LETTERS TO THE EDITORS

SPACE SCIENCE

Existence of Net Electric Charges on Stars

V. A. BAILEY[1] has urged that a variety of geophysical and astrophysical phenomena can be explained by a net charge on the Sun of $-1{\cdot}5 \times 10^{28}$ e.s.u., admitting that this proposal is at variance with some of the "most cherished notions"[2] of theoretical astrophysicists. Attention may therefore be directed to certain deductions from Bailey's hypothesis that are in conflict with unambiguous evidence from observation as well as with what is generally regarded as sound theory.

(1) Bailey suggests two explanations of how the solar charge can be produced and maintained. The first derives from the assumption that neutrinos carry a positive charge in the range between 10^{-15} and 10^{-19} times the electron charge. Now, since the conductivity of the solar material is of the order of 10^{12}–10^{17} e.s.u. (ref. 3), the field created by the leaking of positive charges from the solar core would tend to push electrons off the solar surface at such a rate that there would be no net charge left on the Sun. Accordingly, electrons would have to drift outward, and whether a sufficiently high rate of escape materializes, or fails to, depends on the drift velocity required to compensate the postulated rate of charge production entailed by the nuclear reactions. From Bailey's figures we conclude that less than 1 electron per cm.^{2} and sec. must leave the solar surface. This rate of escape corresponds to a mean drift velocity of free electrons, in the photosphere, for example, of much less than 1 cm./sec., which is a negligible fraction of the average thermal velocity. By the same argument, it follows that this outward current would not stop in the solar corona, or even in interplanetary space. We do not carry this argument forward beyond the confines of the planetary system, since there cannot result a net charge within, say, the Earth's orbit.

(2) Having concluded that the charge production must be so fast that it cannot be compensated by currents, one might fall back on Bailey's alternative explanation and postulate the existence of a polydimensional space, such that charge conservation need not hold exactly in our four-dimensional world. The steady-state charge would be determined essentially by the local value of the conductivity and might follow closely the mass distribution. Then, of course, the atoms of the photosphere are moving in an electric field corresponding to a point charge of $-1{\cdot}5 \times 10^{28}$ e.s.u. at the centre of the Sun. This field ought to produce an excessive Stark effect. A simple calculation with well-known formulæ[4] shows that, for example, the numerous Stark components of the H_β-line would spread over 1000 Å., or so. The observed line width is of the order of 1 Å. In particular, and this is the crucial point, in the case of H_β no undisplaced component should be found at 4861 Å. This implication of Bailey's hypothesis is simply not borne out by the solar observations. By the same argument one can rule out electric fields in the chromosphere (flash spectrum) and the corona (ultraviolet emission lines). Hence, Bailey's second mechanism is incompatible with all spectroscopic evidence.

(3) Bailey's hypothesis predicts the wrong polarity for the general magnetic field of the Sun at the present epoch. Even if one agrees with Bailey in regarding the recent reversal of the solar field as the outcome of some intervening process, one may well question the appropriateness of calling this reversal a "secondary effect"[2], inasmuch as the primary effect was predicted with the wrong sign. Neither is it helpful to appeal, in support of his hypothesis, to the fact that for five stars the ratio of magnetic moment to angular momentum was supposed to be constant. It is well known that the early data on magnetic stars referred to are superseded[5]. Rather it has become obvious that the main feature of stellar magnetism is its enormous variability, and there is now little point in appealing to a mechanism which can produce only a constant field.

(4) Bailey's model could be subjected to test by terrestrial experiments. The ionosphere, according to Bailey, shields the Earth from the solar electric field, but not from its magnetic effects. Consequently, if magnetically polarizable particles are accelerated, to nearly the velocity of light, in a direction perpendicular to the radius vector Sun–Earth, in the reference frame of such particles there would exist a magnetic field of about 100 gauss, and it should be possible to measure the resulting polarization. Also, observers travelling by jet planes past the same point in opposite directions, perpendicular to the radius vector Sun–Earth, would record values for the local field differing by 20γ, provided that the direction of flight was so chosen as to make the excess field parallel to the local terrestrial field.

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[1] Bailey, V. A., *Nature*, **186**, 508 (1960).
[2] Bailey, V. A., *J. Atmos. Terr. Phys.*, **18**, 256 (1960).
[3] Oster, L., *Z. Astrophysik*, **42**, 228 (1957).
[4] Unsöld, A., "Physik der Sternatmosphären", second ed., 320 (Springer Verlag, Heidelberg, 1955).
[5] Babcock, H. W., *Astrophys. J.*, **128**, 228 (1958); *ibid.*, Supp., **3**, 141 (1958).

THE following comments may be made on the communication by Oster and Philip concerning my article in *Nature*[1] and note in the *Journal of Atmospheric and Terrestrial Physics*[2].

Their introductory paragraph states: "Attention may therefore be directed to certain deductions from Bailey's hypothesis that are in conflict with unambiguous evidence from observation as well as with what is generally regarded as sound theory".

This claim cannot relate to their sections 1 and 2, for these refer only to two subsidiary hypotheses on the origin of the solar charge rather than to the main hypothesis, namely, its existence. At most, the arguments in these sections can lead only to the conclusion that the corresponding hypotheses of origin, H_1 and H_2, are untenable and that the origin of the