Letters to the Editor.

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Isolated Quantised Magnetic Poles.

In the last number of the *Proceedings of the Royal Society*, Dirac has come to the conclusion that the quantum theory requires the existence of discrete magnetic poles of a strength equal to $137 \div 2$ times the electronic charge. If such objects were common one might expect the universe to be a good deal different from what experimenters have found it to be, so far.

There seems no a priori reason why the whole theory of atom building which has been built up for electrons and nuclei—an electrostatic problem apart from details—should not be carried over bodily into the corresponding magneto-static problem of the attractions of the oppositely charged poles. In this way we might, at first, expect to get a set of 'magnetic' atoms, similar to the electric atoms of which matter is generally supposed to be built up. These atoms would be a good deal different from those we think we are familiar with. How much different depends to some extent on what the mass of a magnetic pole is. The quantum theory does not tell this, but I think its value, if it exists, can be fixed by an argument based on classical ideas at about 500 times that of the corresponding electronic object. Following this general line of argument, the dimensions of these magnetic atoms come out at 10^{-14} cm. to 10^{-15} cm. compared with 10^{-7} cm. to 10^{-8} cm. for the atoms of the periodic table. The frequencies of the 'spectral' lines emitted by these magnetically constructed atoms would run about 10^{10} times those of the corresponding lines of the electronic spectra; for example, the first line of the Lyman series would be raised from $\nu = 2 \cdot 5 \times 10^{15}$ to $\nu = 3 \cdot 1 \times 10^{25}$ sec.$^{-1}$ if the corresponding states are capable of existence. Even if quite large changes are made in the mass of the magnetic poles, which is the doubtful element, the corresponding numbers will still remain quite wide apart.

Dirac has suggested that the reason these magnetic poles have not been observed may be that the forces between them are so much larger than those between electrons and protons that they cannot be separated. There is reason for believing they could not get together to the extent indicated by the preceding numbers. The number of kinds of atoms with azimuthal quantum number 1 which can be formed from these magnetic units is much less than unity. This follows from Dirac's formula for the spectral terms for hydrogen, or alternatively, from the principle of minimum time. This may be forcing the required atoms too much into the pattern of those with which we are familiar. In any event, no atom with azimuthal quantum number less than $34\frac{1}{4}$ can be made out of these elements. Otherwise the time factors in the wave functions involve real exponentials and become infinite with lapse of time. However, even with such high quantum numbers the forces would still be enormous compared with those in corresponding electronic structures and the frequencies would still be quite high.

There may be an application of these products of the quantum theory in the field of 'ultra-penetrating' radiations. I have no first-hand knowledge of the process of creation, but I should suspect it would be relatively difficult to create objects with the intrinsic energy of these magnetic poles. It seems likely, therefore, that their abundance would be very small compared with that of electrons and protons, but there might be enough in the universe to account for such ultra-penetrating radiations as are not capable of being accounted for otherwise. The possible existence of such isolated magnetic poles, with properties so very different from those of electrons and protons, obviously changes the basis for discussion of a good many cosmological questions.

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Similarity between Cosmic Rays and Gamma Rays.

As heretofore indicated,[1] it was in the fall of 1926 that Millikan and Cameron began to use high pressure electroscopes in order to increase the sensibility of their cosmic ray measurements. They built at first two such electroscopes and filled them to pressures of 8 atmospheres and 30 atmospheres respectively. Their first published results [1] were obtained with the 8-atmosphere filling, and they then assumed that for these hard rays the observed ionisation would be proportional to pressure. By directly comparing, however, a little later, similar spherical electroscopes of 1600 c.c. capacity filled to 1 atmosphere and to 8 and 30 atmospheres respectively, they were surprised to find that the ionisation shown in the 8-atmosphere electroscope was but about five times, and that in the 30-atmosphere electroscope was but 13·8 times that in the 1-atmosphere electroscope. These facts were published in one of their 1930 publications,[2] but since the authors were then interested merely in the *variation* in the ionisation in a given electroscope with depth beneath the top of the atmosphere, they made no attempt to discuss the reasons for these low factors. They did, however, *by direct comparisons find that these factors were the same for the gamma rays of radium and thorium as for the cosmic rays, thus bringing to light another significant similarity in behaviour of these two types of radiations.*[3]

Since Broxon [4] and Hoffmann [5] have both, in recent publications, commented upon these pressure-ionisation relations as measured by them, in entire agreement too with our own measurements, but without directing attention to what we consider to be the correct explanation of the phenomena, we have decided to present it herewith in this brief note. There are two causes of this failure, even for very hard rays, of the expected linear relation between pressure and ionisation. The first and the less important of the two is that mentioned by Hoffmann, namely, the mixture with the hardest beta rays which are formed by Compton-encounters with the original cosmic ray photons, of soft secondary beta rays which may be fully absorbed even within the air of the electroscope at 1 atmosphere, and can contribute no more to the ionisation when the pressure is high than when it is low. We have reasons which, merely for brevity's sake, we omit from this brief note, for thinking this cause of departure from linearity in the pressure-ionisation curve to be relatively small. The main cause of divergence from this relation is the following.

The low energy electrons shaken loose by the original ionising beta ray, if thrown an appreciable distance from the parent positive atom at 1 atmosphere, could be thrown but a small fraction of this distance at 8 atmospheres or at 30 atmospheres. The tendency to recombine then increases very rapidly with pressure. This lack of saturation effect