Letters to the Editor

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Atoms and Molecules as Fitzgerald Oscillators

ACCORDING to the theory of the Raman effect, the depolarisation ρ of the Raman lines in gases and liquids should, when observed at right angles to the natural incident light, never exceed the value $\rho = 6/7$. Whilst values of $\rho \geq 1$, which have frequently been observed, could be ascribed to observational errors, a value of $\rho = 2$, which has been estimated by Bhagavantam [1] for one line of liquid sulphur trioxide, called for a further investigation. I have carried out this work,[2] using polarised incident light with the electric vector perpendicular to the plane through the light source, scattering object and observer. Denoting by σ the depolarisation for this mode of observation, there exists between σ and ρ the relation

$$\sigma = \frac{\rho}{2 - \rho}.$$

It is clear, that, whilst the theoretical limit for σ is 3/4, one should get $\sigma = \infty$ in the case cited by Bhagavantam. This was clearly disproved by the experiment, which gave a value of σ not exceeding unity.

Sir C. V. Raman has lately made [3] the very original suggestion that the observed values of $\rho > 6/7$ might be explained theoretically by assuming that the scattering molecules behave as magnetic dipoles. If this be the case, it is the magnetic vector in the incident light which gives rise to the Raman line; consequently the above-mentioned experiment must be repeated with the incident light polarised at right angles to that used formerly. For σ one now has $\infty \geq \sigma \geq 4/3$, for $\rho \infty \geq \rho \geq 7/6$, the relation between σ and ρ remaining unchanged. As Sir C. V. Raman mentioned in his letter that some new measurements of Venkateswaran had revealed that this phenomenon of "anomalous polarisation" could be best observed with thiophene, I repeated the experiment with this substance. The result was entirely negative; all Raman lines showing complete depolarisation, as was to be expected with an electric dipole radiation.

Sir C. V. Raman, to whom I communicated the result of this investigation, has answered by a letter, the relevant part of which is here published with his authorisation:

"Observations of depolarisation in excess of the 6/7th permissible with incident natural light for an anisotropic electric dipole had been reported by several observers since 1928. The list includes Prof. Cabannes, Carrelli-Pringsheim-Rosen, Bhagavantam, West and Farnsworth, Parthasarathy, Venkateswaran, and others. I was impressed by this array of names, and hence was led to put forward the suggestion that a molecule may possibly scatter light also as a magnetic dipole or else as an electric quadrupole. Regarded purely as a theoretical proposition, I believe the idea to be sound. Spectroscopists have already shown that electric quadrupole radiation from atoms may be observed, and it seems not unlikely that several unexplained puzzles concerning the scattering of light may find an analogous solution.

"The remark in my note in NATURE of Nov. 7, 1931, reporting experimental confirmation of the idea by Venkateswaran was, however, premature. Subsequent experiments by Venkateswaran himself gave highly discrepant and puzzling results. The source of error appeared to be in the use of photographic photometry, which in the case of very faint lines is liable, if sufficient care be not taken, to give misleading results. Bhagavantam has examined the matter systematically, and his conclusion is that all earlier reports of depolarisation of scattered light exceeding 6/7 for incident natural light are to be regarded as spurious and unjustified. No genuine exception to the 6/7th rule has so far been established.

"As you are well aware, it follows from the electric dipole theory that when incident horizontally polarised light is used, all the scattered radiations must be completely depolarised. Your spectrograms with thiophene show this unmistakably to be the case, and hence must be regarded as disproving the existence of anomalous polarisation—at least in this particular case. I, however, still cherish the hope that quadrupole radiation from molecules may be detectable in specially favourable cases, and experiments with this object are being carried on here."

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Zürich, Feb. 17.

[1] *Ind. J. Phys.*, **5**, 59; 1930.
[2] *Helv. Phys. Act.*, **4**, 130; 1931.
[3] NATURE, **128**, 795, Nov. 7, 1931.

Rapid Estimation of Water-Content in Undisturbed Soil and in Bales of Cotton

AN instantaneous method for estimating the moisture content of soil, at any particular spot below the surface of the ground, even approximately, should be very useful in plant physiology, irrigation, and in soil science generally. The high dielectric constant of water suggested to me that the variations in capacity of a 'leaky' condenser permanently buried in the soil should serve this purpose.

Alternating current from a valve oscillator is convenient to use for the purpose, but a capacity-bridge (such as is marketed by Messrs. Heilan, of Frankfort) is impracticable, on account of power-losses to earth from the buried condenser. Resonance methods evade this earth effect (the circuit being symmetrical), and I have now worked out on this basis a technique which seems very satisfactory.

The buried condensers are conveniently made from glass web-tubing filled with mercury to give any desired capacity. Such double tubes can easily be made also in capillary form, and are then very sensitive: for example, a tube of 1½ mm. width externally has a capacity per centimetre of 1·5 $\mu\mu$F. in air, which rises to a 'capacity' of 6 $\mu\mu$F. per centimetre in water; with tubes of this size it is possible to examine localised details, such as the function of single roots.

The readings are but slightly affected by any variations of electrolytes above the level of minimum conductivity likely to be found in any soil. The 'capacity' indicated is predominately that of a zone only a millimetre or so in thickness around the tube, so that intimate contact with the soil is necessary; this is not a difficulty when the condenser is permanently buried in deep soil which never becomes air-dry; for other situations an artificial 'soil' of plaster can be cast round the tube, at the cost of making its responses sluggish.

The method can be used, with caution, for determining the concentration of mixtures of liquids which have different dielectric constants, such as alcohol and water: the web-tube is immersed in the liquid, and its gain in capacity subtracted from the variable condenser in parallel, until resonance is indicated by the grid-circuit galvanometer, which can all be done in a few seconds.

A further possible application is to 'works control'