Group IGR

Project name Optical design and simulations for a novel interferometer that surpasses the Heisenberg Uncertainty Limit

Supervisor Stefan Hild

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Suitability 20 credit yes 30 credit yes 40 credit yes

Suitable for "theoretical physics" yes

Project description (length should not exceed remainder of page)

Gravitational wave detectors can measure the distance between 2 test masses to a precision of about a 1/1000 of a proton diameter. The next generation of these detectors, such as Advanced LIGO, will be limited entierly by quantum noise which is a maifestation of the Heisenberg Uncertainty Principle. A novel interferometer configuration, a so-called 'Sagnac speedmeter' has the potential to increase the sensitivity of gravitational wave detectors even beyond the Heisenberg limit. The world's first Sagnac speedmeter is currently under construction in the IGR cleanroom labs.

This project will offer the student on one hand the opportunity learn and explore numerical simulation techniques as a vital tool for the design and evaluation of complex optical systems and on the other hand to contribute to the final design of an £1.2 million interfeometer build in Glasgow.
Optical simulations allow to quickly access the advantegous and disadvantegous of different interferometer configurations, without the need to actually build them in hardware. This project will include the following aspects: spatial modes in interferometers and optical resonators, opto-mechanical rigidity and optical springs, optical readout and sensing at and beyond the quantum limit, lock-acquisition and length stabilisation of optical resonantors, sensitivity limits from fundamental noise (thermal and quantum) and technical noise (laser frequency noise, relative intensity etc) sources.

This project requires good Matlab skills. Knowledge of a compiled programming language is helpful, but not essential. An curiosity for simulations and an interest in optical systems at the quantum limit are vital.