Design and operation of a 1.5-km laser strainmeter installed in the KAGRA underground site (III)

*Akito Araya[1], Akiteru Takamori[1], Wataru Morii[2], Miyo Kouseki[3], Masatake Ohashi[3]

1. Earthquake Research Institute, University of Tokyo, 2. Disaster Prevention Research Institute, Kyoto University, 3. Institute for Cosmic Ray Research, University of Tokyo

Ground motion have been monitored by various instruments, such as a seismometer, GNSS, SAR, and VLBI over very wide ranges in amplitudes and frequencies. A strainmeter is one of such instruments measuring deformation of the ground by sensing distance between two separated points, and capable of detecting small strain changes at low frequencies. By using a highly stabilized laser wavelength as a reference in the distance measurement [1], instead of using a mechanical reference [2], excellent performances are expected to be obtained. Apart from instrumental detectability, noise sources, such as local disturbances, stability of coupling to the ground, and susceptibility to surrounding environment, need to be evaluated as a geophysical observation equipment.

In 2016, a new laser strainmeter with a 1.5-km baseline was constructed at an underground site and started test observation. The site is a part of KAGRA gravitational wave detector [3, 4] in Kamioka. The strainmeter clearly detected earth tides with a slight amplitude reduction due to the topographic effect, seismic waves from local and distant earthquakes [5], and coseismic strain steps associated with generation of seismic faults by earthquakes [6].

For long-term strain changes, 1.5-km data showed smaller strain changes than that of existing 100-m laser strainmeter [7], however more data are needed to draw a definitive conclusion. In the presentation, we discuss detectability of the 1.5-km laser strainmeter especially for long-term strain changes and prospect for monitoring crustal dynamics using the long-baseline strainmeter.

References

[1] V. Vali, R. S. Krogstad, and R. W. Moss, Laser interferometer for earth strain measurements, Rev. Sci. Instrum., 36, 1352, 1965.

[2] H. Benioff, Fuzed quartz extensometer for secular, tidal, and seismic strains, Geol. Soc. Am. Bull., 70, 1019-1032, 1959.

[3] Y. Aso et al, Interferometer design of the KAGRA gravitational wave detector, Phys. Rev. D, 88, 043007, 2013.

[4] T. Akutsu, M. Ando, S. Araki, A. Araya, T. Arima et al., Construction of KAGRA: an underground gravitational-wave observatory, Prog. Theor. Exp. Phys., 013F01, 2018.

[5] A. Araya, A. Takamori, W. Morii, K. Miyo, M. Ohashi, K. Hayama, T. Uchiyama, S. Miyoki, and Y. Saito, Design and operation of a 1500-m laser strainmeter installed at an underground site in Kamioka, Japan, Earth, Planets and Space, 69:77, 2017.

[6] A. Araya, A. Takamori, W. Morii, K. Miyo, and M. Ohashi, Long-baseline laser strainmeter constructed at the underground KAGRA site in Kamioka as a new tool for monitoring crustal dynamics, IAG-IASPEI 2017,

Kobe, 2017.8.1, G04-3-01.

[7] A. Araya et al., Broadband observation with laser strainmeters and a strategy for high resolution long-term strain observation based on quantum standard, J. Geod. Soc. Japan, 53, 81-97, 2007.

Keywords: strainmeter, laser, crustal deformation, KAGRA, Kamioka

