

Since a dense-rare interface becomes permeable to undulatory energy if ruled with a grating, it is clear that the classical explanation³ of the production of X-ray spectra by glancing 'total internal' reflexion from a ruled glass or metal surface requires reconsideration.

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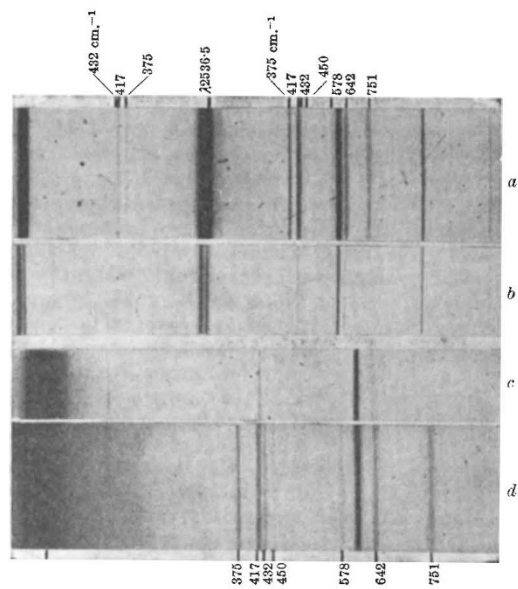
¹ Wood, R. W., "Physical Optics" (Macmillan, 1934), chapter 12, p. 418 *et seq.*, gives a summary of this work.

² Airy, G. B. "Undulatory Theory of Light" (Macmillan, 1877), par. 35, p. 33, Fig. 10.

³ Compton and Allison, "X-Rays in Theory and Experiment" (Macmillan, 1935), pp. 40 and 690.

Raman Spectrum of Alumina and the Luminescence and Absorption Spectra of Ruby

STUDIES of the Raman spectrum of crystalline alumina are rather scanty and incomplete, evidently because of its comparative feebleness and a continuous fluorescence accompanying it. Deutschbein¹, who was the first to investigate the case, recorded only a single frequency shift of 415 cm.⁻¹. Later, a second Raman line with a frequency shift of 376 cm.⁻¹ was noticed by Miss A. Mani². A subsequent unpublished investigation by the latter³ gave a hint of the existence of other faint lines besides the two already reported, among which two with frequency shifts 752 cm.⁻¹ and 633 cm.⁻¹ appeared most definite. It seemed likely that the use of the intense λ 2536.5 mercury resonance radiation as exciter would yield a much more satisfactory Raman spectrum for the substance. This hope has been realized in the present investigation. A large boule of synthetic alumina presented to Sir C. V. Raman by the Linde Air Products Co. of New York gave satisfactory results: unlike the majority of samples of synthetic alumina, this particular one did not become coloured under ultra-violet irradiation.



(a) RAMAN SPECTRUM OF ALUMINA TAKEN WITH A HILGER E3 QUARTZ SPECTROGRAPH; (d) THE SAME TAKEN WITH A HILGER E1 QUARTZ SPECTROGRAPH

(b) AND (c) COMPARISON SPECTRA OF THE MERCURY ARC

Seven Raman lines with frequency shifts 375 (8), 417 (10), 432 (4), 450 (2), 578 (3), 642 (6) and 751 (7) cm.⁻¹ have been recorded in the alumina spectrum. The figures in brackets represent rough estimates of the relative intensities of the lines. Their positions as well as frequency shifts are marked in the accompanying spectrograms. A preliminary examination of the polarization characters indicated that the lines with frequency shifts 751 and 578 cm.⁻¹ should be assigned to the symmetric class and the rest to the degenerate class of vibrations. It is satisfactory to note that these results are in accord with the theoretical work of Bhagavantam and Venkatrayudu⁴, who showed that the unit cell containing two Al₂O₃ groups has eighteen distinct frequencies of atomic vibration, of which two of the totally symmetric class and five of the doubly degenerate class should be active in the Raman effect.

The foregoing results are of interest in relation to the luminescence and absorption spectra of ruby which, as is well known, is crystalline alumina with chromic oxide impurity present as a colouring agent. The electronic transitions of the Cr⁺⁺⁺ ion are responsible for the two intense lines at 6927 and 6942 Å., as well as a few other fainter lines in the neighbourhood appearing at the same position in luminescence and absorption. Besides these, there is a host of bands appearing on both sides of the principal doublet which become sharper at low temperatures: they are then more intense on the longer wave-length side in luminescence and on the shorter wave-length side in absorption. The suggestion⁵ that these may arise from the combination of the vibration frequencies of the alumina lattice with the electronic transitions of Cr⁺⁺⁺ ions has been fully confirmed by the present investigation. In fact, nearly all the bands have been satisfactorily explained by taking account of the seven Raman frequencies as well as the lattice frequencies which are active in infra-red absorption and noticed by Coblenz⁶, Strong⁶ and Parodi⁷. The loading of the lattice by the chromium ions will give rise to a perturbation of the vibrational modes, and this would explain the fact that in fluorescence and absorption the lattice vibrations appear as diffuse bands and not as sharp lines.

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¹ Deutschbein, O., *Ann. d. Phys.*, **14**, 729 (1932).

² Mani, A., *Proc. Ind. Acad. Sci.*, **A**, **15**, 52 (1942).

³ Mani, A., unpublished work.

⁴ Bhagavantam, S., and Venkatrayudu, T., *Proc. Ind. Acad. Sci.*, **A**, **9**, 224 (1939).

⁵ Coblenz, *Investigations of Infra-red Spectra*, **5**, 17, 34 (1908).

⁶ Strong, J., *Phys. Rev.*, **38**, 1818 (1931).

⁷ Parodi, M., *C.R. Acad. Sci. Paris*, **205**, 906 (1937).

A Sedimentation Phenomenon

ONE of us (F. S.) was required some time ago to consider a proposed sedimentation apparatus for particle-size analysis, in which, for reasons beyond the scope of this note, the sedimentation vessel was to be a conical flask. Assuming the motion of each particle to be one of vertical descent, it was shown that an unstable condition would ensue. Suppose time has elapsed for particles of a specified size to fall from AB to A'B'. At this moment, no particle greater