### 3.5 M-Z optical fiber interference

**Objective:** Learn Mach-Zehnder (M-Z) interference principle and its applications, then operate the M-Z interferometer and test performance

**List of Components**

| | |
|---|---|
| LLL-2 He-Ne laser | 1 |
| 633 nm Single-mode fiber (FC/PC at one end) | 1 |
| Fiber interference demonstrator | 1 |
| Fiber scribe | 1 |
| Fiber stripper | 1 |

**Theory**

**M-Z interferometer principle and its application**

An optical fiber M-Z interferometer is constructed by using a piece of optical fiber to replace the air gap of a traditional Mach-Zehnder (M-Z) interferometer. This interferometer can be used to make various passive optical components such as fiber-based optical filter, optical switch, and sensors. It has been widely used in optical fiber communication and optical sensing.

An optical fiber M-Z interferometer is composed of a beam splitter with coherent light entering the input end of the beam splitter, an interference pattern is formed at the joint of the two single mode optical fibers with same length from the output end of the beam splitter.

The light intensity distribution of interference field (interference fringes) is related to the optical path difference and the angle between the two optical fibers on the output ends. If a fixed angle is assumed, the optical path difference caused by external factors corresponds directly to the light intensity distribution (interference fringes) in the interference field.

**Note**: it is recommended to perform the following experiment in a low light environment.

**Experiment**

1) Referring to Figure 14, prepare the 1 m optical fiber, then couple the laser into the end of the 1 m single-mode fiber through the collimating lens. The FC/PC end can be placed in the fiber clamp facing the white screen until optimum coupling is achieved.

**Note:** The power indicator can be used to monitor the output power of the fiber.

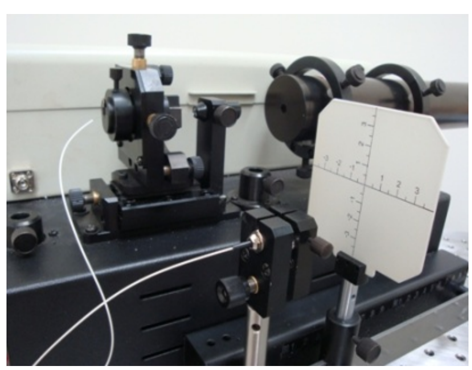

Figure 12 Photo of experimental setup for fiber coupling

2) Connect the FC/PC end of the single-mode fiber to the interferometer through the FC/PC connector labelled as “Fiber Optic Input”. The interference pattern should be observed on the ground glass screen as shown in Figure 13.

   **<u>Note:</u>** ambient light may need to be turned off before observing the interference pattern if it is too weak to observe interference fringes under ambient light.

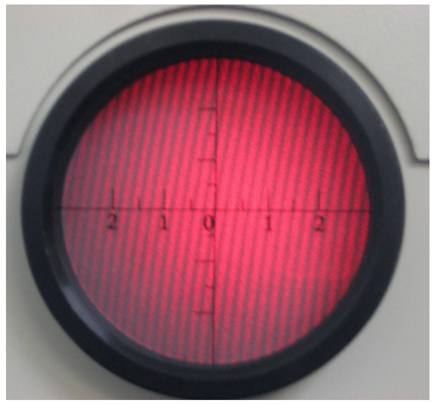


Figure 13 Photo of interference pattern observed on ground glass screen

3) Fix the relative positions and analyse the interference phenomena.

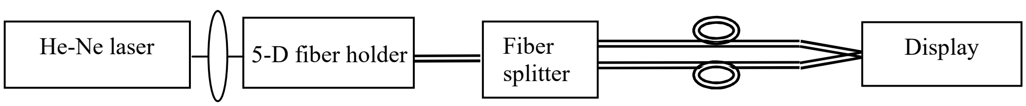


Figure 14 Schematic of optical fiber beam splitter

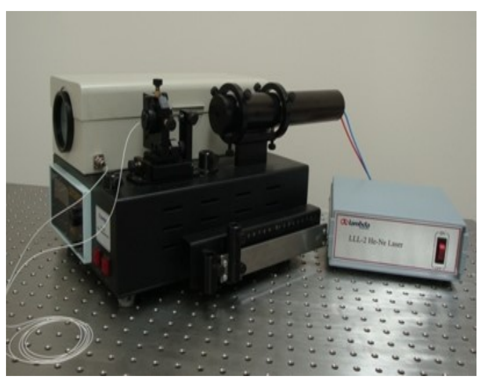

Figure 15 Photo of experimental setup for fiber M-Z interferometer

### 3.6 Optical fiber temperature sensing principle

**Objective**: Understand the principle of optical fiber sensing and conduct temperature sensing experiment

**List of Components**

| | |
|---|---|
| LLL-2 He-Ne laser | 1 |

| | |
|---|---|
| 633 nm Single-mode fiber (FC/PC at one end) | 1 |
| Fiber interference demonstrator | 1 |
| Fiber scribe | 1 |
| Fiber stripper | 1 |

In general, there are two kinds of optical fiber sensors: one is to detect and convert information by a sensing element while optical fiber is only used as a transmission line; the other is that optical fiber itself acts as both sensing element and transmission medium. The working principle of an optical fiber sensor is that the measured condition changes the transmission parameters of an optical fiber or the light wave parameters of a carrier vary with these parameters. The change of optical signals reflects the change of the measured physical condition.

**Note:** it is recommended to perform the following experiment in a low light environment.

**Experiment**

In this experiment, temperature is to be sensed. Because temperature changes the phase of optical waves, temperature measurement actually becomes phase measurement. Using the interference measurement technology, the phase change of optical waves is converted to its intensity change.

1) Prepare the 1 m optical fiber, couple the laser into one end of the 1 m single-mode fiber through the collimating lens. The FC/PC end should be placed in the fiber clamp facing the white screen until optimum coupling is achieved.

   **Note:** The power indicator can be used to monitor the power output of the fiber.

2) Connect the FC/PC end of the single-mode fiber to the interferometer through the FC/PC connector labelled as "Fiber Optic Input". The interference pattern should be observed on the ground glass screen as shown in Figure 13. **Note**: ambient light may need to be turned off before observing the interference pattern if it is too weak to observe interference fringes under ambient light.

3) Fix the position and switch on the temperature controller to analyse the interference pattern.

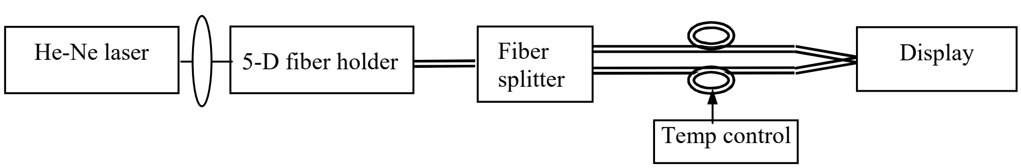


Figure 16 Schematic of fiber temperature sensing

The M-Z interferometer is used to measure temperature, as it has one arm as the reference arm and the other as the sensing arm with a display unit. This experiment is based on the interference observation for the change of interference fringes as caused by temperature variations.

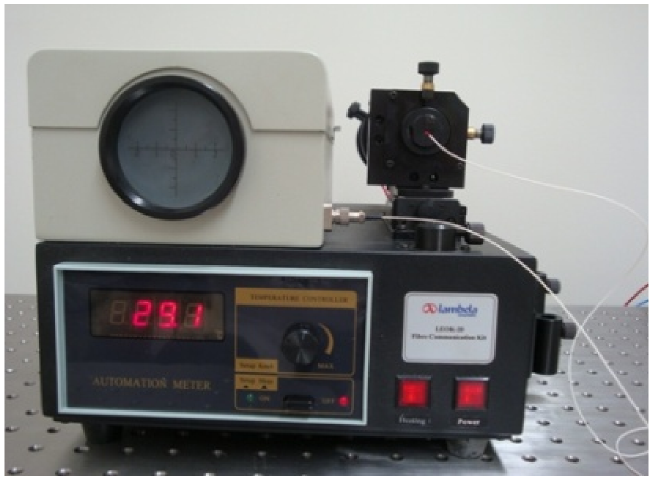


Figure 17 Photo of experimental setup for fiber temperature sensing

**Note**: The length of optical fiber for temperature sensing is 360 mm. To set a temperature value, press “SET” key once, use the “Up” or “Down” key to change temperature, and press “SET” key again to set temperature. **Warning:** Setting the temperature over 60 °C is not recommended.