KAGRA地下サイトに建設された1.5kmレーザー歪計の設計と運用（ＩＩ）

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

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Laser interferometers are widely used for precise measurement in experimental physics, engineering, metrology, etc. In geophysics, as one of its applications, laser strainmeters are used for measuring deformation of the ground based on accurate wavelength of a highly frequency-stabilized laser. The advantages of the laser strainmeter over conventional strainmeters using mechanical references are high resolution with a long baseline, resonance-free response with optical reference, and low-drift detection using absolutely stabilized laser wavelength.
A laser strainmeter with a baseline of 100m was constructed in Kamioka underground site (Gifu Prefecture in Japan) and has been operated since 2003. The observation results were reported in Refs. [1-4]. Construction of a new laser strainmeter, having a longer baseline (1.5km), was reported in [5]. The strainmeter is located in a new tunnel for the large-scale gravitational-wave detector, KAGRA [6]. Along one of the arms of the KAGRA detector, the laser strainmeter is formed by an asymmetric Michelson interferometer with two retro-reflectors and other optics in vacuum. A frequency-doubled Nd:YAG laser, emitting wavelength of 532nm and frequency stabilized at a level of ~10^{-13}, is used as a light source. Fringe signals are converted to displacement between the retro-reflectors with a separation of 1.5km using a quadrature fringe detection [7].
A test run of the new laser strainmeter started in August 2016, and strain data were obtained. Earth tides were clearly observed and were almost consistent with theoretical waveforms, except for slight reduction in amplitudes likely due to topographic effect [2]. Strain detectability was estimated to be ~10^{-12}, which is better than the 100-m strainmeter. Estimated performance of the 1.5-km laser strainmeter in comparison with the 100-m strainmeter and other conventional straineters will be presented based on the results of the test run.

[1] S. Takemoto et al., A 100 m laser strainmeter system installed in a 1 km deep tunnel at Kamioka, Gifu, Japan, Journal of Geodynamics, 38, 477-488, 2004.
[2] S. Takemoto et al., A 100m laser strainmeter system in the Kamioka Mine, Japan, for precise observations of tidal strains, Journal of Geodynamics, 41, 23-29, 2006.
[3] A. Araya et al, Analyses of far-field coseismic crustal deformation observed by a new laser distance measurement system, Geophys. J. Int., 181, 127-140, 2010.
[4] 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.
[5] A. Araya et al., Design and operation of a 1.5-km laser strainmeter installed in the KAGRA underground site, in abstract of Japan Geoscience Union Meeting 2016, SGD23-12, 2016.
[6] Y. Aso et al, Interferometer design of the KAGRA gravitational wave detector, Phys. Rev. D, 88, 043007, 2013.

[7] P. L. M. Heydemann, Determination and correction of quadrature fringe measurement errors in interferometers, Appl. Opt., 20, 3382-3384, 1981.

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