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Sensitive Low Frequency Optomechanical Sensor

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In this poster recent work on the development of an optomechanical detector for weak, low fequency (0.1 - 20Hz) mechanical vibrations is presented. The device is patented, (Coutsomitros, 1993, Cousomitros and Franchi 1994), and some earlier results have previously been presented at international conferences (Coutsomitros 1994, Cousomitros et al. 1994a and b).

The detector is essentially a dynamical interferometer, coupled to and air floated optical table, Critically balanced vertical glass plates, in a set of geometries, produce between them a Fabry-Perot type interferometer, The resulting dynamical interference pattern between the two inner vibrating surfaces is then examined. The mechanical properties of the plates and the effects of the layer between the plates produce a system which is sensitive to weak low frequency mechanical excitation. The introduction of holographic gratings onto the surfaces of the plates has been found to strenghten the observable interference fringes. The device works at room temperature and pressure, is robust, and has been shown to give reproduceable results (in terms of sensitivity). Increased sensitivity with decreased temperature has also been noted.

The development of such a device requires the modelling and examination of the behaviour of optical tables and isolation equipment, at frequencies for which they are in general not designed. It also requires careful analysis of the mechanical properties of the system, including contributions due to surface tension, electrostatic charges, contact forces, thermal and mechanical properties of the glass plates, and fluid flow between the plates, A mechanical model based on these effects and assuming the existence of multiple non-resonant cavities is currently being developed.

The detector, as it currently appears, is non-optimised. Despite this fact a comparison with commercially available accelerometers show that the system appears competitive in performance and potentially cheeper to manufacture, Currently work to produce a more controlled device is being carried out.

Correlation between the variations of the interference fringes produced by the detector and a periodic mechanical excitation system, made using a rotating mass of 4Kg at distances of up to 25m, has been established. Using a high speed CCD camera and signal analysis software developed at the Department of Applied Optics of Strassbourg University further evidence for this correlation has recently been found. (Miehe, 1993, Miehe, 1994).

Other experiments involving the use of a mechanical shaker as a normalieed vibration source are also being carried out. Measurements of the transfer of the resulting vibration into the modes of the table, using ESPI and piezoelectric based accelerometers, allows an examination of the transfer of vibration between the table and the plates to be carried out.

It has also been found that the interference pattern from the parallel plate arrangement can also be stimulated into varying synchronously with an incident modulated low power (>1mW) light source. In this mode the system has characteristics in many ways analogous to those of one manufactured with a material which exhibates bulk non-linear optical Kerr effect, as the optical pathlength in the layer appears proportional to the incident intensity.

Such an arrangement offers the possibility of optically modulating an optical signal. (Coutsomitros, 1993, Coutsomitros et al. 1994a). By coating the plates with metal it might also be possible to modulate the resulting capacitors capacitance using the input optical beam. In relation to the

vibrational sensor this work makes available an alternative method to measure and test the mechanical response of the device. In this way thermal, and mechanical effects can be more carefully examined.

The use of a hypersensitive form of this dynamical interferometer to detect Newtonian graviational gradients and the forces arising due to light radiation pressure on the plates are also being examined. (Coutsomitros 1994b, Coutsomitros et al. 1994b). The sensor may also find use in seismic studies.

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