SPRING BREAK EXPERIMENT

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INTRODUCTION

In this experiment I sought to learn about the polarization of light from the sky as well as the reasons it is polarized in such a way. I also desired to explain the ring of light phenomenon observed when viewing the surface of water from a fully submerged position using my knowledge of waves and optics.

RESULTS

Polarization of Sunlight:

In this section, I used a single polarizing filter and a sheet of paper to view the amount of light intensity shining through the polarizer. During my observations which took place around 2:15 pm, the sun was at an angle of roughly 30 degrees with respect to the directly overhead position. I first moved the polarizer through a variety of orientations and relative angles to the sun’s position and noticed that the light intensity onto the paper varied considerably depending on the relative position of the polarizer to the sun. Based on this dependence of transmitted intensity on relative position, I concluded that the light from the sky is not unpolarized even though I knew that the light directly emitted from the sun is indeed unpolarized. From here, I tried to qualitatively determine the direction of maximum polarization of the sunlight by searching for the position of minimum transmitted light intensity to the paper, which would indicate that the polarizer is absorbing a great deal of the light. I found this minimum of intensity when I positioned the polarizer such that it was parallel to the direct light rays, or in other words the normal vector to the polarizer surface was perpendicular to the direct light rays. I concluded that light is most strongly polarized at a 90-degree angle to the sun.

The explanation for this result is that the air molecules of the atmosphere act as a (non-ideal) polarizer since each molecule in the air can scatter incident light by 90 degrees, producing strongly polarized light at certain positions. The incomplete nature of this polarization can be accounted for by the existence of dust, clouds, and other scattering elements in the air, inexact scattering angles of the molecules, and multiple scattering effects. Light that is single-scattered would be partially polarized while light that is multiply-scattered could end up unpolarized.

Ring of Light:

In this portion, I came up with an explanation for the effect behind why an underwater observer only sees a disc-shaped region of what is above the water when looking up at the surface. The reason for this is that by Snell’s Law, light that travels from the water towards the air can pass through the surface at angles less than the critical angle, but is totally internally reflected at angles greater than the critical angle so that anything that lies wider than the critical angle with respect to the vertical axis above the observer is not visible from beneath the surface. Based on the indexes of refraction of air and water, 1 and 1.33, respectively, the critical angle can be calculated to be 48.7 degrees, which leads to the result that light reaching the submerged observer all comes from a disc on the surface equivalent to the base of a cone with its vertex at the observer and its base at the surface with vertex angle of roughly 97.4 degrees.

SUMMARY

I successfully determined the nature of the polarization of sky light using a single polarizer in this experiment. I also determined that the partially polarized sunlight has maximum polarization at positions perpendicular to the rays of direct light. These results match the theoretical predictions I learned from the lab section as well as the established result for the polarization of the sky’s light. I was also able to explain the underwater ring of light phenomenon using an application of Snell’s Law. In doing so, I successfully completed my goals outlined in the introduction. A question for a future experiment could be the effects of sunlight polarization at varying times of day, such as sunrise, sunset, and high noon.