MITOCW | Optics: Scattered light in a dielectric | MIT Video Demonstrations in Lasers and Optics

PROFESSOR: In this demonstration, I'm going to illustrate one or two interesting properties relating to the propagation of light in a dielectric. The setup is very simple. Here we have a plane polarized laser, helium-neon laser. Here's the beam from the laser. We reflect it by this mirror into a quarter-wave plate.

Now, over here, the light is circularly polarized. Then we pass the circularly polarized light through a polarizer over here, so that, as we rotate the transmission axis of the polarizer, we can generate linearly polarized light over here, with different planes of polarization. For example, when the arrow or the transmission axis or the polarizer is horizontal, we have horizontally polarized light, plane polarized light. And when the arrow is vertical, for example, we have plane polarized light in the vertical plane.

So this polarized light enters this dielectric cylinder here. Normally, one would use a piece of glass. But in this case, I'm using a piece of lucite, because I have a piece of lucite available. And then the light, after passing through the lucite cylinder, goes off onto the wall.

So, now, what I'm going to do is change the polarization of light and look at the light scattered from the rod. First of all, if we take a close look at the rod, we can see-- in fact, we can see very little. We can see a hotspot over here. That's the reflection at this boundary-- Fresnel reflection. And we also see a hotspot over here, which is the reflection at the exit face of the rod.

We don't see any light-- any beams of light-- leaving the cylinder at any other angle. However, what we do see-- and I hope you can see it-- is a faint streak marking the direction of the laser beam in the rod. This is due to Rayleigh scattering in the material.

Now, let's look at the polarization of the Rayleigh scattered light in the material. Now, in the insert, you see that the polarization of the light is vertical, and the camera is looking in a horizontal direction at the scattered light. Here you see-- you make out there is some red light. Now, when I go to horizontal polarization, see that the scattered light is extinguished. When I go back to the vertical polarization, linearly polarized light in the vertical plane, you see that the light comes back, and you can see it. But I know that this is not a great display, so what we'll do now, we'll turn down the lights so we can see the effect much better.

Now that the room lights are dimmed, we can see the effect much better in the lower part of the screen. In the upper right-hand corner, you see the polarizer being rotated-- or the transmission of axis of the polarizer being rotated-- so that we can select any plane of polarization we want. In this case, with a vertical arrow, we have vertically polarized light going into the lucite rod. Then you see that the scattered light is pretty bright.

Now, watch carefully. As I rotate the plane of polarization of the light, of the incident light, you can see that the scattered light is getting extinguished. In fact, when I have plane polarized light in the horizontal plane, I see very little scattered light.

Let's do it again. Let's go back to the plane polarized light in the vertical plane. And you see a lot of scattered light. And where the horizontal plane, when incident light is polarized in the horizontal plane, you see very little scattered light. Remember, the camera is looking from this side of the lucite too.

In summary, we've seen one or two interesting properties relating to the propagation of light in a dielectric material like a piece of lucite. We saw that the scattered light from the beam within the rod varies with the incident polarization. And we're leaving it to you to explain that when the incident polarization is plane polarized in the vertical plane, we saw a lot of scattered light when we looked from the side. And when the incident polarization was plane polarized in the horizontal plane, we saw almost no light at all scattered from the beam within the rod. So this is left to you to explain.