A New Frontier in Matter-Wave Interferometry: From Large Metal Clusters to Biomolecules

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The superposition principle lies at the foundation of quantum mechanics, yet testing its validity at ever-increasing mass and complexity scales remains a major experimental challenge. Matter-wave interferometry provides a direct probe by coherently delocalizing massive particles over mesoscopic distances. Here, we present a high-mass matter-wave interference platform that extends this approach to a new material class: large metal clusters. **We report the first observation of quantum interference with sodium nanoparticles** comprising **more than 7,000 atoms**, corresponding to **masses above 170 kDa [1]**. The resulting spatial superposition states reach a **macroscopicity of μ = 15.5**, improving existing bounds on generic macrorealistic modifications of quantum theory by over an order of magnitude.

I will further discuss recent advances in the generation, detection, and manipulation of **slow, neutral beams of clusters [2] and biomolecules [3]**, as well as the development of **deep-UV laser systems** that promise further scalability in particle mass and structural complexity.

These developments open new perspectives for **molecular metrology** [4,5] and high-resolution spectroscopy, enabling precise characterization of internal particle properties in free flight. Finally, I will outline ongoing efforts to extend quantum interferometry to increasingly **complex biomolecules, including proteins**, thereby broadening the range of composite quantum systems accessible to matter-wave experiments.

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