How can one measure the entropy of a mesoscopic system?

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The additional entropy resulting from coupling a thermodynamic reservoir to a mesoscopic system is a measure of the number of possible microscopic states of that system in thermodynamic equilibrium. This quantity has been a key theoretical tool in determining the properties of the ground state and low lying excited states of the system at low temperatures (e.g. the difference between the ground states of the single- and two-channel Kondo impurity). In bulk systems, the entropy can only be determined by measuring thermodynamic quantities, such as the equation of state or the heat capacity as a function of temperature. However, so far there has been no experimental procedure to measure the entropy in mesoscopic systems.

In this work we demonstrate how transport measurements can be combined into determining the entropy change as additional electrons occupy the mesoscopic system, by carefully analyzing the deviation of the thermopower from the Mott formula. We present analytical derivation of this procedure for a quantum dot with arbitrary SU(N) symmetry, which is valid at high temperatures. Numerical renormalization group calculations, both for a direct determination of the entropy, and using our suggested procedure, show excellent agreement also at low temperatures. Lastly, we apply our formalism to experimental data for quantum dots and demonstrate how the formalism can allow the determination of the ground state degeneracy in each Coulomb valley.