Multimode nanomechanics in non-conservative force fields

Laure Mercier de Lépinay[a], Benjamin Pigeau[a], Benjamin Besga[a], Francesco Fogliano[a] and Olivier Arcizet[a*]

a. Institut Néel, CNRS and Université Grenoble Alpes, 25 rue des Martyrs F-38042 Grenoble, France

∗ olivier.arcizet@neel.cnrs.fr

Nanomechanical resonators display extreme sensitivities to external force fields. Consequently nearly-degenerate modes of multidimensional oscillators such as nanotubes, nanowires or optically trapped particles are strongly affected by transverse force fields components. These resonators are then particularly interesting as force probe since the multidimensionality of vector fields is a necessary condition for the existence of vorticity.

It has been shown that a rotational force field is applied on a singly-clamped SiC nanowire (NW) when it is positioned at the edge of the waist of a strongly focused laser beam[1]. Thanks to a novel vectorial force measurement technique based on the dual-channel optical detection of the NW vectorial displacement[4], we study the perturbation of its thermal and driven motion by the non-conservative force field.

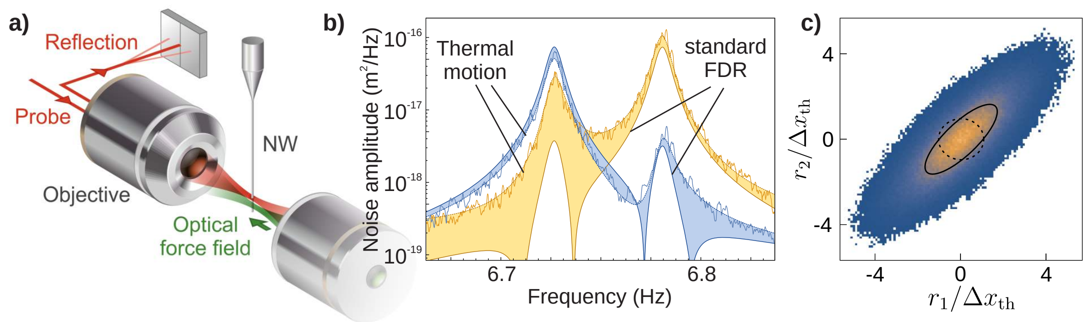

Figure 1: **a.** Experiment scheme. **b.** Experimental observation of the deviation to the FDR. **c.** Thermal noise distribution in space in a purely rotational force field.

In addition to the bifurcation and dynamic instability uncovered previously[1], this experiment reveals the existence of a large deviation to the standard fluctuation-dissipation relation[3]. This deviation can be interpreted as stemming from the shearing of the motion eigendirections, as can be seen from a derived new modified version of the fluctuation-dissipation relation valid in such force fields.

Furthermore, a large excess of total thermal noise is observed. Thanks to an experimental adjustment of our vectorial motion detection setup, we showed that the noise distribution is structured in space so that some directions of the oscillation plane actually show *reduced* thermal fluctuations[4]. A parallel can be drawn with the evolution of motion quadratures in parametric squeezing. The conclusions of this work can also be adapted to the description of non-reciprocal optomechanical systems.

[1] A. Gloppe et al., Nature Nano. **9**, 920-926 (2014)

[2] L. Mercier de Lépinay et al., Nature Nanotech. **12**, 156-162 (2016)

[3] L. Mercier de Lépinay et al., Nature Commun. (accepted)

[4] L. Mercier de Lépinay et al., (in preparation)