Solution for Atomic Clock Puzzle

The resolution of a major discrepancy between theory and experiment for strontium atomic clocks could help improve the precision of these timekeepers.

By **Ryan Wilkinson**

Strontium atomic clocks have important applications, ranging from tests of general relativity to searches for possible variations in fundamental constants. But the precision of these clocks has been limited by an enduring inconsistency between predictions of their properties and corresponding observations. This disparity has now been rectified by two independent research teams [**1**, **2**]. The results could facilitate the use of strontium timekeepers in the space-based detection of gravitational waves, for example.

In the most precise strontium atomic clocks, a lattice of intersecting laser beams, all with the same "magic" wavelength, traps strontium atoms in certain locations. The interaction between the trapped atoms and the lattice's electromagnetic field induces a shift in the energies of the atomic energy levels used for timekeeping. The size of this shift depends on two properties of the atoms, known as their magnetic-dipole and electric-quadrupole polarizabilities. But until now, the predicted values of these polarizabilities have conflicted with those measured in experiments.

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The two teams resolve this discrepancy by considering previously ignored contributions to the polarizabilities from so-called negative-energy states of the atoms, which are predicted by quantum field theory. These contributions greatly impact the atoms' magnetic-dipole polarizability but not their electric-quadrupole polarizability. Sergey Porsev at the University of Delaware and his colleagues explain this feature mathematically [**1**]; Li-Yan Tang and colleagues at the Chinese Academy of Science calculate the contributions both for strontium atomic clocks and for magnesium, calcium, and cadmium ones [**2**]. The teams' findings emphasize the need to consider negative-energy states when performing high-precision studies of the interactions between light and matter.

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REFERENCES

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