MICHELSON INTERFEROMETER AS FOURIER TRANSFORM SPECTROMETER

Keywords: Maxwell's equations, wave equation, Principle of superposition, Interference, Diffraction, Coherence length, Fourier transform, Fellgett's advantage.

I. GOAL OF THE EXPERIMENT

Interferometry is an important diagnostic technique, which is based on the principle of superposition. It is widely used in precision measurements, surface profiling, spectroscopy, seismology, quantum information, etc. In the following experiment we use this versatile interferometry technique to obtain the spectral intensity distribution of different light sources. The experiment aims at familiarizing the student with basic configuration of the Michelson interferometer and its application as a real-time Fourier transform spectrometer. The concept of data resampling is also introduced to address the instability issue of the moving mirror.

II. LEARNING CONTENT

- Construction and working of Michelson interferometer.
- Concept of fringe visibility and coherence length.
- Use of Michelson interferometer as Fourier transform spectrometer.
- Spectral resolution of the interferometer.

III. PROCEDURE

- Never look at the laser beam directly! Wear the laser safety goggles.
- Never touch the optical surface of the mirrors, beam splitter and lens.
- Caution while changing the lamp. Surface could be hot.

FIRST LAB SESSION

Familiarize with the configuration of Michelson interferometer. Use the interferometer to measure the wavelength of given light sources.

- **Alignment of Michelson Interferometer.**

Align the reference laser parallel to the optic axis. Make sure that all the optical elements are perpendicular to the optic axis. Look for visible interference pattern using a diverging laser beam. Adjust the position of the mirror in the translation stage to be close to the *zero path difference* position.

- **Measure the velocity of the moving mirror.**

Using the detector, record the interference pattern of the reference laser for different velocity settings of the movable mirror. From the recorded interferogram, determine the actual velocity of the moving mirror. The instructor will show how to use the data acquisition software and record the data.

- **Measure the wavelength of the given light sources.**

Repeat the procedure for different light sources and determine the respective wavelengths.

SECOND LAB SESSION

Use Michelson interferometer as a real-time Fourier transform spectrometer and obtain the spectrum of different light sources.

- **Alignment for simultaneous measurement.**

Since the velocity of the moving mirror is not constant, record the interferogram of the reference laser and the given light source simultaneously. Spatially separate the two interference pattern and record them with two different detectors. Use appropriate filter in front of the detectors.

- **Data resampling and Fourier transformation.**

Resample the interferogram of the unknown source using the reference laser. Obtain the spectrum of the given source from the resampled interferogram.

IV. REFERENCES

1. Hecht, E., Optics, 4th ed., Addison-Wesley, 2001

2. James, A student's guide to Fourier transforms, 2nd ed