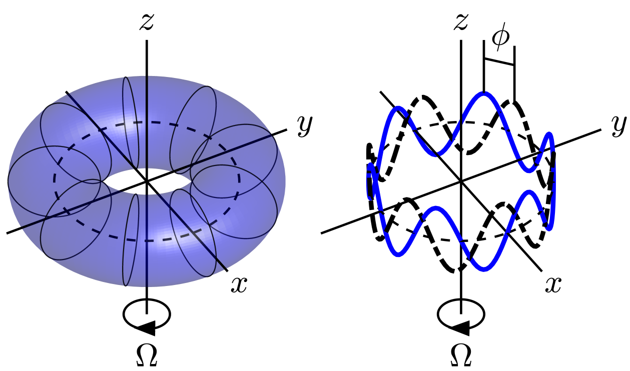
Designing a Quantum Matterwave Vortex Gyroscope

R.W Husband[a], S. Legge[a], S.A Haine[a], R. Thomas[a] and J. Close[a]

[a]*Department of Quantum Science and Technology, Australian National University, ACT, Australia.*

Quantum sensors are a technology which exhibit promising real-world applications of quantum mechanics that exploit its most counterintuitive properties. I present an ongoing project that aims to design, build, and test a new type of quantum rotation sensor, the vortex matterwave gyroscope (VMG). The device uses the quantised azimuthal phase of a torus-shaped Bose-Einstein Condensate (BEC) to measure rotation rates through atom interferometry, making the device robust to long-term drift, giving a quantum advantage over current optical and matterwave gyroscope designs. The VMG sensitivity improves with vortex charge and integration time, making the device suitable for long-term measurements with a potential chip-scale size.

The VMG uses a beam splitter light pulse to imprint the quantised orbital angular momentum of a Laguerre-Gauss (LG) beam onto a BEC, acting as a phase memory. Applying a second beam splitter at a later time compares the BEC phase with an external rotation, enabling the rotation rate to be measured. Experimental work was conducted using a spatial light modulator to generate and characterise LG beams in terms of their mode composition and phase noise. Simulations were then made to characterise different VMG designs, visualise the impact of the measured LG beam data on the sensor's performance, and guide the development of the first VMG prototype currently under construction in our BEC laboratory. Experimental implementation of the VMG shows promising preliminary results and further improvements are planned for increased gyroscope sensitivity.



(a) (b)

Figure 1: A visual of the VMG interferometer. The torus-shaped BEC in (a) is undergoing a rotation, Ω, inducing azimuthal phase shift, ϕ, in (b) between the superimposed matterwaves of the BEC from which Ω can be measured.