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Thermal fluctuations in an out-of-equilibrium state

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Thermal noise manifests itself as a tiny variance around the mean value of an observable x of a physical system. Usually too small to be noticed, it becomes important in an increasing number of applications, such as quantum systems operated close to their ground state, MEMS and NEMS, frequency standards, or the next generation of gravitational wave detectors[1]. Its understanding is thus fundamental.
When in equilibrium, the Fluctuation-Dissipation Theorem (FDT) is a cardinal tool that allows us to couple the fluctuations of x, to the temperature of the system in the form of the Equipartition Principle (EP). Unfortunately, this assumption is often not possible. Our goal is thus probing its validity out of this region.
In our experiment we study a system in a Non-Equilibrium Steady State: a silicon micro-cantilever subject to a heat flux due to a laser heating. We measure the thermal noise driven flexion and torsion and quantify the amplitude of fluctuations with an effective temperature T^{eff}, extending the FDT following recent theoretical developments[2]:
\begin{equation}
k_B T^{eff} = k\langle x^2\rangle
\end{equation}
with k_B the Boltzmann constant, k the stiffness, $\langle x^2 \rangle$ the mean square of the observable, i.e. the thermal noise. Whilst in general an excess of fluctuations is expected, in our case a deficit is instead observed, as in Geitner[3]. Thermal noise is below the average temperature T^{avg} of the system, both for flexion and torsion modes.

[1] Harry, G. M. et al. (2006). Appl. Opt. 45, 1569
[2] Komori, K. et al. (2018). Phys. Rev. D 97, 102001
[3] Geitner, M. et al. (2017). Phys. Rev. E 95, 032138

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