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Controlling nuclear spins in diamond at ambient conditions

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Aula Magna, Istituto di Fisica, via P. Giuria 1

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Abstract

Colour centres in diamond and especially the nitrogen-vacancy centres (NVs), show remarkable physical properties making them good candidates for quantum bits, single photon sources and precise magnetic field sensors with a nanometre spatial resolution. These defects can be measured at the single site level even at room temperature, allowing to perform a variety of fundamental experiments.

In this talk the progress at the Ulm University in controlling nuclear spins at ambient conditions will be reviewed. A scheme for detecting and polarizing nuclear spins by creating microwave dressed states using continuous driving of the NV's electron spin will be presented [1]. The same method was used to polarise the nuclear spin bath (made of ^{13}C carbon atoms with nuclear spin I = 1/2) around a single NV, which lead to a narrowing of the ESR line width by a factor of eight [2]. Later we applied this technique to polarise a macroscopic ensemble of ^{13}C spins, where we achieved an increase of the NMR signal by a factor of 45 [3]. Moreover, due to the long relation times of these nuclear spins at high magnetic fields (in our experiment B = 7 T) it takes more than 13 h for the thermal polarisation to build up. It takes only 5 minutes to reach the maximum polarisation using our method, which results in a significant speed up of the measurement. A possible implementation in nanodiamonds will be discussed where we believe that the imaging of a single nanodiamond in a conventional MRI scanner is feasible, which would revolutionise the field and could find a wide application in pre-clinical research.

[1] J. Cai et al., New J. of Phys. 14, 113023 (2012).
[2] P. London at al., Phys. Rev. Lett. 111, 067601 (2013).
[3] J. Scheuer et al., New J. Phys. 18, 013040 (2016).

The Author

Boris Naydenov received his Master Science in Physics at the University of Sofia, Bulgaria and subsequently his PhD at the Freie Universität Berlin and Hahn-Meitner Institute Berlin (now Helmholtz-Zentrum Berlin für Materialien und Energie), Germany in 2006.

Between 2007 and 2011 he worked at the University of Stuttgart as a member of Prof. M. Mehring, Prof. J. Wrachtrup and F. Jelezko. He has been Senior scientist at the Institute for Quantum Optics at the University of Ulm, Germany, since 2011.

His research interests include quantum computing with defects in diamond, magnetic resonance techniques, quantum sensing schemes with individual spins, spin detection in biological molecules.