

Electron's shapeliness throws a curve at supersymmetry

19 December 2013



A "molecular eye" view of the vacuum chamber used for the measurement of the electron's EDM. Credit: B.R. O'Leary

A small band of particle-seeking scientists at Yale and Harvard has established a new benchmark for the electron's almost perfect roundness, raising doubts about certain theories that predict what lies beyond physics' reigning model of fundamental forces and particles, the Standard Model.

"We know the Standard Model does not encompass everything," said Yale physicist David DeMille, who with John Doyle and Gerald Gabrielse of Harvard leads the ACME collaboration, a team using a strikingly different method to detect some of the same types of [particles](#) sought by huge experiments at the Large Hadron Collider (LHC) in Europe. "Like our LHC colleagues, we're trying to see something in the lab that's different from what the Standard Model predicts."

ACME is looking for new particles of matter by measuring their effects on the shape of the

electron, the negatively charged subatomic particle orbiting within every atom.

In research published Dec. 19 in *Science Express*, the team reported the most precise measurement to date of the electron's shape, improving it by a factor of more than 10 and showing the particle to be rounder than predicted by some extensions of the Standard Model, including some versions of Supersymmetry. This theory posits new types of particles that help account, for example, for dark matter, a mysterious substance estimated to make up most of the universe.

Researchers said they have shown that the electron's departure from spherical perfection—if it exists at all—must be smaller than predicted by many theories proposing particles the Standard Model doesn't account for. If the electron's shape is too round, many of these theories will be proven wrong, they said.

Many variants of Supersymmetry predict a less round shape for the electron than the ACME team found experimentally. If the particles predicted by those versions of Supersymmetry existed, they would have caused greater deformation of the electron, researchers said.

The ACME project looked for a particular deformation in the electron's shape known as an electric [dipole moment](#).

"You can picture the dipole moment as what would happen if you took a perfect sphere, shaved a thin layer off one hemisphere and laid it on top of the other side," said DeMille, who helped establish previous landmark limits in electron deformation. "The thicker the layer, the larger the dipole moment. Now imagine an electron blown up to the size of the earth. Our experiment would have been able to see a layer 10,000 times thinner than a human hair, moved from the southern to the northern hemisphere. But we didn't see it, and that

rules out some theories."

The ACME researchers measured the dipole moment using electrons inside the polar molecule thorium monoxide. The molecule's properties amplify the electron's deformation and diminish the possibility of effects that could fool researchers into thinking they had seen a tiny deformation when none exists.

"It is amazing that some of these predicted [supersymmetric particles](#) would squeeze the electron into a kind of egg shape," said Harvard's Doyle. "Our experiment is telling us that this just doesn't happen at our level of sensitivity."

Gabrielse, also of Harvard, said: "It's unusual and satisfying that the exquisite precision achieved by our small team in a university lab probes the most fundamental building block of our universe at a sensitivity that complements what is being achieved by thousands at the world's largest accelerator."

More information: "Order of Magnitude Smaller Limit on the Electric Dipole Moment of the Electron," *Science Express*, 2013.

Provided by Yale University

APA citation: Electron's shapeliness throws a curve at supersymmetry (2013, December 19) retrieved 22 May 2019 from <https://phys.org/news/2013-12-electron-shapeliness-supersymmetry.html>

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