S081-005 Room: 201B Time: May 29 14:45-15:00

Development of a new type laser tsunami-meter

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Observation of tsunami wave heights in off- shore areas by tsunami-meters installed on the sea flooa would be very important for mitigation of tunami disasters, since the off-shore observations could be used to precisely predict the arrival times and accurate tsunami heighs at the sea shore.

The goal of this project is to develop an innovative tsunami-meter that uses precision measurements by laser interferometry, which was adopted in development of borehole laser strainmeters of the Sakata-Gubin type. The laser tsunami-meter has advantages over conventional qualtz oscillator type instruments, namely, low cost of production and installation, low maintenance cost, higher precision, and long-term reliability.

The tsunami-meter discussed here consists of three parts: the under-water part, the land part, and the optical fiber cable. The cylinder wall of the under-water vessel has two thicknesses, and two resonators are arranged to coincident with two perpendicular diameters. The difference of two diameter changes under an external pressure change is proportional to that pressure change.

Two lasers in the land part are connected to the two resonators by the optical fiber cable, and servocircuits lock the lasers to resonators. The beat frequency change between the two resonators is proportional to the external presure change. Changes of the inner diameters due to thermal expansion are expected to the same when the temperature distribution in the cylinder becomes stationary, this characteristic provides a self-compensation function for temperature changes.

Tests under varying water pressures in the factory showed sensitivity of 12MHz(beat frequency)/1cm(water head). This corresponds to 2.6nm(diameter difference)/1cm(water head). The instrument was installed on the sea floor of depth 20m, and we found that a laser often deviated from a locked state. This is due to pressure fluctuations caused by surface waves. We plan to add a cover around the cylinder to greatly reduce the high frequency pressure changes. In deeper ocean areas no cover is necessary since the wave effects diminish to zero on the sea floor.

The resonators in the under-water part need only four optical fibers, which are contained in a slender 2mmO.D. metal pipe. This means low cost of production and installation of the cable, in which the maximum length is expected to be of 100km order. The cylindrical vessel contains neither moving parts nor electric circuits, and will guarantee a long-term reliability. What is crucially important is reliability of lasers under long-term continuous operation.