SHAOUL EZEKIEL: In this demonstration, we're going to show the effect of the light source on fringe contrast in a two-beam interferometer. But in particular, we want to look at the effect of the spectrum of the light source on fringe contrast.

The setup is here. We have a special laser for this demonstration. And I'll tell you more about it later. The light from the laser is reflected by the mirror here. Then we have a polarizer here. And then light is reflected by a mirror here. This is a beam splitter. I'll explain later.

And then the light here enters the Michelson interferometer. Here is one arm of the interferometer. And here is the other arm of the interferometer. The beams leaving the interferometer are here. And then they are reflected by this mirror into this lens and onto the screen.

Now, the screen is a little bit dim. So let's look at an enhanced image in the insert. As you can see, you can see the fringes from the interferometer. But just to convince you that this is coming from this interferometer, I'm going to adjust the alignment in one arm to show you that, indeed, this is associated with the interferometer here.

All right, now let's look at the light source that we're going to study. This laser here is sort of special. It operates in two frequencies, sometimes three frequencies. But the interesting thing about these frequencies is that they have different polarizations, at least adjacent frequencies have orthogonal polarizations.

So using a polarizer over here, I can select either one frequency or two frequencies. In order to check that, indeed, I've selected one frequency or two frequencies, I'm going to sample the laser beam using this beam splitter here. Now, I don't know if you can see the beam on the card. It's pretty weak. But this beam is being sent into this optical spectrum analyzer, which is a scanning Fabry-Perot interferometer.

The output of the optical spectrum analyzer is displayed on the oscilloscope screen over here. As you can see, it is single frequency. The output of the laser entering the interferometer is single frequency.

Now, as I change the transmission axis of the polarizer here, I can select the other frequency, or, in this case, the other frequencies, as shown over here. Sometimes the laser oscillates two frequencies, sometimes in three. And at the moment, it's oscillating in three.

If I go back, I can select one frequency. And halfway rotation of the polarizer, or 45 degree rotation of the polarizer, I can select more than one frequency. And if I go completely 90 degrees, then I can select two frequencies. Now, let me set my polarizer so that I only have only one frequency.

So let's go to the interferometer and look at the fringes as a function of path length difference. Here we are. Here's the interferometer again. And here are the fringes. And you can see the contrast is pretty good.

The zero over here indicates that this arm is equal to this arm. Now, I'm going to vary the length of the arm over here. And you can see that the fringe contrast is pretty good.

Now, here I am, 11 centimeter path length difference. Fringes are pretty good. Around 20 centimeters, pretty good-- remember, the laser is single frequency at present. At about 30 centimeter difference, fringe is pretty good. And so on, the fringe contrast doesn't deteriorate.

So let me go back to the equal path condition. So let's look at the scope as I bring in more than one frequency from the laser. As we can see on the scope, we have one frequency. Now, as I rotate the polarizer, I can now bring in the other frequencies. So in this position, essentially, we have two dominant frequencies plus another one. Now, let's go back to the interferometer and look at the fringe contrast as a function of path length difference with the laser at several frequencies.

So here, at equal path length, I can see the fringes are pretty good. And then as I go away from equal path length, the fringe contrast begins to deteriorate. And you can see around here, when I'm around about eight or nine centimeters away, the fringe contrast is pretty bad. See, it's still bad, bad still, again, still pretty bad.

Now, it picks up. Now fringe contrast is getting better. Now at a position 22 centimeters, that means a path length difference at 22 centimeters, I have as good fringe contrast as before. Then if I go further, fringe contrast again deteriorates. Here we see it's pretty much gone over here. Now I'm around 30 centimeters path length difference. Then as I go all the way to 44 centimeter path length difference, you can see the fringe contrast is back again.

Let's go even further. Fringe contrast deteriorates. And I think, finally, if I go to 66 centimeters, fringe contrast comes back. But I need some readjustment of the beams. You can see, though, that the fringe contrast has been restored. And so on, so every 22 centimeters, the fringe contrast comes back.

Let me go back again and check around, let's say, 44 centimeters. And fringe contrast is bad. Around 30 centimeters or so-- I'm sorry, at 44 centimeters, fringe contrast's pretty good. Around 30 centimeters, it's pretty bad. Around 22 centimeters, it's pretty good. And around 10 or so centimeters, it's pretty bad.

Now, clearly, the fringe contrast seems to be dependent on the spectrum of the laser. Just to make sure, let's stay at a position where the fringe contrast is pretty bad. And let's change the spectrum of the laser going into the interferometer. Let me first adjust the position of the peaks on the scope. And now what I'd like to do is, while we're watching the contrast, I would like now to go back to the single frequency condition.

As you can see, the contrast is pretty good. And as I go to the multiple, multi-frequency position, the contrast disappears. So clearly, when the laser entering the interferometer has only one frequency, contrast is pretty good. When it has several frequencies, at this path length difference, there is no contrast at all.

Now, let me go to the equal arm position. Let's again look at the fringe contrast as a function of the spectrum of the laser. So if we can look at the scope and now we have single frequency operation. The fringe contrast's pretty good. If you have multiple frequencies, the contrast is also pretty good. So there's no change in the fringe contrast with frequency.

Let me now go to 22 centimeter path length difference. And now, again, we look at the fringe contrast and its dependence on the spectrum of the light. You can see here that when-- let me readjust the fringes a little bit. That's it. You can see when the laser is at a single frequency, fringe contrast's pretty good. When it has several frequencies, fringe contrast is also pretty good.

But when I am at a position about 10 centimeters or so away, now, if we can look at the fringes, let me-- you can see the fringes are-- fringe contrast is pretty bad. And then again, when I go to single frequency, you can see that the fringe contrast is pretty good. And then multiple frequency, fringe contrast is pretty bad.

So what we have seen is the influence of the spectrum of the laser light on the fringe contrast in a two-beam interferometer. We saw that when the laser is operating at a single frequency, the fringe contrast is unaffected by path length difference. When the laser was oscillating at several frequencies, we saw that there were positions where the fringe contrast went to almost zero. But the fringe contrast reappeared every 22 centimeters.

I'd like you to remember that the laser cavity here-- let's look at the laser cavity. The laser cavity is 22 centimeters long. So maybe there is a connection between the length of the laser cavity and the positions of good fringe contrast in the interferometer. What I'd like you to think about is why does fringe contrast deteriorate when the laser is oscillating at several frequencies?