X. "On the Refraction of Plane Polarised Light at the Surface of a Uniaxal Crystal." By R. T. GLAZEBROOK, M.A., Fellow and Assistant Lecturer of Trinity College, Demonstrator in the Cavendish Laboratory, Cambridge. Communicated by Lord RAYLEIGH, M.A., F.R.S. Received October 27, 1881.

(Abstract.)

The paper, of which the following is an abstract, contains an experimental investigation of the relation between the plane of polarisation of light falling on the surface of a crystal of Iceland spar and the angles of incidence and refraction in the cases in which only one refracted wave traverses the crystal. A prism was cut from a piece of spar, one face of the prism coinciding almost exactly with a rhombic face, and plane polarised light allowed to fall on it at a known angle of incidence. The deviation of light of a definite wave-length in both the ordinary and extraordinary spectrum is observed, and from that and the angle of incidence ϕ we can calculate ϕ' and ϕ'', the two angles of refraction. The polariser being then turned until the ray in question disappears from the extraordinary spectrum its position is noted. A known small rotation is then given to the plane of polarisation of the incident light either by turning the polariser through a known angle, or introducing into the path of the light a cell containing a solution of sugar. This causes the reappearance of the ray in question in the extraordinary spectrum, and the spar prism is then moved, thus varying the angle of incidence until it again disappears. The angle of incidence and the deviation of the same ray in the ordinary spectrum being measured, we get a second pair of values of ϕ and ϕ' under the condition that the ordinary ray only traverses the crystal. Now if β be the angle which the optic axis makes with the edge of the prism, λ the angle between the face of incidence and a plane through the optic axis and the edge of the prism, and θ the angle between the direction of vibration of the incident light and this same edge, it follows, either from the electro-magnetic theory of light (Lorentz, "Schlömilch Zeitschrift," vol. 22; Fitzgerald, "Phil. Trans.," vol. 171, 1880), or the theories of Neumann ("Abhand. Akad. Berlin," 1835), MacCullagh ("Trans. Roy. Irish Acad." 1839), and Kirchhoff ("Abhand. Akad. Berlin," 1876), that if the ordinary ray only traverses the crystal—

$$\cot\theta = \tan\beta\cos(\lambda+\phi')\sec(\phi-\phi').$$

We are thus able to obtain a series of theoretical values of θ. The difference between two consecutive values should, if the theory be true, give us the angle through which the plane of polarisation has

been turned. There is some difficulty in determining with certainty the angle between the edge of the prism, from which θ is measured, and the principal plane of the polarising prism in any given position. We, therefore, cannot compare a series of observed and calculated values of θ with accuracy; we can, however, compare the differences between consecutive values of θ given by theory with those differences as produced by the known rotation of the polarising Nicol, or that due to the sugar cell.

Similar observations were made for the case in which only the extraordinary ray traverses the crystal; in this case, if a and b be the principal refractive indices, we have, according to the same theories,—

$$\tan\theta=\tan\beta\cos(\lambda+\phi'')\cos(\phi-\phi'')+\frac{a^2-b^2}{2a^2}\frac{\sin 2\beta\sin(\lambda+\phi'')\sin^2\phi}{\sin(\phi+\phi'')\cos^2\theta''},$$

where θ'' is given by

$$\tan\theta''=\tan\beta\cos(\lambda+\phi'').$$

Two series of observations are recorded in the paper, the one made in November, 1880, the other with new and improved apparatus in August, 1881.

The two series lead to practically identical results. Taking first the case in which the ordinary wave only is transmitted; for high angles of incidence the rate of change in the values of θ as given by theory is considerably greater than that given by experiment. When ϕ lies between 40° and 55° (about), the two agree closely, and as the angle of incidence decreases still further, there is a tendency for the experimental value of the difference to become the greater.

The differences between theory and experiment amount to 6 per cent. of the quantity measured when the ordinary wave is transmitted, and to 15 per cent. when the extraordinary wave only passes through the prism.

When only the extraordinary wave is transmitted the reverse is the case, the theoretical value is for large values of ϕ too small; for angles between 40° and 55° the two agree fairly, and for smaller angles the experimental value becomes too small. Other series of experiments lead to the same conclusions. For details as to the arrangements of the apparatus, the method of determining exactly when one ray is quenched, the probable accuracy of the results, and the effects of small errors in the constants of the formulæ or the adjustment of the apparatus, reference must be made to the paper.

The experiments were conducted by Lord Rayleigh's kind permission in one of the rooms of the Cavendish Laboratory, at Cambridge.