Joint CQSE & NCTS Seminar

2023
Mar. 03, Friday

TIME Mar. 03, 2023, 14:30~15:30pm
TITLE Quantum information processing using semiconductor quantum dot arrays: control, readout, and quantum simulation
SPEAKER Prof. Tzu-Kan Hsiao
(Department of Physics, National TsingHua University)
PLACE NCTS Physics Lecture Hall, 4F, Chee-Chun Leung Cosmology Hall, NTU
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Abstract:

Electrostatically-defined semiconductor quantum dot arrays offer a promising platform for quantum computation and quantum simulation. In this talk I will briefly introduce the basics of quantum-dot spin qubits, and then I will discuss our experimental works on control, readout, and near-term application of quantum dot arrays.

First, we demonstrate efficient calibration of tunnel coupling crosstalk in a quadruple quantum dot array and define a set of virtual barrier gates, with which we show orthogonal control of all inter-dot tunnel couplings [1]. Next, we report on cascade-based fast, high-fidelity and scalable spin readout. The cascade consists of an initial charge transition, far from the sensor, and subsequent charge transitions induced by Coulomb repulsion, with the final transition nearby the sensor. Combined with spin-to-charge conversion a cascade enables the readout of charge and spin occupation of quantum dots remote from the charge sensor [2]. Finally, we used the quadruple quantum dot array as a quantum simulator for Heisenberg model [3]. For this purpose we develop several experimental techniques including many-body spin-state preparation, singlet-triplet correlation measurements, and characterization of the quantum system with energy spectroscopy and global coherent oscillations. We use these techniques to tune and probe a homogeneously coupled Heisenberg spin chain formed in the dot array, and find good agreement between experiment and numerical simulation. Our works pave the ways for scaling up spin qubit systems and studying quantum magnetism with quantum dot arrays.

Reference to publications:
[1] T.-K. Hsiao, C. J. van Diepen, U. Mukhopadhyay, C. Reichl, W. Wegscheider, and L. M. K. Vandersypen, Efficient Orthogonal Control of Tunnel Couplings in a Quantum Dot Array, Physical Review Applied 13, 054018 (2020)
[2] C. J. van Diepen, T.-K. Hsiao, U. Mukhopadhyay, C. Reichl, W. Wegscheider, and L. M. K. Vandersypen, Electron Cascade for Distant Spin Readout, Nature Communications 12, 77 (2021)
[5] C. J. van Diepen*, T.-K. Hsiao*, U. Mukhopadhyay, C. Reichl, W. Wegscheider, and L. M. K.

Vandersypen, Quantum Simulation of Antiferromagnetic Heisenberg Chain with Gate-Defined Quantum Dots, Physical Review X 11, 041025 (2021)

Biography Brief:

2004-2008 學士-清華大學物理系
2010-2012 碩士-台灣大學應用物理系
2013-2018 博士-英國劍橋大學物理系
2019-2022 擔任荷蘭台夫特大學 QuTech 博士後研究員
2023 開始擔任清華大學物理系助理教授