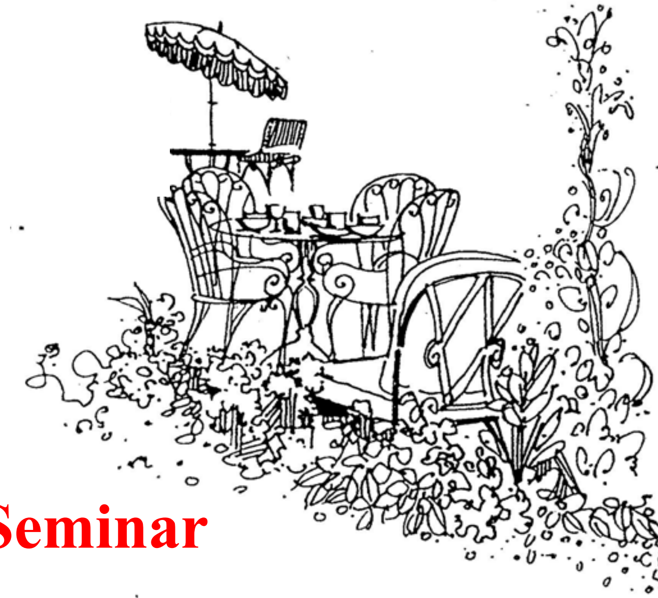
Chez Pierre

Presents ...

Monday, September 28, 2020

12:00pm Noon

Broadcast via Zoom



Chez Pierre Seminar

Ray Ashoori – Massachusetts Institute of Technology

"Paired Electron Additions and other Coulomb Blockade Violating States in Semiconductor Quantum Dots"

We measure capacitance peaks from single electron additions into two-dimensional semiconductor top-gated quantum dots, starting from the first electron up to thousands of electrons. In small dots with minimal disorder, the spectra display level fillings that follow expectations for an "artificial atom" with electron repulsion. The results agree with a "Coulomb Blockade" model, in which electron repulsion creates a minimum nonzero gate-voltage spacing between peaks. However, larger (greater than ~300 nm diameter) disordered dots display a bizarre effect. Two or more electrons can be added to the dot at exactly the same gate voltage, violating basic expectations from Coulomb repulsion. These "pairs" and "bunches" persist up to a critical electron density beyond which, they disappear, and we observe only uniformly spaced single electron peaks. Detailed study reveals that, at densities near the transition, the pairing phenomenon involves electrons at the edge of the quantum dot. One idea behind the origin of these pairs involves a "Negative-U" model in which existing electrons in the dot rearrange after an electron enters the system, thus making it energetically favorable to add another electron. However, such models predict hysteretic electron additions with gate voltage, in contradiction with our observations. Recently, we created large (800 nm diameter) quantum dots with very low levels of disorder. Unlike more disordered dots, these dots show no sign of the pairing effect at low electron densities. However, at high electron density and in a perpendicular magnetic field, paired states occur for Landau level filling factor range $\nu = 2$ to $\nu = 5$ Examination of the magnetic field dependence of these double height peaks reveals that the paired states exist at the edge of the dot. Notably, in sweeping magnetic field, the double-electron peaks are instead further bunched into pairs with pairs spaced h/e apart, except at filling factor 5/2, where the double-electron additions are uniformly spaced by h/2e. At filling factor 5/2, and at no other filling factor, the spectra resemble those from aluminum superconducting dot islands.