Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Velocities of the Spiral Nebulæ.

THE extraordinary velocities of recession which are derived from the shift toward the red of the spectral lines of remote galaxies have led to much scepticism of the interpretation of this shift as a Doppler effect; and this scepticism is enhanced when it is learned that the velocities are proportional to the distances of the galaxies. No other interpretation in terms of other waves seems to be satisfactory, but there is an interpretation in terms of light quanta, or photons, that is much less disturbing.

The energy of a photon is $e = h\nu$, where h is Planck's constant and ν is the frequency. If one supposes that there is a leakage of energy from the photon in its long journey of millions of years, due perhaps to an inherent instability in the photon, or, possibly, to collisions with other photons, it is evident that the frequency declines with the energy, and the lines of the spectrum are shifted toward the red.

For the Doppler effect $\nu = \nu_0(1 - v/c)$, where v is the velocity of recession and c is the velocity of light. Hubble and Humason [1] find, from observation of these distant objects, the relation

$$v \text{ (in km. per sec.)} = \frac{x \text{ (in parsecs)}}{1790},$$

so that

$$\frac{v}{c} = \frac{x \text{ (in parsecs)}}{3 \times 1790 \times 10^5} = \beta x.$$

If, instead of this linear relationship between velocity and distance, one takes $v/c = (1 - e^{-\beta x})$—and the two hypotheses are indistinguishable on the basis of the observational data—then the relation between frequency and distance due to Doppler effect is $\nu = \nu_0 e^{-\beta x}$.

On the other hand, if one supposes that the percentage loss of energy from the photon per unit distance is constant, one has

$$\frac{1}{\epsilon}\frac{d\epsilon}{dx} = -\alpha,$$

where α is some constant. Consequently, $\epsilon = \epsilon_0 e^{-\alpha x}$, or, on dividing through by Planck's constant, $\nu = \nu_0 e^{-\alpha x}$. That is, the assumed tendency of the energy of the photon to evaporate in its long journey through space leads to a law of frequency which is indistinguishable in form from the law of Doppler effect as given by Hubble and Humason.

On the basis of energy leakage and the observed shift of the spectral lines, a light quantum loses one per cent of its energy in 5,400,000 parsecs, or 17,600,000 years. It requires 372,000,000 parsecs, or 1,210,000,000 years, for one-half of its energy to escape. Such an interpretation of the extraordinary shifts that are observed will be more acceptable to many than an interpretation which makes our galaxy a centre from which all others are fleeing with speeds that are proportional to the distances.

If the energy which has evaporated from the photon continues to exist as radiant energy, there should exist an abundance of radiation of very low frequency, and there is at present no evidence of such radiation. Another possibility, however, is that it disappears into the fine structure of space and reappears eventually in the structure of the atom. The process by which this is accomplished, however, lies far outside the range of our experience, and until we know much more about the atom than we do at present, it is useless to speculate about it.

W. D. MACMILLAN.

University of Chicago,
Dec. 9, 1931.

[1] *Astrophys. J.*, **74**, 76, July 1931.

Oxygen and Everest.

MR. ODELL'S interesting letter [1] re-emphasises conclusions drawn from the Everest expeditions as to the value of oxygen breathing apparatus and upholds the importance of acclimatisation. He states that acclimatisation at 27,000-28,000 feet should be aimed at, and then oxygen used for the last 1000 feet of ascent. As it takes weeks for the party to reach 27,000 feet, experiments in pressure chambers conducted on normal men for a few hours' duration are of no significance. We know, however, that natives do not go and live in the summer months above 18,000 feet, and the question arises whether it is the altitude or the extent of the pastures which sets this limit.

It was on account of this that Dr. Argyll Campbell carried out many experiments with animals while I was in charge of the Department of Applied Physiology at the National Institute of Medical Research. He used monkeys, cats, rabbits, guinea-pigs, rats, and mice, enclosing these animals almost continuously in chambers for many weeks, either the oxygen partial pressure, or the barometric pressure being lowered gradually to resemble the conditions on the mountains. In the latter case, use was made of a chamber at the works of Messrs. Siebe Gorman. His results have been published and clearly show that at 20,000-29,000 feet the oxygen tension in the tissues is not kept at normal, but is markedly subnormal; further, there result pathological changes, particularly in the heart, liver, and brain. Also, he found that breathing oxygen at normal pressure for one hour daily did not help these animals materially.

Thus in the so-called acclimatisation at these great altitudes the members of the expeditions will be deteriorating continuously; that they did so in the past expeditions is proved not only by the fact that climbing became most difficult, but also that they all lost weight and appetite. The climbers who persevered at 28,000 feet or above all came to grief.

Another expedition of the same type is likely to end similarly unless other precautions are taken. Dr. Campbell found that out of more than a hundred healthy animals only about ten could tolerate the low oxygen partial pressure which pertains at 29,000 feet for any length of time. A few animals survived for eight days—a record—under this pressure, and recovered their health again when put under normal conditions.

It is obviously very difficult to pick men able to tolerate such a low oxygen pressure for such a prolonged period as is necessary on the mountain. The climbing party should be increased in numbers, and thus the chance of one of them carrying on after 28,000 feet, with or without the use of oxygen breathing apparatus, will be increased. All the evidence from the expeditions and from these experiments on animals leads to one conclusion, namely, above 28,000 feet deterioration is rapid and excessive, and no acclimatisation prevents this. If the climbers were continuously supplied with oxygen at normal pressure they could, of course, proceed straight up to the