

Week #3 – Optical Interference

Reminder! Use proper optics alignment just like last week. Creating an optical interferometer will go quickly IF you practice good alignment techniques, are patient, and observant. Groups that struggle, simply do a poor job in setup and tuning. Note, you can use photos instead of diagrams/or drawings in your lab report where ever it is appropriate and where they can be properly labeled/understood.

1. Michelson Interferometer - Goal: create an interferometer using manual assembly and simple optical parts, and demonstrate several forms of nano-scale sensing it enables.

In order to ensure proper setup, carefully align every optical component such that the back reflected beam is directed back to the aperture of the HeNe laser source. Every component? Yes every component including reflection off the beam splitter. This will allow you to quickly setup the interferometer. If you don't do this, it can be nearly impossible to get this to experiment to work!

Procedure:

(1) Setup the laser and the Galilean beam expander as we did last week. Note, however, the 2nd BSA-1 is far enough from the bottom edge of the optical breadboard to allow space for the bottom arm of the interferometer.

(2) Add the LCA with the 50/50 beam splitter (is a cube or a disk in your kit) and align at 45 degrees to the incoming beam (as precisely as possible).

(3) Add the 3rd BSA as shown in the diagram at right, 5 inches from the beam splitter, sending 1/4th of the light back through the beam splitter by transmission, back to the laser, with proper optical alignment. These BSA's (3 and 4) don't need the COR-1 component because they are always perpendicular to the laser beam (they are not rotated, center of rotation is not an issue). In the diagram, I show a disk beam splitter, obviously a cube beam splitter will not be at 45 deg.

(4) Add the 4th BSA, same as step 3, also 5 inches from the beam splitter, and again 1/4th of the light will be sent back to the laser by reflection off the beam splitter.

(5) Add the target assembly with a white card, the BSA 3 and 4 should cause the two beams overlap on the white card. If you did a very good job in alignment, you might start to see fringes right away!

(6) Slightly adjust the mirrors using their set screws to make fringes appear or to tune them to wider (less) fringes which indicates better alignment of the system. Your alignment and beam propagation back to the laser should never be too far off (don't go too wild with the mirror adjustments). Typically, you should not need to adjust any of the LCA's. Adjust mirrors until you achieve <5 fringes (5 red peaks, 5 dark valleys) across the white card. Capture an image of the minimum fringes you achieve with a camera phone.

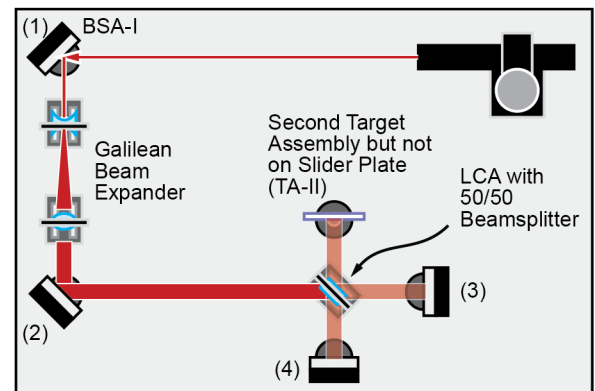
(7) Using a soldering iron, and just your hand, test the effect of thermally-induced refractive index change on the interferometer. Again, take a photo with your camera phone.

(8) Test the effects of physical pressure on optical table or bases of optical components, and describe/diagram how you might use this to make a system that measures and reports vibration frequency or the magnitude of very small mechanical displacements.

2. Viquity ESR Film - Goal: view a >99.9% reflector that is made only of clear polymer films stacked with precise thicknesses and refractive indices.

(1) Obtain from the storage bins a piece of the ESR film, and take a photograph of it being held in your hand and add that to your lab report as evidence you completed this part of the lab.

(2) I originally purchased this product, not knowing how it was constructed/made, to be used as a ultra-efficient UV reflector because most metals are poor UV reflectors, and it failed miserably when I tested it. Why would it be such a poor UV reflector?



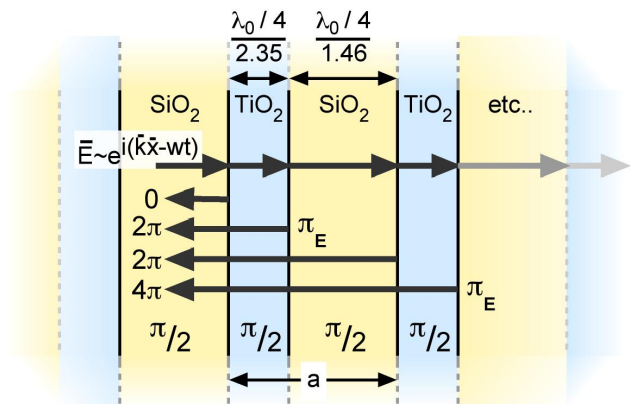
3. Setup Dismantle and Storage – Proper care of optical components is just as important to achieving reliable results as is careful experimental setup. Improper handling, setup, dismantling, and storage will detract from your final grade in this course. Unsure about any component? Just ask. The next group should find all parts neatly stored in the optics kit. There is a card with each kit that shows where each component goes.

4. Theoretical/Calculation Problem - Goal: calculate, simulate and increase understanding of the reflective or transmissive properties of thin films undergoing interference.

Problem 4a – diagram and calculate an anti-reflection film for blue light at 470 nm, using an ideal thin film (you calculate the ideal thickness and refractive index) placed on a glass slide with refractive index of 1.67. Assume the incidence angle is 45 degrees (this will change the effective ‘thickness’ of, and optical path length inside, the thin film. Even though it is technically more correct to also consider polarization, you may use the simple Fresnel reflection equation that is not dependent on polarization (for off-angles, polarization effects the amount of Fresnel reflection, but you may ignore that for this problem).

Problem 4b - Simulate a 1D photonic crystal reflector using a MATLAB simulator (courtesy of a final project done by a group in 2014). The folder w/ files you need and a video tutorial is found on blackboard for this week.

Use input $n_0=1$ (air), first layer $n_1=1.46$ (SiO_2), second layer $n_2=2.35$ (TiO_2), output $n_0=1$ (air). Plot from 400 nm to 900 nm, 500 data points. You should: (1) simulate 3 layer repeats for $\lambda_0=633$ nm and each layer thickness equal to $\lambda_0/4n$; (2) simulate 10 layer repeats for $\lambda_0=633$ nm and each layer thickness equal to $\lambda_0/4n$; (3) simulate 10 layer repeats for $\lambda_0=633$ nm and each layer thickness equal to $\lambda_0/2n$ and write down the transmission at 633 nm and explain how this can be considering each layer reflects 5% of the light due to Fresnel reflection (for your answer, just note the π phase shift between any two adjacent layers, you do NOT need to worry about the total π shifts like we show in the diagram at right). Include these results in your lab report.



Previously we used the java simulator found at this link: http://cops.tnw.utwente.nl/education/5_oc_optlay.html. But now you should use MATLAB, which is our standard tool used in courses for this department.