties.

On the analogy with the magnetic field of moving electric charges, the magnetic field of a rotating neutral mass may be interpreted from the point of view of non-atomic field theory, that is, as a field property depending on the relative motion of the body and the observer, as was done in the previous theory of H. A. Wilson on the magnetic field created by the translational motion of neutral bodies. However, in this interpretation one would expect the magnetic field to be different in a co-ordinate system which follows the body in its rotation, that is, in which the body is at rest, and in one relative to which the body rotates, because the gravitational field is different in these two co-ordinate systems. Since the main magnetic field of the earth as measured on the earth itself is experimentally found to be the same as that measured in even the fastest moving aeroplanes, the main magnetic field of the earth could scarcely be explained on such lines. (Nevertheless, this hypothesis might, of course, be true, that is, give an additional magnetic field not detectable on the earth itself. In that case we would expect the magnetic field acting on cosmic ray particles, which do not partake in the rotation of the earth, to be different from that measured on the earth.) However, on general principles it is rather unlikely that in classical field theory there should exist a connexion between electromagnetic and gravitational phenomena such as (1), because the sign of $\vec{P}$, but not of $\vec{U}$, depends on the definition of plus and minus electric charge, and thus north and south magnetic pole, which definitions are quite arbitrary. The signs can only be defined in an unambiguous way from an atomic theory involving a knowledge of the atomic constitution of matter.

Consequently, if the relation (1) should be generally true, as conjectured by Blackett, it must be interpreted from an atomic point of view as meaning that the body itself is magnetized, that is, that a magnetic dipole moment density is induced in the body when rotated relative to the inertial co-ordinate system of the fixed stars. However, in that case, first one would expect (1) to contain not only classical constants such as G and c, but also both atomic constants and constants characteristic for the material of the body[2]. Secondly, it is difficult to imagine another atomic mechanism to give a relation like (1) than the gyromagnetic—which, however, gives a uniform magnetization, and thus for a sphere $P \propto M\omega \propto \frac{U}{R^2}$. (This form of magnetization is just an example of one which occurs for rotational but not for translational motion.) Thirdly, also in this case of a rotating electrically neutral mass the body would be associated not only with a magnetic field, but also with an electric field, as pointed out by Blackett in the case of translational motion. For from the Lorentz transformation it follows that each volume element carrying a magnetic dipole moment $d\vec{P}$ will show in a co-ordinate system relative to which the element moves with velocity $\vec{v}$ an electric dipole moment given by $\frac{1}{c}\vec{v} \times d\vec{P}$ (for $\frac{v^2}{c^2} \sim 0$). For example, a symmetric rotating body will thus be surrounded by an electric quadrupole field, and no rotating body can be surrounded by a purely magnetic field. (The influence on the motion of cosmic ray particles of this electric field which must surround the earth ought to be investigated more closely.)

We note that it may be possible experimentally to test Blackett's hypothesis (1) by the experiments of Barnett on the gyromagnetic magnetization (or perhaps by the experiment of Einstein and de Haas on the inverse effect of rotation by magnetization)[3]. For example, for a cylinder with radius R and density d and making ν rotations per second we get from Blackett's hypothesis an average magnetization of $\bar{I}_{Bl} = 7{\cdot}9 \times 10^{-15} \nu dR^2$, whereas the gyromagnetic effect gives a uniform magnetization $I_{gy} = 3{\cdot}6 \times 10^{-7} \chi\nu$ (χ is the susceptibility of the body). Thus the two magnetizations are of the same magnitude if $\frac{dR^2}{\chi} = 5 \times 10^7$. Taking, for example, a paramagnetic material like aluminium for which $\chi = 1{\cdot}7 \times 10^{-6}$ and $d = 2{\cdot}7$, this is the case already