Chez Pierre

Presents ...

Tuesday, February 19, 2013

12:00pm

MIT Room 4-331

SPECIAL CHEZ PIERRE SEMINAR

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“Proximity-induced superconductivity in a few-electron system”

We present tunneling spectroscopy of individual quasiparticle bound states in an Al/InAs/Al mesoscopic Josephson junction. The device is a broken superconducting Al loop bridged by a short section of a crystalline semiconducting InAs nanowire. The loop is pierced with a magnetic flux to control the superconducting phase-difference across the junction; the electron density in the nanowire can be gate-tuned down to a full depletion; spectroscopy is performed using a separate normal metal lead.

At a large electron density in the nanowire, the spectrum shows a phase-tunable minigap, characteristic of the proximity effect in diffusive metals. Reducing the density, we resolve a discrete sub-gap resonance corresponding to the Andreev bound state for a quasiparticle in the junction region. We argue that the corresponding BCS-like ground state of the nanowire consists of only a single Cooper pair, which "leaked" into the nanowire from the leads. At densities closer to depletion, Coulomb interaction switches on and turns the junction (at an odd occupancy) into a spin 1/2 quantum impurity. The sub-gap resonance then has a qualitatively different gate and phase dependence and can be explained by the formation of a Kondo-like singlet between a quasiparticle in Al and the impurity.

Our experiments reveal how superconductivity can be proximity-induced in systems containing only a few electronic states, and may find applications in quantum information processing with individual Bogolyubov quasiparticles and in proximity-engineering of topological superconductivity.