MITOCW | Laser fundamentals I: Light amplifier | MIT Video Demonstrations in Lasers and Optics

SHAOUL EZEKIEL: As we have already learned, the most important component in a laser, or the heart of the laser, is the gain medium or the optical amplifier. This is no ordinary amplifier. This is an amplifier for light. And in this demonstration, we're going to show you, and hopefully convince you, that, indeed, light can be amplified. The amount of amplification is not so huge. But I'm sure we'll make it convincing enough so that you get the feel that, indeed, that light can be amplified.

The setup we're going to use is here. We're going to have a laser, which is going to be our light source. Here's the output of the laser. We're going to reflect it by this mirror here and then this mirror over here. Now, the laser beam then enters this optical amplifier. Now, this optical amplifier is essentially this. It's a discharge tube, helium neon gas mixture that will give gain amplification or gain at 6328 Angstroms. In fact, the light enters this window here and then comes out at the other end. And that's what we have essentially mounted here right below.

So then the output through this amplifier-- and the amplifier right now is turned off-- then goes onto a detector over here. And then the output of the detector then goes onto an oscilloscope over here. And also we look at the output on a digital meter. All right, so we have two ways of looking at the same output.

All right, now we are ready to set zero. So first, what I'm going to do is then block the beam of light over here. And let's look at the zero on the scope and the zero on the meter.

Now, the meter says 008, which is not quite zero. And the reason for that is because we have room light hitting the detector. So what I'm going to do to get rid of that, I'm going to put this little hood over the detector. Now we see that the output of the meter now is, indeed, zero. And also, hopefully, then the output of the scope here, this will be our zero on the oscilloscope.

Now, if I take this card away, and let the light go through, you can see that now the output on the scope has changed. And the meter reads around 364, or 63, or thereabout, which is the output of the laser. Now all I have to do is block the laser beam. And we go back to zero on the meter as well as zero on the scope. Here we are. The laser beam's back again. And then we get that same value again.

Now, we're all familiar with absorption of light. And I just want to just demonstrate it, just for reference. I'm going to put a piece of glass in front of the laser beam. And we know that glass at normal incidence has a reflectivity of about 4% per surface. So I should get an attenuation of about 8% or so when I put this piece of glass in the beam of light. Now you can see the meter has dropped now to 330-- 300 and, well, if I can keep it still, 320 something. Now, if I take the piece of glass away, now we go up to the previous number of 360 something. So you can see we have an attenuation of about 8 or so percent.

Now what I'm going to do now is put this piece of glass before the detector also. And, indeed, I'm going to hold it against the tube here so that I don't shake too much. And again you can see that the attenuation is also about 8% or so. Here, let me put it in the front. And then also then I'll put it in the back again. And hopefully I'll put it in the same position. You can see this-- I can hold it still. And then take it away, and then roughly we get this 8% attenuation. So now we've demonstrated that, indeed, light can be easily attenuated.

Now we come to this crucial demonstration of gain. So now I want you to then watch both the scope and the meter as I turn on the amplifier. So here I'm going to now turn on the amplifier. And remember, this number is around 363 or so, 364.

Now you can see on the scope we jumped a little bit. And the meter has gone up to 380 something, which is an increase of about 5%. Let me turn it off. Again, you can see on the scope it went down. In fact, just watch the scope for a little while. I'm going to turn it on and off very fast so that you get a feel that-- here it goes, up a little bit, and down a little bit. Since it's only a few percent, it's difficult to see it on the scope the way I have it set up. But it's much easier to see it on the meter.

So you can see that with amplification we have 380 something. With no amplification, then we're back to 360 something. Again, roughly, it's about 5% amplification.

Now, you may wonder that maybe what we're getting is when I turn on the amplifier that we're getting light from the amplifier that hits the detector. It's not really amplification. So to prove this, what I'm going to do is block the beam of light going into the amplifier so that there's no light going on the detector. We're back to our zero on the meter. And now what I'm going to do, I'm going to turn on the amplifier just by itself just to see if there's any light from the amplifier falling on the detector.

So here we go. Watch the meter and the scope. And here is the amplifier on. Again, you can see that there's no change on the meter or the scope. Here's off. And do it again, on, and off. So, indeed, we've shown that light from the amplifier or spontaneous emission from the amplifier is not hitting the detector and increasing the output.

So again, let me just redo it again for you. Here is the light falling on the detector without amplification, again 360 something. And here comes the amplification again, yes, close to 380. It's a little bit less than we had before. Maybe the amplifier's getting a little old. Here we are without amplification. We have this value.

So in summary, we've shown that light can be, indeed, amplified. In this case, we used a helium neon amplifier to amplify light from a helium neon laser. We showed you a gain or amplification of 5% per pass. Now, you may think that's a small amount of gain. But a lot of helium neon lasers use gain of even less than 5%. And they have many, many applications. Of course, if you have even more gain, then you can get more powerful laser outputs with even greater number of applications.