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Truer Ticks and Tocks

Atoms that inherently avoid one another keep better time than those that naturally clump together, a team of physicists reports. The result could lead to better atomic clocks, but more importantly, the experiment marks an important step toward observing a weird new state of matter.

Atoms can be sorted into two categories depending on how many protons, neutrons, and electrons they contain. Those containing an even number of parts are known as bosons, and at low temperatures they prefer to snuggle into a single quantum state. Atoms containing an odd number of parts are known as fermions, and they behave precisely the opposite way: No two fermions can wedge into a single quantum state. As a result, theory predicts fermions should avoid each other, while bosons swarm together.

The chumminess of bosons limits the precision of today's best atomic clocks. Researchers define the second by counting the oscillations of radio waves absorbed by ultracold cesium atoms as the electrons in them rearrange in a specific way. But the bosonic cesium atoms crash into each other, and the collisions slightly shift the frequency and limit the precision of the clocks.

Fermionic atoms, however, show no shift, report physicists from the Massachusetts Institute of Technology (MIT) in Cambridge and the Eindhoven University of Technology in the Netherlands. Subhadeep Gupta and Wolfgang Ketterle of MIT and their colleagues measured the radiation absorbed by ultracold fermionic lithium atoms as their electrons flipped between two configurations. If the atoms collided, then the frequency should have depended on just how many atoms were in each configuration. But it remained the same regardless of whether most of the atoms started in the lower or higher energy configuration, the researchers report online this week in *Science*. That means the fermionic lithium atoms must have avoided each other as anticipated.

The results confirm a key prediction, says Carl Williams of National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland. But fermions may not be the best components for atomic clocks, Williams notes, as there are other ways to avoid the frequency shift. The researchers also showed they could induce collisions among the fermions by applying a magnetic field in just the right way, and that's the real advance says Randall Hulet of Rice University in Houston, Texas. Such control could help physicist produce a new state of matter in which the fermions pair and flow without resistance, just like the electrons in a superconductor, Hulet says. "That's where this field is going," he says. "This is a very important step in that quest."

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