MITOCW | Laser fundamentals I: Simple laser | MIT Video Demonstrations in Lasers and Optics

SHAOUL EZEKIEL: We're ready to take a close look at a laser and see how it ticks and why it ticks. We've picked on a helium-neon laser because a helium-neon laser is a very simple one, and also it's one of the first lasers. In fact, the first laser was the ruby laser and helium-neon was right after it. So it was the second laser action that was observed. Also, the red light from the helium-neon laser is familiar to almost every one of you, especially when you go to the supermarket and see it at the checkout counter. Usually, a red helium-neon laser is used.

So let me start by showing you what a helium-neon laser looks like. Here is a helium-neon laser, at least a helium neon laser. They're all different. Now what I would like you to see here is that it's made up of a discharge tube, which is this, which is the amplifier that is necessary for laser action. And then the discharge tube is terminated by two mirrors. Here's a mirror on this side. You can see it. Here's one mirror, and here is the other mirror. So it's a small laser, and the mirrors are sealed right onto the discharge, too.

Now let's see this laser in action. And we have it already set up for you over here. And then all I have to do is to turn the power supply on and count to five, and the laser will come on, and here it is. Laser's on. And see, here is the glow in the discharge. And you see a pink streak, and that's where the light goes backwards and forwards and gets amplified. And here is the output mirror. The other mirror is a sealed, and the output from the mirror here then goes onto the screen. And that's it. As long as we power the discharge and have enough gain to overcome the losses and we choose the mirror transmission appropriately, you'll get laser action.

Now with this kind of a laser, it's very difficult to adjust anything and to play with it. So what I'm going to do, just so that you can see a little bit more of how a laser works, I'm going to go on and have a laser that the mirrors, in which the mirrors are external to the two. Now in order to separate the mirrors out from the amplifier, from the discharge tube, in this case, we have to seal the discharge tube.

Now here is-- you can see here, if we take a close-up of this-- here is a sealed discharge tube. It doesn't have mirrors on it but it has windows. Let's let me show it to you again. Here is the amplifier section, and here is the cathode. And the anode is over here. So this charge, then, runs along this line over here, this capillary tube over here.

Now let's focus at the ends. We don't have, as you can see, we don't have square mirrors. You can see that we don't have windows, I should say, not mirrors, because we're going to have the mirrors external to the discharge tube. But you can see that the windows are sealed but they're not square to the tube.

And the angle, in fact, is called the Brewster angle because at that angle there is no reflection from the glass surfaces for a sudden polarization. So that's why one uses windows at the Brewster angle, so that there is no reflection in the windows. And you can see both ends. Now if you take a look at the other end over here, close look at the other end, you see that, again, both windows are at a Brewster's angle.

So here is, then, the amplifier tube. And now we have another one, a similar one, that is placed-- and I'll position it in the same way-- that is placed over here, held in place over here in this setup. And there's wires running to run the discharge. So here is, then, the amplifier tube inside this laser. And let me again point to the mirrors now. Here is one mirror, and here is the other mirror. And each mirror is held in a hefty mirror mounts, and the adjustments are over here. We have two adjustments over here. And then we have similar adjustments over here.

All right. So here is, then, the tube, the amplifier tube. The windows are terminated with windows at Brewster's angle, and then we have the two mirrors. So now I'm going to turn the discharge on. And here it is. And let's see if the laser is lasing. So if I put a card here, see that, indeed, the laser is lasing. So what I'm doing here is reflecting it by this mirror here and this mirror here-- here is the laser beam-- and, again, onto the screen.

So on the screen now, we have essentially two spots. One is coming from the laser with the fixed mirrors. That's this one. And then the other one, the other spot, is coming from the laser with the adjustable mirrors here. So what I'm going to do is first block the laser with the fixed mirrors so that we don't have any confusion, and the only spot, then, is from the one from the laser with the adjustable mirrors. So now here we are. Here's the laser, then, all opened up. And now I'm going to show you how touchy the alignment is.

So now, if you watch the intensity on the screen as I slightly misalign, you can see the light is out already, just by very small misalliance. So here we are. It's at peak value. And then I go the other way, and it's gone. So the alignment has to be very, very stable. Now I can also adjust the horizontal alignment again. Show you how touchy everything is.

So here we are. Here is, then, in a nutshell, here's the amplify section. The longer it is, of course, the more gain we have, and the mirrors are placed, in this case, about 50 centimeters apart. This one is a flat mirror, and this one is a spherical mirror. And the alignment has to be very stable because a small misalignment would create a lot of loss, and then we just don't have enough gain in the amplifier to overcome these losses and the laser quits.

Now later on, we're going to have other demonstrations that illustrate the properties of the laser. So when we come back, then we're ready to show you a variety of effects associated with the laser.