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Entropy measurements in mesoscopic quantum systems

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Mesoscopic quantum devices offer the experimentalist the ability to implement arbitrary Hamiltonians on a chip, and to measure them with exquisitely sensitive electrical probes. Mesoscopic circuits are used to realize, for example, coupled spin systems with long-lived coherence for qubit applications, or strongly interacting Hamiltonians with frustrated entanglement between a localized state and multiple reservoirs. One reason that experiments based on mesoscopic electronic circuits are so effective is that conductance measurements can be performed with such sensitivity. For example, a conductance measurement of a charge sensor in a mesoscopic quantum circuit can detect charge rearrangements amounting to less than one thousandth of an electron, enabling spin readout on microsecond timescales. This talk will discuss the extension of mesoscopic circuit measurements to the detection of entropy in quantum devices. We start from a proof-of-principle measurement of the entropy change as a single spin is added to a localized quantum state, where the outcome of the measurement (k_B ln(2)) is well known, then move on to interacting systems involving a localized state coupled to other localized states, or to a bath. As an orthogonal metric to ubiquitous conductance measurements, entropy offers a stringent test of our understanding of complex mesoscopic systems.

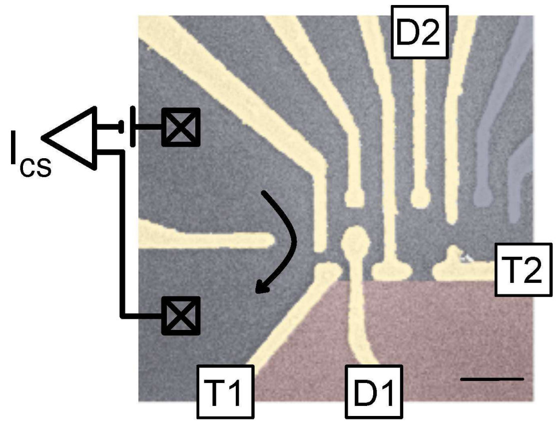

Figure : A prototypical device enabling entropy measurements of a quantum system, in this case consisting of capacitively coupled quantum dots.

Keywords : Entropy, quantum electronics, mesoscopic physics, Kondo effect, quantum dots

Joshua Folk has been a professor at the University of British Columbia since 2005. He leads an experimental group building and measuring quantum electronic devices based on semiconductor platforms (typically GaAs 2D electron gases) or van der Waals heterostructures (typically based on graphene). The group's current research interests centre around thermodynamic probes of quantum circuits, and exploring emergent electronic phases in 2D materials hosting flat electronic bands.