energy range probed by the LHC. But some theorists counter that plenty of remaining theories — supersymmetric and otherwise — predict an electron EDM smaller than those ruled out by the ACME team. Gabrielse finds the surviving theories more and more contrived. "Theorists are wily," he says. "Every time we exclude something, they try to wiggle out."

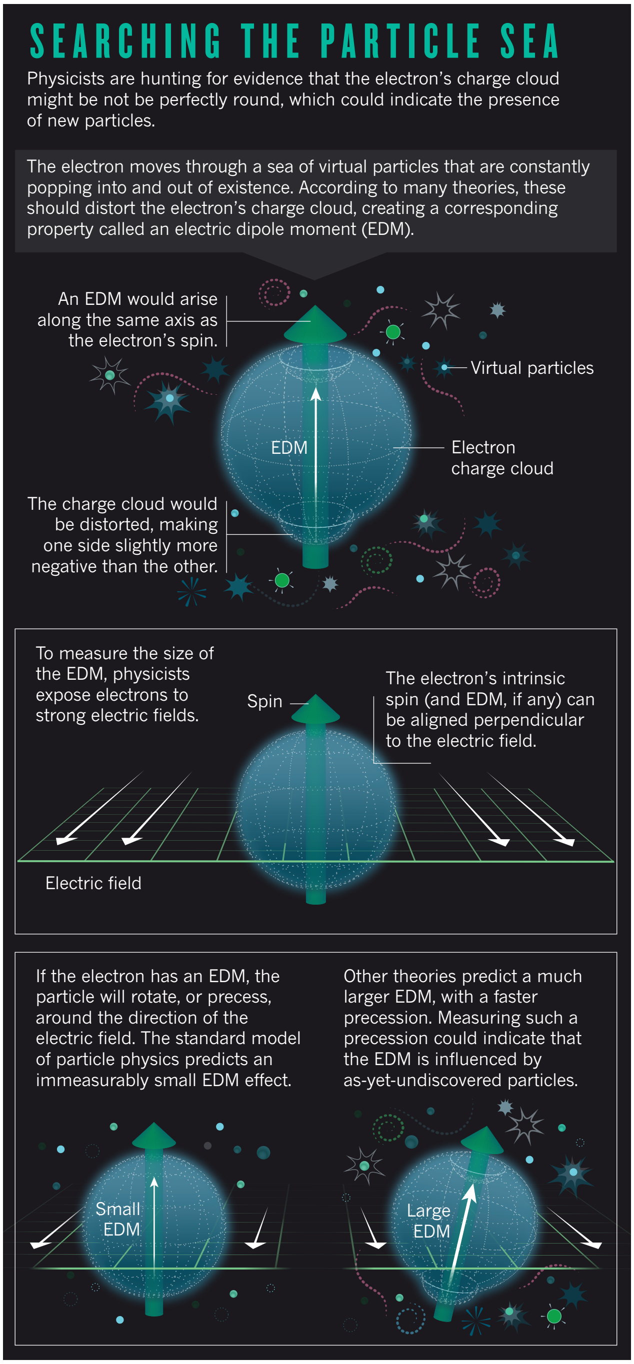
ACME is not alone in this effort. After earning a Nobel prize in 2001 for creating a new phase of matter called a Bose–Einstein condensate, JILA physicist Eric Cornell teamed up with Jun Ye, also at JILA, to look for an EDM. Rather than manipulate molecules as they pass by in a beam, as ACME does, Cornell and Ye decided to use a rotating electric field to trap molecular ions with large internal fields, giving electron precessions longer to reveal themselves. DeMille calls the idea "brilliant and far from obvious".

Cornell faced a setback when he lost an arm to necrotizing fasciitis in 2004. But it led to a joke he likes to tell when he gives talks: "His left sleeve is empty, and he'll say, 'If anybody should know about asymmetry, it's me,'" says former lab mate Chris Monroe, now a physicist at the University of Maryland in College Park. After a decade building and refining what Cornell calls a "two-tabletop experiment" (because it occupies two tables in his lab), he and his co-authors finally published their first results last year[5], coming within a factor of 1.5 of ACME's 2014 limit. "I might not have started if I had realized how hard it would be," says Cornell.

Now, researchers are closing in on new EDM results. The ACME physicists have increased the number of molecules they can send into their experimental apparatus by a factor of 400. They expect this and other improvements to sharpen the experiment's precision by a factor of ten — allowing them to hunt for effects beyond the energy range of the LHC. The JILA team is also gearing up for experiments set to push beyond the LHC's reach. And researchers at Imperial College London who held a former electron-EDM measurement record[6] have plans for experiments with laser-cooled ytterbium monofluoride molecules; they hope their test will be 1,000 times more precise than ACME's first run.

The electron isn't the only low-energy peephole into the world beyond the standard model. Some physicists are searching for EDMs in neutrons or atoms, which, like the electron, could reveal a violation of one of nature's symmetries. Others are adapting an entirely different technology in service of fundamental physics: atomic clocks. The frequencies of radiation absorbed and emitted by the atoms that make up these clocks depend only on certain fundamental constants of nature. A slight deviation in those frequencies could lend support to theories that attempt to explain why gravity is so much weaker than the Universe's other forces.

The ability to test this idea was out of reach until the early 2000s, when researchers developed atomic clocks that operate in the optical range of the electromagnetic spectrum instead of in the microwave. Their higher frequencies meant that time could be sampled at a much higher rate, enabling the creation of clocks so precise that they would lose or gain less than one second over the age of the Universe. Researchers have since used data from such clocks to search for changes in the ratio between the electron's and proton's masses and in the fine-structure constant — a fundamental parameter that governs the strength of the electromagnetic force. Others, following a proposal[7] by Asimina Arvanitaki, a theorist at the Perimeter Institute for Theoretical Physics in Waterloo, Canada, are using clocks to look for subtle oscillations that might be created by a hypothesized dark-matter candidate called the axion, or a related particle.



So far, these investigations have yielded no new physics. But they show how a younger generation of physicists is infusing the field with new ideas, says Dimopoulos, who was Arvanitaki's PhD adviser. "There's a lot of theoretical ideas that have been, in a sense, overlooked because everybody was focusing on the LHC and the previous colliders," he says.

No one expects such tabletop experiments to replace particle colliders. Rather, they could guide physicists to the right energy range for more detailed study. Right now, the collider community suspects that it needs more energy than the LHC is designed to reach, but it's unclear how much will be sufficient. Findings from low-energy experiments might influence a multibillion-dollar decision about the next big collider, and that has put added pressure on researchers working in this tabletop realm. "We have to do almost everything with more care than is typical in the standard atomic-physics experiment," says DeMille.

Gabrielse has high hopes for the team's next experiment — and for the work at his centre at Northwestern, which is set to open this year. But he can make no promises. "We're fishing for a fish whose shape and colour and speed and equipment for biting are completely unknown." ■

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