PROFESSOR: Previously, we've shown several ways of getting low contrast fringes in a Michelson two-beam interferometer. For example, when the mirrors are shaking, you get poor contrast-- when the intensities in the two arms are unequal, when we have orthogonal polarization between the beams and the two arms of the interferometer. In this demonstration, we're going to show another way, and probably the most common way, of getting low contrast fringes in a two-beam interferometer. And here the setup.

Again, we have a helium-neon laser here. Here's the beam from the laser being reflected by this mirror into an optical isolator made up of a quarter-wave plate and a polarizer to prevent light going back into the laser. The beam leaving the isolator is here, getting reflected by this mirror into the interferometer. Here's one arm of the interferometer, and here is the other arm of the isolator. And the two beams leaving the isolator will be reflected by this mirror into this lens, and then from the lens onto the screen.

So, now, let's look at the screen. And we see that we have fringes, and the contrast in the fringes look pretty good. And you can see, I can adjust the alignment of one of the arms-- that's what I'm doing right now-- to separate the spots and bring them back together again. And then when I take my hand away, you can see I have pretty good contrast in the fringes.

You also notice that, in this arrangement, the two arms of the interferometer are equal. And we've indicated this by the 0 over here. So the 0 indicates that this arm is equal to this arm.

Now, as I move one arm, let's say by a few centimeters-- and, also, you want to note this, that the scale here is in centimeters. This is 10, 30 50, and so on. So let's say around 5 centimeters. Let's look at the fringe contrast. And we again look at the fringes, and you can see that, indeed, the contrast is a little less than what it was when we had equal path length.

Let me go a little bit more, let's say around 10 centimeters or so. Again, let me check the alignment by adjusting one of the mirrors. And you can see that, now, the contrast is indeed getting very poor.

Let's go even further, let's say around 30 centimeters path length difference. Again, here are the two spots. And the fringe contrast is pretty bad. Let's go, let's say, around 45 centimeters or so. Again, check on the alignment of the interferometer, and, indeed, we don't even see any fringes at all or essentially 0 contrast.

But let's go on. Let's go on, let's say, to position around 72 centimeters. And now, let me check the alignment. And we can see that now we're beginning to see some fringes. So the contrast is not quite 0.

Let me go further, say, around 80 or so centimeters. Again, check on the alignment. A little bit better. And we go to 95 or so centimeters. And, wow, we see some very good contrast. The contrast has come back. In fact, it's just as good as when we were at equal arms.

Now, let's go further than 95 centimeters, around maybe 105. And let's look, again, at the fringe contrast. You can see that they're getting poorer again. Let's go even further, here, around 115 centimeter path length difference. And let me readjust, and see that the fringes have almost disappeared.

So let's go back and make sure that we didn't do anything wrong before. Let me go back to where we had good fringe contrast, around 95 centimeters. And you can see that we have excellent contrast.

And we go to, say, 70 or so centimeters. Fringe contrast is pretty bad. Go to about 45 or so centimeters. Wow, that's really awful. Can't see anything.

Now, just let me take this opportunity to show you that, indeed, I do have two beams. And I can block, in fact, one beam, or block the other beam. Indeed, I do have two beams that are superimposed, but yet absolutely no fringes can be seen.

And then, let me go all the way to equal arms, to the 0 position. We adjust the two beams. Now, we can see we have good fringes again, good fringe contrast. But let me go and make this arm here even shorter than the other arm. Let me make it shorter by about 2 or 3 centimeters. You can see that the fringe contrast is not so wonderful as it was at the 0 position.

Let me go to a path length difference of minus 10 centimeters and readjust the other mirror. And we see that fringe contrast is very poor. So let me go back to the zero position. and look at the fringes. Very good. And about 45 centimeters, and we don't have any fringes.

Now, what could the reason be for the fringes disappearing? This setup is a good setup. I think the alignment is pretty good. We're paying careful attention to the alignment.

And so, what can it be? Certainly not-- it's not in the interferometer. It must be in the light source. Now, the light source in this case is a helium-neon laser, and the separation between the mirrors or the length of the cavity is about 95 centimeters.

The laser certainly puts out a lot of light. The only thing we don't know about the laser is the spectrum of the light. For example, is it single frequency, or is it multiple frequency, or what?

Now, what I'm going to do, I'm going to set up an arrangement that will tell us what the spectrum of the laser light is. And when we come back, we'll have it already, and we can show you what the spectrum of the laser light is.

Now we've set up the arrangement for observing the spectrum of the laser light. The setup is essentially what we had before. Here is the interferometer-- the two arms of the interferometer-- and the fringes, again, we can see on the screen. What we've done to observe the spectrum of the laser light, we've added this beam splitter over here to reflect some of the laser light before it enters the interferometer and reflects it into this scanning Fabry-Pérot interferometer.

The output of the interferometer is displayed on an oscilloscope over here. What we have displayed on the face of the oscilloscope is one complete free spectral range of the scanning Fabry-Pérot, which is about 1 and 1/2 gigahertz, corresponding to the 10 centimeter length of the scanning Fabry-Pérot. Now, if the laser were indeed oscillating at one frequency, we would only see just one peak. But we see about eight or nine peaks, which means that the laser must be oscillating at several frequencies.

Again, from the 1 and 1/2 gigahertz free spectral range, we see that the separation between the frequencies of the laser is about 160 megahertz. And this is what we expect, because this corresponds to the 95 centimeter length of the laser cavity. So as you see that the laser is not a single frequency laser, it has many frequencies. So maybe the fact that the contrast in the fringes varies so dramatically with path length difference may have something to do with the spectrum of the laser light.

And I would like you to think about that. But in another demonstration, we're going to bring in a single frequency laser. And, indeed, we're going to study this problem very carefully.