New POP atomic clock design achieves state-of-the-art frequency stability

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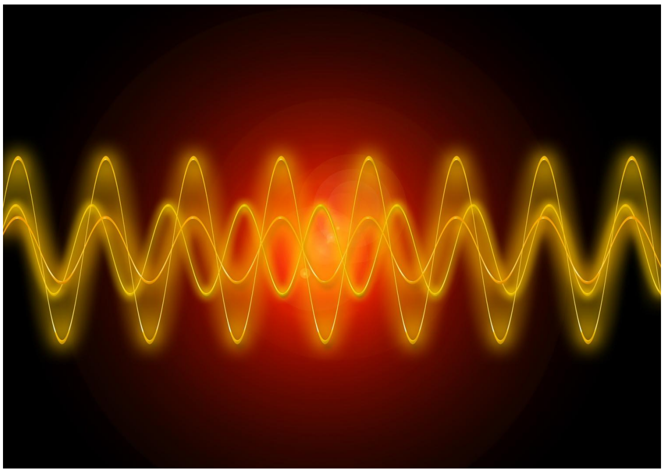

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Chinese researchers have developed a pulsed optically pumped (POP) atomic clock with a frequency stability of 4.7 x 10^{-15} at 10^4 seconds based on a new design.

The achievement is noteworthy because atomic clocks—often considered the most stable frequency standard for timekeeping—are crucial components in global navigation systems and international communication services, and frequency stability is key to their accuracy.

POP atomic clocks are an important research focus because they are lightweight and show excellent frequency stability.

The research was led by Deng Jianliao from the Shanghai Institute of Optics and Fine Mechanics (SIOM) of the Chinese Academy of Sciences. Results were published in *Review of Scientific Instruments* on 21 April 2020.

"Atomic clocks employ a quantum mechanical system as a 'pendulum' where the frequency of the local oscillator is locked to the transition between atomic energy states," said Deng Jianliao, corresponding author of the paper. "The accuracy of the atomic clock depends on determining the accuracy of the center of the atomic transition and the stability of the central frequency itself."

The new design uses a compact optical module consisting of a distributed Bragg reflector (DBR) laser and an acousto-optic modulator in a POP vapor-cell rubidium atomic clock.

Containing the physics package in a sealed vacuum chamber improved temperature control and also reduced the negative influence of the barometric effect.

Deng noted that the atomic clock is "sensitive to the fluctuations of many parameters," thus making it a challenge to optimize medium- to long-term frequency stability in laser-based vapor-cell clocks, such as POP clocks.

The frequency stability of 4.7 × 10^{-15} at 10^4 seconds achieved by the new design "is comparable to the state-of-the-art POP rubidium clock," according to the study.

The researchers are now working to improve frequency stability at an average time greater than 10^4 seconds and are also seeking to further reduce temperature sensitivity.

More information: Qian Shen et al, Pulsed optically pumped atomic clock with a medium- to long-term frequency stability of 10?15, *Review of Scientific Instruments* (2020). DOI: 10.1063/5.0006187

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