Turning ions into quantum cats

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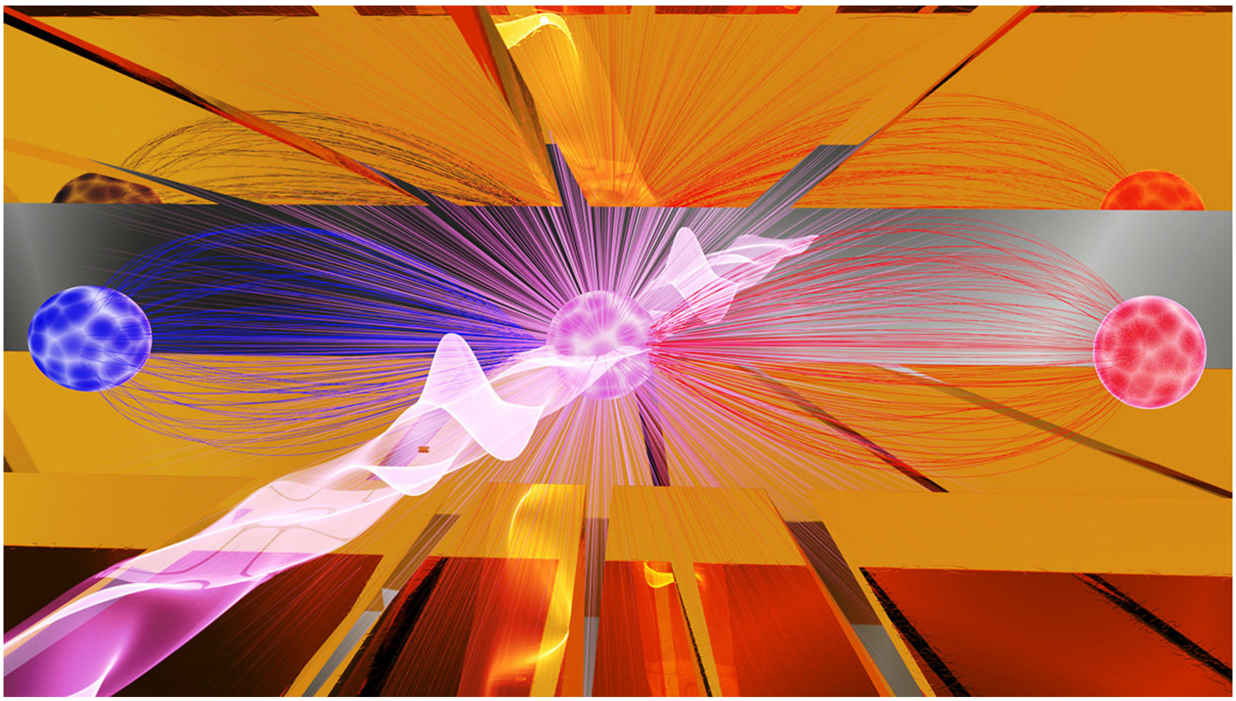

An ion (purple) sits in the center of an ion trap. Ultrafast laser pulses create a "cat state" by pushing apart the ion's internal quantum states (red and blue). Credit: E. Edwards/JQI

In Schrödinger's famous thought experiment, a cat seems to be both dead and alive—an idea that strains credulity. These days, cats still don't act this way, but physicists now regularly create analogues of Schrödinger's cat in the lab by smearing the microscopic quantum world over macroscopic distances.

Such "cat states" have found many homes, promising more sensitive quantum measurements and acting as the basis for quantum error-correcting codes—a necessary component for future error-prone quantum computers.

With these goals in mind, some researchers are eager to create better cat states with single ions. But, so far, standard techniques have imposed limits on how far their quantum nature could spread.

Recently, researchers at the Joint Quantum Institute developed a new scheme for creating single-ion cat states, detailing the results this week in *Nature Communications*. Their experiment places a single ytterbium ion into a superposition—a quantum combination—of two different states. Initially, these states move together in their common environment, sharing the same motion. But a series of carefully timed and ultrafast laser pulses apply different forces to the two ion states, pushing them in opposite directions. The original superposition persists, but the states end up oscillating out of phase with each other.

Using this technique, the JQI team managed to separate the states by a distance of almost 300 nanometers, roughly twelve times further than previously possible. There's still just one ion, but its quantum nature now extends over a distance more than a thousand times larger than its original size. Such long-range superpositions are highly sensitive, and could enable precise atom interferometry measurements or robust quantum cryptographic techniques.

More information: K. G. Johnson et al. Ultrafast creation of large Schrödinger cat states of an atom, *Nature Communications* (2017). DOI: 10.1038/s41467-017-00682-6

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