

Intro:

We finished off the semester with diffraction and interference. From slits, to thin films, to interferometers these effects are the basis of many visually striking effects as well as high precision measurement.

From the Livingston, LA LIGO observatory

Laissez les bonnes ondes rouler! (Let the the good waves roll!)

Optional Problems:

- (1) Two plane mirrors are separated by an angle ϕ . If a light ray is reflected once off each mirror, what angle ϕ ensures that the ray returns the same direction as it came? When folks landed on the moon they placed objects on the surface which would reflect light back the way it came. (These devices were used to locate the moon's position to within 15 cm.) How would you arrange three mirrors so that light coming in from any angle is reflected back the way it came?
- (2) Explain why you can receive a radio signal even when your view of the antenna is blocked by a hill.
- (3) **Double Slit Redux:** In 1905, to explain some mysterious results of the “photoelectric” experiment, Einstein suggested that light comes in discrete packages (“photons”) with energy $E = hf$. This photon model prompted several investigators to try preserving the older wave picture by proposing modifications of classical theory. Among these people was J. J. Thomson who suggested that electromagnetic energy might be “clumped” together across the wave front. This hypothesis led to the suggestion that at very low intensities, ordinary diffraction patterns might be modified in some way. G. I. Taylor undertook an experimental study of this. Using a very low intensity light (reduced using a slit and smoked glass screens) photographs were taken of an interference pattern. The longest exposure was 2000 hours. (Rumor has it that Taylor, an avid sailor, went off sailing for this 3 month period.) The intensity was $3.45 \times 10^{-13} \text{J s}^{-1} \text{m}^{-2}$.
 - (a) Taking the energy of one of these packages of energy to be 2 eV, show that the intensity corresponds to about 100 photons per second per cm^2 (1 eV is 1.6×10^{-19} J).
 - (b) Show that this intensity implies an average distance of separation of about 300 m. With an apparatus of about a meter, it is extremely unlikely that more than one photon would have been present in the system at the same time!
 - (c) For a double slit experiment, what do you infer from the fact that the usual interference pattern is still formed under extremely weak illumination?