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.]

Remarkable Optical Properties of the Alkali Metals

RECENTLY Wood¹ has published a full account of some beautiful experiments on the optical behaviour of the alkali metals, of which a preliminary report appeared in these columns². His main results are:

1. The alkali metals, which have a large coefficient of extinction in the visible part of the spectrum, become more or less transparent sufficiently far in the ultra-violet. As a consequence, they have in this spectral region a Brewsterian angle at which ordinary light upon reflection becomes plane polarised.

2. The limit of the transparent region on the side of long wave-lengths shifts toward the red with increasing atomic number, lying at about 2050 Å. for Li, 2100 Å. for Na, 3150 Å. for K, 3600 Å. for Rb, 4400 Å. for Cs, while no limit was observed on the side of short wave-lengths as far as the experiments permitted to penetrate (about 1860 Å.).

3. The index of refraction in the transparent region is less than unity, so that the phenomenon of total reflection occurs.

It is the purpose of this note to point out that all the interesting phenomena mentioned above can be fully accounted for by means of the quantum theory of metallic dispersion developed by the present writer³, in which the electrons of the metal are considered as moving in a periodic field of potential. In such a field the stationary states of the electrons are grouped together in zones, the energy of the stationary states within one and the same zone being a continuous function of the variables distinguishing these states, while in passing from one zone to another it shows a discontinuity. This discontinuity and a selection rule derived by me have the result that the absorption spectrum of the metal consists of a number of continuous bands bounded both on the low and on the high frequency side, each band being due to the transitions from a zone occupied by electrons to an unoccupied zone. While very far in the ultra-violet, as well as in the X-ray region, these bands will partially overlap, it is to be expected that in some cases the band lying farthest toward the red and corresponding to transitions from the highest occupied zone to the lowest unoccupied zone will be separated from the other bands by a finite frequency interval in which no absorption can take place. This is evidently the case for the alkali metals. The optical data for silver and gold, discussed by me in my first paper, make it probable that here too a transparent region will be found when going farther to the ultra-violet than has been done hitherto.

The shift of the first absorption band toward longer wave-lengths with increasing atomic number of the alkali can also be understood. The theory shows that, for electrons not too firmly bound, the energy differences between the zones, and hence the transition frequencies, vary roughly as $1/a^2$ for similar lattices, a being the lattice constant, so that the absorption bands shift towards the red with increasing a . Now for the alkali metals a does indeed become greater with increasing atomic number, having the

following values: Li 3.46 Å., Na 4.24 Å., K 5.25 Å., Rb 5.62 Å., Cs 6.05 Å.⁴

Finally, as regards the index of refraction in the transparent region, this is just what one would expect. For one is here immediately on the violet side of a band of strong absorption, so that the contribution to the electric polarisation from this band, which due to its proximity outweighs by far the influence of the other bands, is 180° out of phase with the electric vector of the light wave, causing a diminution of the index of refraction below unity.

R. de L. KRONIG.

Natuurkundig Laboratorium,
Groningen.
Sept. 24.

¹ R. W. Wood, *Phys. Rev.*, **44**, 353; 1933.

² R. W. Wood, *NATURE*, **131**, 532; 1933.

³ R. de L. Kronig, *Proc. Roy. Soc. A*, **121**, 409; 1929. *A*, **133**, 255; 1931. See also Y. Fujioka, *Z. Phys.*, **76**, 537; 1932. H. Fröhlich, *ibid.*, **81**, 297; 1933.

⁴ F. Simon and E. Vohsen, *Z. phys. Chem.*, **133**, 165; 1928.

Solar Activity and Cosmic Rays

THE intensity of the cosmic radiation on the summit of the Hafelekar (2,300 metres above sea-level) near Innsbruck (Austria) has been recorded almost continuously for two years by means of a Steinke-Standard apparatus (steel ionisation chamber of 22.6 litres, filled with carbon dioxide at 9.5 atm.). The room temperature in the observatory was kept constant within $\pm 0.1^\circ$ at 15° C. during the whole period by an automatic regulator. All ionisation values were reduced to the same barometric pressure and outdoor temperature. A detailed account of the results has been given elsewhere¹, so far as the diurnal, seasonal and irregular variations of the cosmic radiation are concerned.

It may be mentioned that no regular diurnal variation according to sidereal time was detected. The existence of a small diurnal variation according to local time was, however, proved again beyond doubt: the midday intensity is higher by about 0.012 J than the intensity at night. The maximum intensity occurs not exactly at noon, but at 2 p.m., indicating some indirect rather than a direct influence of the sun. Our results agree with the observations of G. Hoffmann, Lindholm, Steinke and A. H. Compton.

The large number of observations accumulated at the Hafelekar Observatory makes it possible now to investigate whether solar activity (sunspots, earth-magnetic storms) has any influence on the intensity of cosmic radiation.

Quite recently O. Freytag², by an analysis of Lindholm's observations at Muottas Muraigl in 1930, concluded that the diurnal variation of the more penetrating components of the cosmic radiation is more marked in periods with large sunspot numbers.

We analysed our observations extending over nineteen months and could not find any relation with the relative sunspot numbers observed at the same time. It might be suggested that this result was not very decisive, since our observations were made in years of minimum sunspot numbers.

We therefore selected from the heliographic maps of the Astronomical Observatory in Zurich only such days when a large sunspot or group of spots was near the centre of the sun and analysed the intensities of the cosmic radiation observed at the same time and also on the following days. Again no certain influence could be detected. A slight