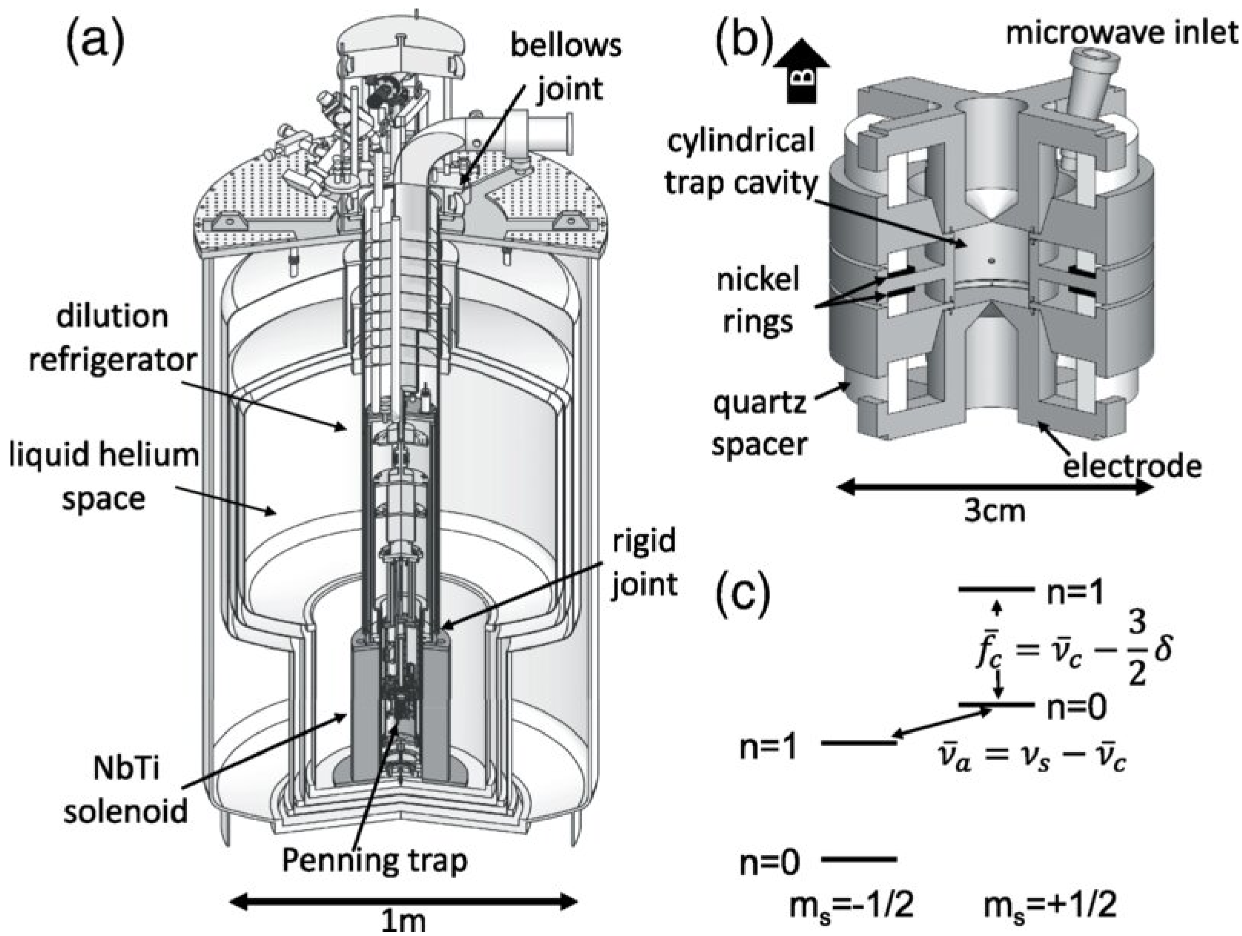
Physicists make most precise measurement yet of magnetic moment of an electron

February 20 2023, by Bob Yirka



(a) Cryogenic system supports a 50 mK electron trap upon a 4.2 K solenoid to provide a very stable *B*. (b) Silver electrodes of a cylindrical Penning trap. (c) Quantum spin and cyclotron energy levels used for measurement. Credit: *Physical Review Letters* (2023). DOI: 10.1103/PhysRevLett.130.071801

A combined team of physicists from Harvard University and Northwestern University has found the most precise value yet for the magnetic moment of an electron. In their paper published in the journal *Physical Review Letters*, the group describes the methods they used to measure properties of an electron and implications of the new precision.

The magnetic moment of an electron, also known as the electron magnetic dipole moment, results from its electric and spin properties. Of all the elementary properties that have been studied, it is the one that has been the most precisely measured, and also the most accurately verified.

Measuring the magnetic moment of an electron to ever higher standards of accuracy is important because physicists believe that at some point, such measurements will help to complete the standard model of physics. In this new effort, the research group has measured the magnetic moment to a precision twice that of any other effort—the last best effort was 14 years ago.

Physicists use the magnetic moment of particles like electrons to test the standard model by studying interactions between them and virtual particles that come into existence inside of a vacuum chamber. Such study involves measuring the effect of collisions on both the magnetic moment and its g factor and then comparing the results to what is described by the standard model.

The work involved suspending a single electron in a Penning trap with a magnetic field held constant at 5 T. The chamber was then chilled to nearly absolute zero. Measurements were taken of what the team describes as "quantum jumps" of the electrons between energy levels. Then, by using a magnetic field gradient, they were able to carry out quantum nondemolition detection—a technique to measure quantum jumps without changing the quantum state, which reduced the uncertainty of the measurements of the magnetic moment. The end result was measurement of the magnetic moment to a degree of precision never before achieved—0.13 fractions of 1 trillion.

The new measurements are expected to impact work involved in future tests of the standard model.

More information: X. Fan et al, Measurement of the Electron Magnetic Moment, *Physical Review Letters* (2023). DOI: 10.1103/PhysRevLett.130.071801

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