Spintronic Implementations of Quantum Information Engines to Harvest Ambient Thermal Energy: Experiment and Theory

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Abstract

As areas of frontier research in energy, mesoscopic quantum thermodynamics (QTD) offer on-chip (i.e. applicative) solutions to harvest thermal energy with fast (≈10GHz) electronic engine strokes, but operate at very low temperature and below the classical Carnot limit [1]. Atomic QTD at room temperature (RT) can exceed the Carnot limit [2] if out-of-equilibrium quantum resources, such as coherent states and non-thermal baths, are involved, but utilize slower (≈10MHz) engine strokes and require auxiliary equipment, i.e. remain model experiments. We propose a novel spintronic implementation of QTD that utilizes the generation and manipulation of electrical currents based on the electron spin [3]. Rather than implement classical thermodynamics (e.g. spin Seebeck across the MTJ’s interfaces [4], [5], or harvesting (artificial) RF power [6] from Wifi/GSM signals), we combine spintronics and quantum thermodynamics at an atomic/mesoscopic intersection to harvest thermal fluctuations as a natural source of energy.

Our quantum engine implements THz spintronic interactions between fully spin-polarized interfaces and paramagnetic centers that, ultimately, rectify thermal fluctuations on the latter to produce a dc electrical current. I will present our first report [7] of a spintronic engine implementation using an industrially mature device platform: the MgO magnetic tunnel junction (MTJ) that, as a device class, is used in next-generation magnetic memories [3]. We have also studied an implementation using Co phthalocyanine molecules [8], and developed several analytical/computational models [9] that describe how to power such a quantum spintronic engine using either quantum vacuum fluctuations or a phonon bath.

References