Electronic Realizations of a Maxwell's Demon

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150 years ago, James Clerk Maxwell presented a thought experiment where a 'demon' decreases entropy of a system using microscopic information, challenging the second law of thermodynamics. Theoretical investigation ever since has led to the understanding that information has a vital role in physics. However, only recently has a sufficient control of microscopic degrees of freedom been reached to enable experiments on Maxwell's demons. This talk will cover such experiments on electronic systems, where charge is measured and controlled at the level of individual electrons. A device known as a single-electron box is operated as a Szilard's engine[1], demonstrating how one bit of information about its charge is used to extract energy from the heat bath, amounting to up to 75% of the fundamental limit $k_{\mathrm{B}}T\ln(2)$, where k_{B} is the Boltzmann's constant, and T is the temperature. It is also shown how mutual information between the microscopic state and the measurement outcome contributes to the extracted energy[2]. Finally, a self-contained, 'autonomous' Maxwell's demon is realized[3]. The performance of the device is directly observed as cooling of the measured system and heating of the demon.

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