Non-Hermitian dynamics and nonreciprocity of two optically coupled nanoparticles

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Optical levitation of dielectric objects in vacuum provides a unique optomechanical platform due to means of optical control of potentials and good isolation from the thermal environment. In recent years, different control techniques led to the demonstration of the motional quantum ground state cooling of single optically levitated dielectric nanoparticles in several experiments. Recently, tunable and nonreciprocal optical interactions have been measured between two nanoparticles levitated in two distinct optical tweezers, with single-site readout of particle motion. I will present our experimental platform for tweezer arrays of nanoparticles, and show our recent results on non-Hermitian collective dynamics of two nonreciprocally interacting nanoparticles [1]. We also observe a mechanical lasing transition once a threshold coupling rate is achieved, supported by our nonlinear theory model. This work paves the way towards upscaling this platform to multiparticle arrays, in view of studying their nonequilibrium and collective mechanical behavior in the quantum regime.

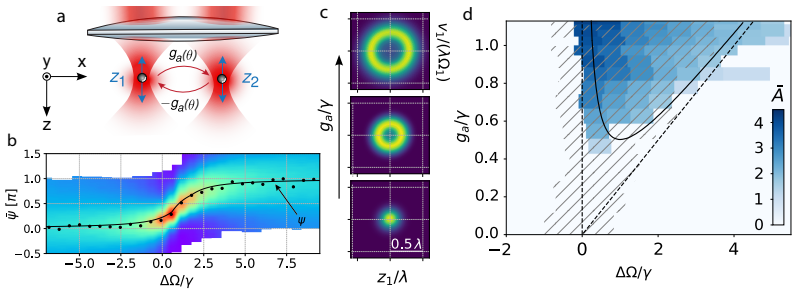

Fig. 1: a. Schematic visualisation of the setup. b. Distribution of mechanical phase difference as function of the mechanical detuning and the phase difference angle, in presence of the anti-reciprocal coupling. c. Phase space of an individual particle motion for three different coupling strengths, increasing from bottom to the top. d. Phase diagram of the limit cycle "radius" (displaced amplitude).

References

[1] Manuel Reisenbauer, Henning Rudolph, Livia Egyed, Klaus Hornberger, Anton V. Zasedatelev, Murad Abuzarli, Benjamin A. Stickler, Uroš Delić, ArXiv.**2310.02610** (2023)

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