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Performance evaluation of a test mass launch system including a reaction reduction mechanism for a rise-and-fall AG

SAKAI, Hirotaka[1*] ; ARAYA, Akito[1] ; TSUBOKAWA, Tsuneya[2]

[1]Earthquake Research Institute, University of Tokyo, [2]Shin-ei Keisoku

We describe the test mass launch system including a reaction reduction mechanism for the compact rise-and-fall absolute gravimeter (AG). Absolute gravimeters measure the local value of the gravitational acceleration g in the accuracy of few μgal (1μgal = 10^{-8} ms^{-2}). Absolute gravimeters are used to establish the gravity standard network. They can be also used to survey of magma movement in the volcano. The data provide significant information of volcanic activities and various studies are proceeded to estimate volcanic eruptions and underground density structures. Absolute gravimeters are accurate, but the equipment is too bulky and heavy for field observation. As a result, for volcanic observations, a gravity value is usually measured by an absolute gravimeter at a reference point of foot, and then a gravity value of an observation point can be obtained from the gravity difference of a reference point and an observation point measured with the relative gravimeter. Therefore such an observation is troublesome, and requires long time. An apparent gravity change by the drift of the relative gravimeter happens, and measurement accuracy may worsen. Furthermore it is dangerous to observe at a reference point when a volcano erupts. If compact absolute gravimeters are completed and put to a volcanic area, we will acquire accurate data continuously even when the volcano is active. To achieve these, my studies are very important.

We adopt a rise-and-fall method to realize the downsizing of the absolute gravimeters. The measurement of gravity acceleration is based on the reconstruction of the orbit of the test mass thrown up or dropped in vacuum chamber. This method has some advantages. The simple free-fall method has several problems such as bulky mechanism to lift up the test mass, repeated measurements, and long time to take for the preparation. Hence, we developed the launch equipment that has no need for lifting up the test mass and can measure repeatedly. In addition the finite speed of light effect and drag effect are offset. As a result, systematic error becomes small. The equipment can throw up the test mass by 3mm in height simply by applying the signal to a piezoelectric element which is incorporated in the displacement enlarging mechanism. And the reaction reduction system is attached for the purpose of improvement of the measurement accuracy. When the test mass is thrown up, the floor recoil affects the interferometer and generates a systematic error. Specifically, we put the same piezoelectric element and the displacement enlarging mechanism on the other side of the baseplate to which the launch system is attached. These displacement enlarging mechanisms move symmetrically by applying the same signal to the piezos. When the test mass is thrown up, the counter mass fixed by springs is launched downwards at the same time to compensate the recoil effect. Moreover, to avoid the vibration occurrence by movement of displacement enlarging mechanism, we applied the signal of which acceleration is as continuous as possible. We could observe the reaction as much as 20% of peak acceleration without its mechanism. The result of gravity measurement in February and development status will be reported.

Keywords: absolute gravimeter, launch system, reaction reduction mechanism, gravity, prediction of volcanic eruption, estimating a subsurface density structure