The single ion heat engine - a sensitive quantum probe for non-classical baths

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Thermodynamic machines can be reduced to the ultimate atomic limit [1], using a single ion as a working agent. The confinement in a linear Paul trap with tapered geometry allows for coupling axial and radial modes of oscillation. The heat-engine is driven thermally by coupling it alternately to hot and cold reservoirs, using the output power of the engine to drive a harmonic oscillation [2]. From direct measurements of the ion dynamics, the thermodynamic cycles for various temperature differences of the reservoirs can be determined [3] and the efficiency compared with analytical estimates. I will describe how the engine principle can be exploited to implement a differential probe for non-classical baths. Furthermore I will speak about the observation of the KibbleZurek scaling law for defect formation in ion crystals [4] and how this effect could be exploited for the heat engine.

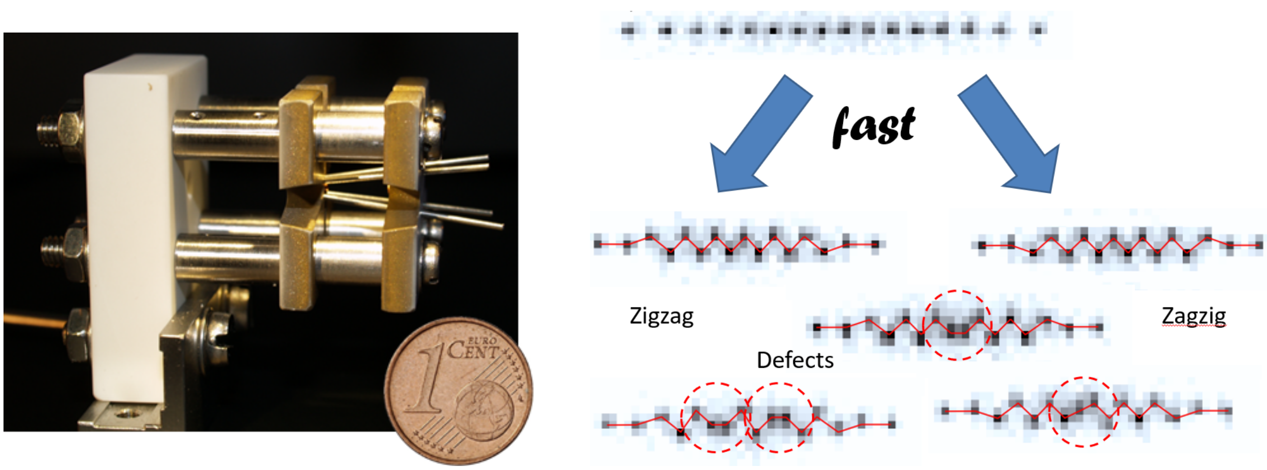

Figure 1: Left: Linear Paul trap. Right: Defect formation in ion crystals.

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[2] O. Abah, J. Roßnagel, G. Jacob, S. Deffner, F. Schmidt-Kaler, K. Singer, and E. Lutz, *Single-Ion Heat Engine at Maximum Power*, Phys. Rev. Lett. **109**, 203006 (2012).

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[4] S. Ulm, J. Roßnagel, G. Jacob, C. Degünther, S.T. Dawkins, U.G. Poschinger, R. Nigmatullin, A. Retzker, M.B. Plenio, F. Schmidt-Kaler, and K. Singer, *Observation of the KibbleZurek scaling law for defect formation in ion crystals*, Nature Comm. **4**, 2290 (2013).