SHAOUL EZEKIEL: In this demonstration, we're going to show a simple way of rotating the plane of polarization of laser light from zero degrees to anywhere to 90 degrees using simple techniques, for example, by the use of polarizers. The setup that we're going to use is here.

We have a laser, helium neon laser. And here is the beam of the laser light. We're going to reflect it off this mirror and then reflect it again off this second mirror. And then we'll go through a polarizer. And then the light coming out of the polarizer will go onto the screen.

The purpose of this polarizer is to establish the state of polarization of the light coming out of the polarizer. If the polarizer is any good, the state of polarization after the polarizer should be plane polarized. Now the little arrow here labels the transmission axis of the polarizer, which means that the state of polarization of the light then is aligned with that arrow.

Now let us show, indeed, that the state of polarization of that polarizer is indeed as we said it was. So we take another polarizer. And we put it over here. Again, the arrow labels the transmission axis of this second polarizer. Now, when I have the arrow vertical, the same as in this case, the light is around its peak value. It's very difficult for us to see what's happening around the peak value. So it's nice to turn the transmission axis of this polarizer until we extinguish the light, which means that the transmission axis of this polarizer, which is going to be referred to as the analyzer, is orthogonal to the axis here.

And the fact, as we look on the screen, the fact that we can null the light means that the polarization here before entering this analyzer is, indeed, plane polarized. And the direction of the arrow here, which labels the null intensity, which means that the transmission axis now of the polarizer is orthogonal to the polarization of the light, is then indicated by the direction of the arrow. But we all know that the true polarization of the light is in the vertical direction. But it's much easier for us to label the block axis, the direction of the block axis. So please keep in mind that even though I might show you the null on the screen, the actual polarization is 90 degrees away from that.

Now I'm going to demonstrate the rotation of the plane of polarization by means of the polarizer. First, what I'm going to do is set this analyzer back to where it was, set the arrow vertical, and then take another polarizer, then, to rotate the plane of polarization.

Now, at the beginning, I'm going to set this polarizer arrow, which again labels the transmission axis of this polarizer, in line with all the others. Then I want to rotate the plane of polarization of the light by this polarizer, let's say by 45 degrees.

Well, in order to check that, indeed, I have rotated by 45 degrees, again I'm going to track the null. So now if we look on the screen, and I rotate the analyzer, let's see where null is this time. And here it is. We can see that null is when the arrow is in this direction, which is, again, 90 degrees to the position in this direction, which is about 50 degrees or so from where it was before.

Now let me go back to aligning the analyzer with the peak transmission. And you can see that the peak transmission-- it's not that difficult to see. But you can see that it is about half or so, about half the intensity of the peak transmission that I had when this polarizer was in the vertical direction.

Now, if I want to rotate the polarization some more, let's say close to 90 degrees, again track the direction of the null, now, as we watch on the screen here, the position of null now is over here. And it shows that the arrow is pretty close to vertical, which means, again, we've rotated the plane of polarization some more.

Now, the interesting thing about going close to 90 degrees is that the peak transmission, the peak transmission of the light, as you can see over here, is not so big. And, in fact, if I go even closer to 90 degrees, I don't even get any light transmitted through the polarizer.

So the conclusion, then, is that I can rotate the plane of polarization of light using a simple polarizer. But the penalty is that as I get close to 90 degrees of polarization rotation, I get very little light transmitted.

So in order to overcome this problem, we use a second polarizer. And we place the second polarizer. In this case, I'll place it before the first, before this polarizer here. And remember, even before I put it in, that the polarization of the light now is along this axis, which is 90 degrees with respect to this one. And that's why we didn't get any light through the analyzer.

Now, I'm going to put this polarizer here. And this polarizer is still along this direction, which is orthogonal to this one. And before, remember, there was no light coming through. And now you can see by adjusting the axis of this polarizer here, I can get some light to come through with polarization that is orthogonal to the original one. And again, to go demonstrate that the null, now, is along the vertical direction, which means I have achieved 90 degree rotation using now two polarizers and still have light left.

The sad story is that you only get one quarter of the light coming out when you rotate the polarization by 90 degrees. But a quarter of the light at 90 degree rotation is better than no light at all. So to summarize, if you use only one polarizer, you can rotate the state of polarization by, let's say up to about 45 degrees or so and only lose half the intensity. If you want to go more, then you pay a penalty in intensity. If you use two polarizers, then you can rotate any way you want. And the worst thing you can do, at 90 degree rotation, is that you get only a quarter of the light coming through.