MITOCW | Laser fundamentals I: Polarization of laser light | MIT Video Demonstrations in Lasers and Optics

SHAOUL EZEKIEL: Now that we know all about how lasers work, we're ready to ask some very important questions. For example, what is the nature of laser light? Here's some questions. What is the wavelength? Is the light tunable in wavelength? Is the output or the spectrum of the output-- is it single frequency, is it multiple frequencies, or what?

Is the output columnated? Can it be columnated to a diffraction limit? Is it focusable to a small spot or a diffraction-limited spot? Is the output polarized? How much power do we get out of the laser, and is it continuous power or pulse power? Now, these are all very important questions, and we should have answers for all of these questions.

Now we're going to illustrate as many of these properties as possible. The only problem is that I can't use the same laser to illustrate all these properties. I'd like to use a variety of lasers that we can lay our hands on to illustrate these properties. For example, we'll use helium neon lasers to illustrate some basic properties, then we'll go on and use a tunable dye laser to show how tunable some lasers can be, and so on.

So first, we're going to start with a very simple property, which is, is the laser light polarized? So we're going to start with a helium neon laser over here with external mirrors. And the amplifier is a helium neon amplifier here in the middle. So what I'll do first is turn it on-- turn this laser on-- and here's the output from the laser. I'm being reflect it by this mirror. And then this mirror is the output here, and then the output goes onto the screen.

So let's now look at that spot on the output in close-up, and then I will put a polarizer here in the way of the light beam and see whether, indeed, the light is plane-polarized. So what I'm going to do-- here's the polarizer, and the arrow indicates that the transmission axis of the polarizer is along the vertical.

Now, if we see that when I'm along the vertical here, the spot has maximum intensity-- but as I rotate the transmission axis of the polarizer, you see that the light gets extinguished. Here I go back to vertical polarization. The light has a maximum. And I go to the orthogonal position, and the light is extinguished.

So all this says, very simply, that the light from this laser is plane-polarized. Simple as that. Now, you may wonder, why is it plane-polarized? Well the answer is that, in this particular laser, we have the mirrors mounted outside the discharge tube, and the discharge tube is terminated by windows that are placed at Brewster's angle.

And you may recollect that at Brewster's angle, only certain polarizations have zero loss as they go through the windows, but the orthogonal polarization through that has a lot of loss and, therefore, will not lase because we don't have enough gain to make those polarizations lase.

So in this case, it's the polarization in the vertical plane that actually suffers no loss as it goes through the Brewster windows because the way the tube is oriented. And that's why the output is plane-polarized and plane-polarized in the vertical plane.

All right, let's now take a look at another helium neon laser, the one that we have over here. I'll just take this mirror mount out, and I'll turn this one off and turn this little one on. So here we are. Here's the output of this laser. And then, again, just like before, we put it onto the screen.

Now, if we look at it in close-up as I put the polarizer here in the way, now we're ready to look at the polarization of the light coming out from this laser. Now, you can see when the transmission axis is in the vertical plane, we have a lot of light. Now, as I rotate the transmission axis of the polarizer, I find small changes, but not a lot.

And in fact, when I go to the orthogonal position, I find that I cannot extinguish the beam-- the light. Here we go back to vertical polarization, and now to horizontal polarization. And indeed, it's small changes, but not huge like in the other laser, where we, indeed, extinguished all the light when we went to horizontal polarization.

So the conclusion here is that for this laser with internal mirrors, the light is not plane-polarized. The question is, what is the polarization of that light? Is it unpolarized, is it circularly polarized, and what have you. And I want you to think about.

But the only difference, then, between this laser and the previous one is the fact that the previous one had external mirrors and Brewster windows, and this one here has no windows, and the mirrors are just attached to the discharge tube. Now, in the next demonstration, we're going to look at the spectrum of laser light from the one with the internal mirrors and the one from external mirrors. And we'll see what we can learn from that.