2008 PhD Project: Matter Wave Interferometry on a Chip

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Project description: The rapidly emerging field of physics called 'atom chips' capitalizes on advances in the micro-fabrication industry to produce complex miniaturised current-carrying circuits. These inturn can create unique magnetic potentials above the wires which are used to trap, manipulate and transport ultracold atoms while also allowing engineering of the atoms internal states via RF and MW fields. While atom chips have both simplified and expedited the production of Bose-Einstein condensates (BEC) their true potential is now being realised with the recent demonstration of atom interferometry in a trapped system [1-3]. In this project the new technique of radio frequency dressed states will be investigated where an atom chip uses both a DC current to create a single-well magnetic trap which inturn is split into a double-well system through the application of a radio frequency current in a parallel microwire nearby. For a Bose-Einstein condensate the coherence of the splitting process is of paramount importance and this will be investigated for a range of experimental conditions (splitting times, RF frequency and amplitude, chemical potential, trap frequencies). In addition once the condensate is coherently split the evolution of the relative phase difference between the two condensates and the phase uncertainty will be studied as a function of hold time, double-well asymmetry and chemical potential. This knowledge will ascertain the suitability of trapped atom interferometry and to what systems it may prove useful, (for example: miniaturized rotational sensor for inertial navigation). In addition to the current carrying wire RF dressed double-well system our laboratory has also developed the ability to make atom chips using permanently magnetised materials and these chips have yielded extremely low in trap heating rates, a possible decoherence mechanism [4]. As such the production and characterisation of an atom chip combining RF and magnetic films to realise a trapped atom interferometer may also be considered.

At present a new atom chip has been fabricated using femtosecond laser ablation to laser machine the microwires structure for the RF and DC currents. This is installed in the UHV system which has a high flux cold ^{87}Rb atom source for rapid MOT loading. The project is well funded within the ARC Centre of Excellence for Quantum-Atom Optics with postdoctoral support and a large friendly team environment that is committed to excellence in physics.

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[2] Shin *et al* Phys.Rev.A **72** 021604R (2004)
[3] Schumm *et al* Nature Physics **1**, 57 (2005)
[4] B.V. Hall *et al* Phys. Rev. Lett. **98**, 30402 (2007).