ionisation, we can apply Nernst's theorem of the "reaction-isobar" to calculate the amount of ionisation under any given thermal stimulus. The method is based upon a remark of Nernst in his book, "Der Neue Wärmesatz . . ." (p. 154), that the electron may be regarded as a monatomic gas of molecular weight $\frac{1}{1836}$, and that its chemical constant can be calculated according to the Tetrode-Sackur relation

$$C = \log \frac{(2\pi m)^{\frac{3}{2}} k^{\frac{3}{2}}}{h^3}.$$

It has recently been applied by Eggert (*Ver. d. D. Phys. Gesell.*, December 15, 1919) for the calculation of the degree of ionic dissociation in the interior of a star, as supposed by Eddington in his theory of stellar structures. But Eggert calculates U in a rather artificial manner for iron from assumed atomic dimensions and structures of the iron atom.

We can, however, calculate U directly from the value of the ionisation potential as experimentally determined by Franck and Hertz, MacLennan, and others, or from the quantum relation

$$V = \frac{h\nu}{e}, \quad \nu = (1{\cdot}5, s).$$

Using the value of U determined in this way for calcium, barium, strontium, hydrogen, and helium, the following remarkable results appear:

(1) About 30–40 per cent. of the Ca atoms are ionised just over the photosphere; in the chromosphere, when the pressure falls to $10^{-4}$ atms., almost all the Ca atoms are ionised. The same conclusion holds to a varying degree for Ba and Sr.

(2) Hydrogen and helium are not ionised anywhere in the solar atmosphere. (This is due to their high ionisation potential. V is 13·6 for H and 20·5 for He, while for Ca, Sr, and Ba the figures are 6·12, 5·7, and 5·12.) Helium can become ionised only in stars of which the temperature exceeds 16,000 K.

(3) Pressure has a great influence on ionisation, a reduction in pressure causing great enhancement of ionisation.

It therefore appears that the ionisation in the upper layers of the solar atmosphere, as revealed by the enhanced lines of Ca, Sr, and Ba, and probably also of Fe, Ti, and Sc, is due to reduced pressure and the low ionisation potentials of these elements, and not to an increased temperature.

The full theory has been worked out in a paper communicated to the *Phil. Mag.*

M. N. SAHA.

University College of Science, Calcutta,
March 8.

## Gravitational Deflection of High-speed Particles.

IN a letter published in NATURE of March 11 Prof. Eddington has shown that the statement made by me in an earlier letter to the effect that Einstein's law of gravitation seems to lead to a zero deflection for a material particle moving with the velocity of light is not in accord with the exact equation of the orbit contained in his report to the Physical Society, and suggests that my approximations were not sufficiently close to warrant my conclusion. The line element from which Prof. Eddington derives the equation of the orbit is expressed in co-ordinates which make the velocity of light different in different directions at any one point, whereas the one used by me requires that the velocity of light should be a function of position only, and not of direction. In terms of my co-ordinates the equation of the orbit of a particle moving with the velocity of light is

$$u = 2\frac{m}{R^2} + \frac{1}{R}\left(1 - 2\frac{m}{R}\right)\cos\theta,$$

which leads to the same deflection $4\frac{m}{R}$ for a material particle moving with the velocity of light as for a light-ray. Hence it is clear that my previous conclusion was based on an insufficiently close approximation, and therefore erroneous.

I am glad to see that Prof. Eddington has verified the other principal conclusion of my letter.

LEIGH PAGE.

Sloane Laboratory, Yale University, New Haven, Connecticut, March 29.

## Science and the New Army.

IT requires some courage to offer any opposition to the chorus of approval which has greeted the suggestion that a proportion of officers endowed with the scientific spirit should be included in the General Staff; but I venture to think that it is by no means so easy to give effect to this proposal as some correspondents in NATURE seem to suppose. No doubt it would be delightful if we could have Staff officers who knew all about everything, but in actual practice the man who does useful work in the world is a specialist in one particular subject or in one particular branch of work.

A good regimental officer requires a particular kind of training and possesses a certain set of qualifications. Similarly, a good Staff officer requires a different training and possesses a different set of qualifications. A man of science, again, is different from either of the other two.

The proportion of officers in the Army as a whole who possess any scientific training is comparatively small. There are a certain number of specialists whose ordinary duties are of a technical nature, and there are a few officers who take up some branch of science as a hobby, but the work of the average officer is not such as to bring him into touch with scientific thought and scientific methods. Men are to be found who are good Staff or regimental officers and also scientific workers, but they are exceptions, and it seems to me that a system which demands a regular supply of exceptional men is not one which is likely to work in practice.

There is also a further difficulty. Granting, for the sake of argument, that there are sufficient officers in the Army who possess both the scientific spirit and the qualities necessary for potential Staff officers, it is still necessary to devise a method of selecting them from their more ordinary fellows. Two methods are in common use, namely, examination and nomination.

An examination is a good method of testing that form of knowledge which is acquired by study, but it will be generally agreed that it is not a good method for detecting the scientific spirit. The difficulty in the case of nomination is that the candidates must be selected by ordinary regimental officers who can alone be acquainted with the qualifications of the individual candidates. The average regimental officer, however, is not himself a man of science, and I cannot see that he can ever become a judge of another officer's scientific attainments.

Without arguing, therefore, against the desirability of a General Staff containing an appreciable proportion of scientific officers, I suggest that the ideal is unattainable except in so far as specialists are attached to the Staff for their own particular work, and I think the object in view must be attained by some other means. It might be done by raising the general standard of education in scientific matters throughout the country but this is a very large question, and not a very easy one.