On parasitic oscillations of superconducting gravimeters

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The superconducting gravimeter (SG) has a long-period instrumental noise at periods around 100 seconds. This is a sort of parasitic oscillation characterized by a very high Q value. Although it is generally regarded as a proper oscillation of the superconducting sphere levitated in the magnetic field, its precise mechanism has not yet been identified. If it is an oscillation associated with rotational degrees of freedom of the sphere, there may be two unidentified modes in addition to the one already known.

Here we analyze the high-rate gravity data from two SG stations in Japan, Matsushiro and Kamioka, which are acquired through the GWR5 channel of the gravimeter controller. As a result, another parasitic mode is detected at much higher frequencies than the low-frequency mode. This is characterized by frequencies on the order of 1 Hz and even higher Q values. Detailed spectra reveal that the mode actually consists of two split modes with small frequency separations. The 2007 Niigataken Chuuetsu-oki Earthquake strongly excited the three modes on the SG at Matsushiro, and yielded very complicated spectra in which interactions between the modes can be identified.

In order to interpret the observed spectra, we have developed a simple theory on the rotational motions of the superconducting sphere with respect to its center of mass, based on realistic assumptions on the geometry of the sphere and the magnetic field. As a result, it is derived that a slight asymmetry in the mass distribution of the sphere gives rise to rotational oscillations of the sphere about two orthogonal axes in the horizontal plane. The observed high-frequency modes can be identified consistently as these rotational oscillations. Although this model does not explain the mechanism of the low-frequency mode, observed features of the earthquake spectra suggest that the low-frequency mode is associated with rotations of the sphere about the vertical axis.