Acrobatics for anyons: New test for elusive fundamental particle proposed

June 21 2011

Anyons are hypothetical particles that have been postulated to represent a third class of fundamental particles alongside the known bosons and fermions. Physicists from Ludwig-Maximilians-Universitaet in Munich, Germany, have now proposed a novel experimental design that should make it possible to create and detect them for the first time.

In quantum physics there are two classes of fundamental particles. Photons, the quanta of light, are bosons, while the protons and neutrons that make up atomic nuclei belong to the fermions. Bosons and fermions differ in their behavior at a very basic level. This difference is expressed in their quantum statistics. In the 1980s a third species of fundamental particle was postulated, which was dubbed the anyon. In their quantum statistics, anyons interpolate between bosons and fermions.

"They would be a kind of missing link between the two known sorts of fundamental particles," says LMU physicist Dr. Tassilo Keilmann. "According to the laws of quantum physics, anyons must exist – but so far it hasn't been possible to detect them experimentally."

An international team of theorists under Keilmann's leadership has now taken an in-depth look at the question of whether it is possible to create anyons in the context of a realistic experiment. Happily for experimentalists, the answer is yes. The theoreticians have come up with an experimental design in which conventional atoms are trapped in a so-called optical lattice. Based on their calculations, it ought to be possible to manipulate the interactions between atoms in the lattice in such a way as to create and detect anyons. In contrast to the behavior of bosons and fermions, the exotic statistics of anyons should be continuously variable between the endpoints defined by the other two particle types.

"These novel quantum particles should be able to hop between sites in the optical lattice," says Keilmann. "More importantly, they and their quantum statistics should be continuously adjustable during the experiment." In that case, it might even be feasible to transmute bosons into anyons and then to turn these into fermions. Such a transition would be equivalent to a novel "statistically induced quantum phase transition", and would allow the anyons to be used for the construction of quantum computers that would be far more efficient than conventional electronic processors. "We have pointed to the first practical route to the detection of anyons," says Keilmann. "Experimentalists should be able to implement the set-up in the course of experiments that are already underway."

More information: Statistically induced Phase Transitions and Anyons in 1D Optical Lattices, Tassilo Keilmann, Simon Lanzmich, Ian McCulloch & Marco Roncaglia, *Nature Communications*, dx.doi.org/10.1038/ncomms1353

Provided by Ludwig-Maximilians-Universitat Munchen