Could a quantum motor do work?

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(PhysOrg.com) -- Ever since the idea of a quantum world was discovered, physicists have been trying their best to create applications and uses that mirror the accomplishments of the classical world. However, due to the fact that the quantum world is often quirky and not always well understood, sometimes these attempts go awry. In the case of a quantum motor, though, a theoretical paper out of the University of Augsburg in Germany might shed some light on how some of the quantum quirks might be overcome, resulting in an ac-driven quantum motor.

Sergey Denisov is one of the coauthors of "ac-Driven Atomic Quantum Motor," which appears in *Physical Review Letters*. Along with Alexey Ponomarev and Peter Hänggi, Denisov worked to set up a quantum motor. With a quantum motor, rotation would occur both clockwise and counterclockwise, cancelling out movement and resulting in no work output. Denisov explains how the Augsburg team managed to overcome this problem: "We have to use a starter. Using two atoms, we are able to get net movement for our motor. One atom serves as a carrier, and the other as the driver starter."

The quantum motor is set up using cold atoms trapped in an optical lattice shaped into a ring. A magnetic field is applied to the ring. A carrier atom is charged, allowing it to "feel" the magnetic field and forcing it to move. However, this single atom moves in such a way as to produce no net motion. This is where the starter atom comes in. Denisov says that an uncharged atom is introduced into the system, forcing net movement into the system. Further probing with the use of a force akin to gravity yielded the theoretical possibility that this motor could work under load.

Denisov points out that so far, this work is just theoretical. “We are not as concerned about application and technology,” he says, “although this is likely to have its uses in the future. We are more excited from a theoretical point of view. We wanted to know how many atoms are needed to make a quantum motor. The next step is to see what happens if we introduce more atoms into the system. We want to expand our set up to see if we could get more work out of the motor.”

However, before the Augsburg group gets too excited about looking into expanding their system, the two-atom motor needs to be tested experimentally. “While it would be difficult to set up such an experiment,” Denisov acknowledges, “it is doable.” The biggest problem, he says, is that atoms tend to adsorb and emit photons when excited to this degree. These photons would cause stability problems for the system. While a solution to that issue would have to be found, Denisov nonetheless believes that testing should be possible.

“Optical potential has been looked at for quite some time, and access to cold atoms is not so rare. There are at least 15 labs that can prepare such a set of atoms. Besides, similar experiments have been done using a cloud-like set-up. With some effort, it should be possible to test our theory in the lab using current technology.”

More information: A.V. Ponomarev, S. Denisov, and P. Hänggi, “ac-Driven Atomic Quantum Motor,” Physical Review Letters (2009). Available online: link.aps.org/doi/10.1103/PhysRevLett.102.230601 .