Lab 3b Single-Photon Interference - Week 6

Phys434L Quantum Mechanics Lab
2018

March 3, 2018

1 Procedure

The objective of today's lab is to finish aligning the interferometer. It is important that we get it right. Let us assume that you have an interferometer set up. That is, the 4 components (2 beam splitters and 2 mirrors) are in place and aligned.

1. Place a diverging lens (L) after the interferometer to expand the beam. Fringes should be seen. Adjust the tilt of the second beam splitter for broadest fringes until you only have fully constructive or fully destructive interference. Destructive interference should be a *completely dark* output. A bulls-eye indicates that the alignment is not good enough and likely has to be redone.

2. Place the fiber that sends light into the spectrometer so that it is looking into the output of the interferometer, as shown in Fig. 1(b). Place a small incandescent bulb at the input of the interferometer. Observe the fringes modulating the continuous the spectrum of the incandescent light, as shown in Fig. 1(c). This is the Alford-Gold effect. The instructor will be helping you at this point. The fringes reveal the difference in path length ΔL. This path length difference can me calculated. Pick two adjacent maxima in the spectrum. With the cursor you can measure their values. Suppose that they are λ_1 and λ_2, where $\lambda_2 > \lambda_1$. There is a maximum because the path length difference is an integer multiple of the wavelength:

$$\Delta L = n\lambda_1. \tag{1}$$

The adjacent maxima will involve one less multiple of the wavelength, or

$$\Delta L = (n-1)\lambda_2. \tag{2}$$

Combining Eqs. 1 and 2, we get

$$n = \frac{\lambda_2}{\lambda_2 - \lambda_1}. \tag{3}$$

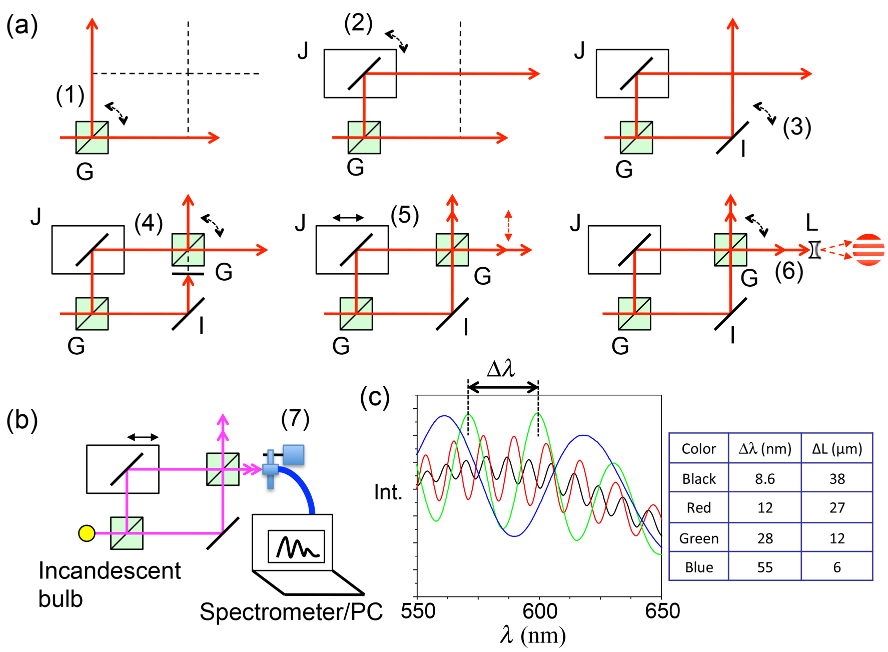
Replacing Eq. 3 into Eq. 1 gives us

$$\Delta L = \frac{\lambda_1 \lambda_2}{\lambda_2 - \lambda_1}. \tag{4}$$

When $\lambda_2 - \lambda_1 = \Delta\lambda \ll \lambda_1, \lambda_2 \sim \lambda$, we can approximate the result by

$$\Delta L \simeq \frac{\lambda^2}{\Delta\lambda}. \tag{5}$$

Figure 1(d) shows a few examples of spectra for different values of ΔL.



Color	Δλ (nm)	ΔL (μm)
Black	8.6	38
Red	12	27
Green	28	12
Blue	55	6

Figure 1: (a) Step by step schematic of the set up and alignment of the interferometer. (b) Schematic of the final adjustment of the interferometer using a spectrometer. Numbers within parenthesis refer to steps in the procedure. (c) Modulated spectrum of continuous light passing through the interferometer with different path lengths ΔL.

Question 1 Calculate ΔL for one setting of the interferometer where you see fringes in the spectrum.

3. Increase the distance between adjacent maxima by translating the stage via the micrometer. Your final result be that the entire spectrum moves up and down when you gently push one of the mirrors. If you do not get to this point, we need to better align the interferometer. It may imply redoing the alignment. The instructor should help you by this point.

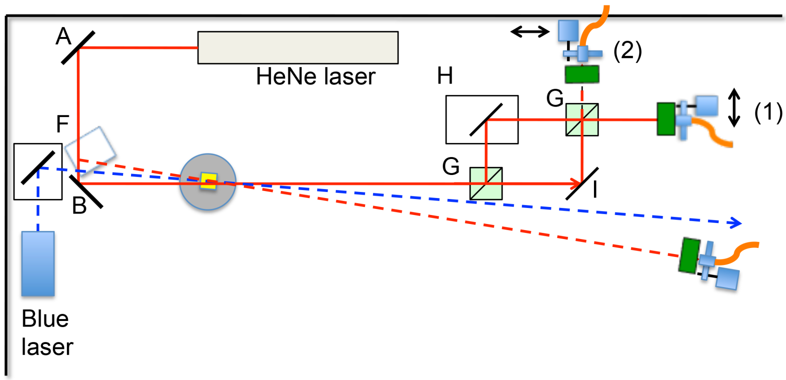


Figure 2: Layout of the interferometer plus collimators.

4. Remove the bulb and spectrometer and allow HeNe beam to go through the interferometer. Check that the interferometer is still aligned (full constructive or full destructive). If you see fringes, you may have to realign by gently tilting the second beam splitter. This should not alter the value of ΔL.

5. Align collimator B to receive the light from the through output of the interferometer, as shown in Fig. 2. Place the collimator and fiber, and align it so that the beam enters the collimator. Optionally, place a straight plate guide to translate the collimator into alignment (1). You should not need to align it vertically. Otherwise it is not a good sign. Make sure that when you are done you place the filter in front of the fiber.

6. Align the collimator C to receive the second output of the interferometer. Use the same procedure as above (2).