Experimental Physics II - Report 1
The Fresnel Relations

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1 Introduction

1.1 The law of reflection and Snell's law

When light hits the interface between two media of different refractive indices n_1 and n_2, both refraction and reflection of light can occur. The law of reflection, equation (1), and Snell's law, equation (2) give the angles of reflection and refraction for given angle of incidence and refractive indices.

$$\theta_{incidence} = \theta_{reflection} \tag{1}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \tag{2}$$

TILFØJ EN FIGUR MÅSKE

1.2 Polarization

Light consists of mutually perpendicular oscillating electric and magnetic fields. The orientation of these oscillations is called the polarization of light. Unpolarized light consists of fields oscillating in all possible orientations, however any polarization can be broken into a combination of two orthogonal linear polarizations, i.e. if we can determine the behavior of light of each linear polarization, we can describe the behavior of light of any (complicated) polarization.

Typically these orthogonal linear polarizations are chosen to be so-called s- and p-polarized light. The plane spanned by the incoming beam of light and the normal vector of the surface at the point of incidence is called the plane of incidence. If the polarization of the light is parallel to the plane of incidence, it is p-polarized. If the polarization of the light is perpendicular to the plane of incidence, it is s-polarized.

TILFØJ EN FIGUR MÅSKE

1.3 The Fresnel relations

We are interested in the intensities of transmitted (refracted) and reflected light for s-polarized and p-polarized light respectively. The Fresnel relations give the amplitudes of transmitted and reflected light for the two polarizations, and from these one can find the corresponding intensities:

$$R_p = \frac{\tan^2(\theta_1 - \theta_2)}{\tan^2(\theta_1 + \theta_2)} \tag{3}$$

$$T_p = \frac{\sin 2\theta_1 \sin 2\theta_2}{\sin^2(\theta_1 + \theta_2)\cos^2(\theta_1 - \theta_2)} \tag{4}$$

$$R_s = \frac{\sin^2(\theta_1 - \theta_2)}{\sin^2(\theta_1 + \theta_2)} \tag{5}$$

$$T_p = \frac{\sin 2\theta_1 \sin 2\theta_2}{\sin^2(\theta_1 + \theta_2)} \tag{6}$$

Here R and T are the intensities of reflected and transmitted light and the indices s and p stand for s-polarized and p-polarized light.

1.4 Brewster's angle and the critical angle

For p-polarized light, there exists the so-called Brewster's angle, at which there is no reflected light. Brewster's angle is given by $R_p(\theta_B) = 0$. There is no reflected light, when $\theta_1 + \theta_2 = \frac{\pi}{2}$. From Snell's law we then have:

$$\begin{aligned} n_1 \text{sin}\theta_B = n_2 \text{sin}(\frac{\pi}{2} - \theta_B) = n_2 \text{cos}\theta_B \\ \text{tan}\theta_B = \frac{n_2}{n_1} \\ \theta_B = \text{arctan}(\frac{n_2}{n_1}) \end{aligned} \tag{7}$$

When light transitions from a medium of higher refractive index to one of lower refractive index there exists the critical angle for total internal reflection, i.e. no transmitted light. This occurs for both s- and p-polarized light. This angle, θ_C follows directly from Snell's law with $\theta_2 = \frac{\pi}{2}$:

$$\theta_C = \text{arcsin}(\frac{n_2}{n_1}) \tag{8}$$

1.5 Experiment FIND BEDRE TITEL

In case one knows the refractive index of one medium and can measure the four intensities of reflected and transmitted light for the two polarizations respectively as a function of the angle of incidence, one can determine the refractive index, Brewster's angle and the critical angle for the given second medium. This will be further discussed in the following section.

INDSÆT MÅSKE FIGURER DER VISER GRAFER FOR INTENSITETER OG DE SPÆNDENDE VINKLER.

2 Experimental setup

2.1 Equipment

2.2 Method

3 Results

4 Discussion