MITOCW | Optics: Polarization of Light and Polarization Manipulation; Linear polarizer

SHAOUL EZEKIEL: In this demonstration, we're going to determine what the state of polarization of this laser is. This laser is a helium neon laser. It's a little bit more powerful than the normal ones we see, for example, in supermarket checkout counters. The light coming out is about 35 milliwatts. And you can see the beam here along this path.

We're going to analyze the state of polarization of the laser with this polarizer. And the light transmitted through the polarizer, as you can see here, will be reflected by this mirror and then will be reflected again by this mirror. And then we let the spot hit the screen. So then the purpose of this test is to rotate the plane of polarization or the transmission axis of the polarizer to find out whether the polarization of the laser light is indeed plane-polarized or not.

So now, while we look at the spot on the screen, let me start rotating the plane of polarization of the polarizer or the transmission axis, if you want, of the polarizer. And we start in the vertical position. And then we'll start rotating as we observe the spot on the screen.

As you can see, the intensity gets weaker and weaker until it is-- if you watch carefully, until it's completely extinguished. And here, you notice that the arrow is about 90 degrees away from where we started out. And this shows-- let's do it again.

We can go here to the vertical position-- lot of light coming out. And now we go to the horizontal position and extinguish the light. At least to the eye, it looks pretty much complete, which shows that the state of polarization of this laser is plane-polarized. And the axis or the plane of polarization is indeed established by the transmission axis of the polarizer, which is, in this case-- is shown to be vertical by the vertical arrow.

Some of you may have noticed on the screen a secondary weak spot near the main one and probably wondered where it's coming from. It's not coming from the laser. And you can show that by rotating the polarizer. And you see that indeed, the spot rotates with the polarizer, which is-- which means that it's probably coming from internal reflection within the polarizer. So it's nothing to be concerned about.

Spot on the screen is not very clean-looking. And there's a lot of fuzz and fringes and what have you around-- surrounding the spot. Again, this is not inherent to the laser. This is due to the fact that the laser beam had to go through some optics, like the output mirror of the laser, the polarizer, the two mirrors. And that's where you're getting the corruption. We can easily clean that up with a technique called spatial filtering, which we will demonstrate later.

Now, I'd like to show how easily one can corrupt the plane of polarization of laser light. And what I'm going to do here is take this polarizer out from here, let the laser beam hit this mirror and hit the second mirror, and let the spot go onto the screen. And now I would like to analyze the state of polarization not as I did before, close to the laser, but over here after the two reflections. And again, if the state of polarization has not been corrupted by the reflection through these two mirrors, then we would be able to extinguish the laser beam as it goes through the polarizer.

So let's see now as we look at the spot on the screen and then I rotate the transmission axis of the polarizer-- let's see if we can extinguish the laser beam. So I keep turning now, getting close to the orthogonal position. And you'll see that I go through a minimum. And I cannot extinguish it the way I could in the previous-- when the polarizer was close to the laser.

So what this shows-- that it's very easy to corrupt the polarization of the laser. So it means that if we go through many components, we have to then place a polarizer, like this one, to establish the state of polarization after going through all these components. And the state of polarization will be established then by this polarizer.

Now, just to make sure that indeed we do have perfectly polarized light, plane-polarized light, what I'm going to do is analyze now the polarization of the light coming out of this polarizer by means of a-- yet another polarizer, which, again, used as a polarization analyzer-- and you can see the arrow here, again, is along the transmission axis of the polarizer. And if I now rotate the transmission axis of the polarizer-- and then we'll see whether I can extinguish the light coming through this polarizer. And as you can see, I can extinguish it now because it's been established by this polarizer.

So the conclusion of all this is that if laser light, plane-polarized laser light, is passed through many optical components, the polarization or the state of polarization will be corrupted. And therefore, we have to use another polarizer to re-establish the state of polarization.