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The DarkSide-20k experiment sensitivity to Dark Matter candidates

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Dark matter constitutes approximately 85 % of the Universe's total mass, yet its particle nature remains unresolved. While several astrophysical observations support its existence, the underlying constituent has evaded direct identification. Weakly Interacting Massive Particles (WIMPs) represent a leading class of candidates, motivating a sustained experimental program over the past decade that has progressively tightened exclusion limits on the WIMP–nucleon interaction cross-section and WIMP mass.

The Global Argon Dark Matter Collaboration (GADMC) contributes to this direct-detection effort through its forthcoming apparatus, DarkSide-20k, following the successful DarkSide-50 experiment, which implements a dual-phase liquid-argon time-projection chamber (LAr TPC) encased within two active veto systems. The entire assembly resides in an $8 \times 8 \times 8\,\mathrm{m}^3$ cryostat installed at the Laboratori Nazionali del Gran Sasso (LNGS), an underground laboratory inside the Gran Sasso mountain providing a natural shielding from cosmic-rays. The detector is designed to minimize background events and achieve a nearly background-free operation by employing strategies to suppress unwanted signals such as neutrons, beta particles, and gamma rays. Liquid argon offers intrinsic discrimination between electronic recoils (β/γ) and nuclear recoils (neutrons, potential WIMP interactions) via pulse-shape discrimination (PSD), thereby enabling efficient rejection of dominant backgrounds.

Taking advantage of the intrinsic PSD capability of liquid argon, the NR background from the detector components is one order of magnitude smaller compared to the irriducibile contribution due to CEvNS from neutrinos. With a target mass of 20 t of active argon and an exposure of 200 t·yr, DarkSide-20k is expected to achieve a 90 % confidence-level upper limit on the spin-independent WIMP–nucleon cross-section of $7.4 \times 10^{-48}\,\mathrm{cm}^2$ for a $1\,\mathrm{TeV/c^2}$ WIMP. At lower masses ($\approx 10\,\mathrm{GeV/c^2}$), the experiment retains competitive sensitivity, reaching $1 \times 10^{-42}\,\mathrm{cm}^2$ and with 10 years exposure, the neutrino fog can be reached for WIMP masses around $5\,\mathrm{GeV/c^2}$.

Auteur: KUNZE, Pablo

Orateur: KUNZE, Pablo

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