Probing Quantum Linearity with Biomolecules and High Mass Nanoparticles

M. Arndt

University of Vienna, Faculty of Physics, QNP Group, VCQ, Boltzmanngasse 5, A- 1090 Vienna, Austria

Markus.arndt@univie.ac.at

Quantum physics is our best theory of nature, but important questions have remained: Why is quantum mechanics linear, allowing for superpositions of classically mutually exclusive states that we do not see on the macroscopic scale we live in? What is the role of complexity or gravity in the quantum-to-classical transition? Can we utilize non-classical superpositions for novel measurements?

Starting from text-book like matter-wave diffraction experiments we will analyze which beam splitter and configurations are needed to see de Broglie interference of massive and complex particles in the lab. We see that molecular matter waves can be delocalized in position and momentum, even when each molecule avails of a rich set of internal vibrational, rotational and conformational states with a variety of electronic and optical properties. Quantum coherence in the center of mass motion persists even at internal microcanonical temperatures of 500 - 1000 K. It even was seen for molecules as massive as 10'000 amu and even molecules that we eat every day can be delocalized.

What is it then, that prevents the realization of Schrödinger cat states in our macroscopic world? The search for possible mass and complexity limits of quantum linearity is experimentally valid, independent of any theory. I will discuss the most recent interferometer developments that will allow to push this limit by almost two orders of magnitude and progress in nanoparticle source developments as required and foreseeable to realize matter-wave interference for free-falling particles of 10^7 -10^8 amu.