

Scientists take an atomic clock on the road and use it to measure the height of a mountain [REDACTED]

By Deborah Netburn
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Most of us 1) _____ of time as a 2) _____ to measure 3) _____ things as the 4) _____ of our days and the 5) _____ of our lives. But if you had 6) _____ to a pair of extremely high-precision clocks, you could use time in a 7) _____ way — to measure the height of mountains.

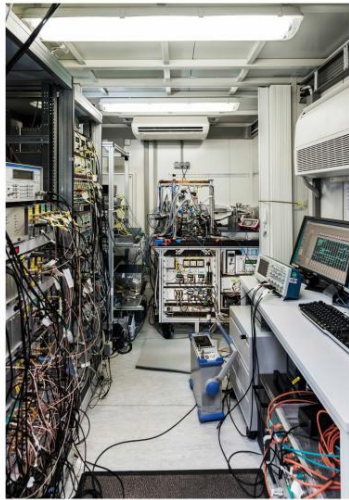
According to Einstein's 8) _____ of relativity, time moves differently 9) _____ on where you are in a gravity field. A clock on 10) _____ of a tall mountain will move a tiny 11) _____ faster than a clock at the 12) _____ of that mountain, where the gravity is stronger. It's not a mechanical 13) _____. Time 14) _____ actually passes 15) _____ at the top of the mountain.

GAP A:

By 16) _____ (compare) the tick rate of the portable atomic clock on a mountain with a similar clock in a lab in Torino, Italy, researchers 17) _____ (show) that the altitude difference between the two locations 18) _____ (be) about 1,000 meters, or 3,280 feet.

Some optical lattice clocks 19) _____ (break) a single second into such tiny parts that they 20) _____ (detect) a minuscule shift in the speed of time. With the right setup, one of these clocks 21) _____ (measure) 9 billion ticks per second. Lisdatt and his colleagues 22) _____ (want/build) an optical lattice clock that 23) _____ (go) on the road. The key 24) _____ (be/determine) which trade-offs 25) _____ (allow) the clocks 26) _____ (leave) the lab without 27) _____ (lose) too much accuracy.

GAP B:



Pictured: Inside view into the trailer with the transportable optical atomic clock.

For its first test run, the 28) _____ (authorial) took their 29) _____ (portage) clock to a lab in the French Alps. Using an 30) _____ (optics) fiber link, they connected the clock with 31) _____ (other) one about 55 miles 32) _____ (way) in Torino.

The first experiments went 33) _____ (smooth): A tunnel was being built 34) _____ (near), and the drilling compromised the clock's 35) _____ (stable). In addition, a combination of lower-than-expected 36) _____ (humid) and warmer-than-expected temperatures made it 37) _____ (hard) to keep the clock's components 38) _____ (suffice) cool.

GAP C:

"It didn't work as nicely as we hoped, but we learned a lot and it's a start," Lisdatt said. "Sometimes you just have to begin, and then you can figure out how to improve."

- 1 "What we did is take something state-of-the-art and make it transportable," Lisdatt said. "It's not easy."
- 2 Still, they were able to tell that the portable clock was about 1,000 meters higher than its counterpart in Torino.
- 3 That means that your friend who lives in the Rockies is aging just a tiny bit faster than your friend who lives on the beach in Malibu.
- 4 Atomic clocks follow the same principle. They use the quantum jump of electrons as a pendulum.
- 5 "The idea of using portable clocks this way has been in the geophysical literature for a long time," said Duncan Agnew, a geophysicist at the Scripps Institution of Oceanography in San Diego, who was not involved in the work. "What these guys managed is to actually do it."
- 6 Lisdatt said his team is already making improvements.