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Suppression of phonon-mediated dephasing in adiabatic rapid passage on a single semiconductor quantum dot

Kimberley C Hall[1], **Reuble Mathew**[1], **Eric Dilcher**[1], **Angela Gamouras**[1], **Ajan Ramachandran**[1], **Sabine Freisem**[2] and **Dennis Deppe**[2]
[1]Dalhousie University, Canada
[2]University of Central Florida, USA

The ease and efficiency of coherent optical control of fundamental charge and spin states in semiconductor quantum dots (QDs) makes these materials promising for realizing the building blocks of a solid state quantum computer. Optimal quantum control techniques may be used to tailor the QD-light coupling, providing a direction for optimizing the speed and fidelity of elementary quantum gates as well as the pursuit of complex-instruction-set quantum computing. This potential was recently illustrated through the application of femtosecond pulse shaping to the theoretical optimization of a C-ROT gate in a single QD, and the experimental demonstration of a parallel single qubit gate involving two qubits in distant quantum dots. Here we report the demonstration of adiabatic rapid passage (ARP) on a single semiconductor QD. Through the application of femtosecond pulse shaping techniques to broad-bandwidth control pulses, we achieve a 20-fold reduction in the gate time for ARP in comparison to previous work. Our experiments also explore a new regime of strong and rapidly-varying Rabi energies, which we exploit to gain new insight into electron-phonon coupling. Our experiments show that the exciton inversion efficiency depends on the sign of the pulse chirp, with a suppression of resonant coupling to acoustic phonons for positive pulse chirp at low temperatures.

Biography

Kimberley C Hall completed her PhD at the University of Toronto in 2002, followed by Postdoctoral studies at the University of Iowa. Since 2004, he has been a faculty member in the Department of Physics and Atmospheric Science at Dalhousie University and holds a position of Canada Research Chair in Ultrafast Science. At Dalhousie University, he directs a research group focused on ultrafast spectroscopy and quantum control in semiconductor materials.

km730924@dal.ca