the term which is responsible for them. The perturbation of the $4p(9)$ term shows a doubling of the corresponding Q-line into two components with unequal intensity. This might be explained in the following way. The spectrum of the helium molecule must consist of single and triple electronic terms. But as the interaction of the electronic spin with the rest of the molecule is very small, the triplets are not resolved and thus have the appearance of single levels. It seems possible that in the case of a perturbation the interaction with the spin gets an abnormally large value, so that the corresponding term is split up. We must imagine, then, that the more intense component of the corresponding line is, as in the case of the atomic lines of helium, an unresolved doublet.

Full particulars of these and other properties of the terms of the helium molecule will be given elsewhere.

G. H. DIEKE.

Natuurkundig Laboratorium der
Rijks-Universiteit,
Groningen.

Cosmic Rays.

IN an earlier communication [NATURE, Feb. 16, p. 241] it was stated that an examination had been made of the results of experiments on cosmic rays. The experiments referred to were those of Millikan and his colleagues. In a recent paper (*Physical Review*, October 1928), Millikan and Cameron divide the rays into four bands with absorption coefficients per metre of water, 0·30, 0·08, 0·04, and 0·02 respectively. There is very little, if any, evidence for the existence of the last band, and I find that their results are fitted just as well by the division of the rays into two bands only, with absorption coefficients 0·30 and 0·051 respectively, rays of type A and type B, say. The experiments of Millikan and Otis and others show that there is a third type of radiation present, type C, say. Rays of this type are of local origin and consist, in part at least, of β-rays with an energy of the order of 100,000,000 electron volts.

Rays of type B are probably γ-rays. If so, according to the Klein–Nishina formula, which, for large values of $\alpha = h\nu/mc^2$ reduces to

$$\sigma/\rho = \frac{4\cdot17}{\alpha}(1 + 2\log 2\alpha) \quad . \; . \; . \text{ per metre of water.}$$

α for these rays equals 173, corresponding to an energy of 88,000,000 electron volts.

Rays of type C are doubtless γ-rays, with a value of α equal to 1330 and an energy of 675,000,000 electron volts.

The energy presumably released when an oxygen nucleus is formed in a single step from protons and electrons is 116,000,000 electron volts, and that when a proton is destroyed 940,000,000 electron volts. I believe that the formula used gives values of α which are too small, so that rays of type B may correspond to the radiation emitted when an oxygen nucleus is formed in a single step and those of type C to that when a proton is destroyed. Incidentally, it has been tacitly assumed that rays of both types exert no appreciable action on hydrogen and oxygen nuclei. The evidence that rays of either type have any effect on atomic nuclei is not conclusive.

An analysis of the results of experiments showing the variation of intensity of cosmic rays with depth below the surface of the atmosphere affords, then, no evidence of rays corresponding to the formation of helium nuclei from protons and electrons. This renders it difficult to accept the attractive hypothesis of Millikan and Cameron that atom building is taking place in outer space, following the transformation of radiation into protons and electrons. Another difficulty that occurs is this. If all the energy in starlight is so transformed, less than eight-tenths of one per cent of it can be re-radiated as cosmic rays. As the radiation from the sun apparently has no effect on the intensity of the rays, this amount seems too small to account for the large intensity of cosmic rays, estimated by Millikan and Cameron to be about one-tenth that of starlight.

Rays of type C are not easy to classify. Their intensity in air is approximately proportional to that of the rays of type B, although it is difficult to estimate the exact value of either. They are not produced in water or in lead, and are therefore not recoil electrons. Many methods of explaining their origin have been tried, one being that they are photoelectrons ejected from the nuclei of atoms, such as nitrogen, but this explanation is not altogether satisfactory.

We have assumed that rays of type A and C are cosmic in origin, the greater part of the evidence favouring this view, but one experiment carried out by Millikan and Otis indicates that a part at least of these rays may be of terrestrial origin and also that rays of type C may be more penetrating than is usually assumed. They measured the ionisation in an electroscope before and after a snowstorm. When the electroscope was shielded by 4·8 cm. of lead, the ionisation per c.c. per sec. (corrected for natural leak) dropped from 4·9 to 3·6. If this result is not due to experimental error, it would appear that something had occurred in the atmosphere to diminish the intensity of the rays of one or more types.

A more complete discussion of the questions raised above will be given later. In searching for an explanation of the results, equations of the following type have been used, namely:

$$14\cdot008x + 4\cdot0022x + \alpha_k = 17\cdot000x + 1\cdot0078x + p_k + A_k + h\nu.$$

This is an energy equation representing the ejection of a proton from a nitrogen nucleus by an α-particle, the α-particle being captured by the recoil atom forming an oxygen isotope of mass 17 (the number 17 being assumed). x represents the energy in electron volts radiated when unit mass is destroyed (the mass of an oxygen nucleus being taken as 16 units), α_k, p_k, A_k, and $h\nu$ representing the kinetic energies in electron volts of the α-particle, ejected proton, recoil atom, and assumed radiation respectively.

$$h\nu = 0\cdot0024x + \alpha_k - p_k - A_k.$$

As $x = 930,000,000$ electron volts and $p_k + A_k$ is less than α_k, $h\nu$ should be greater than $0\cdot0024x$, that is, than 2,230,000 electron volts.

It should be possible to detect radiations of this type. Similar equations have been written down for the other atoms from which protons can be ejected, but the results are somewhat indefinite, as we do not know the mass of the recoil atom.

J. A. GRAY.

Queen's University,
Kingston, Ontario,
Feb. 7.

The Ice Age and General Drayson's Theories.

I AM sure your able contributor H. C. P. did not intentionally misrepresent Drayson in his article in NATURE of Dec. 29, p. 1002, but it would seem that some initial unfamiliarity with Drayson's writings, or possibly lack of sympathy with his claims, has led to misapprehension, and I would ask you to be so good as to permit me to direct attention to the more serious mistakes.