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atmosphere would form, after condensation, a stratum of water the thickness of which would differ but little from 4 centims.—*Comptes Rendus de l'Académie des Sciences*, Feb. 12, 1877, tome lxxxiv. pp. 285, 286.

ON THE POLARIZED LIGHT OF THE RAINBOW.

BY PROF. J. DECHANT.

In vol. clix. of Poggendorff's *Annalen*, M. Schiel communicates the observation that the light of the rainbow is completely polarized. This fact had also previously been observed by Tyndall, in 1870, on the occasion of his journey to Algeria*; and he also states the direction of the polarization, saying, "The light of the bow could in all cases be extinguished by a Nicol's prism the greater diagonal of which was placed tangential to the arc."

The phenomenon finds its satisfactory explanation in the reflection of the light at the back of a rain drop. For, in the first place, the direction of undulation of the light which arrives at the eye from the rainbow agrees with that of the polarized light produced by reflection. If, namely, the light of the rainbow is extinguished by the Nicol with its longer diagonal held parallel to the tangent to the bow, the undulations of the light itself take place in the direction of the longer diagonal, consequently parallel to the tangent. But parallel to the tangent is perpendicular to the plane which passes through the sun, the rain drop, and the eye; hence it follows that the undulations are perpendicular to the plane of incidence.

Secondly, however, the angle under which the rays fall upon the posterior wall of the drop is not far from the angle of complete polarization; for while the latter for water in air amounts to about 37°, the former averages 40°.

Calculating according to Fresnel's intensity-formula (and taking into account the double refraction in the rain drop) the ratio of the intensities of the light whose undulations are perpendicular to, and of that whose undulations are in, the plane of incidence, we get

$$\left[\frac{\cos^2(\alpha - \beta)}{\cos(\alpha + \beta)} \right]^2,$$

where α denotes the angle of incidence of the effective rays, and β the angle of refraction. This gives for the extreme red rays ($n = 1.3317$) 24.5, and for the extreme violet ($n = 1.3448$) 34.9.

Thus the rainbow appears from 25- to 35-fold fainter when the Nicol is rotated 90° from the position in which the shorter diagonal is held parallel to the tangent of the bow—which certainly comes very near complete extinction when we consider that the secondary bow already appears tolerably faint whose intensity according to the calculation is yet only 2½-fold less than that of the primary.

Lastly, we can also indirectly, by an experiment, convince ourselves of the correctness of the explanation above given, if we try to obtain a rainbow with a liquid in which light is not so strongly polarized by reflection at the back of a drop as in water. For this purpose we first seek the exponent of refraction of the liquid with which light would be completely polarized.

* *In den Alpen*, deutsche Ausgabe, 1872, S. 382.

If β is the angle under which the rays fall upon the back of the drop, and n the refraction-exponent (from air into the liquid), then

$$\tan \beta = \frac{1}{2} \sqrt{\frac{4-n^2}{n^2-1}}.$$

But $\tan \beta$ must be also equal to $\frac{1}{n}$ if complete polarization is to enter; from this we find

$$n = \sqrt{2} = 1.414 \dots$$

We must now select a liquid whose refraction-exponent is as distant as possible from $\sqrt{2}$, consequently oil of cassia for instance, or sulphide of carbon—of which the first is more suitable for producing a rainbow, since, not to mention that its smell is less unpleasant, it more readily scatters in fine drops, which remain longer floating in the air. Calculation gives as the intensity-ratio of the light whose undulations take place perpendicular to, and of that whose undulations are in, the plane of incidence, for the red rays ($n = 1.5945$) 6.3, and for the violet rays ($n = 1.7025$) 2.8.

In fact, when oil of cassia is scattered in sunlight before a dark background by a current of air driven through a fine glass tube at right angles above another tube which dips in the liquid, a splendid rainbow is seen, the light of which cannot at any intensity be completely extinguished by the Nicol.—Poggendorff's *Annalen*, 1877, No. 1, vol. clx. pp. 123–125.

ON THE NATURE OF GAS MOLECULES.

BY LUDWIG BOLTZMANN, OF GRAZ.

Since the assumption that gas molecules behave as aggregates of material points (atoms) led to results not in accordance with experience, it has been dropped by the author, and the hypothesis is adopted that we are permitted, in calculating the push-action of the molecules, to regard as approximately rigid the aggregate which we designate as a single gas molecule, and which may consist of various corporeal and probably also æthereal atoms. He finds, on the basis of his earlier results generalized by Maxwell and Watson, that then the ratio of the heat-capacities of a gas must be $1\frac{2}{3}$ when its molecules have a spherical form. The ratio of the heat-capacities becomes equal to 1.4 if the molecules have the form of rigid solids of rotation which are not spheres, and $1\frac{1}{3}$ if they are rigid bodies of any other form whatever. These numbers appear to accord at least so far with those found by experiment, that it cannot be said that experiment furnishes any confutation of the theory thus modified. It is also pointed out that the values found experimentally for the heat-capacity of gases on this hypothesis are in satisfactory accordance with the heat-capacities of solids. It is self-evident that gas molecules cannot be absolutely rigid bodies; this is disproved by spectrum-analysis. It may be that the vibrations which give rise to gas-spectra are only brief agitations lasting during the collision of two molecules, comparable to the sound-exciting vibrations which ensue when two ivory balls strike one another.—Poggendorff's *Annalen*, 1877, No. 1, vol. clx. p. 175–6.