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Quantum interference experiments with complex organic molecules

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ABSTRACT:

Matter-wave interference with complex particles is a thriving field in experimental quantum physics. The quest for testing the quantum superposition principle with highly complex molecules has motivated the development of the Kapitza-Dirac-Talbot-Lau interferometer (KDTLI). In this doctoral thesis I describe quantum superposition experiments with molecules ofmasses beyond 10 000 amu and consisting of more than 800 atoms. These experiments define the currently most stringent bound of the experimental macroscopicity parameter for quantum superpositions. Typical de Broglie wavelengths of the investigated particles are in the order of 0.3-5 pm. This is significantly smaller than any molecular extension (nanometers) or the delocalization length in our interferometer (hundreds of nanometers). Many vibrationaland rotational states are populated since the molecules are thermally highly excited (300-1000 K). And yet, high-contrast quantum interference patterns could be observed. The visibility and position of these matter-wave interference patterns is highly sensitive to external perturbations. This sensitivity has opened the path to extensive studies of the influence of internal molecular properties on the coherence of their associated matter waves. In addition, it enables a new approach to quantum-assisted metrology. I describe how KDTL interferometry can be used to investigate a number of different molecular properties, including electric moments and optical absorption cross sections.