

Monitoring volcanoes with ground-based atomic clocks

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An international team led by scientists from the University of Zurich finds that high-precision atomic clocks can be used to monitor volcanoes and potentially improve predictions of future eruptions. In addition, a ground-based network of atomic clocks could monitor the reaction of the Earth's crust to solid Earth tides.

Atomic clocks measure time with unbelievable accuracy. The best atomic clocks are so precise that they would lose less than one second over a period of 10 billion years. However, they are generally only used in laboratories. Science and industry have yet to take full advantage of their unprecedented ability to measure time. An international team including Dr. Ruxandra Bondarescu, Andreas Schäfer and Prof. Philippe Jetzer from the Institute of Physics from the University of Zurich discusses potential applications for atomic clocks.

Their analysis shows that the slow down of time predicted by [general relativity](#) can be measured by local clocks and used to monitor volcanoes. General relativity states that clocks positioned at different distances from a massive body like the Earth have different tick rates. The closer a clock is to a massive object, the slower it ticks. In a similar manner, subterranean objects influence the tick rate of local clocks that are located above the Earth's surface. New lava filling a magma chamber beneath a [volcano](#) makes a clock located above that volcano tick more slowly than a clock that is located further away. Volcanoes are currently monitored using GPS receivers. The resulting data often has to be integrated over a period of several years before an estimate of the

volume of new magma can be made. A network of local, highly precise atomic clocks may provide the same information within a few hours. This would make it possible to monitor processes inside volcanoes more closely and to make better predictions for future volcanic eruptions.

Monitoring the solid Earth tides with a global network of atomic clocks

Atomic clocks can also be used to monitor the solid Earth tides. Tides occur because the Earth moves in the gravitational field of the Sun and the Moon. It reacts to this outer field by deforming, which in turn leads to ocean tides and to the ground on the continents lifting and falling regularly. The ground can rise as much as 50 cm. A global network of [atomic clocks](#) that are connected via fiber optic cables used for internet, could provide continuous measurements of the Earth tides and check existing theoretical models. It would also be possible to examine any local differences in the response of the Earth's crust to the Earth tides.

The researchers hope that high precision clocks could be deployed in volcanic areas in the next few years. This is, however, subject to sufficient interest and investment from industry. "We need this additional tool to monitor magma movement under volcanoes such as the Yellowstone supervolcano, which is overdue for an explosion that would alter life on Earth as we know it", explains Bondarescu.

More information: "Atomic Clocks as a Tool to Monitor Vertical Surface Motion." Express letter in the *Geophysical Journal International*, in Press. arXiv:1506.02457

Provided by University of Zurich

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