MITOCW | Optics: Half-wave plate | MIT Video Demonstrations in Lasers and Optics

SHAOUL EZEKIEL: In this demo, we're going to show how we can rotate the plane of polarization of light using a half-wave plate. We're going to use this setup. We have a helium neon laser. You can see the output of the laser is here. And then we're going to reflect the laser off this mirror and then reflect it again off this mirror, pass it through this polarizer here, and then let the light fall onto the screen.

The polarizer here establishes the state of polarization of light, regardless of what the state was before. And the little arrow here is the axis, the transmission axis, of the polarizer. So the light here is then-- the polarization of it is established by the transmission axis of this polarizer.

Now, before we rotate the plane of polarization, we want to first analyze the state of polarization of the light. So we have a means of checking on what we're doing to the state of polarization. We do this. We do this with this polarizer acting so-called analyzer.

Again, the arrow labels the transmission axis of this polarizer. And, to establish that indeed the polarization coming in of the light is plane-polarized, we get a null when the arrow is in the horizontal direction, which means that the light coming in is plane-polarized and, also, that its axis, its axis, polarization axis, is perpendicular to the horizontal, which means it's along the vertical.

So now, if we look on the screen, we can get maximum transmission around vertical and close to zero around horizontal. So now we've established the plane of polarization of the light here.

Now we would like to rotate the plane of polarization using a half-wave plate. Here is the half-wave plate, which we now will place right in here. And, as we know, half-wave plates have two principal axes. And, if the light propagates along either principal axis, the polarization of the light is unaffected. That means there's no rotation of the plane of polarization.

So let's check on that. Let's first place this arrow, which is lined up with one of the principal axes of the half-wave plate, and let's check, indeed, with the analyzer that, indeed, that the polarization is not rotated when we are aligned along the principal axis. Again, let's rotate it to find null, and here is null. And you can see that null is, again, when the arrow of the analyzer shows horizontal, which means that the plane of polarization is really vertical.

Now let's check-- while we're here, let's check on the other propagation along the other principal axis, which is 90 degrees away from this one. So let's go find horizontal. Let's say it's around here. Let's check again where null is. And you can see that null is again in the same place when the analyzer is showing horizontal, which again means that the plane of polarization is in the vertical direction.

All right, so we established that there's no rotation when propagating along the two principal axes of the half-wave plate. Now let's demonstrate rotation of the polarization using this half-wave plate. So let me now set it at let's say around 45 degrees or so with respect to the vertical axis.

Let's now go to the analyzer and see what happened to the state of polarization. Again, let's track the null. And I'll keep rotating the analyzer until I find null. Here it is. Here it comes. Here's null.

Now what does that mean? It means that the light here after the half-wave plate is plane-polarized and that, indeed, the plane of polarization is along the horizontal direction because the block axis or the null axis is vertical. So it means that we've rotated the plane of polarization from the original one, which was along here, to the horizontal one, which means by 90 degrees, using the half-wave plate.

So the thing that you want to notice is that, when the half-wave plate is rotated by 45 degrees, the polarization, the state of polarization, is-- the plane of polarization is rotated by twice that, by 90 degrees. And the interesting thing about the half-wave plate, using a half-wave plate, is that the peak intensity-- and now let me get the peak intensity here. The peak intensity does not drop with rotation or polarization.

For example, if I decide to rotate by a smaller amount, like this, again, let's establish the state of polarization. Again, null now is no longer pointing below, but is pointing at this angle here, which means that the plane of polarization is different. And then we go see what the peak value of the transmitted light is, which is around here somewhere. And you can see that the peak value has not dropped.

So the conclusion of this is that a half-wave plate or at least a good half-wave plate can rotate the plane of polarization from 0 to 90 degrees without any loss of intensity.