"**Generation and Detection of Quantum Coherence and Entanglement with Quantum Dots**"

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Generation and detection of quantum coherence and entanglement is the core of quantum information processing. In this talk I will discuss new approaches to these concepts for electrons with quantum dots.

We have recently developed a two-path interferometer consisting of an Aharonov-Bohm ring connected to two tunnel-coupled quantum wires [1]. Conventional AB rings are connected to two terminals and therefore suffer from phase rigidity which fixes the phase of AB oscillations at either 0 or pai at zero-magnetic field. On the other hand, our interferometer operating in the non-adiabatic transport through the tunnel coupled wire does not suffer from the phase rigidity. We electrically control the dynamical phase through the AB ring and apply this technique to achieve full electrical control of a flying charge qubit defined by the presence of electron in either part of the two paths. We also use the same interferometer but having a quantum dot in one of the two AB ring arms to detect the transport phase through the dot. We observe a well-defined pai/2 phase through the dot when the dot is in the Kondo regime.

The concept of non-local entanglement is well established for correlated photon pairs, but not yet for electrons in solid state systems. We have studied non-local entanglement using double dot Josephson junctions. The splitting of Cooper pairs into both dots may contribute to generate supercurrent, because Cooper pair tunneling through the same dot is strongly suppressed by the electron-electron interaction [2]. We observe the supercurrent depending on the double dot charge state and discuss
the contribution from the split Cooper pair tunneling to the supercurrent [3].

[1] M. Yamamoto et al. Nature Nanotechnology, 7, 247 (2012).
[2] Y. Kanai et al. Appl. Phys. Lett. 100, 202109 (2012).
[3] R. Deacon et al. submitted (2013).