Letters to the Editor.

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The Angular Momentum of Light.

THE work of Compton on X-ray scattering led to the general acceptance of the idea that the scattering of radiation by a material particle is a unitary process in which energy and linear momentum are conserved. A molecule is, however, a much more complicated structure than an electron, and the conservation principles by themselves would give us an erroneous idea of what we should expect in light-scattering. This follows from the fact that a molecule has in general three degrees of freedom of rotation, several degrees of freedom of vibration according to its complexity, and various possible modes of electronic excitation, and that each of these may correspond to one or other of an extended series of quantum numbers. Restricting ourselves to the cases in which the molecule takes up a part of the energy of the quantum, the conservation principles would indicate that the spectrum of the scattered light should contain an immense number of new lines.

Actually, a remarkable simplicity characterises the observed spectra of the light scattered by polyatomic molecules, a simplicity which is in striking contrast with the complexity of their absorption and emission spectra. It is clear that the Compton principles cannot be regarded as capable of *predicting* the observed phenomena of light-scattering, and that their utility lies solely in the *interpretation* of results discovered by experiment. These remarks seem necessary to correct an impression to the contrary which finds expression in some recent publications.

We may extend Compton s principle and add angular momentum to the quantities which we should expect to find conserved in the collision between a light-quantum and a molecule. The fact that, in liquids and solids, the mutual influence of the material particles is very considerable, attaches some uncertainty to the interpretation of the results obtained with them. The recent success of Bhagavantam at Calcutta in measuring the polarisation and intensity of light scattered by gases, however, opens up new possibilities for the development of the subject.

As a working hypothesis, we may follow Dirac and assume that the angular momentum of a photon is *plus* or *minus* $h/2\pi$, intermediate values being inadmissible. This supposition enables us to interpret very simply the known selection rule $\Delta m = 0$ or ± 2 for the change of rotational quantum number of a diatomic molecule in light-scattering, which follows as a natural consequence of it. Further, it follows [1] that a change in rotational quantum number of the molecule should be accompanied by a reversal in the sign of circular polarisation of the photon, when the latter is scattered in the forward direction. This reversal has been actually observed by Bär and by Bhagavantam with the rotational wings accompanying the original mercury lines scattered in liquids, and the data obtained by Bhagavantam with hydrogen gas may also be interpreted as a confirmation of the same result.

It is remarkable that the latter result is also predicted by the classical electromagnetic theory of light for the case of a rotating anisotropic particle scattering circularly polarised radiation. Nevertheless, it is clear that the observed phenomena may be regarded as an experimental proof that radiation has angular momentum associated with it, and that it has the values $\pm h/2\pi$ for each quantum.

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210 Bowbazar Street, Calcutta,
Aug. 15.

[1] NATURE, **128**, 114, July 18, 1931.

The Penetration of Light through Successive Layers of Tissue Paper.

IN a letter to NATURE,[1] J. R. Ashworth mentioned the use of a stepped wedge of fine quality tissue paper in describing a method of measuring ultra-violet light from the sky, photographically. In a later issue,[2] P. W. Cunliffe pointed out that "a step wedge constructed of a diffusing medium, such as thin tissue paper, does not obey the logarithmic 'law', which is valid only for transparent media". It so happens that I obtained data last spring which bear on this subject.

Mr. G. M. Spooner, working on phototropism, was desirous of reducing illumination by steps, and used sheets of tissue paper for the purpose. The alteration in the intensity of diffuse daylight was measured, using a vacuum sodium photoelectric cell, covered with a double surface flashed opalised-glass plate. The combination has a maximum sensitivity in the violet or near ultra-violet. The results are shown in the table.

No. of sheets.	Series A.	Series B.	Transmission per cent.	B (calc.).
1	67·0	69·5	..	..
2	48·7	52·5	75·5	55·0
3	..	40·1	76·4	43·5
4	29·1	30·8	76·8	34·4
5	..	25·3	82·1	27·2
6	..	19·7	77·9	21·5
7	..	16·2	82·3	17·0
8	..	12·8	79·0	13·5
9	..	10·4	81·3	10·7
10	..	8·4	80·8	8·4
			Mean 79·1	

The calculated values in the last column were obtained by using the mean percentage transmission, 79·1 per cent, and multiplying the Series B value for one thickness, namely, 69·5 per cent, by it, to obtain the amount transmitted by two thicknesses, and so on to the tenth.

It may be seen that the calculated and observed values agree well, when allowance has been made for the extra loss by reflection and scattering at the first surface. This amounts to 9·6 per cent. The transmission coefficient appears to increase somewhat with increasing numbers of sheets, at the start. This is probably due to heavy absorption of the shortest wavelengths, which are thus eliminated.

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Marine Biological Laboratory,
Plymouth, Aug. 25.

[1] NATURE, **127**, 893; 1931.
[2] NATURE, **128**, 35; 1931.

Analysis of Complicated Band Spectra with the Aid of Magnetic Rotation Spectra.

THE absorption spectra of polyatomic molecules are usually so complicated that an analysis of their rotational fine structure seems impossible. We have therefore tried if the magnetic rotation spectra which are obtained by putting the absorbing gas in a magnetic field between crossed nicols [1] will not simplify those spectra sufficiently so that an analysis becomes possible. It was found that with NO_2 a remarkable simplification occurred. But in this case also the simplified magnetic rotation spectrum is very complicated