LETTERS TO THE EDITORS

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The Sun's General Magnetic Field

WITH their admirable experimental technique, Babcock and Babcock have been able to measure certain very small line displacements in the Sun's spectrum, from which they deduce a general magnetic field of the order of -1 gauss. In order to draw this conclusion they use (although implicitly) two theories: (1) the theory of the Zeeman effect, connecting the line displacements with the magnetic field in a small homogeneous volume of gas; (2) the theory of magneto-turbulence in the photosphere, which, as Babcock's 'point' measurements include many thousand granulæ, is necessary for computing the average.

Whereas the first of these is in order, the second simply does not exist at present. In an answer to criticism by Alfvén, Babcock[2] declares his belief that the effect of magneto-turbulence is small, but does not give any evidence for this point of view. There are several possible mechanisms which have a reasonable chance of occurring. One has been discussed earlier[1], and another can be demonstrated in the following simple example, which does not claim to be rigorous proof but merely serves as another illustration.

Let us consider a quasi-stationary, isothermal state where the generalized pressure is constant in space:

$$nkT_0 + \frac{1}{8\pi}(\mathbf{H}_0 + \mathbf{h})^2 = n_0kT_0 + \frac{1}{8\pi}\mathbf{H}_0^2 = \text{const.} \quad (1)$$

In equation (1) n is the particle density, n_0 its value when the turbulent magnetic field $\mathbf{h}$ vanishes, $\mathbf{H}_0$ the general magnetic field and T_0 the temperature, which is constant. The total contribution to the Zeeman displacement from a region the extension of which largely exceeds the scale of the turbulence will be given by the mean value $\overline{(nH_z)}/n_0$, where the z-azis is in the direction of sight. From equation 1 the following equation is deduced:

$$\frac{\overline{nH_z}}{n_0} = H_{0z}\left[1 - \frac{\overline{\mathbf{h}^2} + \overline{2h_z^2}}{8\pi n_0kT_0}\right] \quad (2)$$

It is quite reasonable that in the photosphere the turbulent field should be so strong that the expression in parentheses becomes zero or even negative. Thus, for strong turbulent fields h, the weighted mean given by equation (2) may differ from the proper value H_{0z}, both in magnitude and in the sign.

Babcock[2] cites two observational facts in support of his view: (1) No 'bias' is observed, which according to him is evidence against an influence of turbulence. Dr. Babcock writes that "According to Alfvén's arguments, the systematic effect of f and the way in which ρ and T are coupled with H should provide a large bias . . .". This is erroneous. Alfvén has never drawn this conclusion, nor has Babcock given any arguments for it. Further, according to Lehnert[3] it can be shown, even under very general assumptions, that turbulence will not give a bias.

(2) The Hale polarity law of bipolar sunspots is preserved down to very low magnetic fields. This is very interesting, but as the investigation from which this result is quoted is unpublished, it is impossible to discuss it. In view of the fact that this argument—if valid—is the only existing support for Babcock's sign and magnitude of the solar magnetic field, it is highly desirable that the details should be worked out and published, so that it may be possible to judge whether the conclusion is convincing or not.

The final verdict, whether Babcock's interpretation can be upheld or not, can only be given after a rigorous theory of the magnetic effects of granulation and their influence on the solar spectrum has been provided. No real attempt to develop such a theory has yet been published.

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[1] Alfvén, H., *Arkiv för fysik*, **4**, No. 24, 407 (1952); *Tellus*, **8**, 1 (1956).
[2] Babcock, H., *Nature*, **178**, 533 (1956).
[3] Lehnert, B., Proceedings of the Symposium on "Electromagnetic Phenomena in Cosmical Physics" in Stockholm, August 1956 (in the press).

Direct Measurement of Long-Range van der Waals Forces

ACCORDING to the current theory of the stability of colloids, there exists a universal force of attraction between any two particles which has its origin in the summation of the London dispersion forces between atoms in the two bodies. Although the force between colloid particles is too small to be measured directly, that between macroscopic bodies is just measurable. For example, the theoretical force, F, between two plane parallel plates separated by a gap, d, is given by[1-3]:

$$F \approx A/d^3 \quad (1)$$

if d is less than about 100 A., or

$$F \approx B/d^4 \quad (2)$$

if d is greater than about 2000 A. A and B are force constants which can be calculated. As the theoretical value of B for glass (calculated from the expression given by Lifshitz[3]) is about $1{\cdot}4 \times 10^{-19}$ erg cm., the force at a spacing of 1μ (10^{-4} cm.) should be about $1{\cdot}4 \times 10^{-3}$ dyne per cm.^{2} (that is, $1{\cdot}4$ μgm.).

Two previous attempts which have been made to verify the magnitude of this force experimentally have given highly discrepant results. Derjaguin and Abricossova[4], using an electronically balanced knife-edge microbalance, obtained for quartz over the range $0{\cdot}1$–1μ results which correspond to $B \approx 1 - 2 \times 10^{-19}$ erg cm. Independently, Overbeek and Sparnaay[5] used a method in which the force between parallel glass plates, separated by $0{\cdot}7$–$1{\cdot}5\mu$, produced a small measured deflexion of a spring. These authors observed a force of 2 dynes at 1μ and their results were represented by equation (1) with $A = 3{\cdot}8 \times 10^{-11}$ erg. If their results were interpreted according to equation (2), the value of B would be 2×10^{-16} erg cm.

We have now carried out a new series of measurements with an apparatus similar in principle to that of Overbeek and Sparnaay but of improved sensitivity. The results of many reproducible experiments, in