PROFESSOR: In a previous demo, we studied how light is reflected and transmitted at a dielectric interface or a piece of glass. In that demo, we studied the air-glass interface. In this demo, we're going to do it the other way around. We're going to look at reflection and transmission of light at, again, a glass interface. But we're going to come in from the other side and look at the glass-air interface.

The setup is here. We have a helium-neon laser. Here's the beam from the laser. We're going to reflect it by this mirror and passed it through a quarter-wave plate. Now, the purpose of this quarter-wave plate is to make the light in this region circularly polarized, so that when we pass it through a polarizer, the light out here can be changed in polarization by simply rotating the polarizer here-- by rotating the transmission axis of the polarizer. And the white arrow indicates the transmission axis of the polarizer.

We could have also done this using a polarizer and a half-wave plate. But then, when you rotate the half-wave plate, the polarization changes by twice the angle. So for you, the viewers, you will get confused. Here, it's simpler because we you can see that indeed we can rotate the polarization by 90 degrees just by watching this arrow. And in addition, the intensity here will also remain constant, even though the polarization is being rotated by 90 degrees.

Now, this plane-polarized beam now impinges at the interface. Now in this case, we have a prism. And the light coming into the prism will enter at this surface and then impinges at this interface. And this is our glass-air boundary. And then, the transmitted beam will come out in this direction. And the reflected beam will come out in this direction. Let me illustrate this.

Here's the transmitted beam that hits the circular screen. And here is the reflected beam for a certain angle of incidence. And when I mention angle of incidence, I mean the angle of incidence with respect to the glass-air interface. And as I vary the angle of incidence, you can see that the transmitted beam will vary in angle, and the reflected beam will vary in angle.

The interesting thing about the transmitted beam is that as I increase the angle of incidence to about 41 degrees-- if you watch the spot on the screen, as I bring it to 41 degrees-- the spot disappears. That means I've reached the critical angle. And at that angle, we get total internal reflection. And the transmitted beam gets extinguished. And all the light comes out along the reflected beam.

What's interesting about total internal reflection, or just before that, is that the beam itself-- let's go back just a little bit before total internal reflection-- the beam comes out right along the surface of the glass. And in order to demonstrate this a little bit better, I'm going to set up a little better way of observing this. And I'm going to place this screen on this rail, so that I can move it right along the rail. So you can observe where the beam comes out from the glass, which is about here.

And then, as I move it out, you can see that the beam, the transmitted beam, is coming out at an angle, as you observe it move along the surface of the card. So this is then the transmitted beam at an angle of incidence that is smaller than the critical angle. As I approach the critical angle, the beam should-- whoop, too much-- the beam should travel pretty much along the surface of the glass.

So now, as you can see, I have the card right where the spot is on the glass. And now, I'm going to move it along the surface of the glass. And you can see that this spot essentially hugs the surface of the glass. Let's do it again. And here, you can see that the spot hugs the surface of the glass and goes on to the screen.

Now, we're going to look at the reflected beam which is this one over here. Since the intensity of the reflected beam varies as a function of angle of incidence, what we'll do, we'll dim the room lights a little bit, so that we can get a better look at the variation intensity of the reflected beam.

Now that the room lights are dim, and as we make a few camera adjustments to enhance the effect, we're ready to observe the intensity of the reflected beam as a function of angle of incidence. Let me remind you, here is the transmitted beam. And here is the reflected beam. So let's go to zero angle of incidence around about here. Now, let me remind you that the polarization is in the vertical plane or S polarization.

Let's look at then the reflected beam as I increase the angle of incidence. And what you see that the intensity increases slowly and then, a little bit faster here until I reach the critical angle. And around the critical angle, you also observe that the transmitted beam is just about ready to be extinguished, or it is extinguished. And all the intensity is in the reflected beam and stays high, supposedly 100%, all the way to an angle of incidence of 90 degrees.

Now, we go back, back, and the intensity stays constant until we reach the critical angle. And from here, the intensity starts to go down all the way to 4% at zero angle of incidence. So that was for S polarization. Now, I'm going to change the polarization P polarization, or polarization in the horizontal plane. Let's go and look at the intensity of the reflected beam, starting from zero angle of incidence. And as I increase the angle of incidence, you can see now that the intensity is starting to drop, while for S polarization is starting to increase.

In here, again, for P polarization, the intensity drops until an angle of 33.5 degrees, which is the Brewster angle for glass-air interface. The intensity goes to zero. And then, it starts to pick up again for angles bigger than 33.5. And you can see, it picks up intensity very fast.

And as we get close to the critical angle, intensity is pretty high. And then, at the critical angle, you can see the spot on the left has been extinguished. That's the transmitted beam being extinguished. All the light is in the reflected beam, and it stays like that until we reach an angle of incidence of 90 degrees.

Let me go back now an angle. The intensity stays constant until we reach the critical angle. Then, intensity starts to drop, and drops to zero at the Brewster angle, and picks up again on the other side. Now let me go back to the Brewster angle. It's zero. And let me now change the polarization to S polarization and show you that intensity picks up for S polarization. And now, I will go back to P polarization to extinguish this spot.

In summary then, we have shown how the intensity of light varies at the glass-air interface, the reflected beam, and also for the transmitted beam. We have shown how we have a Brewster angle for P polarization at 33.5 degrees. And we have also shown that for the transmitted beam, at the critical angle, the beam runs right along the surface of the glass.

Now, we're going to look at the polarization or the state of polarization of the reflected beam and also the transmitted beam as a function of the state of polarization of the incident beam. But before we do this, we have to make a few adjustments to our setup.