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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.

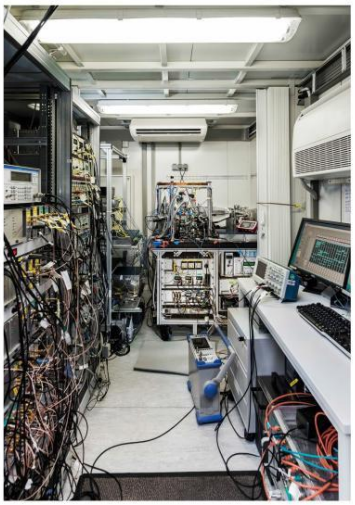
According to Einstein's **8)** _____ of relativity, time moves differently **9)** _____ on where you are in a gravity field. A clock on **10)** _____ of a tall mountain will move a tiny **11)** _____ faster than a clock at the **12)** _____ of that mountain, where the gravity is stronger. It's not a 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. Lisdat 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," Lisdat 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," Lisdat 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. Lisdat said his team is already making improvements.