Physicists working up from atoms to Schrodinger's cat

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(PhysOrg.com) -- Schrodinger's cat, a macroscopic object that is both alive and dead at the same time, illustrates the strangeness of quantum mechanics. While such quantum properties have been widely observed for electrons and molecules, recent experiments have shown that larger objects may also demonstrate quantum effects. Just how large, though, is still an open question.

In the emerging field of cavity optomechanics, physicists may have the opportunity to investigate the boundary between quantum and classical systems. Optomechanical systems are mechanical systems that can be manipulated by light - for example, a thin membrane being vibrated by light in an optical cavity. Two recent studies have proposed that, with current technology, it should be possible to cool down two of these millimeter-scale membranes in such a way that they act like a single molecule. No matter how far apart they are, the membranes could be interrelated through quantum entanglement, so that measuring one membrane instantly affects the other.

In a study published in *Physical Review A* last October, physicists Mishkat Bhattacharya and Pierre Meystre from the University of Arizona in Tucson took the first steps toward showing how a pair of vibrating membranes can form a molecule-like state. By interacting with photons from a laser, the membranes become coupled together. According to the scientists' calculations, this results in a state with two different modes with different resonant frequencies: in one mode, the membranes move together, while in the other mode, the membranes move opposite to each other. By shining a particular laser frequency on the membranes, it should be possible to cool down each mode's vibrations separately. Since these vibrational states are analogous to the excitations of a single molecule, the experiment demonstrates how the two membranes act as a single system.

In a second study published in *Physical Review Letters* last November, Michael Hartmann and Martin Plenio of Imperial College London proposed a similar experiment, with the additional step of entangling the two membranes. The researchers calculated that, by using certain laser frequencies to cool the modes, the interactions between them could entangle the membranes for as long as the lasers remain on. Two weak lasers could then verify the entanglement without destroying it.

Experimentally demonstrating this membrane entanglement will require precise and challenging methods, but the results could enable physicists to investigate the transition from the quantum to classical world.

More information:

M. Bhattacharya and P. Meystre. "Multiple membrane cavity optomechanics." *Physical Review A* 78, 041801(R) (2008).

M. J. Hartmann and M. B. Plenio. "Steady State Entanglement in the Mechanical Vibrations of Two Dielectric Membranes." Physical Review Letters 101, 200503 (2008).

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