# LETTERS TO THE EDITORS

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## The Magnetic Field of the Moon ?

IN a most comprehensive and interesting study of the magnetic field of massive rotating bodies, Prof. P. M. S. Blackett[1] has revived and discussed the formula

$$P = \beta \frac{G^{1/2}}{c} U \qquad (1)$$

for the magnetic moment $P$ of such a body, with angular momentum $U$, where $G$ denotes the gravitational constant, $c$ the speed of light and $\beta$ a constant of order unity. For the earth, taking account of the central condensation, he finds $\beta = 0{\cdot}30$. For the sun, taking its field to be that of a dipole, with polar intensity 52 gauss, and making reasonable assumptions as to its central condensation and mean angular speed, he finds $\beta = 1{\cdot}14$. For 78 Virginis, the magnetic field of which has lately been detected by H. W. Babcock[2a], by a pioneer research brilliant both in conception and execution, Blackett similarly finds $\beta = 1{\cdot}16$. More recently[2b,c], Babcock has made determinations for certain other stars, most notable being that for the peculiar $A$-type star B.D.—18° 3789 (HD 125248), for which the polar field is found to be 5,500 gauss; this is the strongest measured natural magnetic field, so that this star displaces sunspots as the most naturally magnetic region known.

Babcock has independently remarked[2c] that the ratio $P/U$ is of order $10^{-15}$, agreeing with Blackett's formula (1) for the earth, the sun and 78 Virginis. In a recent note he considers what this formula would imply for the magnetic field of our Milky Way system and other rotating galaxies.

In recent correspondence with Prof. Blackett, I remarked (April 18) that for the moon (1) would imply a magnetic moment less than that of the earth in the ratio $(M'/M)\,(R'/R)^2\,(\omega'/\omega)$, where $M$, $R$ and $\omega$ denote the mass, radius of gyration and angular speed of the earth, and accented symbols refer similarly to the moon. Taking, in round figures, $M'/M = 1/80$, $R'/R = 1/4$, $\omega'/\omega = 1/30$, the ratio is 1/38,400. The surface field at the pole would be less than that of the earth in the ratio $(M'/M)\,(R/R')\,(\omega'/\omega)$ or 1/600, so that it would be 0·001 gauss or 100 gamma.

It will obviously be of great interest to determine whether or not the moon has a magnetic field of this order of magnitude, and thereby to test whether the validity of the formula (1) extends not only upwards from the earth to bodies the magnetic and mechanical moments of which are $10^{10}$ times as great, but also downwards to the moon with a mechanical moment (angular momentum) $2{\cdot}6 \times 10^{-5}$ smaller.

It might have seemed in 1939 a matter for the most speculative future to determine whether the moon has such a magnetic field, but it may at least be said that war-time technical advances have brought the possibility very much nearer. It has become feasible to measure variations of total magnetic field intensity of the order of 1 gamma by airborne magnetometers, and to signal the existence of such variations to ground stations by radio transmission; it has also become possible to impart to rockets a speed of the order required to carry them out of the earth's gravitational field, and to control their motion in part of their flight, by radio signals, from the ground. These various technical advances have been so rapid as to make it rash to deny the prospect of the accomplishment of the further advances required for the project here proposed. The rocket speed needs to be stepped up somewhat; after passing beyond the control of the earth's gravitational field it would, if well directed, be drawn moonwards by the lunar gravitational field, and perhaps some homing device (for example, depending on reflexion of radio signals from the moon's surface) could be used to bring the rocket within one or two lunar diameters from the moon's centre, or even to cause it to collide with the moon. As the surface magnetic intensity (assuming the field to be of dipole character) only varies by a factor of 2 from equator to pole, in the case of impact the intensity measurement (if it could be signalled successfully back to the earth) would check (1) to within this factor of uncertainty, which is less than the discrepancy between the values calculated by Blackett for the three bodies he considered.

Such an experiment applied to any of the planets would, of course, be incomparably more difficult, and would also not extend so greatly the range of $U$ over which the formula (1) would be tested.

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[1] Blackett, P. M. S., *Proc. Roy. Soc.*, A, in the press; *Nature*, **159**, 658 (1947).

[2] Babcock, H. W., (*a*) *Astrophys. J.*, **105**, 105 (1947); (*b*) *Pub. Ast. Soc. Pac.*, **59**, 112 (1947) (in the press); (*c*) *Phys. Rev.*, **72**, 83 (1947).

## Occurrence of Upward Streamers in Lightning Discharges

FOR some time past it has been suspected that, at some instant during the leader process of the normal lightning discharge, streamers may be produced which rise from earth to meet the downcoming leader stroke. However, information on the lengths of such streamers has so far been lacking.

In the course of an attempt to determine from electrostatic considerations the attractive range of a lightning conductor[1], it has been possible to calculate approximately the height of the tip of the leader stroke above earth at the instant at which an upward streamer may be expected to start. This calculation was confined to the more frequent negative lightning discharge for which alone sufficient observational information is available. The results of this calculation are plotted in Fig. 1, which also shows the frequency of occurrence of lightning strokes of varying amplitudes. As a first approximation, it is now assumed that roughly one half each of the heights indicated is covered by the last downward step and the upward streamer respectively; although there are no definite data available as yet on this point, the data as they are support the assumption made. It then follows that the length of upward streamers increases with the intensity of the lightning discharge, and that for the median value of lightning strokes, upward streamers of about 16 metres may be expected for a stroke to a lightning conductor, or of 5 metres for a stroke to open ground.

Photographs of lightning flashes down to the point of contact with earth are often impossible to obtain, while in particular the detection of the rare long