SYQR 2: Quantum Optics and Quantum Information with Rigid Rotors 2

Time: Friday 14:30–16:30 Location: E415

Invited Talk SYQR 2.1 Fri 14:30 E415

Rotational optomechanics with levitated nanodumbbells — •Tongcang Li — Purdue University, West Lafayette, USA

Thanks to its geometry, an optically levitated nanodumbbell is ideal for studying rotational optomechanics. We have synthesized and optically levitated silica nanodumbbells in a high vacuum. With a linearly polarized laser, we observed the torsional vibration (liberation) of a levitated nanodumbbell. With a circularly polarized laser, we drove a nanodumbbell to rotate beyond 1 GHz. We show an optically levitated nanodumbbell is an ultrasensitive torque detector. Recently, we levitated a nanodumbbell near a surface to study surface interactions.

Invited Talk SYQR 2.2 Fri 15:00 E415

Quantum rotations of nanoparticles — •Benjamin A. Stickler — University of Duisburg-Essen, Duisburg, Germany

Rotations of rigid bodies exhibit pronounced quantum phenomena that do not exist for their center-of-mass motion. By levitating nanoparticles in ultra-high vacuum, researchers are developing a promising platform for observing and exploiting these quantum effects in an unexplored mass and size regime [1]. This talk will discuss the prospects of observing orientational quantum revivals [2], quantum tennis racket flips [3], and spin-controlled interference [4] with nanoscale particles. I will review how rotational cooling into the quantum regime can be achieved [5] and how environmental decoherence impacts quantum experiments with nanoscale rotors [6].

[1] Stickler, Hornberger, and Kim, Nat. Rev. Phys. 3, 589 (2021) [2] Stickler, Papendell, Kuhn, Millen, Arndt, and Hornberger, New J. Phys. 20, 122001 (2018). [3] Ma, Khosla, Stickler, and Kim, Phys. Rev. Lett. 125, 053604 (2020). [4] Rusconi, Perdriat, Hétet, Romero-Isart, and Stickler, Phys. Rev. Lett. 129, 093605 (2022). [5] Schäfer, Rudolph, Hornberger, and Stickler, Phys. Rev. Lett. 126, 163603 (2021). [6] Stickler, Papendell, and Hornberger, Phys. Rev. A 94, 033828 (2016).

Invited Talk SYQR 2.3 Fri 15:30 E415

Quantum control of trapped molecular ions — •Stefan Willitsch — University of Basel, Department of Chemistry, Klingelbergstrasse 80, 4056 Basel, Switzerland

Molecules are quantum systems of prime significance in a variety of contexts ranging from physics over chemistry to biology. In spite of their importance, the development of quantum technologies for molecules has remained a long-standing challenge due to their complex energy-level structures. Trapped molecular ions are particular attractive in this context as it is possible to observe, manipulate and control single isolated molecules under precisely controlled conditions. In the talk, we will highlight new experimental methods for the detection, preparation and manipulation of the quantum states of single trapped molecular ions and discuss applications of these techniques in the realms of precision molecular spectroscopy, quantum science and chemistry.

Invited Talk SYQR 2.4 Fri 16:00 E415

Full control over randomly oriented quantum rotors: controllability analysis and application to chiral observables — •Monika Leibscher — Dahlem Center for Complex Quantum Systems and Fachbereich Physik, Freie Universität Berlin, Berlin, Germany

Full quantum control over randomly oriented molecules requires complete breaking of the rotational symmetry by external fields. We present a graphical method to analyze the controllability of quantum asymmetric tops and determine the number, polarization and frequencies of the external fields which are required to fully control the rotational dynamics [1,2]. The results of the controllability analysis allow us to design pulse sequences which drive the molecules to the desired target states. We apply this strategy to observe and control chiral properties in randomly rotating molecules [1]. As an example, we discuss the creation of chiral wavepackets in achiral molecules. Planar molecules can become temporarily chiral upon coherent excitation of the out-of-plane vibration [3]. With the help of controllability analysis, we identify different excitation schemes that result in a net chiral signal and simulate the resulting ro-vibrational dynamics.

[1] M. Leibscher, E. Pozzoli, C. Pérez, M. Schnell, M. Sigalotti, U. Boscain, C. P. Koch, Commun. Phys. 5, 110 (2022). [2] E. Pozzoli, M. Leibscher, M. Sigalotti, U. Boscain and C. P. Koch, J. Phys. A: Math. Theor. 55, 215301 (2022). [3] D. S. Tikhonov, A. Blech, M. Leibscher, L. Greeman, M. Schnell, and C. P. Koch, Science Advances in press (2022).