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Guest Lecture Information

Arzhang Ardavan

After completing his BA in Physics (1994) and D.Phil in experimental condensed matter physics (1998) at Corpus Christi College, Oxford, **Arzhang Ardavan** spent three years as a Junior Research Fellow at Wolfson College, Oxford. Between 2003 and 2012 he held a Royal Society University Research Fellowship. Since 2001 he has held a Tutorial Fellowship at Magdalen College, Oxford, and since 2015 a Professorship in Physics. He is currently the Head of Condensed Matter Physics, University of Oxford.

Exploiting hyperfine-coupled nuclear spin qudits for quantum error corrected memories

Abstract: The realization of effective quantum error correction protocols remains a central challenge in the development of scalable quantum computers. Employing high-dimensional quantum systems (qudits) can offer more hardware-efficient protocols than qubit-based approaches. Using electron-nuclear double resonance, we have explored the implementation of a logical qubit encoded on the four states of a I = 3/2 nuclear spin hyperfine-coupled to a S = 1/2 electron spin qubit; the encoding protects against the dominant decoherence mechanism in such systems, fluctuations of the quantizing magnetic field. We explore the dynamics of the encoded state both under a controlled application of the fluctuation and under natural decoherence processes [1]. Our results confirm the potential of these proposals for practical fault tolerant quantum memories.

However, a full implementation of this and related schemes requires projective measurement of the spin qubit, which, generally, remains challenging for molecular candidate systems. Addressing this, we have investigated the potential offered by DNA as an assembly technology for integrating molecular quantum components into electrical devices with high yield and high reproducibility [2].

[1] Demonstrating experimentally the encoding and dynamics of an error-correctable logical qubit on a hyperfine-coupled nuclear spin qudit, S Lim, MV Vaganov, J Liu, A Ardavan, Phys. Rev. Lett. **134**, 070603 (2025)

[2] A scalable, reproducible platform for molecular electronic technologies, S Helmi, J Liu, K Andrews, R Schreiber, J Bath, HL Anderson, AJ Turberfield, A Ardavan, arXiv:2503.13642