Reflection, Transmission and Fresnel's Coefficients*

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Brewster's angle is the angle of incidence at which ***p*** polarized light is perfectly transmitted through a transparent dielectric surface such as glass, without any reflection. In this experiment, you will find the Brewster's angle by measuring the reflectance of a glass slide for ***p*** polarized light. You will also measure the reflectance for ***s*** polarized light and light polarized at 45° with respect to the incidence plane. Furthermore, Brewster angle will be used to calculate the refractive index of glass.

Essential pre–lab reading: "*Physics of Light and Optics*" by Justin Peatross and Michael Ware, Brigham Young University, 2013; (Chapter 3: Reflection and Refraction, Sections 3.1 to 3.4).

1 Test your understanding

1. Derive Fresnel's reflection and transmission coefficients for ***s*** and ***p*** polarized light. Let's call these coefficients r_s, r_p, t_s and t_p.
2. Use MATLAB (or a software of your choice) to plot the following quantities for air–glass interface as a function of the incident angle. Use $n_i = 1$ for air and $n_t = 1.6$ for glass.
   (a) r_p and t_p.
   (b) R_p and T_p, where $R_p = {r_p}^* r_p$ and $T_p = {t_p}^* t_p$.
   (c) r_s and t_s.
   (d) R_s and T_s, where $R_s = {r_s}^* r_s$ and $T_s = {t_s}^* t_s$.
3. On our website, you are provided with a simulation named *reflectance.m*, which shows the effects of changing the refractive index and the polarization on R. Use this simulation to further investigate the relation between these entities.

2 The Experiment

The setup includes a HeNe laser which emits unpolarized light of 633 nm wavelength. The unpolarized light passes through a linear polarizer and then a half–wave plate (HWP). Orient

the HWP such that the light coming out of it is ***p*** polarized. To make sure that the light is ***p*** polarized, follow this technique: `https://goo.gl/zGxphV`. Now, this linearly polarized beam will pass through an iris and fall on a glass slide of some unknown Brewster angle.

Q 1. Why are we using an iris in this setup?

This glass slide is mounted on the second level of a two–level rotation mount. The reflected beam is measured by a photodetector which is mounted on the first level of rotation mount. The photodetector outputs current proportional to the light intensity, which is first converted to voltage by an I–V converter and then displayed on a multimeter, as shown in Figure 1.

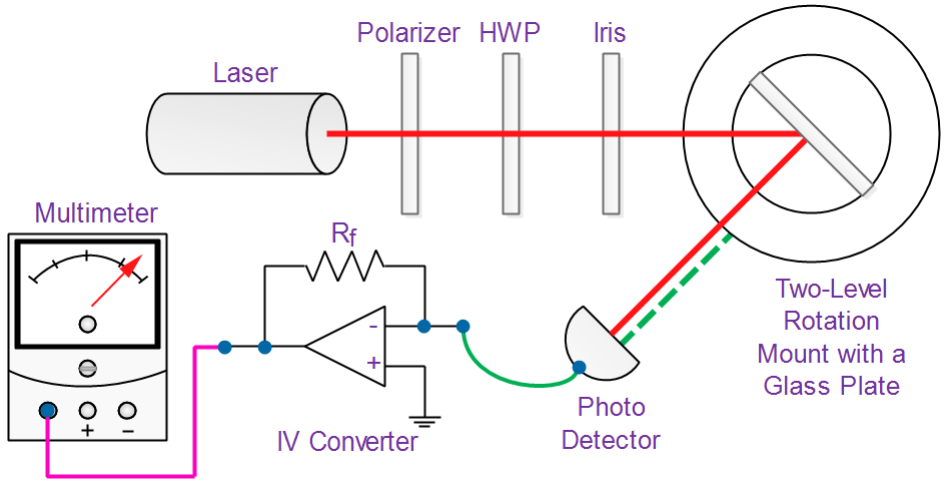

Figure 1: Schematic of the experimental setup. The red line represents the conceived path of the laser beam.

Q 2. Using the arrangement of Figure 1, find the reflectance curve for ***p*** polarized light and use it to determine the Brewster angle. Determine the uncertainty as well.

Orient the HWP to obtain ***s*** polarized light and then, in another experiment, 45° linearly polarized light. If the incident linear polarization makes an angle θ with the *fast axis* of the HWP, the polarization of the outgoing beam is rotated by 2θ. Therefore, you can now obtain ***s*** or 45° polarizations from ***p*** polarized light by rotating the HWP through 45° or 22.5° respectively.

Q 3. Find the reflectance curves for 45° linearly polarized and ***s*** polarized light.

Q 4. Why are we using a HWP and not just rotating the polarizer to achieve the required polarization state?

Q 5. Reflectance can only have values from zero to one. Therefore you need to normalize your data. At some suitable angle (e.g. 20°), use the theoretically calculated value to normalize your data. Then plot your results superimposed with theoretically calculated curves. Include uncertainty bars with your data.

Q 6. Find Brewster's angle and refractive index of the glass sample. Quote the uncertainty in your results.