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Design and Testing of a MEMS Semi-Absolute Pendulum Gravimeter

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Gravimetry has many useful applications from volcanology to oil exploration; being a method able to infer density variations beneath the ground. Therefore, it can be used to provide insight into subsurface processes such as those related to the hydrothermal and magmatic systems of volcanoes. Existing gravimeters are costly and heavy, but this is changing with the utilisation of a technology most notably used in mobile phone accelerometers: MEMS – (Microelectromechanical-systems). A team at the University of Glasgow has already developed a MEMS relative gravimeter and is currently collaborating with multiple European institutions to make a gravity sensor network around Mt Etna - NEWTON-g. A second generation of the MEMS sensor is now being designed and fabricated in the form of a semi-absolute pendulum gravimeter. Gravity data for geodetic and geophysical use were provided by pendulum measurements from the 18th to the 20th century. However, scientists and engineers reached the limit of fabrication tolerances and readout accuracy approximately 100 years ago. With nanofabrication and modern electronics techniques, it is now possible to create a competitive pendulum gravimeter again. In this presentation the design and fabrication techniques of a new MEMS pendulum gravimeter will be outlined. The design comprises two pendula, which oscillate in anti-phase to reduce the influence of seismic noise. Nanofabrication methods have been used to create both flexure and knife-edge pivot points. An optical shadow-sensor has been developed to monitor the position of the pendula. This optical readout can provide measurements to sub-nanometre precision. Data collected from laboratory testing will be presented, demonstrating the progression being made towards a prototype field device. This data will include measurements of the influence of tilt-sensitivity and the seismic and shadow sensor noise floors. Altitude tests of the free-air effect will be presented to demonstrate the current sensitivity of the device. If semi-absolute values of gravity can be measured, then instrumental drift concerns are reduced. Additionally, the need for calibration against commercial absolute gravimeters may not be necessary. This promotes improved accessibility of gravity measurements at an affordable cost.