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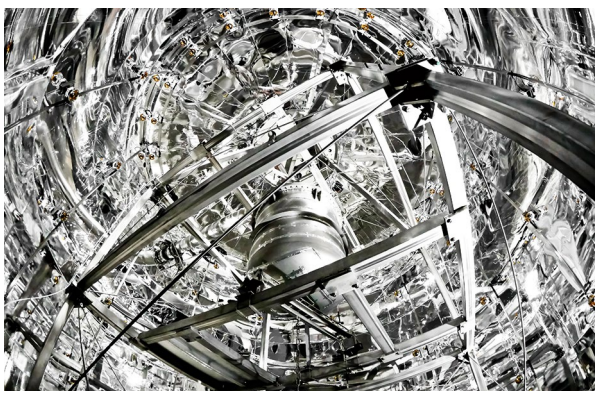
PARTICLE PHYSICS

Constraints on light dark matter

One way to search for the elusive traces of the interaction between dark and ordinary matter is to look for signs of dark matter particles bouncing off normal atoms. This is exactly what the XENON1T experiment (pictured), located deep underground at the Gran Sasso National Laboratory in Italy, was built for. So far no signs of dark matter have been detected, but the XENON collaboration now reports in *Physical Review Letters* how it is pushing the limits, further constraining the regions where dark matter could be lurking.



Credit: XENON Collaboration

XENON1T is a particle detector — a liquid/gas time projection chamber — a cylindrical tank filled with 2 tonnes of ultra-pure liquid xenon. If a dark matter particle hits a xenon atom, the atom recoils, exciting other atoms and causing a small flash of light, or primary scintillation (S1), detected at the bottom of the tank. At the same time, electrons are freed, producing a secondary signal (S2) as they drift in an applied electric field towards the top of the tank.

Light-mass dark matter particles would have a tiny effect, but could still be detected with a combination of the S1 and S2 signals. However, this is not easy because the radioactive background in the detectors causes fake events. The XENON collaboration used advanced data analysis and improvements in the detectors to search for light dark matter using only the S2 signal, which is sensitive to lower energies than traditional analyses and hence can provide constraints on light dark matter by several orders of magnitude.

In another analysis, the XENON collaboration looked for the effects of secondary electronic recoils that can accompany a nuclear recoil. The elastic scattering of a light dark matter particle off a xenon atom can result in the excitation and ionization of the recoiling atom, a phenomenon known as the Migdal effect, or the emission of a photon through Bremsstrahlung. Looking for electronic recoil signals in a S2 and combined S1 and S2 analysis enhanced the sensitivity to light dark matter beyond what was previously possible.

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ORIGINAL ARTICLES Aprile, E. et al. A search for light dark matter interactions enhanced by the Migdal effect or Bremsstrahlung in XENON1T. *Phys. Rev. Lett.*, in the press. Preprint available at: https://arxiv.org/abs/1907.12771 (2019) | Aprile, E. et al. Light dark matter search with ionization signals in XENON1T. *Phys. Rev. Lett.*, in the press. Preprint available at: https://arxiv.org/abs/1907.11485 (2019)