New experiment provides route to macroscopic high-mass superpositions

October 23 2014

University of Southampton scientists have designed a new experiment to test the foundations of quantum mechanics at the large scale.

Standard quantum theory places no limit on particle size and current experiments use larger and larger particles, which exhibit wave-like behaviour. However, at these masses experiments begin to probe extensions to standard quantum mechanics, which describe the apparent quantum-to-classical transition.

Now, Southampton researchers, with colleagues from the University of Duisburg-Essen in Germany, have designed a new type of experiment which will advance the current state-of-the-art experiments by a factor of 100, from 10,000 atomic mass units (amu), roughly equal to the mass of a single proton, to one million amu.

The research is published in *Nature Communications*.

They propose an interferometer with a levitated, optically cooled, and then free-falling silicon nanoparticle in the mass range of one million amu, delocalised over more than 150 nm. The scheme employs the near-field Talbot effect with a single standing-wave laser pulse as a phase grating.

Individual particles are dropped and diffracted by a standing UV laser wave, such that interference of neighbouring diffraction orders produces a resonant near-field fringe pattern. In order to record the interferogram, the nanospheres are deposited on a glass slide and their arrival positions are recorded via optical microscopy. The researchers argue that the choice of silicon, due to its specific material characteristics, will produce reliable high mass interference, unaffected by environmental decoherence, in a setup that can be produced with current technology.

Dr James Bateman, from Physics and Astronomy at the University of Southampton and co-author of the study, says: "This work is a natural extension of atomic physics, which has revolutionised many technologies. Our analysis, which accounts for all relevant sources of decoherence, indicates that this is a viable route towards macroscopic high-mass superpositions.

"This current work is not technology-driven, but it does ask difficult questions of relevance to future quantum devices. Placing larger and larger mechanical systems into quantum states has implications for what can be done with the technology. We hope that our work will lead to a better understanding of the fundamental physics and hence to more advanced quantum devices."

As time-of-flight, and therefore mass, is limited by the free-fall distance under earth's gravity, a space-based mission is planned by the Macroscopic quantum resonators (MAQRO) consortium with which the researchers are involved; this could bring a further factor of 100 in mass.

Provided by University of Southampton

Citation: New experiment provides route to macroscopic high-mass superpositions (2014, October 23) retrieved 20 March 2024 from https://phys.org/news/2014-10-route-macroscopic-high-mass-superpositions.html