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Researchers build two versions of new most accurate clock ever

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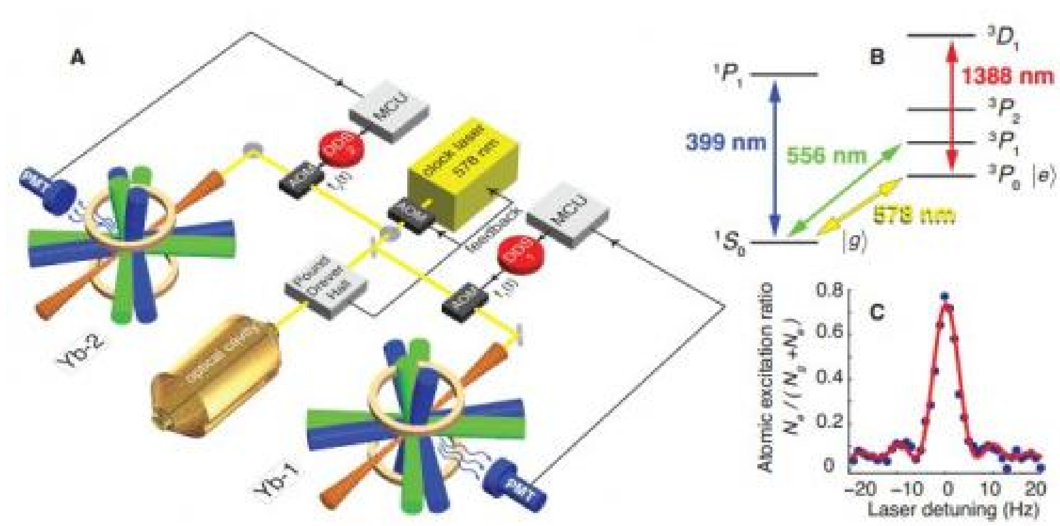

(A) Laser light at 578 nm is pre-stabilized to an isolated, high-finesse optical cavity using Pound-Drever-Hall detection and employing electronic feedback to an acousto-optic modulator (AOM) and laser piezoelectric-transducer. This stable laser light is then delivered to the Yb-1 and Yb-2 systems, where it is aligned along the optical lattice axis to probe the atomic clock transition. Resonance with the atomic transition is detected by observing atomic fluorescence collected onto a photomultiplier tube (PMT). The fluorescence signal is digitized and processed by a microcontroller unit (MCU), which computes a correction frequency, f1;2(t). This correction frequency is applied to the relevant AOM by way of a direct digital synthesizer (DDS), and locks the laser frequency onto resonance with the clock transition. (B) Relevant Yb atomic energy levels and transitions, including laser cooling transitions (399 and 556 nm), the clock transition (578 nm), and the optical pumping transition used for excited state detection (1388 nm). (C) A single-scan, normalized excitation spectrum of the 1S0- 3P0 clock transition in 171Yb with 140 ms Rabi spectroscopy time; the red line is a free-parameter sinc2 function fit. Credit: arXiv:1305.5869 [physics.atom-ph]

(Phys.org) —Researchers at the National Institute of Standards and Technology in Boulder Colorado have succeeded in building a record breaking clock—one that has an instability of just one part in 10^{-18}. They describe their new clock in a paper they've uploaded to the preprint server *arXiv*. In it they suggest that if their clock could somehow be used to gauge the age of the universe, it would be able to do so within just a single second.

As time has passed, clock-making has become more important—besides helping people get together at prearranged times, clocks now help run the GPS system, keep networks on track and are key to unlocking the fundamental laws of the universe. As technology has grown in sophistication, so too has the need for ever more accurate clocks. This has led to atomic clocks which use the electronic transition frequency in the ultraviolet, optical or microwave region of the electromagnetic spectrum to keep very accurate time. In this new effort, the researchers built a new type of atomic clock that is more accurate than any that has come before.

To build their clock the researchers employed a laser and mirrors to build a lattice trap capable of capturing atoms—its purpose was to hold atoms steady so that there wouldn't be any frequency interference, a problem with other atomic clocks. The trap was then filled with ytterbium atoms which were then shot with a second laser to measure their electronic frequencies. The result was a clock that if allowed, would be off by less than a second if run for 31 billion years.

Building a clock that is believed to be the most accurate in the world creates a problem though, how to accurately measure its accuracy? The answer is by building another clock exactly like the first of course and then comparing the two against one another. That's what the researchers did, running both clocks for a short period to see if they came up with exactly the same time duration, which the researchers report, they did.

One of the first uses for the new clock will be in measuring gravitational redshift, which is a means of measuring very precisely, the height of geographic areas. This can be done because time moves slower in areas of higher gravity. The researchers say their new clock is capable of measuring redshit to within 1 centimeter.

More information: An atomic clock with 10^{-18} instability, arXiv:1305.5869 [physics.atom-ph] arxiv.org/abs/1305.5869

Abstract
Atomic clocks have been transformational in science and technology, leading to innovations such as global positioning, advanced communications, and tests of fundamental constant variation. Next-generation optical atomic clocks can extend the capability of these timekeepers, where researchers have long aspired toward measurement precision at 1 part in $bm{10^{18}}$. This milestone will enable a second revolution of new timing applications such as relativistic geodesy, enhanced Earth- and space-based navigation and telescopy, and new tests on physics beyond the Standard Model. Here, we describe the development and operation of two optical lattice clocks, both utilizing spin-polarized, ultracold atomic ytterbium. A measurement comparing these systems demonstrates an unprecedented atomic clock instability of $bm{1.6times 10^{-18}}$ after only $bm{7}$ hours of averaging.

via Arxiv Blog