Nanoscale Electronics / Single-Electron Transport in Quantum-Dot Arrays

A quantum dot is a small particle, a few nanometers in diameter. At this size the particle behaves similarly to a single atom concerning interactions with electrical charges: a quantum dot can hold a single electron in addition to the electrons it usually holds to balance the nuclear charge. Therefore, it can acquire a single charge. Crucial to the construction of many nanodevices is the ability to arrange quantum dots into arrays, networks, and circuits in a precise and controlled manner. Networks of nanometer-sized metal or semiconductor islands, or quantum dots, may exhibit a variety of quantum phenomena, with applications in optical devices, nanometer-sized sensors, advanced computer architectures, ultra dense memories, and quantum-information science and technology. This research is focused on simulations of single-electron transport in one- and two-dimensional arrays of quantum dots. The goals of this research include understanding the physical conditions necessary to realize high-contrast, non-linear features in the current through an array as a function of the applied potential difference. Nonlinear current-voltage relations are the result of Coulomb-blockade and Coulomb-staircase phenomena in the electrical charging of nanoscale electrical conductors. Applications include the development of pattern classification algorithms modeled after neuromorphic networks.

Category: Computational Nanoscience

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