Laser Interferometer in the Kamioka Mine

Masatake Ohashi,[1] and the LISM collaboration
(1) Institute for Cosmic Ray Research, University of Tokyo, Kashiwa, Chiba 277-8582, Japan

Abstract

We started to construct Cryogenic Laser Interferometer Observatory (CLIO) with 100m baseline length in the Kamioka mine. Before that we operated 20m interferometer near Super-Kamiokande to investigate the underground site. The aim of this program called LISM is to get a long and high-quality data by taking advantage of low seismic noises. Consequently we succeeded in proving the superiority of the Kamioka underground site.

1. Introduction

We have developed a 20m prototype interferometer since 1991 [1]. When the final experiment for TAMA project (a high-gain recycling [2]) was finished, we decided to move a 20m interferometer from TAMA site into the Kamioka Mine and started it at July 1999. The Kamioka Mine is famous as the site of Super-Kamiokande neutrino detector and is also a planned site of the Japanese future project LCGT (See Fig.1).

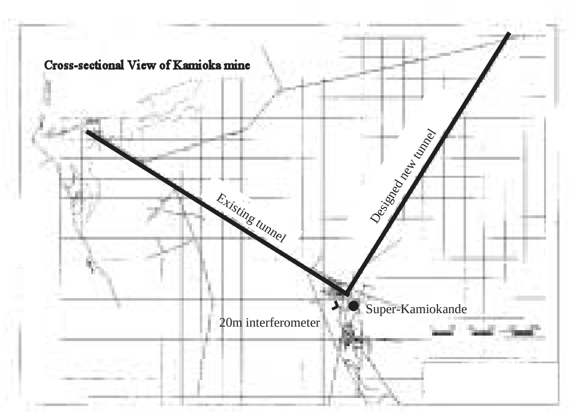

Fig. 1. The location of 20m interferometer with Super-Kamiokande and LCGT

The aim of this program called LISM (Laser Interferometer Small obser-

pp. 3077–3080

vatory in the kamioka Mine) is to take a long and high-quality data since its quiet ground motion (Fig.2) is expected to make an operation of the interferometer very stable. We carried out several observations since 2000. The aimed sensitivity is $h_{\mathrm{rms}} = 10^{-18}$.

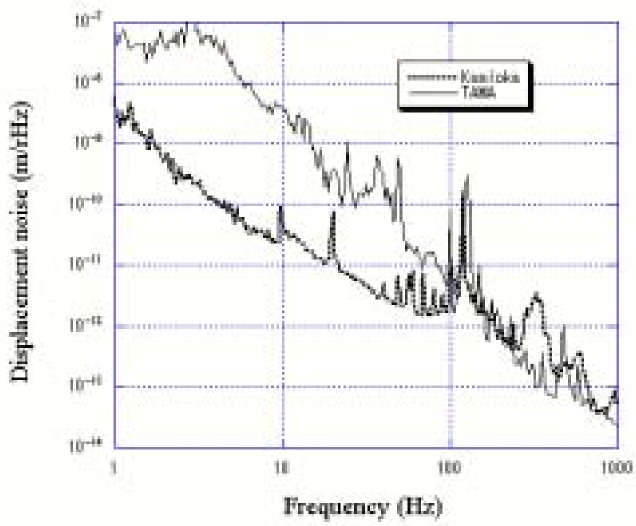

Fig. 2. Seismic noise spectrum of Kamioka and TAMA site

2. 20m interferometer: LISM

LISM consists of three parts; a light source with a mode cleaner, a primary cavity as a frequency reference and a secondary cavity to sense gravitational wave. A light source is a commercial laser with wavelength of 1064 nm and output power of 700 mW. Two cavities are formed by a pair of high quality mirrors with a finesse of about 25000 [3] and length of 20 m.

The optical layout is called as Locked Fabry-Perot configuration (Fig. 3). The main part of LISM is housed in vacuum chambers and the pressure is kept at 10^{-4} Pa by two ion pumps. Data acquisition system has eight channels with 20kHz sampling and another eight channels with slow sampling for monitoring the interferometer and environments.

We started observations early in 2000. The operation of LISM is very stable owing to quietness of the underground site and 120 hours successive operation was demonstrated without any alignment control. After several improvements, mainly frequency stabilization of the laser, the strain sensitivity of LISM reached $h_{\mathrm{rms}} = 6.0 \times 10^{-20}$ around 800Hz (See Fig.4).

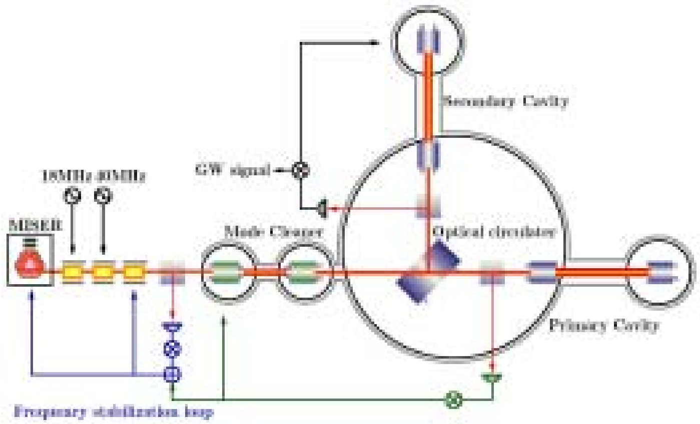

Fig. 3. Optical layout of 20m interferometer

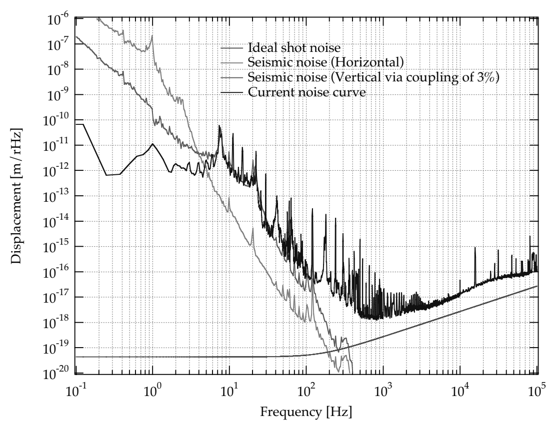

Fig. 4. The displacement noise of LISM

3. Summary

We moved 20m interferometer from TAMA site into the Kamioka Mine. The sensitivity was improved to catch the event of binary neutron star inspirals up to 1kpc with signal-to-noise ratio 10. The operation was very stable because of the quietness in the Kamioka Mine. We synchronized its observation with the sixth Data Taking of TAMA300 and recorded over 700 hours data [4]. Based on the above results, the advantage of the underground site is confirmed.

4. References

1. Ohashi M. et al. 1997, in Gravitational Wave Detection, ed. Tsubono K., Fujimoto M.-K. and Kuroda K. (Universal Academy Press, Tokyo)
2. Sato S. et al. 2000, Appl. Opt. 39, 4616.
3. Sato S. et al. 1999, Appl. Opt. 38, 2880.
4. Ohashi M. et al. submitted to Class. Quantum Grav.