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RE-MEASUREMENT OF THE RAY DISPLACEMENT EFFECT
IN TOTAL REFLECTION

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Summary

The measurements for our paper entitled "A New and Fundamental Experiment on Total Reflection"¹⁾ were repeated with a new, highly refractive plane-parallel glass plate, and the polarization effect of the ray displacement predicted by K. Artmann²⁾ and later by C. von Fragstein³⁾ was found. Its magnitude corresponded numerically with theoretical predictions.

§ 1. The modified apparatus

The measurements were made using a plane-parallel plate 10 cm long, 3 cm high and 0.2 cm thick made of heavy flint glass ($n = 1.762$ for the 546 m/ μ green mercury line used), the end surfaces of which were bevelled off to allow the light to enter and leave. The plate was silvered above and below on both sides. Total reflection from air took place at the central strip, 0.5 cm wide, which was not silvered. The light was reflected back and forth sixty-eight times at a critical angle for total reflection of $34^{\circ}35'$. The phenomenon was observed and measured optically with a focusing screw micrometer immediately after the beam of light had left the plate.

According to the theory, the polarization effect, i.e. the splitting of the totally reflected light into two parts which are polarized at right angles to each other and differently displaced against the zero ray, increases with the square of the refractive index of the plate used. With this highly refractive plate and natural incident light, it was even possible to observe, within a narrow angular region close to the critical angle of total reflection, both parts close to each other but separated by a perceptible interval.

(This effect was not discovered during our initial experiments because observations were made at that time with the differential

method (§4 of our first paper) at a distance of $3\frac{1}{2}^\circ$ from the critical angle, where the effect is still so slight that it is lost among the errors of measurement).

§2. Measurements and Results

A large number of measurements (some 200) were made with linearly polarized light, starting at $30'$ from the critical angle and continuing virtually up to the critical angle for total reflection itself (up to about $1'$ from it). The ray displacements were plotted on a graph as a function of the angle of incidence, and averaged out.

In the region from $30'$ to $20'$ from the critical angle, our constant k for the portion of the light polarized parallel to the plane of incidence was

$$k_{//} = 0.60 \pm 10\%$$

and for the portion polarized perpendicularly to the plane of incidence

$$k_{\perp} = 0.20 \pm 10\%$$

This part of our measurements falls within the limits of validity of Artmann's theory, according to which $k_{//} = 0.56$ and $k_{\perp} = 0.18$. Within the limits of experimental error, therefore, it corresponds to theoretical predictions. From $20'$ to close to the critical angle (that is to say, within the range in which the theory is no longer valid), neither k value remains constant. The values for k found for various angular distances ($\varphi - \varphi_G$) from the critical angle are set out in the table below:

$\varphi - \varphi_0$ angular distances	$k_{//}$	$k_{\perp}$
30'	0.60	0.19
25'	0.58	0.20
20'	0.63	0.21
15'	0.66	0.24
10'	0.76	0.27
5'	0.87	0.33
1'	0.61	0.32

all figures to an
accuracy of about 10%

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Footnotes

- 1) F. Goos and H. Hänchen: Ann. Physik (6) 1, 333 (1947).
- 2) K. Artmann: Ann. Physik (6) 2, 87 (1948).
- 3) C. v. Fragstein: Ann. Physik (6) 4, 271 (1949).