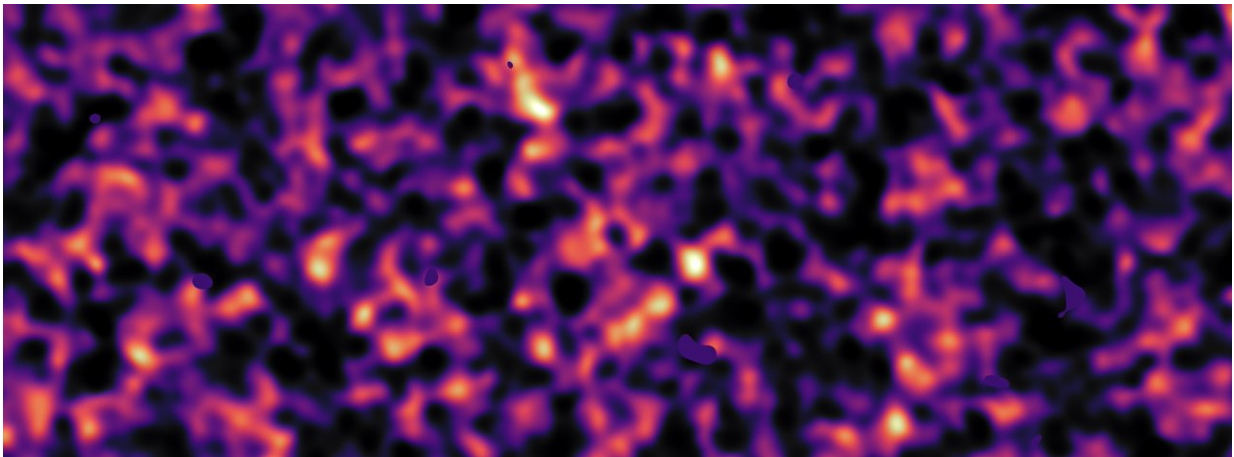


Cesium vapor aids in the search for dark matter

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Dark matter map of KiDS survey region (region G12). Credit: KiDS survey

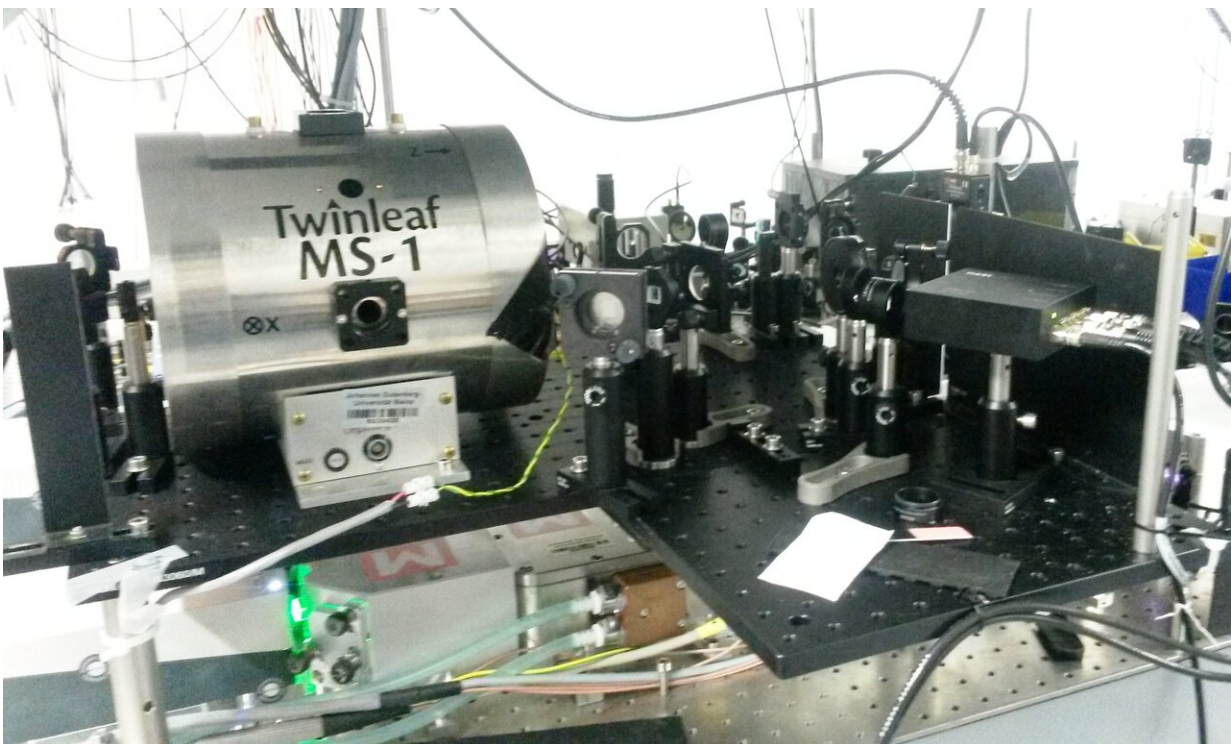
The hunt for dark matter is one of the most exciting challenges facing fundamental physics in the 21st century. Researchers have long known that it must exist, as many astrophysical observations would otherwise be impossible to explain. For example, stars rotate much faster in galaxies than they would if only 'normal' matter existed.

In total, the matter we can see only accounts for, at the most, 20 percent of the total matter in the universe—meaning that a remarkable 80 percent is [dark matter](#). "There's an elephant in the room but we just can't see it," said Professor Dmitry Budker, a researcher at the PRISMA+

Cluster of Excellence of Johannes Gutenberg University Mainz (JGU) and the Helmholtz Institute Mainz (HIM), explaining the problem he and many of his colleagues worldwide are contending with.

Dark matter could consist of extremely light particles

But so far no one knows what dark matter is made of. Scientists in the field are considering and researching a whole range of possible particles that might theoretically qualify as candidates. Among these are extremely lightweight bosonic particles, currently considered to be one of the most promising prospects. "These can also be regarded as a classical field oscillating at a specific frequency. But we can't yet put a figure on this—and therefore the mass of the particles," explained Budker. "Our basic assumption is that this dark matter field is coupled to visible matter and has an extremely subtle influence on certain atomic properties that would normally be constant."



Experimental setup for atomic spectroscopy using cesium atom vapor. Credit: Dionysis Antypas

Budker and his team in Mainz have now developed a new method which they describe in the current issue of the leading specialist journal *Physical Review Letters*. It employs atomic spectroscopy and involves the use of cesium atom vapor. Only on exposure to laser light of a very specific wavelength do these atoms become excited. The conjecture is that minute changes in the corresponding observed wavelength would indicate coupling of the cesium vapor to a dark matter particle field.

"In principle, our work is based on a particular theoretical model, the hypotheses of which we are experimentally testing," added the paper's principal author, Dr. Dionysis Antypas. "In this case, the concept underlying our work is the relaxion model developed by our colleagues and co-authors at the Weizmann Institute in Israel." According to the relaxion theory, there must be a region in the vicinity of large masses such as the Earth in which the density of dark matter is greater, making the coupling effects easier to observe and detect.

Previously inaccessible frequency range searched

With their new technique, the scientists have now accessed a hitherto unexplored frequency range in which, as postulated in relaxion theory, the effects of certain forms of dark matter on the atomic properties of cesium should be relatively easy to spot. The results also allow the researchers to formulate new restrictions as to what the nature of dark matter is likely to be. Dmitry Budker likens this meticulous search to the hunt for a tiger in a desert. "In the frequency range that we've explored in our current work, we still have not pinpointed dark matter. But at

least, now that we've searched in this range, we know we don't have to do it again." The researchers still don't know where dark matter—the tiger in his metaphor—is lurking, but they now know where it is not. "We just keep on targeting in more closely on the part of the desert where the tiger is most likely to be. And, at some point, we will catch him," maintained Budker with confidence.

More information: D. Antypas et al, Scalar Dark Matter in the Radio-Frequency Band: Atomic-Spectroscopy Search Results, *Physical Review Letters* (2019). [DOI: 10.1103/PhysRevLett.123.141102](https://doi.org/10.1103/PhysRevLett.123.141102)

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