Sensitivity and Range Characterization of Optical Gyroscope using Controlled Rotation Stage

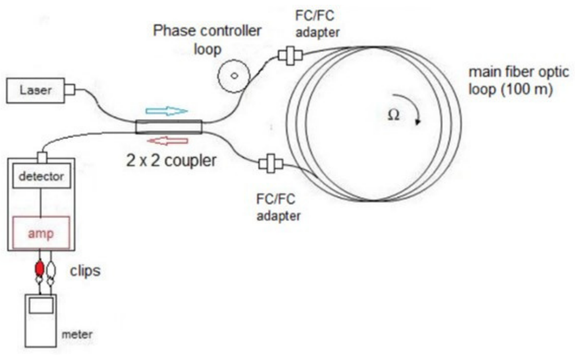
Reuben S Mathew[*], Athira T S[#], Dinesh N Naik[#], Harikrishnan P[#]

[*]National Institute of Technology, Calicut, Kerala

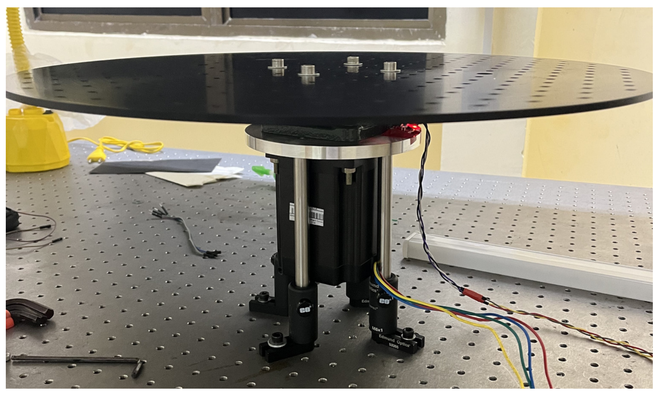
[#]Applied and Adaptive Optics Laboratory, Department of Physics, Indian Institute of Space Science and Technology, Thiruvananthapuram, Kerala

Objectives

- Design realization and testing of **rotating stage** for carrying out experiments on optical gyroscopes with following characteristics
  - High **torque**
  - Stability and **accuracy** at low speeds
- Testing with fiber optic gyroscope
- Study of **higher order modes**



Layout of Fiber Optic Gyroscope

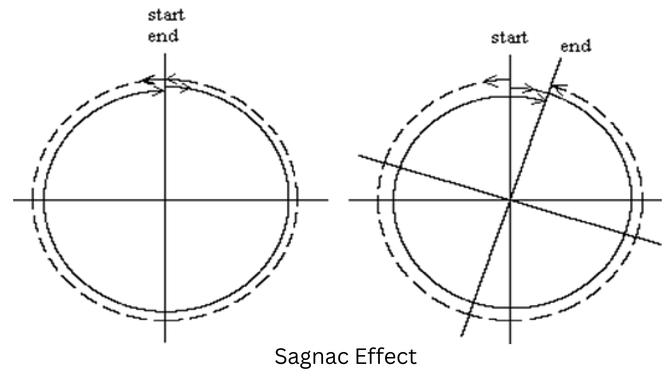


Assembled Rotation Stage

Optical Gyroscopes

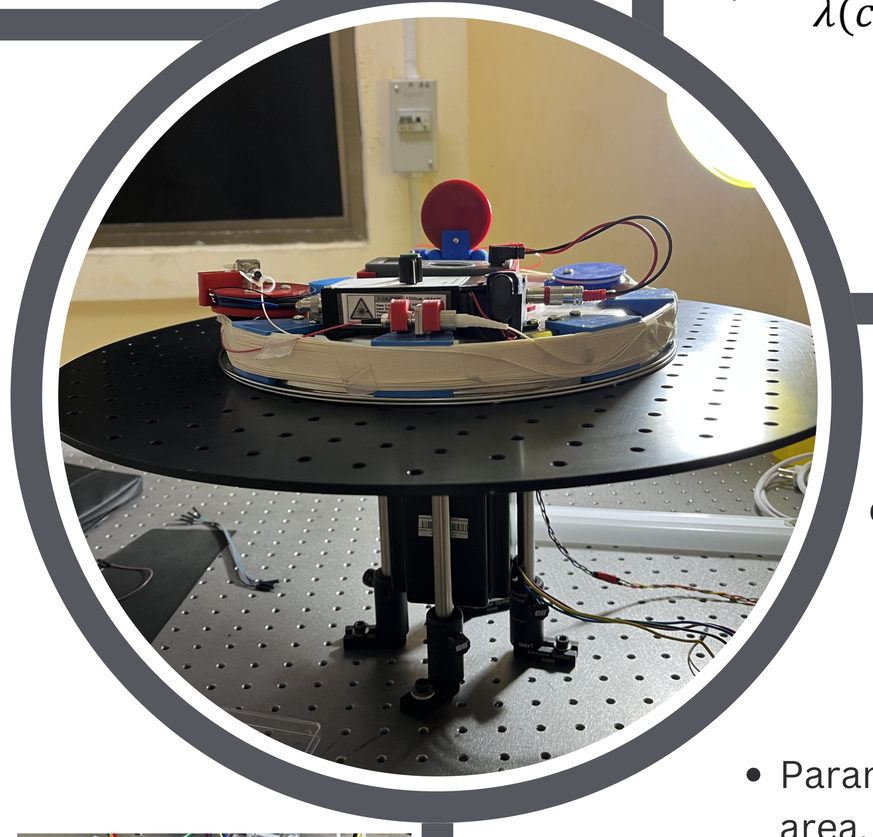
- **Sagnac effect**
  - Light passing in **opposite directions** through closed path
  - Path rotates - one beam **travels longer** distance
  - Causes **phase change - interference**
  - Angular velocity as function of intensity of interference pattern
- Advantages
  - **Highly sensitive**
  - No moving parts, **no wear and tear**
  - Opto-electronic system

$$\Delta\emptyset = \frac{8\pi NAc\omega}{\lambda(c^2 - v^2)}$$

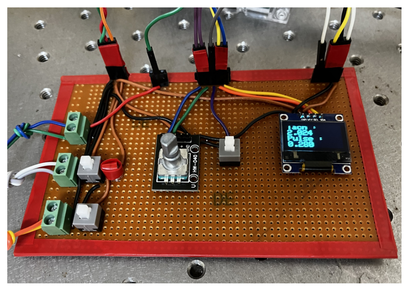


Sagnac Effect

Design and realization of rotation stage



- Motor
  - **High Torque** at Low Speeds
    - Stepper Motor - NEMA34
- Motor Driver
  - Motor control using simple **PWM** signals
    - RMCS 1101 - 7A Peak draw stepper driver
- Micro-controller
  - Brains of setup
    - **Arduino Uno**
      - Written in C/C++
      - Sets motor speed through PWM
      - Reads angular velocity from **tachometer**
- Tachometer
  - **Feedback loop** to set precise angular velocity
  - **IR sensor** module
  - Triggers everytime black strip on assembly passes over sensor
  - Interval betwen triggers measure angular velocity



Control Board

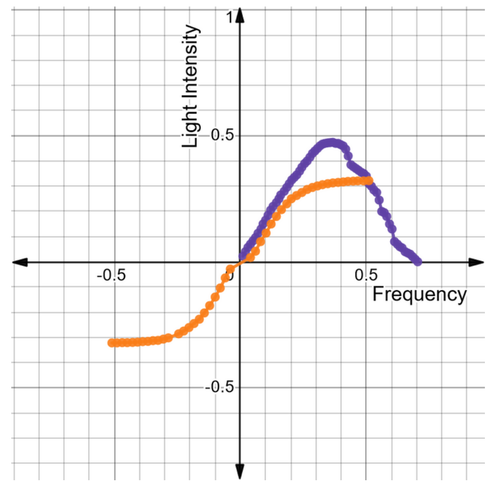
Tachometer

Testing and Data

- Fiber optic gyroscope mounted onto the rotation stage
  - Multiple sets of data collected
    - Measure **photo-diode voltage** read by the multi-meter, as function of **angular velocity**
  - Parameters of the gyroscope including area, number of loops, wavelength contained in a constant factor **k** .
    - Phase difference proportional to angular velocity
- Intensity (*I*) proportional to **cosine squared** of angular velocity (ω)

$$I \propto \cos^2(k\omega)$$

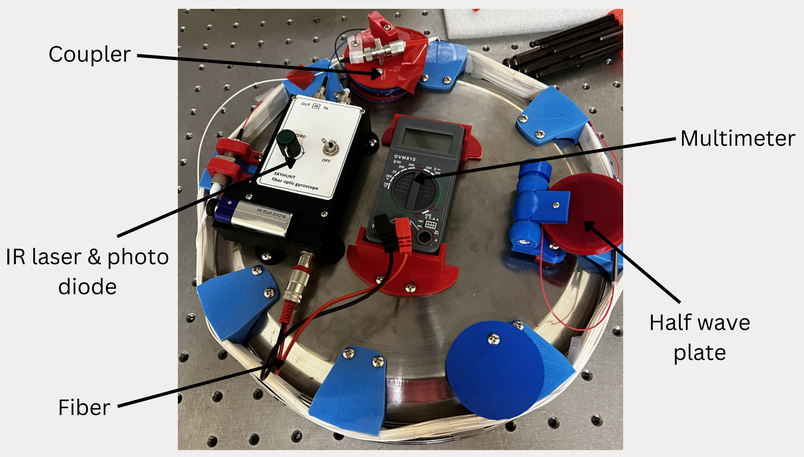
- Sagnac effect validated using the setup
- Rotary stage design proven



Plot of Intensity vs Frequency

Further scope

- **Imaging the modes** of the light received
  - Check for secondary modes providing any **additional information** that is lost by measuring intensity using a photo diode
- Short-Wave Infrared (SWIR) camera for 2-D imaging
  - Output image **unstable** and **highly sensitive** to ambient disturbances



Fiber optic gyroscope

Acknowledgment

We thank Prof Umesh R Khadane for his guidance, Dr. Priyadarshnam for the discussions and Small Satellites and Payloads Centre (SSPACE) for the support with FOG kit and related electronics

Reuben S Mathew :
reuben_b200150ep@nitc.ac.in

Dr Dinesh N Naik :
dineshnnaik@iist.ac.in