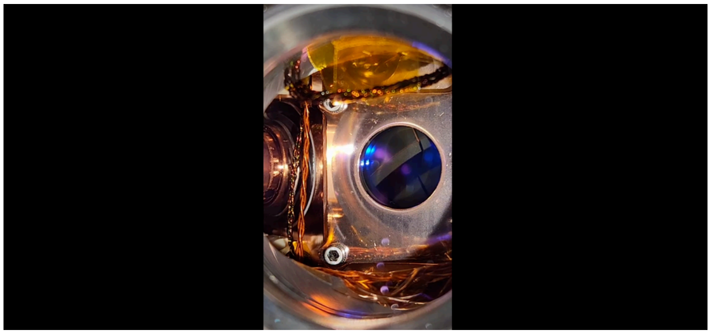
Radiation Shield Improves Optical Clocks

A new experimental design eliminates the top source of clock uncertainty.

By **David Ehrenstein**

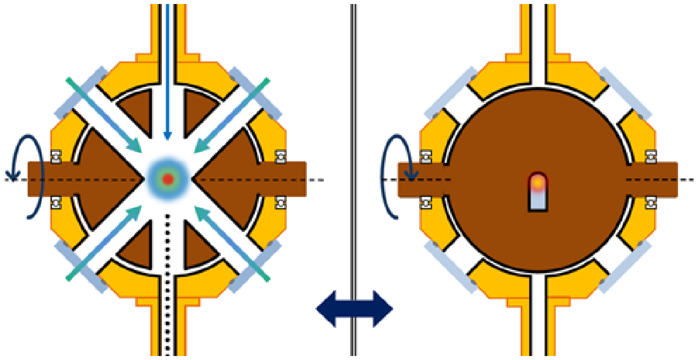
Optical lattice clocks (OLCs) are among the world's best atomic clocks. Their largest source of uncertainty results from the ubiquitous blackbody radiation (BBR). Now Youssef Hassan of the National Institute of Standards and Technology in Colorado and his colleagues have demonstrated a cryogenic OLC with a radiation shield that virtually eliminates BBR-associated uncertainty [**1**]. The researchers expect this OLC design to allow major improvements in clock accuracy.



Video 1: The 2.5-second-long experimental cycle involves a green laser that cools and traps the atoms before the radiation shield is shifted to the closed position. The atoms are then excited by the clock laser (not visible) for about half a second, and then the shield is opened, and the atoms' state is determined with another laser (not visible), whereupon the cycle restarts.
Credit: Y. Hassan/NIST

In an OLC, hundreds to tens of thousands of atoms are lined up in a 1D lattice formed by a laser beam. A second (clock) beam, whose frequency can be tuned, then excites the atoms to a specific quantum state. The clock-beam frequency that maximizes the number of atoms making the transition defines the "ticking rate" of the OLC. BBR perturbs the atoms' quantum states and decreases the OLC's accuracy.

Hassan and his colleagues suppress BBR by cooling the atoms' immediate surroundings to 77 K, although cryogenic OLCs are not new. But blocking external, room-temperature BBR is challenging because the experimental chamber needs openings through which to load atoms and to send in laser beams.



Credit: Y. S. Hassan *et al.* [**1**]

The team designed a radiation shield with two main components—a fixed outer structure and a rotatable inner sphere. When preparing the atoms, the sphere is oriented with several openings aligned with windows and openings in the outer structure. But before turning on the clock beam, the sphere is rotated to block nearly all external, room-temperature BBR. Some external BBR still leaks through two windows on opposite sides of the sphere, which are necessary for the lattice and clock beams. However, the windows' small sizes and the glass's low infrared transmission result in suppression of external BBR to about one millionth the amount that would be present without the shield.

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REFERENCES

1. Y. S. Hassan *et al.*, "Cryogenic optical lattice clock with 1.7×10^{-20} blackbody radiation Stark uncertainty," **Phys. Rev. Lett. 135, 063402 (2025).**