# Compact dark object search: Scanning Earth's core with superconducting gravimeters

February 21 2020, by Ingrid Fadelli


Technician Peter Duffner (left) and earth scientist Thomas Forbriger working on the superconducting gravimeter in an abandoned silver mine deep in the Black Forest of Germany. Credit: Horowitz & Widmer-Schnidrig.

Physics theory suggests that the universe is made up in great part by a type of matter that does not emit, absorb or reflect light, and hence cannot be observed using conventional detection methods. This type of matter, referred to as dark matter, has so far never been experimentally observed or detected.

Detecting dark matter has so far proved to be incredibly challenging, yet it could be far easier if this type of matter were concentrated into macroscopic objects. In fact, some physicists have suggested that dark matter, or at least a key component of it, may be made up of compact dark objects (CDOs), which are assumed to exhibit small nongravitational interactions with normal matter.

Charles Horowitz and Rudolf Widmer-Schnidrig, two researchers at Indiana University and the Black Forest Observatory (BFO) in Germany, respectively, have recently carried out a study investigating the use of gravimeters to search for compact dark matter objects (CDOs) inside the Earth. Their paper, published in *Physical Review Letters*, highlights the potential of using superconducting gravimeters in the ongoing search for dark matter.

"Much of the universe is made of unknown dark matter," Horowitz told Phys.org. "In our previous work, we searched for clumps of dark matter, which we call compact dark objects, CDOs, in neutron stars or in the sun. Since dark matter may interact very weakly with normal matter, it can move about inside normal bodies in ways that conventional matter can't."

Astrophysics theory suggests that dark matter has gravitational interactions with normal matter. Searching for CDOs using tools that can detect differences in gravitational forces between one location and another thus seems like a promising option.

With this in mind, Horowitz and Widmer-Schnidrig set out to investigate the potential of searching for CDOs using gravimeters, highly sensitive devices that can measure the acceleration that results from gravity with remarkable accuracy. On Earth, the acceleration due to gravity is approximately g(t) = 9.8 $m/s^2$, while a gravimeter can measure changes in this number in the 12th digit to about 12 digits (with a part-per-trillion precision).

"Gravity from a CDO will change the value of g slightly as the CDO moves closer to or away from the gravimeter," Horowitz said. "We look for a time dependence to g(t) that changes with the 55-minute period of the CDO's orbit inside the Earth."

Horowitz and Widmer-Schnidrig calculated that CDO moving in Earth's inner core would have an orbital period of almost 55 minutes, and would produce a time-dependent signal in a gravimeter. The data they collected using superconductive gravimeters, however, rules out the presence of such objects inside the Earth's core, unless these objects have an extremely low mass or small orbital radius.

In the future, the researchers would like to repeat their study using gravimeters with a higher sensitivity or focusing on other celestial bodies. Their work could also inspire physicists at other institutions worldwide to carry out similar experiments using gravimeters.

"We have shown how to use the sensitivity of gravimeters to probe for one possible form of dark matter," Horowitz said. "We demonstrated that no such objects are moving inside the Earth unless their mass and or orbital radius is very small. In our future work, we plan to try and improve the sensitivity of our search and to possibly search for CDO in other solar system bodies."

**More information:** C. J. Horowitz et al. Gravimeter Search for Compact Dark Matter Objects Moving in the Earth, *Physical Review*

*Letters* (2020). DOI: 10.1103/PhysRevLett.124.051102