Elementary Photo-micrography. By W. Bagshaw. Third edition. Pp. 143. (London: Iliffe and Sons, Ltd., 1915.) Price 2*s.* 6*d.* net.

SOME idea of the scope of this volume may be gathered from the fact that about ninety of its pages, which are not very large, are devoted more especially to photo-micrography, and rather more than thirty to photography—that is, developing and printing. The author takes it for "granted that the reader is already familiar with the use of the microscope," and also presumably that he is an amateur photographer, and seeks to show how the two may be brought together without the need for expensive appliances, and furnish results which, "though not perfect, are good and acceptable for nearly all purposes." He succeeds not only by precept but also by example, giving twenty-nine good reproductions of photo-micrographs taken by the simple means that he describes, using only objectives supplied with students' microscopes. These examples are illustrative of the methods dealt with in the text, and include magnifications from 2 up to 4000 diameters, the use of transmitted light, reflected light, a combination of the two, dark ground illumination, the use of polarised light, oblique illumination, illumination by flashlight, multiple-colour illumination, and a photograph on an autochrome plate. They are of excellent quality, including even a photograph of *Bacillus subtilis*, ×1000. But the *Amphipleura pellucida*, ×4000, shows that such simple methods will not serve for an extreme test, although taken by means of a one-twelfth immersion lens of 1·4 N.A. and an oiled-on condenser. By the way, such an objective and condenser scarcely come within the range of "students'" microscopical apparatus. In giving "pre-war" prices for chemicals, perhaps the author expresses his faith in an early return to peace conditions.

LETTERS TO THE EDITOR.

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The Masses of Heavenly Bodies and the Newtonian Constant.

IN a well-known treatise on physics we find the following statement:—"By the third law of Kepler we are led to the conclusion that the same value of G (the Newtonian constant of gravitation) applies to the sun and all planetary bodies." This conclusion appears to be fallacious, as we see by the following elementary considerations:—

(1) Take the case of Poynting's famous balance experiment for determining G. The attraction of the large mass M on the small mass m at distance d is

$$\text{couple} = G_M \cdot Mma/d^2 = m'gl' \quad . \quad . \quad . \quad (1)$$

where m', l' are the mass of the balancing rider and its displacement necessary to counterpoise the gravitative pull of M on m.

Equation (1) gives G_M, for we know all the other factors. The suffix used here denotes that the "constant" G_M only applies to a mass if its temperature is that of M.

(2) The earth's attraction on mass m is

$$mg = G_E \cdot Em/R^2. \quad . \quad . \quad . \quad . \quad (2)$$

where E, R are earth's mass and radius respectively.

Equation (2) gives us $G_E \cdot E$. The earth's mean temperature may be, say, 4000° C., whereas that of M above is, say, 15° C. We have no experimental knowledge that the Newtonian "constant" is the same at 15° as at 4000°. Hence we cannot write $G_M = G_E$ and obtain from equation (2) the earth's mass. It is thus evident that the values commonly given for earth's mass and mean density are based on the unwarrantable assumption that $G_M = G_E$. Thus it is quite possible (for we have no evidence to the contrary) that $G_E = 2G_M$, in which case the earth's mean density would work out to be 2·76 instead of 5·52, as generally accepted.

(3) When we come to the case of the revolution of the earth and other planets round the sun, we have similar considerations to the above. Let two planets have mean radial distances d_1, d_2 and periodic times t_1, t_2, we obtain in the form of Kepler's third law

$$G_S \cdot S = 4\pi^2(d_1^3/t_1^2) = 4\pi^2(d_2^3/t_2^2) = 4\pi^2 k,$$

where S = sun's mass and G_S the Newtonian constant for the sun's temperature, whence we obtain $G_S \cdot S$; as we know Kepler's constant k. We do not know S alone, for we may not write $G_S = G_E = G_M$.

Thus we see that the masses and densities of all heavenly bodies, including the earth, are based on an assumption for which there is no experimental support, and which (considering the great range of temperature involved) is probably false.

In the case of the sun, the stars, and all the major planets the mean temperature is certainly as high as four figures, and in many cases probably five figures, on the Centigrade scale. It is thus inconceivable that any laboratory experiment will ever be made to determine the values G_S, G_P, or even G_E. But it is not unlikely that sure experimental evidence will be forthcoming as to the value of G, say, up to 500° C.

I have recently concluded a long research on the value of G up to 250° C., and I have found an increase in that "constant" of about 1 in 10^5 per 1° C. The full results I hope to publish shortly.

No doubt it has been for the sake of simplicity that astronomers and physicists have assumed constancy in G, and have thus obtained the accepted values for mass and density. But in reality these values (by analogy with the terminology of radiation) are not the mass and density, but the *effective-mass* and the *effective-density* respectively, and would only be true-mass and true-density if $G_S = G_E = G_M$, etc. If any temperature effect, such as is mentioned above, can be firmly established, then these terms ought to be adopted in the interests of accuracy.

So far, for simplicity, we have considered the temperature effect of gravity on the large mass only and have ignored any effect on the small mass. In equations (1) and (2) we have the small mass m at ordinary temperatures, say 15° C., so that we have not to consider temperature effect in connection with it. But in equation (3) the two planets in question may differ in temperature. Even then the equation is correct as it stands, supposing (a) the temperature effect on a mass considered as one member of a gravitative couple is identical with (b) its effect on mass considered as so much inertia; for these terms (a) and (b) occur on the left and right sides of the equation and cut out. But, on the other hand, if (a) is not identical with (b) the equation would have other factors. But neither in this