Spectroscopy to observe Maxwell's Demon

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In the middle of the 19th century successful implementation of steam engines encouraged systematic investigations into heat, work, and energy in physical systems, leading to the development of classical thermodynamics and statistical mechanics. Heat engines convert thermal energy into useful work by leveraging the flow of heat across a temperature gradient. Unfortunately, some of the energy is lost in exhausted waste heat due to practical limits related to the materials and substances involved. A principal limiting factor is typically the 'cold' reservoir temperature available in the environment [1, 2].

In the Maxwell's Demon thought experiment information about the particle's location can be used to cool the particle, demonstrating the interplay between energy and information [1, 2, 3]. As a result of this we can consider using two spin reservoirs and a single thermal reservoir to achieve 100% energy conversion from heat to work while not violating the second law of thermodynamics as we are separating out the energy from the entropy in the heat [1, 2, 3].

In our planned proof of concept experiment we will detect the emission spectrum of near-resonant spontaneous Raman scattered 370 nm photons by a trapped $^{171}Yb^{+}$ ion in the Lambe-Dicke regime with a secular frequency on the order of 1-2MHz. The motional energy of the ion is quantised and this will enable us to resolve conversion of motional thermal energy into increased photon energy. Detecting this small shift in energy from single scattered photons requires the development of a free-space narrow-linewidth (<300 kHz) Fabry-Perot cavity with high-finesse (≈1000) and high absolute transmission (>10%). We report on progress towards the development of this high-resolution ultraviolet spectrometer.

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