Optics 505 – Diffraction and Interferometry

1. Introduction to theory of interferometry and diffraction

When two or more light beams are superimposed, the distribution of intensity can no longer in general be described in a simple manner. If light from a source is divided into two beams that are superimposed, the intensity in the region of superposition varies from point to point between a maxima which may exceed the sum of the intensities, and minima which may be zero. This phenomenon is called interference. If two interfering light beams originate from the same source, fluctuations in the two beams are in general correlated and the beams are said to be completely or partially coherent depending on whether the correlation is complete or partial. In beams from different sources, the fluctuations are mutually incoherent. When beams from different sources are superimposed, no interference is observed under ordinary experimental conditions, the total intensity being everywhere the sum of the intensities of the individual beams.

Two general methods of obtaining two or more beams from a single beam of light.

1) division of wavefront
   Small sources
2) division of amplitude
   Can be used with extended sources

We can have two-beam interference or multiple beam interference.

Historically, interference phenomena has been the means of establishing the wave nature of light and today has important practical uses for example in spectroscopy and metrology. (Can measure from millionths of an inch to millions of miles.)

First phenomenon of interference, the colors exhibited by thin films, now known as "Newton's rings", was discovered independently by Robert Boyle (1627-1691) and Robert Hooke (1635-1703).

It was not until 19th century that decisive discoveries were made which led to the general acceptance of the wave theory. The first step toward this was enunciation in 1801 by Thomas Young of the principle of interference and the explanation of the color of thin films.

The enormous increase in precision in determination of optical paths by means of the Michelson (1852-1931) interferometer led to a new normality; it proved impossible to demonstrate the existence of an ether drift required by the theory of stationary ether. Einstein resolved the anomaly in 1905 in his special theory of relativity.

First reference to diffraction appears in the work of Da Vinci (1452-1519). Grimaldi first described such phenomena in a book published in 1665. Corpuscular theory could not describe diffraction. Fresnel in 1818 showed that diffraction could be explained by application of Huygen's construction, together with the principle of interference.

Fresnel's analysis later put on sound mathematical analysis by Kirchhoff (1882) and many writers have since extensively discussed the subject.

Interference and diffraction are very similar. In interference we have a discrete, but perhaps infinite, number of beams while in diffraction we have a continuum of beams. That is, interference becomes diffraction when the beams being combined goes from a discrete number to a continuum, i.e. summation signs become integrals.