Clock Comparison Limits Dark Matter

A search for oscillations in the frequencies of optical clocks has come up empty, implying new bounds on ultralight dark matter particles.

By **Michael Schirber**

At the extreme end of the dark matter mass range lies ultralight bosonic dark matter (UBDM), which is expected to behave like a sea of light-year-long waves. One way to detect this highly extended dark matter is to look for small oscillations in fundamental constants, such as the fine structure constant. A new experiment using an optical clock made of a single ion has set the tightest constraints so far on UBDM candidates [1].

The sea of UBDM particles is predicted to have an influence on fundamental quantities, such as the electron charge or quark masses. The wave motion of the sea would cause this influence to vary over time, leading to tiny oscillations in fundamental constants. To search for these oscillations, researchers have previously used high-precision optical clocks, whose frequencies depend on fundamental constants but in atom-specific ways. By comparing two different clock frequencies, past work has placed strong limits on UBDM models (see **Synopsis: Optical Clocks Join the Hunt for Dark Matter**).

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To up the ante, Nils Huntemann from the National Metrology Institute (PTB) of Germany and colleagues performed a UBDM search with ytterbium, whose clock frequencies are especially sensitive to changes in the fine structure constant. The team's primary experiment involved a single trapped ytterbium ion, which has two separate clock frequencies. The researchers looked for a UBDM signal by measuring both frequencies in an alternating sequence. This single-ion setup might be of interest for future space missions that could explore the UBDM density near the Sun, Huntemann says. The team also compared the ytterbium clock to a strontium clock. Together, the data offer world-leading constraints on UBDM in the mass range of 10^{-24} to 10^{-17} eV/c^2.

Michael Schirber is a Corresponding Editor for ***Physics Magazine*** based in Lyon, France.

REFERENCES

1. M. Filzinger *et al.*, "Improved limits on the coupling of ultralight bosonic dark matter to photons from optical atomic clock comparisons," **Phys. Rev. Lett. 130, 253001 (2023).**