BEC–based phononic sensors
for oscillating gravitational fields of moving masses and light pulses

Bose–Einstein condensates (BECs) are very small and extremely cold systems of a large number of atoms. These properties are famously exploited for high precision measurements of forces using atom interferometry. A further way of utilizing BECs as sensors for forces is to measure the forces’ effect on phonons, the collective oscillations of atoms in BECs. A specific example is the measurement of the thermal Casimir–Polder force induced by a material slab [1].

I will explain how BECs could be used to measure gravitational fields on the micrometer scale. Accelerations due to gravitational fields and their gradients give rise to effective external potentials. Moving the source of the gravitational field on resonance with elastic modes of BECs lead to the creation of phonons. For strong enough gravitational fields this effect can, in principle, be detected. For weaker gravitational fields, a squeezed probe state can be prepared and its change due to the interaction with the oscillating gravitational field may be measured. High precision BEC based gravity sensors may be used for the measurement of gravitational fields due to very small objects, which would offer opportunities for new experiments investigating the interface of quantum mechanics and gravity. Due to the small extension of BECs (of the order of few micro-meters), they can be brought very close to the surface of the source masses, where the gravitational effects are stronger. Researchers around the world are attempting to bring very small massive systems, such as silica–spheres at almost the pico-gram range, into superposition states [3]. The envisioned ability to measure the gravitational field of masses in superposition states may lead to new exciting experiments, for example, about aspects of quantumness of gravity [4]. High precision sensors for oscillating gravitational fields may also be useful in performing searches for fifth forces (e.g. [5]) and measuring the gravitational field of light [6].

I illustrate my experimental proposal with the easily accessible example of the gravitational field of a small oscillating gold sphere in the milligram range. Additionally, I will discuss the gravitational properties of light, and I will give some numbers to illustrate the challenge of its detection.


All DQ-mat members and all interested are cordially invited to attend.