Quantum control of nanostructures: From atomic scale control of physical properties to coherent control of electronic states

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In the era of nano-science and nanotechnology, one of the most exciting possibilities is to be able to control the properties of nanostructures quantum mechanically. In this talk, I will cover a few novel aspects related to engineering of the electronic and photonic properties of nanostructures. First, I will discuss how confinement of single-particle electronic states can profoundly impact the thermodynamic stability of metallic nanostructures. I will then discuss that such Quantum Size Effect (QSE) can also impact the collective electronic properties such as superconductivity. Moreover, through atomic control of thin film I will show superconductivity in the extreme two-dimensional limit is where only single quantum channel exist [1]. The second topic is related to quantum coherent control of optic properties in semiconductor quantum dots (SQDs) within the context of quantum information processing. Here I will present the progress in our own research group, including the demonstration of quantum operation in single and two qubits, as well as initial steps toward interfacing the matter qubits and photon qubits [2].