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Interferometer

In our experiment, as shown in **Figure 1** below, we successfully set up the Michelson interferometer and placed an argon-filled tube with a thickness of 6.35 cm along one arm of the interferometer. We observed the interference pattern on the screen and counted 4 fringes as the interference rings changed. To set up the Michelson interferometer, the support parts are arranged, and the height of the laser is set to approximately 16.5 cm above the optical rail. The laser is turned on, and the output is adjusted parallel to the optical rail by adjusting the set screws of the laser mount. The beam splitter is then inserted at an angle of 45 degrees with respect to the beam axis, and its tilt is adjusted to make the two beams (transmission and reflection) parallel to the table. The tilt of mirrors M1 and M2 is adjusted to make the reflected beams coincide with their incident paths, and the two beam spots on the screen S overlap together. The beam spots on the beam splitter are also made to overlap as close as possible. The beam expander lens is then inserted, and beam splitter, M1 and M2, are finely adjusted until concentric interference rings can be observed on the screen S. The critical elements of this setup procedure are adjusting the tilt of the mirrors and making the two beam spots overlap. The total number of fringes seen on the screen depends on the difference in the path lengths of the two beams.To determine the index of refraction of argon, we used the

Formula:

$$n_{argon} = 1 + \frac{\lambda \Delta m}{2L}$$

With a He-Ne laser wavelength (λ) of 632.8 nm, 4 fringe shifts (Δm), and a 6.35 cm (0.0635 m) thick argon-filled tube (L), we calculated the index of refraction of argon as follows:

$$n_{argon} = 1 + \frac{(632.8e{-}9\ m)(4)}{(2)(0.0635\ m)}$$

$$n_{argon} = 1 + \frac{(\ m)}{(\ m)}$$

$$n_{argon} \approx 1.00019906$$

Our calculated index of refraction for argon was approximately 1.00019906. Comparing this value to the actual index of refraction of argon, which is around 1.00028, we found that our result was reasonably close. The difference between the calculated and actual values was 0.000068, which is a deviation of about 0.0068% from the actual value. This indicates that our experimental setup and measurements provided a fairly accurate estimation of the index of refraction of argon.

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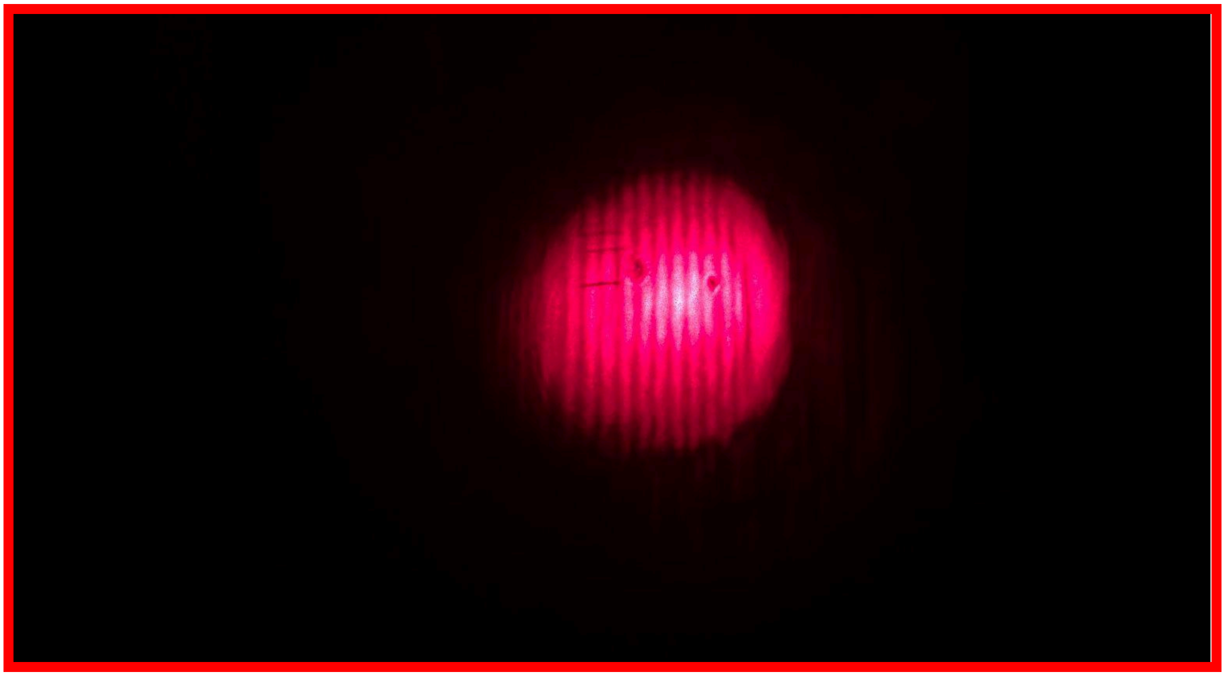

Figure 1: Experimental Observations

LIGO, or the Laser Interferometer Gravitational-Wave Observatory, is a groundbreaking scientific project that has successfully detected gravitational waves, which are ripples in spacetime caused by the acceleration of massive objects like merging black holes or neutron stars. LIGO's detection of gravitational waves confirmed a major prediction of Albert Einstein's general theory of relativity and opened up a new way of observing the universe. The core of LIGO's detection mechanism is a highly sensitive laser interferometer, which is conceptually similar to the Michelson interferometer used in the experiment we performed. LIGO comprises two observatories in the United States—one in Washington and the other in Louisiana—each with L-shaped arms that are 4 kilometers long. A laser beam is split into two beams at the vertex of the L-shape, with each beam traveling down one of the arms. The beams are then reflected back by mirrors at the ends of the arms, recombining at the beam splitter, and creating an interference pattern. When a gravitational wave passes through LIGO, it causes a slight, temporary distortion in spacetime, changing the relative lengths of the arms. This change in length is extremely small, on the order of 10^-18 meters or less, which is a thousand times smaller than the size of a proton. The recombined beams create an interference pattern that is sensitive to such minute changes in length, allowing LIGO to detect gravitational waves.
In your Michelson interferometer experiment, we measured the index of refraction of argon by observing fringe shifts in the interference pattern as the argon-filled tube's length changed. Similarly, LIGO detects gravitational waves by observing changes in the interference pattern due to the minute changes in the relative lengths of its arms. Both experiments rely on the principle of interference and the high sensitivity of interferometers to detect small displacements or changes in path length. The primary difference between the two is the scale and the purpose of the measurements: our experiment focused on determining the index of refraction of argon, while LIGO aims to detect and study gravitational waves from astronomical events.