Cooling a levitating nanodiamond containing a spin qubit

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Background

Single nitrogen-vacancy (NV^-) centres in diamond have isolated electronic and nuclear spins which can store quantum information at room temperature for over one second. We have built an experiment to study nanodiamonds while they are levitated by a focused laser beam. Our theoretical proposals (together with the groups of Sougato Bose and Peter Barker in UCL and Myungshik Kim at Imperial College) suggest that we could put these diamonds into a quantum superposition in which they try out being in two places at once [1-3]. We have made nanodiamonds (with collaborator Oliver Williams' group in Cardiff) that are 1000 times purer than commercially-available nanodiamonds, so they don't overheat when we shine in light [4]. Our latest paper proposes the use of helium gas to cool the levitated diamonds, extending their quantum coherence [5].

The green dot is a levitated nano-diamond in our optical tweezers.

The project

The goal of this PhD project is to build in and test this helium gas cooling inside of a magnetogravitational trap. This trap is beneficial as it can levitate nanodiamonds without heating them up. After cooling the diamonds, you will measure the spin coherence time of the NV^- centres, which will reveal how long is available for creating macroscopic superposition states. The long-term vision for this research is to better understand fundamental physics by testing what is the most macroscopic Schrödinger cat state that can be created. This could help to solve the quantum measurement problem: why do systems evolving according to the Schrödinger equation suddenly experience a measurement?

Our lab in Warwick also benefits from several other NV^- experiments for quantum technology focused on nanoscale and bulk magnetometry both at room temperature and in helium cryostats. You would start off by learning how to use our equipment for studying single NV^- centres without levitation, as well as our optically-levitated experiment. Your research project would start in the lab from day one without doing an initial Masters course. For informal enquiries, please contact gavin.morley@warwick.ac.uk.

[1] M. Scala *et al.*, Physical Review Letters **111**, 180403 (2013).
[2] C. Wan *et al.*, Physical Review Letters **117**, 143003 (2016).
[3] S. Bose *et al.*, Physical Review Letters **119**, 240401 (2017).
[4] A. C. Frangeskou *et al.*, New J. Phys. **20**, 043016 (2018).
[5] S. Bose and G. W. Morley, arXiv:1810.07045 (2018).