Fabry Perot Etalon

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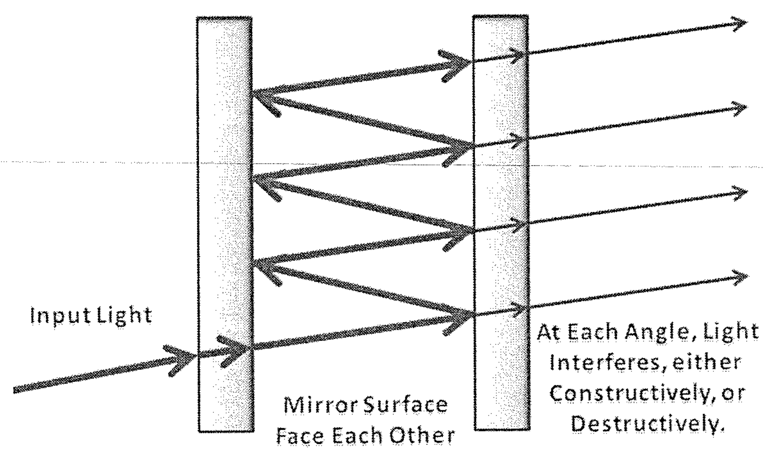
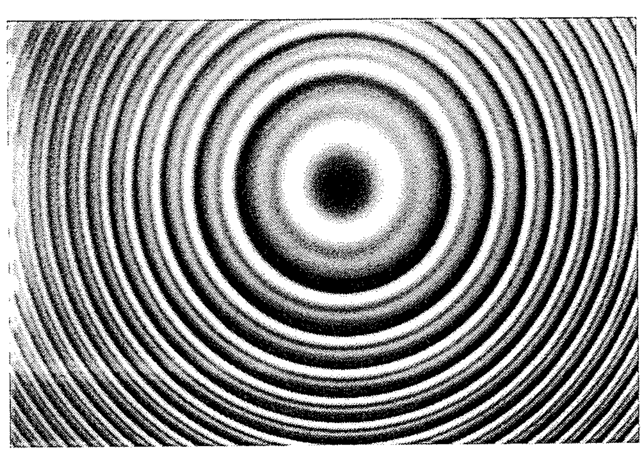
An etalon is an optical interferometer that consists of two glass plates, separated by a small, fixed distance. A beam of light undergoes multiple reflections between the surfaces of the glass plates. This results in optical transmission (or reflection) that is periodic in wavelength. This creates an image of many fringes. A sodium lamp was used as a light source, and the interference produced by the etalon was recorded. We were able to show that the radius squared was proportional to the order number. The finesse was calculated to be 9.67± 0.34.

I. Introduction

The Fabry Perot interferometer consists of two flat, parallel, semi-transparent mirrors separated by a certain distance. This arrangement is called an etalon. Light that enters the etalon goes through multiple reflections and the interference of the light emerging from the etalon during each bounce causes a modulation in the transmitted and reflected beams.



The resulting optical transmission is periodic in wavelength. An image of ring fringes is formed, similar to the one below.



Etalons can be used as precise wavelength references in telecommunication applications. They are mostly used to compare wavelengths and to study atomic spectra.

II. Experimental Procedure

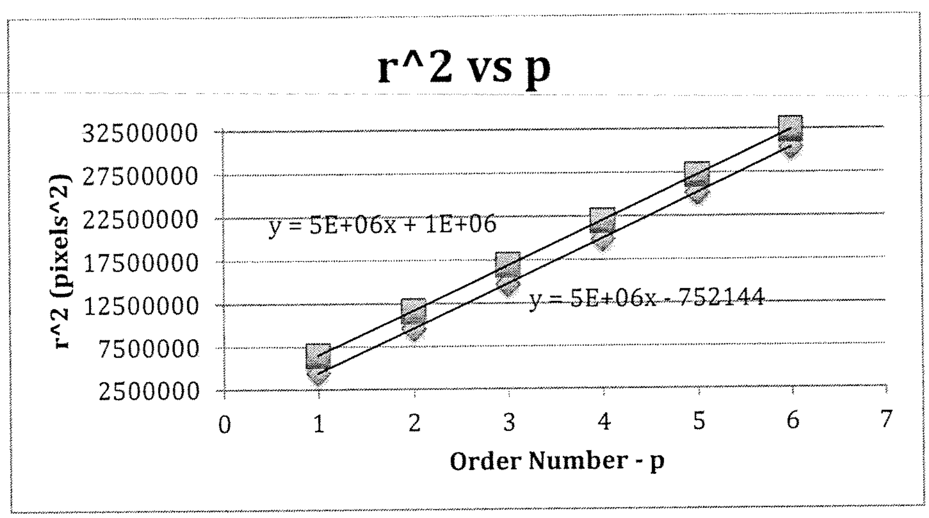
detail

A sodium lamp, a one-millimeter solid etalon, and a camera were used for this experiment. The etalon was placed on stand 10 cm from the sodium lamp, and the camera was placed 13.7 cm from the etalon. The height of the camera was adjusted so that it was almost leveled with the etalon. The angle of the etalon was adjusted until many rings were visible from the camera. The image captured the fringes created by the etalon.

To analyze the data, the radii of each of the light rings were measured. An "Etalon" program in the spectroscopy lab easily allowed us to do this. Circles were placed over the ring, and the radius was automatically measured in pixels. detail

III. Data/Results

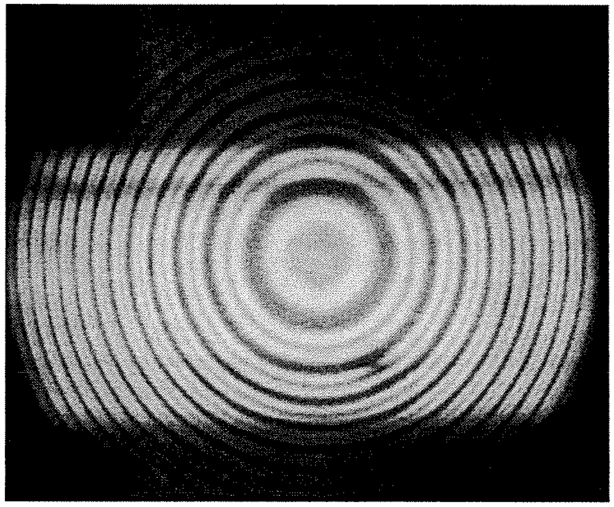
After measuring the radii of the fringes, we took the measurements, squared them, and plotted them against the order number.



This plot shows that the radius squared is proportion to the order number because of the straight lines formed. The order number increases as the size of the circles get larger. The first rings in each pair have are the blue and the set rings are the red. There are two rings in each set because sodium has two peaks: one at 588.9 nm and the other at 589.5 nm.

why is $r^2 \propto p$?

The image below shows the fringes created by the etalon using a sodium lamp.



IV. Analysis

In order to find the order number, the following formula was used:

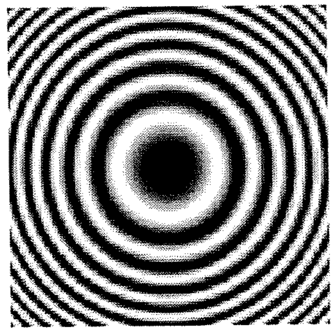
$$p\lambda = 2ndcos\theta$$

In this equation, p is the order number, λ is the wavelength of the sodium lamp (589.6 nm), n is the refraction index (1.55), d is the width of the etalon (1 mm), and θ is the angle which the light travels through the etalon. We assume that the angle is extremely small, so $cos\ \theta=1$. An approximate estimate of the starting order number is 5258. from where?

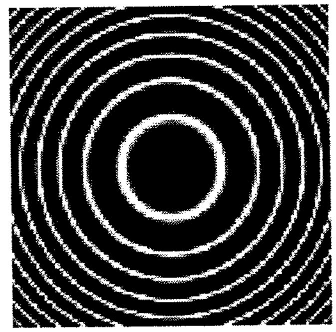
In order to find the finesse, the equation below was used.

$$F = \frac{R_{n+1} - R_n}{\Delta R_n}$$

R_n is the radius of the ring of the first order number and R_{n+1} is the radius of the next order number that is one up. The difference between the radii gives the free spectral range (FSR). This value divided by ΔR_n, which is the width of the first ring of the set, or the full width at half maximum (FWHM). The finesse was calculated to be 9.67 ± 0.34. The sharpness of the rings depends on the reflectivity of the etalon plates. If the reflectivity is high, the light is able to produce a set of narrow bright rings against a dark background. A clearer image means a higher finesse. The image below compares an image of low finesse versus high finesse.



LOW



HIGH

V. Conclusion

In this experiment, we were able to show the interference created by the Fabry-Perot etalon and that the radius squared is proportional to the order number. The finesse was calculated to be 9.67 ± 0.34. Possible sources of error include inconsistent measuring of the radii. Because the image was slightly pixelated, it was difficult to place a perfectly fitting ring on each circle to accurately measure the radius of each circle. We are also assuming that the light beam was perpendicular to the etalon. This would affect the value of the finesse.

why?. I don't think it will.

VI. References

"Fabry–Pérot interferometer." . N.p., n.d. Web. 21 May 2014. <http://en.wikipedia.org/wiki/Fabry%E2%80%93P%C3%A9rot_interferometer>.

Rev, A. "Etalon." Photop, 1 Jan. 2008. Web. 17 May 2014. <http://www.photoptech.com/main/products_gx/pdf/Telecom%20Optics/Etalon/Etalon.pdf>.

"Scanning Fabry-Perot Interferometers." *Thorlabs.com*. N.p., 1 Jan. 2014. Web. 21 May 2014. <http://www.thorlabs.us/tutorials.cfm?tabID=21118>.