Primary vibration calibration at ultra-low frequency for broadband seismometers

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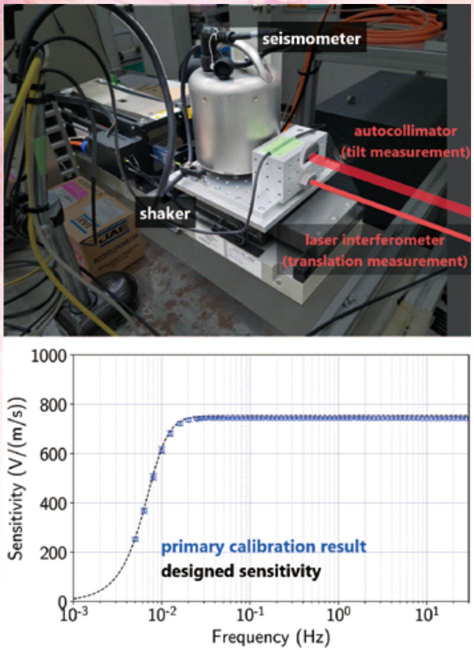

Developed primary calibration system (top) and example of calibration results for a broadband seismometer (bottom)

Broadband seismometers are essential instruments for monitoring ultra-low-frequency vibrations ranging from a few millihertz to several tens of hertz and are deployed globally for earthquake observation and nuclear test detection. The calibration of these instruments across their observational frequency spectra has become increasingly important to ensure the accuracy and reliability of measurements. Traditional primary vibration calibration involves vibrating a calibration target with a shaker and comparing its output signal to that of a reference laser interferometer. However, this method encounters limitations at frequencies below 0.1 Hz, where the gravitational influence of the earth exacerbates measurement errors due to even minimal tilting of the shaker, particularly as the applied acceleration diminishes.

Addressing this challenge, NMIJ has developed an accurate correction technique that simultaneously measures both the translation and tilt of the shaker. This approach utilizes a combination of a laser interferometer and an autocollimator, effectively minimizing the error source associated with the tilt of the shaker and coupling with the gravity of the earth. Consequently, this advancement extends the measurable frequency range down to 5 mHz, setting a new global standard for the lowest frequency attainable in primary calibration.

The development of this calibration method marks a significant milestone, enabling the direct confirmation of the low-frequency cutoff in broadband seismometer sensitivity through real vibrations. When integrated with in situ comparison calibration, this enhanced primary calibration technique promises to improve the observational precision of the worldwide seismometer network significantly.

Reference: T. Shimoda et al., *Meas. Sci. Technol.* **33**, 125021, 2022, DOI: 10.1088/1361-6501/ac9077