The Polarization of Luminescence of Ruby

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THE state of polarization of the two intense red lines (λ6927 and 6947) emitted by ruby when optically excited has been investigated. I used a single crystal of synthetic ruby, cut parallel to the optic axis. This was mounted in a glass cell filled with a liquid of nearly the same refractive index as the crystal. The ruby was excited by a narrow beam of light, suitably filtered and the luminescent light was analyzed in the transverse direction.

With the optic axis of the crystal along the vertical, say along OZ, and denoting the direction of incident light by OY, and that of observation by OX, all being mutually perpendicular, I found that the red luminescence is very strongly polarized, as much as 95 percent of the intensity being due to the vibration along OY, i.e., along the direction perpendicular to the optic axis. The intensity of luminescence due to vibration along OZ, the optic axis, is extremely feeble. When the crystal is mounted so that the optic axis was along OX, i.e., parallel to the direction of observation, the intensity of luminescence due to both the vibrations, OZ and OY, is the same, both these directions being perpendicular to the optic axis. Thus it is found that the direction of vibration in nearly the whole of the red emission is confined to one definite plane in the crystal, perpendicular to the optic axis. There is no preferred direction of vibration within this plane.

The crystal of ruby is dichroic. It has a well defined absorption band (from about λ5300–5800) in the green-yellow region, when the incident light is plane-polarized with the direction of vibration perpendicular to the optic axis. There is no such absorption band shown when the direction of vibration in the incident light is parallel to the optic axis. Also there is no selective absorption noticeable for the red region. It thus appears that the process of absorption as well as of luminescence is confined to the same definite plane in the crystal—the plane perpendicular to the optic axis. Also these two processes are definitely related. For, with the exciting light plane-polarized the intensity of red luminescence is greatest when the optic axis is so oriented that the crystal has the strongest absorption for the green-yellow region.

In my previous contributions to the subject,[1,2] I have shown that the fluorescent chromium ion Cr^{+++}, in ruby which emits the sharp red lines, must be replacing in random locations the aluminum ions of the mother-lattice —of corundum, Al_2O_3. In this picture of the structure of ruby, the chromium ions which enter the corundum lattice as impurity become regular components of the lattice, being all situated along the optic axis which is the symmetry axis of the crystal. It is also shown from magnetic considerations that the L vectors of the fluorescent chromium ions must have the same fixed direction in the crystal. If this fixed direction is the optic axis, the orbital moment in all the ions would be along this direction and the electronic orbits would lie in the plane perpendicular to the optic axis. The processes of absorption and emission of light by the chromium ion would then naturally be confined to this orbital plane. The observations reported above, namely, the red luminescence being all due to vibrations in one plane of the crystal and also its dichroism are well explained on this hypothesis.

I am at present engaged in investigating other bands of ruby from this point of view and also the scattering of light in the crystal and its dichroism.

[1] B. V. Thosar, Phys. Rev. **54**, 233L (1938).
[2] B. V. Thosar, Phil. Mag. **26**, 878 (1938).

Absorption Coefficient of β-Rays

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MANY authors[1–3] have shown that the absorption of natural heterogeneous β-rays is really not exponential. They are usually more absorbable for large thickness of absorbers. Thus the mass absorption coefficient of UX_2 as measured by certain experimenters varied from a minimum[4] of $\mu/\rho = 4.1$ (in Al absorbers) to a maximum[5] of the generally accepted value of $\mu/\rho = 6.7$. It is thought that this discrepancy is possibly due to the fact that the absorption curve is not exponential, so that when the measurement was made at different thickness of the absorber, it gave different values of μ/ρ.

We have measured the complete absorption curve of UX_2 from only a few mg/cm² to the ultimate range of UX_2. It is definitely established that its entire logarithmic curve is not exactly a straight line, but can be well defined as a broken line composed of four to five segments (according to the conditions of measurement as shown below) of straight lines. (See Fig. 1.) The slope of each segment represents a definite value of absorption coefficient for a certain range of absorber thickness.

The intersection of the segments usually occurs at definite points corresponding to definite values of screen thickness, no matter what the measuring condition might be, but the slopes of the separate segments are not in-

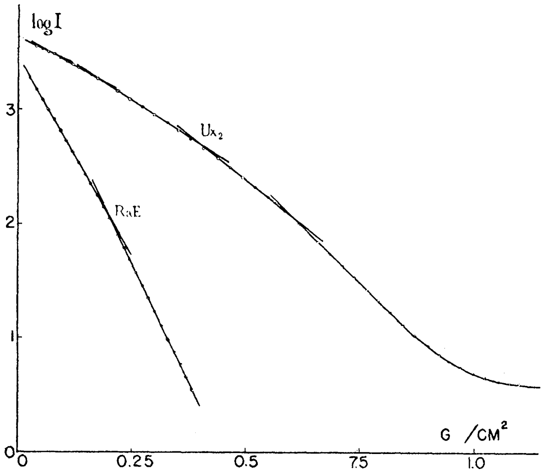

FIG. 1. Absorption of β-rays in aluminum.