

## 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.

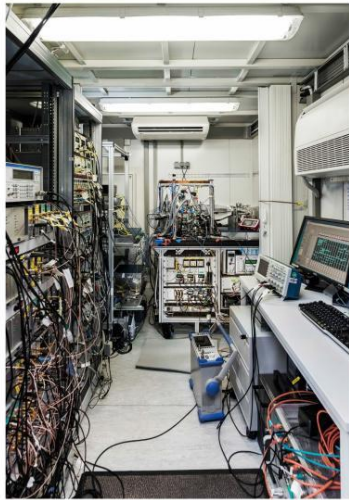
According to Einstein's 8) \_\_\_\_\_ of relativity, time moves differently 9) \_\_\_\_\_ on where you are in a gravity field. A clock on 10) \_\_\_\_\_ of a tall mountain will move a tiny 11) \_\_\_\_\_ faster than a clock at the 12) \_\_\_\_\_ of that mountain, where the gravity is stronger. It's not 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.