Quantum control of an array of optically levitated nanoparticles

Uros Delic, University of Vienna

The field of quantum optomechanics aims to exploit light-matter interaction in order to realize macroscopic quantum states of massive solid-state mechanical objects. Within optomechanics, optically levitated dielectric nanoparticles have emerged as a promising platform for tests of fundamental physics, development of novel sensing techniques or investigation of complex non-equilibrium physics. Optical trapping provides unique possibilities for quantum state preparation, for example through engineering of dynamic and nonlinear optical potentials. I will discuss recent experimental advances in levitated optomechanics, such as the motional quantum ground state preparation [1] and the observation of non-reciprocal optical interactions between two nanoparticles [2]. The rapidly developing control toolbox allows us to create a fully programmable array of levitated nanoparticles in the quantum regime. This will enable the realization of large-scale entanglement and investigation of novel phases of collective mechanical states, which is a fundamentally hard task for other optomechanical systems.

[1] U. Delic *et al.*, Science 367, 892 (2020)
[2] Rieser *et al.*, Science 377, 987 (2022)