Project with Gravitational Wave Group (experimental)

--Optical springs: towards measurements below the standard quantum limit

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This project aims to develop optomechanical devices to improve the sensitivity of the advanced detectors. Optomechanical devices make use of strong interactions between light (or electromagnetic waves in general) and mechanically resonant mirrors in optical cavities. The detection of gravitational waves from a black hole binary coalescence on 14 September 2015 was a masterpiece of optomechanics.

Australia plays an active role in developing technologies for the advanced gravitational wave detectors. The University of Western Australia group is a member of LIGO Scientific Collaboration. We work on developing techniques to further improve the sensitivity of the advanced detectors below the standard quantum limit (SQL), which is currently the limiting sensitivity. The development of advanced techniques to improve the sensitivity of gravitational wave detectors leads to exciting new physics phenomena and techniques that may have application beyond gravitational wave detectors.

Student participate in this research will be working with our postgraduate students on developing low loss cavities with novel resonator design, and test optical spring effect.

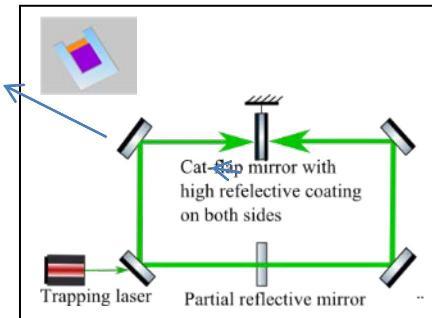

Figure 3. An optical cavity with a "cat-flap" resonator mirror design (the purple part is the coated mirror)

Optical springs are created by radiation pressure forces in optical cavities. This effect could be used to modify the dynamics of the resonator/mirror in the optical cavity and thus creating an opto-mechanical system with very low loss that could be used in a range of schemes for beating the standard quantum limit for gravitational wave detectors.

We are collaborating with researchers in Austria, Taiwan, Holland and France to fabricate the "thermal noise free" resonators. An optomechanical system as shown in Figure 3 has been designed. The project involves modelling the resonator using finite element analysis, constructing and tuning optical cavities to observe optical spring dilution to achieve very low loss resonators. This scheme has the potential of measuring macroscopic objects with resolution better than the "standard quantum limit" predicted by naïve application of quantum mechanics. This offers a new technique for improving gravitational wave detectors as well as allowing a range of new experiments in quantum experiments.

Pictures of UWA optical laboratory table top opto-mechanics experiments and the 80m high optical power facility