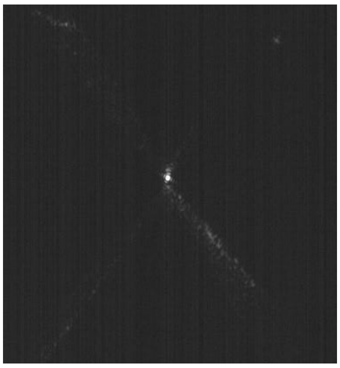
Levitating microdiamonds towards a test of the quantum nature of gravity

Supervisor: Gavin W Morley

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 microdiamonds while they are levitated diamagnetically between two sharp magnets. Our theoretical proposals (led by our theory collaborators including Sougato Bose at UCL) suggest that we could put these diamonds into a quantum superposition of being in two places at once [1, 2]. We have made microdiamonds (with collaborator Oliver Williams' group in Cardiff) that are 1000 times purer than commercially-available microdiamonds, so they don't heat up so much when we shine in light. The high purity means that the spins remain coherent for longer than other microdiamonds or nanodiamonds [3, 4]. Our new magnetic levitation allows us to levitate a microdiamond with much less light hitting it, so that we could cool the diamond below room temperature.



The white dot is a levitated nanodiamond in our magnetic trap with sharp magnets above and below.

The project: The goal of this PhD project is to develop the quantum control of a single NV^- spin in a microdiamond that is levitated in our magnetic trap, so as to put this diamond into a quantum superposition of being in two places at once. We have already demonstrated world-leading quantum control of our non-levitated microdiamonds which we will now set up in the trap [3, 4]. 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 lead to a groundbreaking experimental test of the quantum nature of gravity [1]. The microdiamonds we have developed also have applications in nanoscale quantum sensing.

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 learn how to use our equipment for studying single NV^- centres without levitation, as well as our 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.

The research will be carried out in the Physics Department at Warwick and supported by the Warwick Centre for Doctoral Training in Diamond Science and Technology. Applicants must have (or expect to obtain) at least the equivalent of a UK first or upper second-class degree in Physics (or related subjects). The studentship will commence in October 2024 (although an earlier start is possible based on your availability) and for UK students will provide funding for tuition fees and a maintenance grant at the standard UKRI rate. Funding may be available on a competitive basis to exceptional students of any citizenship. Applications are welcome from those able to support themselves or with funding already arranged. Such applications will go through the same level of academic assessment. For further details please contact Gavin Morley (gavin.morley@warwick.ac.uk) and DST.Admin@warwick.ac.uk, and provide a CV.

[1] S. Bose, A. Mazumdar, G. W. Morley, H. Ulbricht, M. Toroš, M. Paternostro, A. A. Geraci, P. F. Barker, M. S. Kim & G. Milburn, PRL **119**, 240401 (2017).

[2] B. D. Wood, S. Bose & G. W. Morley, PRA **105**, 012824 (2022).

[3] B. D. Wood, G. A. Stimpson, J. E. March, Y. N. D. Lekhai, C. J. Stephen, B. L. Green, A. C. Frangeskou, L. Ginés, S. Mandal, O. A. Williams & G. W. Morley, PRB **105**, 205401 (2022).

[4] J. E. March, B. D. Wood, C. J. Stephen, S. Mandal, A. M. Edmonds, D. J. Twitchen, M. L. Markham, O. A. Williams & G. W. Morley, arXiv:2301.10188 (2023).