Matter-Wave Interferometry with Macromolecules and Nanoparticles

Stefan Gerlich[1]

University of Vienna, Faculty of Physics, VCQ, Boltzmanngasse 5, 1090 Vienna, Austria

Matter-wave interference experiments provide a direct confirmation of the quantum superposition principle and thereby put constraints on possible modifications of quantum mechanics. Recent experiments demonstrated quantum superposition of nanometer-sized particles with masses beyond 25.000 Da [1] while next generation experiments aim to further push this limit by 1-2 orders of magnitude in mass [2, 3].
In this lecture series I will sketch the developments which led to the current state of the art [4] and provide an overview of the experimental challenges and solutions involved in observing matter-wave phenomena of high-mass objects, from beam creation and detection to shielding the quantum state from environmental decoherence.
We will discuss recent applications of matter-wave experiments in molecular metrology [5,6] and the potential of high-mass quantum interference experiments to test fundamental physics.

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[3] F. Kiałka et al., AVS Quantum Sci. **4**, 020502 (2022).
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[5] Y. Fein et al., Phys Rev. X **10**, 011014 (2020).
[6] Y. Fein et al., Phys. Rev. Lett. (accepted 2022).