Torsion-Bar Antenna for Early Earthquake Alert

Yuka Oshima[1], Satoru Takano[1], Ching Pin Ooi[1],
Kentaro Komori[2], Yuta Michimura[2,3], and Masaki Ando[1,2]
[1]*Department of Physics, University of Tokyo*
[2]*RESCUE, University of Tokyo*
[3]*LIGO Laboratory, California Institute of Technology*
yuka.oshima@phys.s.u-tokyo.ac.jp

Introduction

Torsion-Bar Antenna (TOBA) is a highly sensitive gravity gradient sensor using torsion pendulums [1]. We use test masses suspended horizontally and aim to detect the torsional rotation caused by tidal forces as shown in FIG. 1. The resonant frequency of torsional motion is ~1 mHz, therefore TOBA has good design sensitivity in low frequencies (0.1 – 10 Hz). TOBA is useful for gravity-based earthquake early warning [2], and the observation of Newtonian noise and gravitational waves. A prototype detector Phase-III TOBA with a 35 cm-scale pendulum is under development [3]. The target sensitivity is set to 10^{-15} /√Hz at 0.1 Hz. Phase-III TOBA can detect earthquakes with a magnitude 7 or larger within 10 seconds from a 100 km distance [3].

Method

For Phase-III TOBA, we operate torsion pendulums at cryogenic temperatures to reduce thermal noise. We have successfully demonstrated cooling down test masses at 6 K [4]. Now, torsion pendulums are under development to achieve our target sensitivity. Differential Fabry-Perot cavities are used to read out the rotational angle to the pendulums. We finished designing the parameters of Fabry-Perot cavities and the mechanical parts for the pendulums.

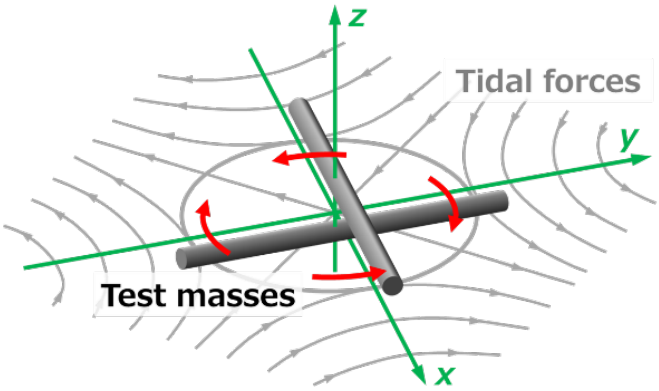

FIG. 1. the schematic of TOBA. Test masses are suspended horizontally in the x-y plane and a suspension wire is stretched in the z-axis. Grey lines represent tidal forces, red arrows show the rotational motion of the pendulums.

Acknowledgments

We would like to thank Shigemi Otsuka and Togo Shimozawa for manufacturing the mechanical parts used. This work was supported by MEXT Quantum LEAP Flagship Program (MEXT Q-LEAP) Grant Number JPMXS0118070351. Y.O. was supported by JSPS KAKENHI Grant Number JP22J21087 and JSR Fellowship, the University of Tokyo.

Reference

[1]M. Ando *et al.*, *Phys. Rev. Lett.*, 105, 161101 (2010).
[2]J. Harms *et al.*, *Geophys. J. Int.*, 201, 1416 (2015).
[3]T. Shimoda *et al.*, *International Journal of Modern Physics D*, 29, 1940003 (2020).
[4]T. Shimoda, PhD thesis, The University of Tokyo (2019).