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Prof. A. Anderson

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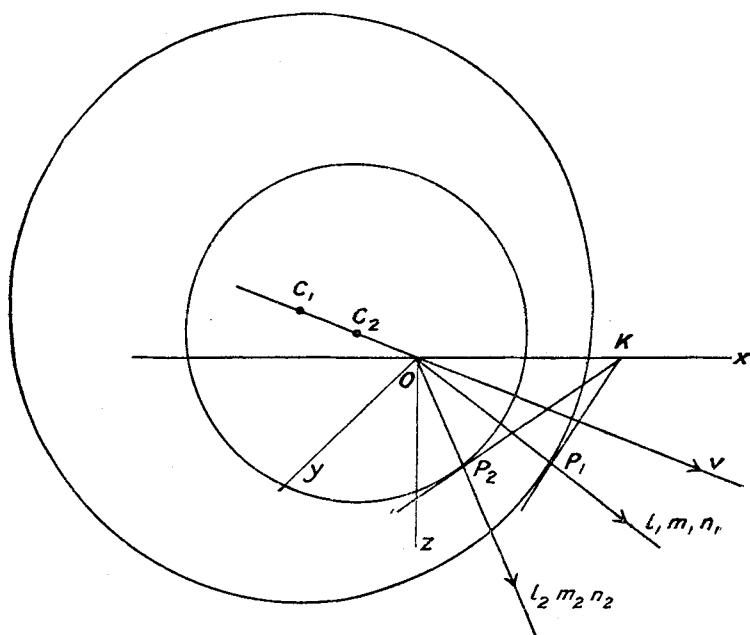


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XI. *On Fresnel's Convection Coefficient.*

By Prof. A. ANDERSON*.

THE condition that the laws of refraction and reflexion of light shall hold for media in uniform motion with reference to a supposed stationary æther, the index of refraction being independent of the velocity, has been obtained in various ways. The following method is merely an application of Huygens' construction.



Oz is the trace of the plane bounding surface of the two media which are moving with velocity v in the plane of the paper relative to a stationary æther. When $v=0$, let the velocity of light in the upper medium be c_1 and that in the lower c_2 , and suppose that in the actual case the relative velocities in the two media are given by the vector differences $c_1 - v_1$ and $c_2 - v_2$.

Let O be a point in the bounding surface, and let C_1O be the direction of v in the plane of the paper. Take $OC_1 = v_1$ and $OC_2 = v_2$, and with centres C_1 and C_2 describe spheres whose radii are respectively c_1 and c_2 . Take O as origin of

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co-ordinates, and let Ox in the plane of the paper, Oy perpendicular to the plane of the paper, and Oz be the rectangular axes. Thus the normal to the refracting surface is Oz . Draw any line through O representing the incident ray whose direction cosines are l_1, m_1, n_1 , and let it meet the sphere whose centre is C_1 in P_1 . In like manner draw another line representing the refracted ray whose direction cosines are l_2, m_2, n_2 , and meeting the other sphere in P_2 . The points P_1 and P_2 are, of course, not generally in the plane of the paper. If, now, tangent planes be drawn to the spheres at P_1 and P_2 , they must intersect in a line lying in the plane of xy .

We now assume that $v_1 = \kappa_1 v$ and $v_2 = \kappa_2 v$, and in the work squares of v_1 and v_2 will be neglected. Let the angle $xOv = \phi$.

We have $OP_1 = C_1 - v_1(l_1 \cos \phi + n_1 \sin \phi)$,

and the co-ordinates $\alpha_1, \beta_1, \gamma_1$ of P_1 are

$$\alpha_1 = c_1 l_1 - v_1 l_1 (l_1 \cos \phi + n_1 \sin \phi),$$

$$\beta_1 = c_1 m_1 - v_1 m_1 (l_1 \cos \phi + n_1 \sin \phi),$$

$$\gamma_1 = c_1 n_1 - v_1 n_1 (l_1 \cos \phi + n_1 \sin \phi).$$

In like manner the co-ordinates $\alpha_2, \beta_2, \gamma_2$ of P_2 are

$$\alpha_2 = c_2 l_2 - v_2 l_2 (l_2 \cos \phi + n_2 \sin \phi),$$

$$\beta_2 = c_2 m_2 - v_2 m_2 (l_2 \cos \phi + n_2 \sin \phi),$$

$$\gamma_2 = c_2 n_2 - v_2 n_2 (l_2 \cos \phi + n_2 \sin \phi).$$

On writing down the equation of the tangent plane at P_1 we find that it meets the plane of xy in the line

$$x \left(\frac{l_1}{c_1} + \frac{v_1 \cos \phi}{c_1^2} \right) + y \frac{m_1}{c_1} = 1,$$

and that the tangent plane at P_2 meets the plane of xy in the line

$$x \left(\frac{l_2}{c_2} + \frac{v_2 \cos \phi}{c_2^2} \right) + y \frac{m_2}{c_2} = 1.$$

We thus have

$$\frac{m_1}{m_2} = \frac{c_1}{c_2} = \frac{\mu_2}{\mu_1} = \mu,$$

where μ_1 is the absolute index of refraction of the first medium and μ_2 that of the second, μ being the index of refraction from the first medium to the second.

We have, also,

$$\frac{l_1 + \frac{v_1 \cos \phi}{c_1}}{l_2 + \frac{v_2 \cos \phi}{c_2}} = \frac{c_1}{c_2} = \frac{\mu_1}{\mu_2} = \mu.$$

If θ_1 be the angle of incidence and θ_2 the angle of refraction,

$$\cos \theta_1 = n_1, \text{ and } \cos \theta_2 = n_2,$$

$$\therefore \sin \theta_1 = \sqrt{l_1^2 + m_1^2}, \quad \sin \theta_2 = \sqrt{l_2^2 + m_2^2};$$

also $m_1 = \mu m_2$, and $l_1 = \mu l_2 + \mu \frac{v_2 \cos \phi}{c_2} - \frac{v_1 \cos \phi}{c_1}$,

$$\therefore l_1^2 + m_1^2 = \mu^2 [l_2^2 + m_2^2] + 2\mu l_2 \left(\mu \frac{v_2 \cos \phi}{c_2} - \frac{v_1 \cos \phi}{c_1} \right).$$

Hence $\sin \theta_1 = \mu \sin \theta_2$, if $\frac{\mu v_2}{c_2} = \frac{v_1}{c_1}$,
that is, if

$$\frac{\mu_2}{\mu_1} \cdot \frac{c_1}{c_2} = \frac{v_1}{v_2} = \frac{\kappa_1 v}{\kappa_2 v} = \frac{\kappa_1}{\kappa_2},$$

or if
$$\frac{\kappa_1}{\kappa_2} = \frac{\mu_2^2}{\mu_1^2}.$$

Thus, if c_1 be the velocity of light in any medium at rest in the æther, and if μ_1 be the absolute index of refraction of the medium, the sine law of refraction will always be satisfied if we assume that the velocity of light relative to the medium when moving with velocity v in the æther, is

$$c_1 - \frac{Av}{\mu_1^2},$$

where A is a constant which must be the same for all media.

Further, the condition that the incident ray, the refracted ray, and the normal shall lie in the same plane is

$$\frac{l_1}{l_2} = \frac{m_1}{m_2}.$$

Therefore

$$\frac{l_1 + \frac{v_1 \cos \phi}{c_1}}{l_2 + \frac{v_2 \cos \phi}{c_2}} = \frac{l_1}{l_2} = \frac{\frac{v_1 \cos \phi}{c_1}}{\frac{v_2 \cos \phi}{c_2}} = \frac{v_1}{v_2} \cdot \frac{\widetilde{c_2}}{c_1} = \frac{c_1}{c_2},$$

or

$$\frac{\kappa_1}{\kappa_2} = \frac{c_1^2}{c_2^2} = \frac{\mu_2^2}{\mu_1^2},$$

the same condition as before.

Thus both laws of refraction are satisfied on the above assumption.

In the limiting case when the absolute index of refraction of the first medium is unity, the expression $c_1 - \frac{Av}{\mu_1^2}$ becomes $c - Av$, where c is the velocity of light in the æther, and v the velocity of the second medium. But the relative velocity must then be $c - v$. Thus $A = 1$, and hence the velocity of light relative to any medium moving with velocity v is $c_1 - \frac{v}{\mu_1^2}$, the actual velocity being $c_1 + v \left(1 - \frac{1}{\mu_1^2}\right)$, where c_1 is the velocity of light in the medium when $v = 0$, and μ_1 is the absolute index of refraction of the medium. The case of reflexion, being a particular case of refraction, is included in the above discussion. Refraction in crystalline media can be similarly treated.

XII. *The Fundamental Law for the true Photographic Rendering of Contrasts.* By F. F. RENWICK, A.C.G.I., F.I.C.*

THE paper by Prof. Porter and Dr. Slade bearing the above title, in the July number of the Philosophical Magazine (vol. xxxviii. p. 187, 1919), on a method of deriving the relations which must hold good between the "characteristic" curves of the negative and positive materials if exact reproduction of the tones of the original subject is to be obtained, has shown me that the more general method which I adopted in treating this part of my subject in the nineteenth Traill Taylor Memorial Lecture (Phot. Journal, vol. lvi. p. 222, 1916) is not self-evident, as I had supposed.

Inasmuch as my method, unlike theirs, is not restricted to exact nor even to proportionally correct reproduction, but can be employed with equal facility for any desired relation between the original and the final copy, it is probably worthy of record.

The relations between the incident light and the effects produced in the subsequent development process are usually represented by Hurter and Driffeld's method of "characteristic curves," in which the abscissæ are values of $\log E$ (E , the exposure, being the product of intensity I and time t), while the opacity-logarithms to base 10 (generally

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