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Superconducting inertial sensor with low-noise actuators for gravitational-wave observatories

The cryogenic environment of gravitational-wave detectors, such as Einstein Telescope (ET), can be used in combination with superconducting materials to open up pathways to low-loss actuators and sensor mechanics. We are developing a Cryogenic Superconducting Inertial Sensor (CSIS) with a displacement sensitivity of several fm/√Hz at 0.5 Hz. Such highly sensitive device can monitor the effects of low-vibration cryocoolers applied to the penultimate stage of ET as well as possibly assist in the suspension control.
In CSIS, superconducting thin film spiral coils use the Meissner effect to form actuators as part of a force feedback sensing scheme. This actuator reduces losses of the sensor mechanics by not using magnets in the actuator, which greatly reduces viscous eddy current damping. We investigate properties as magnetic field and current density distribution of the coil by finite element analysis using COMSOL. The magnetic field and force applied by the actuators have also been simulated analytically and the results agree with COMSOL ones. We also present results from the thin film fabrication process to produce 1 cm diameter coils. Superconducting thin films deposited on silicon substrate are being cryogenically tested.

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