

Gravity measurements in Antarctica with pendulums and ticker-tape timers

KAZAMA, Takahito^{1*}, Chizuko Higashino², Koichiro Doi³

¹Kyoto University, ²Kansai University Dai-ichi High School, ³National Institute of Polar Research

In high school physics classes, the value of gravitational acceleration (or gravity) is taught as about 9.8 m/s^2 , which is often observed with simple experiments using pendulums and ticker-tape timers. In reality, however, the gravity value differs depending on place and time; for example, the gravity difference becomes about 0.5 % between equator and pole on the Earth. Although geodesists measure the minute gravity differences with high-accuracy gravity meters such as absolute gravimeters, it must be important for high school students to measure the gravity difference with the simple equipment such as pendulums and ticker-tape timers, in order to get students interested in gravity and physics.

We were thus motivated to measure the gravity value with a pendulum at Syowa Station in Antarctica, where we visited as the 53rd Japan Antarctic Research Expedition (JARE-53). We chose Syowa Station as the location to measure the gravity, because [1] Syowa Station is located at 69 degrees south latitude, close to the South Pole, and [2] an absolute gravimeter, installed at the gravimeter room in Syowa Station by JARE-53, observed the gravity value to an accuracy of more than eight orders. We first put a cylindrical brass (weight: about 750 g) to the lower end of a stainless steel wire (length: about 3 m), which was hanging from the ceiling of the gravimeter room. We then oscillated the brass with the amplitude of about 15 cm, and recorded the brass oscillation on video. And finally, we estimated the average oscillation period with movie analyses, and calculated the gravity value using a formula for the oscillation period of a single pendulum.

As a result, the gravity value with the above pendulum experiment at Syowa Station was estimated as 9.8462 m/s^2 , which deviated by about 0.2 % from the gravity value observed with the absolute gravimeter (9.8252432 m/s^2). The causes of the gravity deviation possibly lie in [1] the measurement error of the oscillation period, [2] the measurement error of the pendulum length, and/or [3] the effect of air resistance and supporting point's friction. We will evaluate the accuracy of the gravity value estimated by the pendulum experiment, with quantitatively discussing the causes of the gravity deviation.

In addition, we will regularly measure the gravity values with ticker-tape timers on the ice-breaker ship Shirase on the way back to Japan from Antarctica, although we are still at Syowa Station on February 10th 2012. Furthermore, we will measure the gravity value with the same pendulum as we measured the gravity in Antarctica, to discuss the difference of the gravity value between Japan and Antarctica.

Keywords: Gravitational acceleration, Antarctica, Pendulum, Ticker-tape timer, Absolute gravimeter, Syowa Station