Friday, August 1st :: 3:00pm :: Allen Room (36-462)

The mechanical and thermal properties of the NV center in diamond

Dr. Marcus W Doherty

Laser Physics Centre, Research School of Physics and Engineering, Australian National University, ACT 0200, Australia

The nitrogen-vacancy (NV) center is a remarkable point defect in diamond that is at the frontier of quantum technology [1]. In particular, the NV center has many exciting applications as a quantum sensor in nano-metrology, including magnetometry, electrometry, thermometry, piezometry and gyroscopy. Indeed, it is possible for a single NV center to measure the complete three-dimensional vector of a local electric field or the position of a single elementary charge in ambient conditions [2]. The promising applications of the center have driven fundamental inquiry into its properties, which combined with a simple and robust physical model, has yielded a rich understanding of its physics. However, there are several issues with important implications for the center's applications that are yet to be resolved.
In this presentation, I will report recent investigations into the theory and applications of the mechanical and thermal properties of the NV center. This will include my discussion of a novel technique to comprehensively determine the orientation of a single center's defect structure [3,4] as well as the behavior of the center's optical and spin resonances under hydrostatic pressure [5], uniaxial stress [6,7] and variations in temperature [8,9]. The orientation measurement technique is a critical enabler of the center's vector sensing applications and motivates new applications in multi-axis rotation sensing, NV growth characterization and diamond crystallography. The hydrostatic pressure and uniaxial stress studies provide the foundation for the application of the NV center in piezometry and force sensing as well as yield new insight into the center's electronic and vibronic properties. The temperature studies deliver an explanation of the temperature shifts of the center's spin resonances as well as highlight an avenue to NV sensing in environments with varying temperature and pressure. Additionally, the temperature studies inspire an all-optical nano-thermometry technique that may rival the current technique exploiting the center's spin resonances.

References:

[1] M.W. Doherty, N.B. Manson, P. Delaney, F. Jelezko and L.C.L. Hollenberg, Phys. Rep. 528, 1 (2013).
[2] F. Dolde, M.W. Doherty, J. Michl, I. Jakobi, B. Naydenov, S. Pezzagna, J. Meijer, P. Neumann, F. Jelezko, N.B. Manson and J. Wrachtrup, Phys. Rev. Lett. 112, 097603 (2014).
[3] M.W. Doherty, J. Michl, F. Dolde, I. Jakobi, P. Neumann, N.B. Manson and J. Wrachtrup, New J. Phys. 16, 063067 (2014).
[4] J. Michl, T. Teraji, S. Zaiser, I. Jakobi, G. Waldherr, F. Dolde, P. Neumann, M.W. Doherty, N.B. Manson, J. Isoya and J. Wrachtrup, Appl. Phys. Lett. 104, 102407 (2014).
[5] M.W. Doherty, V.V. Struzhkin, D.A. Simpson, L.P. McGuinness, Y. Meng, A. Stacey, T.J. Karle, R.J. Hemley, N.B. Manson, L.C.L. Hollenberg and S. Prawer, Phys. Rev. Lett. 112, 047601 (2014).
[6] N. B. Manson, K. Beha, A. Batalov, L. J. Rogers, M.W. Doherty, R. Bratschitsch, and A. Leitenstorfer, Phys. Rev. B 87, 155209 (2013).
[7] L.J. Rogers, M.W. Doherty, M.S.J. Barson, S. Onoda, T. Oshima and N.B. Manson, submitted (preprint available soon).
[8] M.W. Doherty, V.M. Acosta, A. Jarmola, M.S.J. Barson, N.B. Manson, D. Budker and L.C.L. Hollenberg, Phys. Rev. B, in publication (preprint available at arXiv: 1310.7303).
[9] T. Plakhotnik, M.W. Doherty, J.H. Cole, R. Chapman and N.B. Manson, in preparation.