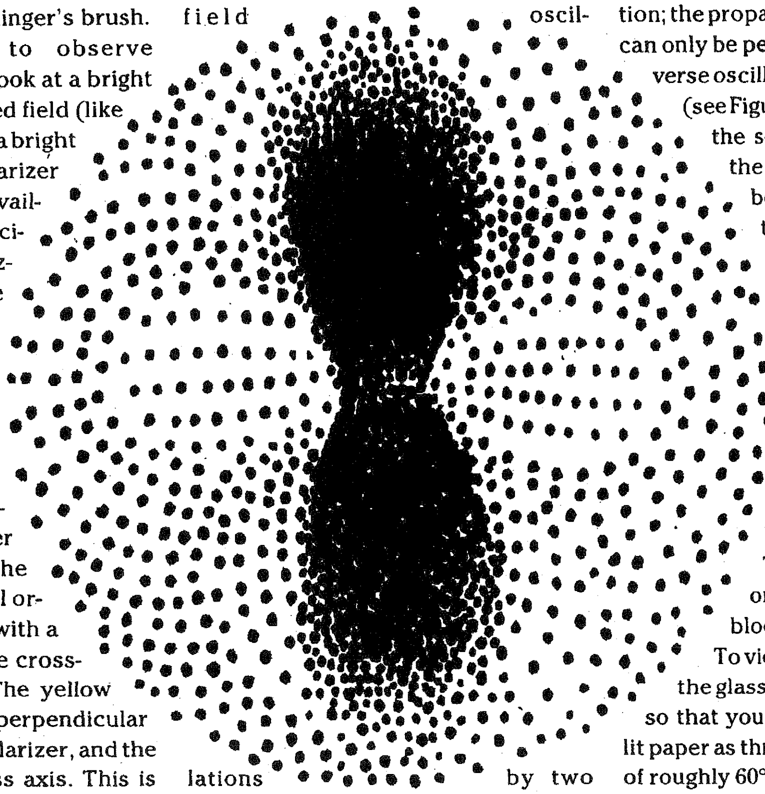
# Haidinger's brush

It is commonly appreciated that light in the sky is partially polarized and that some insects (*e.g.*, honey bees) use the polarization for cues in navigation. It is less well appreciated that our eyes can also detect polarized light and that we can distinguish the azimuth of linearly polarized light under rather common circumstances. The accompanying visual effect is called Haidinger's brush.

The easiest way to observe Haidinger's brush is to look at a bright and uniformly illuminated field (like a white sheet of paper or a bright sky) through a sheet polarizer (*e.g.*, "Polaroid HN-32," available through Edmund Scientific catalog, or polarizing sunglasses). Rotate the polarizer and gaze at the most uniform region of the background. It may take a few minutes the first time, but you will eventually notice a small, dimly colored pattern in the center of your visual field. The pattern consists of a dull orange or yellow "brush" with a similar pale blue feature crossing it (see Figure 1). The yellow brush will be oriented perpendicular to the pass axis of the polarizer, and the blue parallel to the pass axis. This is Haidinger's brush. It is attributed to the dichroism of the yellow spot of the retina.[1]



## Glass slab polarizer

If sheet polarizer is unavailable, you can generate your own polarized light using a slab of glass or plastic and an incandescent light bulb. The surface of the block of glass or plastic should be flat and polished so that it is quite shiny and relatively scratch-free. A microscope slide is suitable. If the reflections from the back side interfere with your observations, it will help to paint the back black.

Now consider the light emanating from the bulb. The propagation of light can be described as a wave motion. The wave is an electromagnetic field that oscillates transverse to the direction of propagation. We represent all of the field oscillations by two "polarizations"—one parallel to ("p"-light) and the other perpendicular to ("s"-light) the plane described by the normal to the interface and the incoming ray. These are shown in Figure 2.

The vibrations of the optical field drive electrons that are loosely bound to the atoms in the glass into an oscillatory motion. In an isotropic medium like glass or plastic, the motion of the electrons follow the oscillations of the optical field. After being driven into oscillations by the incoming optical field, the electrons reradiate light to generate transmitted and reflected light. Both the transmitted and reflected light will, in general, consist of both p- and s-light. However, reflected p-light will not be observed when the block is oriented so that the radiating electrons happen to be oscillating along an axis that is parallel to the direction of the reflection; the propagation of the optical field can only be perpendicular to the transverse oscillations of the optical field (see Figure 2). On the other hand, the s-light can be radiated in the direction of the reflected beam. The result is that the reflected light is completely s-polarized. The angle of incidence for which this occurs is called the "Brewster angle," which increases with the refractive index of the glass block. In a typical glass, it occurs about 60° from the surface normal. Therefore, we can use an ordinary glass or plastic block as a polarizer.

To view Haidinger's brush with the glass block, position the block so that you are viewing the brightly lit paper as through a mirror at an angle of roughly 60°. Rotate either your head or the glass block about the axis shown in Figure 2 and again you will see the Haidinger's brush. It is a little harder to see because not all of the light incident on the block will be exactly at the Brewster angle, but one can pick it out easily after a little practice.

## Polarization of the sky

One might expect to see Haidinger's brush when directly viewing a clear, haze-free sky, since light from the sky is also partially polarized. However, in practice one sees the micro-organisms in one's aqueous humor much more readily than the brush. If you're willing to work at it, it is best to try when the sun is near the horizon. Looking straight up toward the zenith, rotate your head and look for a faint marbling appearance near the center of your field of vision. Your neck is likely to get tired before you convince yourself that you are indeed seeing the brush, and you may need to try for a couple of days. However, those persistent enough will observe the yellow brush roughly parallel to the line connecting the spot of sky overhead and the sun. The effect is subtle and the pattern seems to fade when standing still.

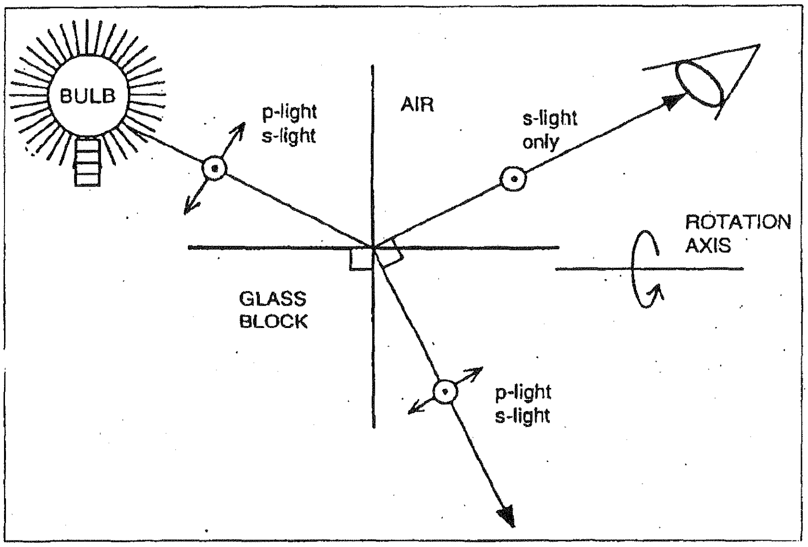



Figure 2. Geometry for using the Brewster angle to view the Haidinger brush. Rotation of the block or one's head should be about the axis shown.

It is necessary that the sky be free from haze. Light scattered from fog and haze and clouds is essentially unpolarized. Indeed, photographers frequently use polarizers to dim the sky background with respect to the clouds for enhanced contrast effect. By the same token, polarizers can be used to diminish the reflected light off windows of buildings.

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**Reference**

1. M. Minneart, *The Nature of Light and Color in the Open Air*, Dover Publications, New York, 1954.

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