On the cross-fertilization of de Broglie interferometry and cluster physics

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Matter-wave interferometry with clusters and large molecules, as pursued in our lab, has currently three goals: the exploration of the quantum-classical boundary, the development of new methods for cluster metrology as well as the implementation of new ways of creating surface-bound molecular nanostructures.

Matter-waves were originally introduced by Louis de Broglie in 1923 as a quantum concept for the description of the center-of-mass motion of massive bodies. It has proven correct for all objects studied so far and one may readily find arguments why the intrinsic quantum nature of mice and men will not appear in our everyday world.
However, it remains an open challenge to try and push the experimentally validated limits of de Broglie interferometry as far as possible. This motivated our first quantum experiments with large molecules, i.e. diffraction with fullerenes already several years ago [1]. We were able to show that the internal degrees of freedom may fully decouple from the translational degrees of motion and that large molecules can build up single-particle quantum interference patterns in spite of their high thermal excitation [2]. We will discuss how biomolecular clusters now emerged as intriguing objects for future quantum interference experiments in our lab.

Interestingly, cluster interference is also dependent on all internal cluster properties that couple to translational degrees of freedom mediated by external fields. For instance, the cluster polarizability grows with the volume of the particle and the interaction with both optical and material diffraction elements therefore increases dramatically with cluster size. This requires the implementation of specialized interferometric concepts. One of these, the Kapitza-Dirac Talbot Lau interferometer has recently been successfully realized in Vienna [3]. The sensitivity to external fields turns matter-wave interferometry also in a highly precise sensor, which allows us to measure polarizabilities or susceptibilities with improved accuracy [4]. And it allows us to sort a beam of clusters or molecules according to their polarizability-to-mass ratio [5].

We shall discuss the current status of molecule interferometry and the prospects for experiments on cluster coherence in the mass range of 1.000.000 amu [6] and potentially beyond…

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