School of Physics
Trinity College Dublin

Research project in **Theoretical & Computational Solid State**

Research project in **Photonics**

Theory of quantum state control with solid-state qubits -- the single-atom refrigerator.

Research supervisor: Prof. Paul Eastham

The potential to exploit quantum-mechanics in technology, from sensors to computers, is vast. Essential for these developments, however, is the ability to take a quantum system with a few discrete states, such as an exciton in a quantum dot or impurity state in a crystal, and control its wavefunction – i.e., prepare it in a specified state. Such an ability would also provide new probes of the physics of these solid-state quantum systems, which is extremely rich due to their interactions with the surrounding host crystal.

Recent experiments [Physical Review Letters 106, 067401 (2011)] have shown that state preparation can be performed in a quantum dot, in a controlled and robust way, using laser pulses. We have shown theoretically how the interaction between the quantum dot and the surrounding crystal destroys quantum superpositions and hence limits this control [Physical Review B 87, 195306 (2013)]. The effect is due to the lattice vibrations (phonons) excited in the control process, and we predict it is sensitive to the precise form of the pulse.

The aim of this project is to show how these state control processes, applied to electronic excitations, may be used to indirectly control the lattice vibrations. We will show theoretically that state control protocols applied to a single dot can cool the crystal, and calculate the maximum cooling rate achievable. This will be done by extending existing theories of excitation-dependent decoherence to include the back-action on the phonons, going beyond the Born-Markov approximation. This will allow us to design a refrigerator using the simplest quantum system, a single qubit, as its working medium; it could also be used to explore whether state control can be performed using only a few quanta in the control fields; and to link to developing experimental work in TCD on NV centers in diamond. The project would involve both analytical and numerical work.

Funding

Applicants should apply for funding from the following sources: TCD PG Scholarship and School of Physics Studentship schemes.

Contact details

easthamp@tcd.ie Room no Lloyd 2.34 tel. +353 1 896 8456

For more information

Drop me an email to arrange an informal discussion.