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A new way to search for dark matter reveals hidden materials properties

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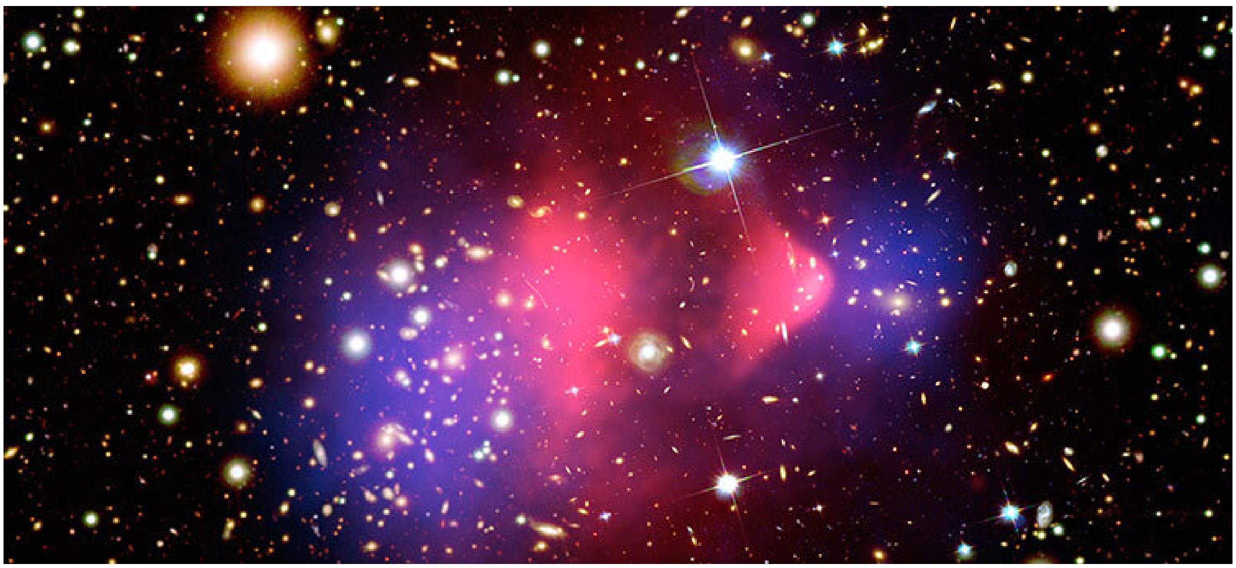

New research from Chalmers and ETH Zürich, Switzerland, suggests a promising way to detect elusive dark matter particles through previously unexplored atomic responses occurring in the detector material. The illustration above is a composite image (optical, X-ray, computed dark-matter) of mass distribution in the bullet cluster of galaxies. Credit: Chandra X-Ray Observatory, NASA/CXC/M. Weiss/Wikimedia Commons

New research from Chalmers, together with ETH Zürich, Switzerland, suggests a promising way to detect elusive dark matter particles through previously unexplored atomic responses occurring in the detector material.

The new calculations enable theorists to make detailed predictions about the nature and strength of interactions between dark matter and electrons, which were not previously possible.

"Our new research into these atomic responses reveals material properties that have until now remained hidden. They could not be investigated using any of the particles available to us today—only dark matter could reveal them," says Riccardo Catena, Associate Professor at the Department at Physics at Chalmers.

For every star, galaxy or dust cloud visible in space, there exists five times more material which is invisible—dark matter. Discovering ways to detect these unknown particles which form such a significant part of the Milky Way is therefore a top priority in astroparticle physics. In the global search for dark matter, large detectors have been built deep underground to try to catch the particles as they bounce off atomic nuclei.

So far, these mysterious particles have escaped detection. According to the Chalmers researchers, a possible explanation could be that dark matter particles are lighter than protons, and thereby do not cause the nuclei to recoil—imagine a ping pong ball colliding into a bowling ball. A promising way to overcome this problem could therefore be to shift focus from nuclei to electrons, which are much lighter.

In their recent paper, the researchers describe how dark matter particles can interact with the electrons in atoms. They suggest that the rate at which dark matter can kick electrons out of atoms depends on four independent atomic responses—three of which were previously unidentified. They have calculated the ways that electrons in argon and xenon atoms, used in today's largest detectors, should respond to dark matter.

The results were recently published in the journal Physical Review Research and performed within a new collaboration with condensed-matter physicist Nicola Spaldin and her group at ETH. Their predictions can now be tested in dark matter observatories around the globe.

"We tried to remove as many access barriers as possible. The paper is published in a fully open access journal and the scientific code to compute the new atomic response functions is open source, for anyone who wants to take a look 'under the hood' of our paper," says Timon Emken, a postdoctoral researcher in the dark matter group at the Department of Physics at Chalmers.

More information: Riccardo Catena et al. Atomic responses to general dark matter-electron interactions, *Physical Review Research* (2020). DOI: 10.1103/PhysRevResearch.2.033195

Provided by Chalmers University of Technology

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