Exciton transport in a germanium 4x2 ladder quantum dot array

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Quantum systems with engineered Hamiltonians can be used as quantum simulators of many-body systems to provide insights beyond the capabilities of classical computers [1]. Semiconductor gate-defined quantum dot arrays, owing to their in-situ tunability, are an ideal platform for quantum simulation [2]. Furthermore, the naturally-occurring long-range Coulomb interaction offers unique opportunities for exploring excitonic phenomena such as Wigner crystals [3] and excitonic insulators [4]. In this work, we fabricate a germanium 4x2 ladder quantum dot array and show important ingredients for excitonic simulation such as well-controlled chemical potentials and tunnel couplings as well as strong inter-channel Coulomb interaction. We tune the array into two capacitively-coupled channels and exploit Coulomb drag as a probe for exciton formation. As we decrease the bottom-channel potential while propagating carriers through the top channel using voltage pulses, a transition from single electron transport to exciton transport is observed. Our work paves the way to study excitonic state of matters in quantum dot arrays.

References

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Figures

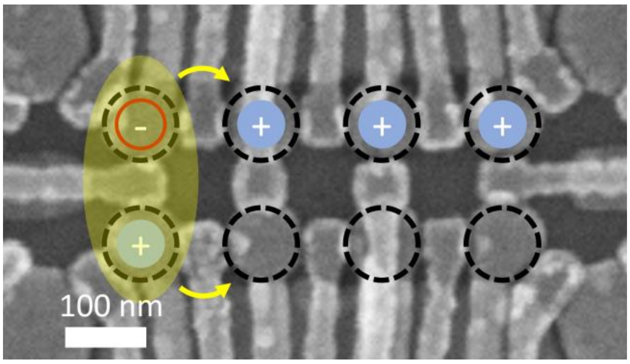

Figure 1: A scanning electron microscope image of a germanium 4x2 quantum dot array with a schematic showing excitonic transport. An electron (missing of a hole) is shuttled through the top channel and a hole in the bottom channel is dragged along because of the inter-channel Coulomb interaction.

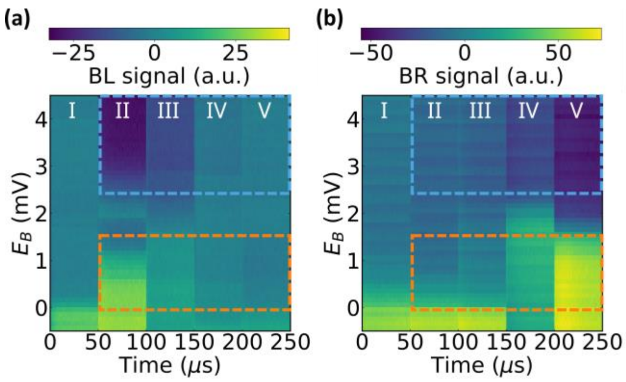

Figure 2: Coulomb drag measurement data. (a) Bottom-left and (b) bottom-right sensor signals as a function of time and energy offset of the bottom channel E_B. In the time domain from II to V an electron is shuttled in the top channel from left to right. As E_B decreases, a transition from single-electron transport (blue dashed region) to correlated electron-hole pair transport, i.e. exciton transport (orange dashed region), is observed.