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Optical readout design for 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). Glasgow University has already developed a relative MEMS 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. The pendulum method is used to determine gravity values from the oscillation period of a pendulum with known length. The current design couples two pendulums together. Here, an optical shadow-sensor pendulum readout technique is presented. This employs an LED and split photodiode set-up. This optical readout can provide measurements to sub-nanometre precision, which could enable gravitational sensitivities for useful geophysical surveying. 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.