Speed of Light

Introduction

Efforts to measure the speed of light date back to Galileo, but Foucault's 1862 experiment provided the first accurate measurement using a high-speed rotating mirror. This method calculates the travel time of light by measuring the mirror's rotation angle, using the equation v=d/t.

Concept and Theory

A laser emits light that passes through a beam splitter and hits a rotating mirror. The light is reflected to a fixed mirror at distance D. After reflecting back from the fixed mirror, the light hits the rotating mirror again and is directed through the beam splitter into a CCD camera. The mirror's rotation during the roundtrip creates two distinct points on the CCD. The separation *Δx* between these points, relative to the mirror's rotational frequency, determines the speed of light.

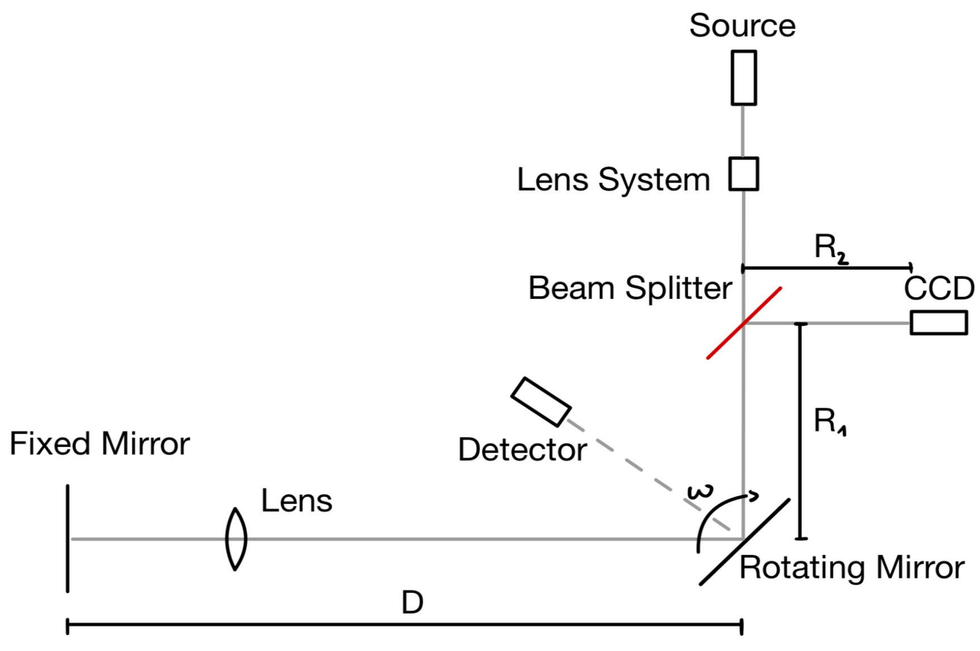

Fig.1: Setup for the Foucault Method

Setup

Our setup includes a laser light source followed by an optical system with a slit, two convex lenses, and another slit to collimate the laser light and prevent diffraction. After the optical setup, a beamsplitter directs the light to a rotating mirror, then through a lens to the fixed mirror to create parallel rays. A detector near the rotating mirror measures its rotational frequency. It is important to remark that the lens seen in Fig.1 is crucial as it guarantees discrete points on the CCD camera by aligning all beams perpendicular to the fixed mirror.

Data Analysis

By analyzing the intensity along a horizontal line on the CCD camera and fitting Gaussian curves to each laser point (Fig.2), we calculated their modes, standard deviations, and FWHM. Knowing the CCD pixel size, we determined the distance *Δx* .

To determine *c* we took advantage of a linear relationship between the *Δx* and the frequency *f,* finding:

$$\Delta x = \frac{8\pi r D n_{air}}{c} f_{mirror}$$

We fitted our data using the least-squares fit method and calculated the errors with Gaussian error propagation.

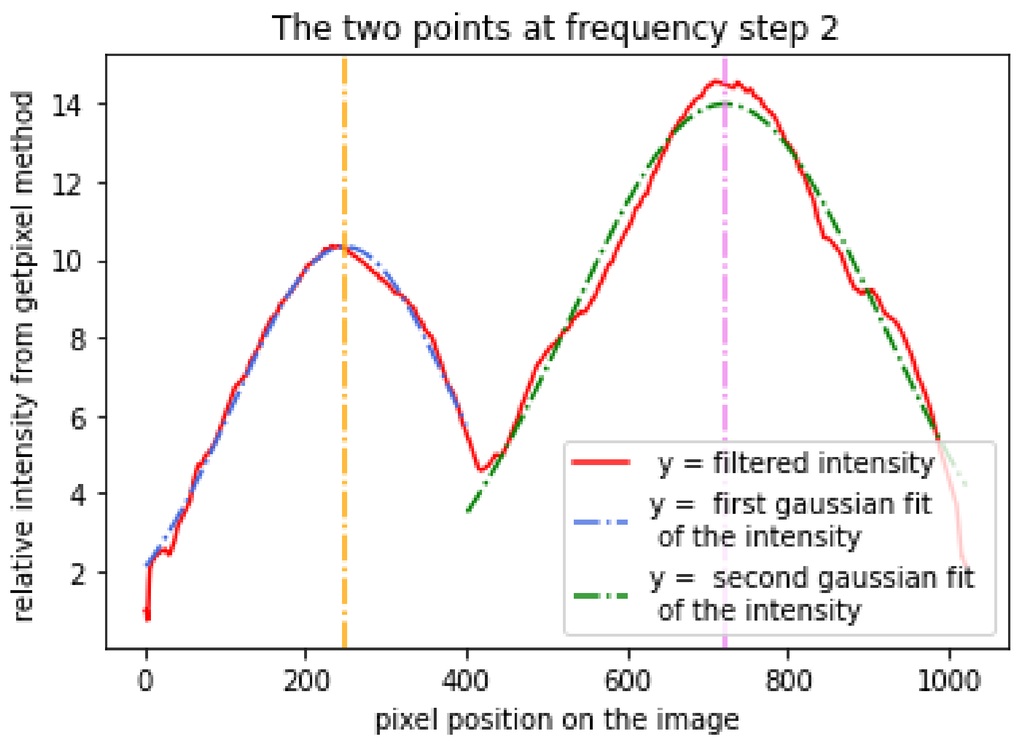

Fig.2: Intensity pixelplot of the second frequency step. The two vertical lines correspond to the points at pixels 249 and 722. The domains of each fit are on each side of pixel 400.

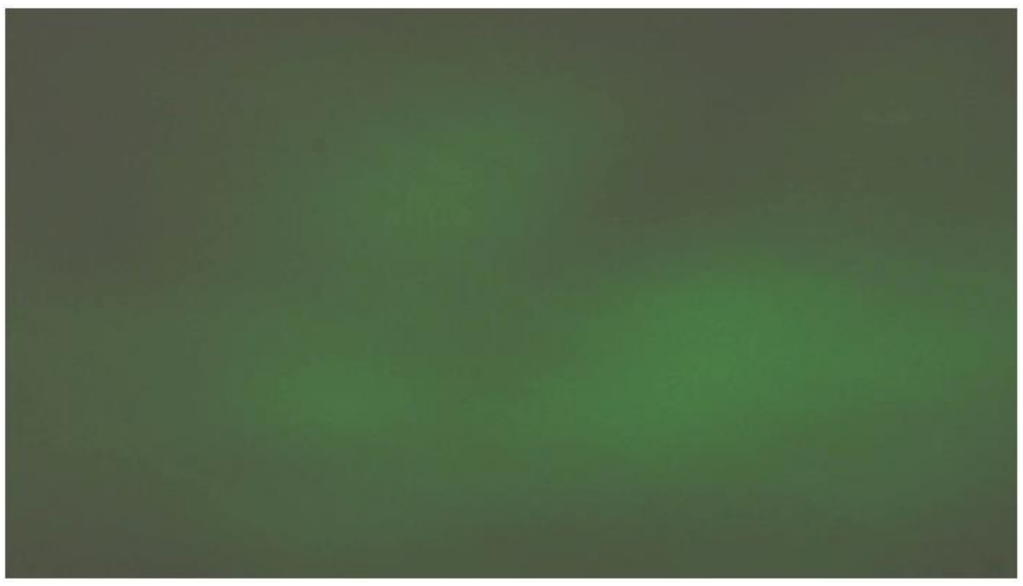

Fig.3: The CCD image shows two prominent light hotspots amid significant noise.