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DarkSide status and prospects

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Summary. — DarkSide uses a dual-phase Liquid Argon Time Projection Chamber to search for WIMP dark matter. The current detector, DarkSide-50, is running since mid 2015 with a target of 50 kg of Argon from an underground source. Here it is presented the latest results of searches of WIMP-nucleus interactions, with WIMP masses in the GeV-TeV range, and of WIMP-electron interactions, in the sub-GeV mass range. The future of DarkSide with a new generation experiment, involving a global collaboration from all the current Argon based experiments, is presented.

The hypothesis of dark matter was introduced more than 80 years ago to explain anomalous motions of galaxies gravitationally bound in clusters. Observational evidence has continued to accumulate since then, including rotation curves of galaxies and their clusters and discrepancies in the distributions of galaxy cluster mass estimated from luminosity vs. gravitational lensing [1-3]. One of the most favored dark matter candidate is the Weakly Interacting Massive Particle (WIMP) [4, 5], which explains the current abundance of dark matter as a thermal relic of the big bang. Most models predict dark matter WIMP masses near the electroweak scale of 100's of GeV/c^2. However, dark matter particle masses ≤ 10 GeV/c^2 can also be compatible with experimental constraints if a significant asymmetry between dark matter and their anti-particles existed in the early universe.

The DarkSide-50 experiment [6, 7] is located in Hall C of the Gran Sasso National Laboratory (LNGS) in Italy. It is a two-phase Time Projection Chamber (TPC) with an active mass of (46.4 ± 0.7)kg of underground liquid argon (UAr) deployed in a liquid-scintillator veto (LSV) for neutron and γ-ray rejection, and a water Cherenkov veto (WCV) for shielding and muon detection. Detailed descriptions of the DarkSide detectors, their signals, the calibration and the Monte Carlo simulation can be found in [8-14].

High mass analysis is reported in [15]. Results are reported from blind analysis of a (16660 ± 270)kg d exposure using a target of low-radioactivity argon extracted from underground sources. Unblinded data shows no excesses in the defined dark matter search region; while the background-free and signal-free result sets the best upper limit for an argon based direct DM search experiment to be 1.14×10^{-44} cm^2 for a WIMP mass of 100 GeV/c^2.

A search for DM particle with a much lower recoil analysis threshold, sensitive to DM masses down to 1.8 GeV/c^2 [16, 17], it is also presented. WIMPs in this mass range produce nuclear recoils well below 10 keV$_{nr}$ where the efficiency for detecting the prompt scintillation signal S1 is low and pulse shape discrimination (PSD) is no longer available. The analysis in this case is mainly based on the gain inherent in the ionization S2 signal of the dual-phase LAr TPC. S1 pulses are not usually large enough to be detectable,

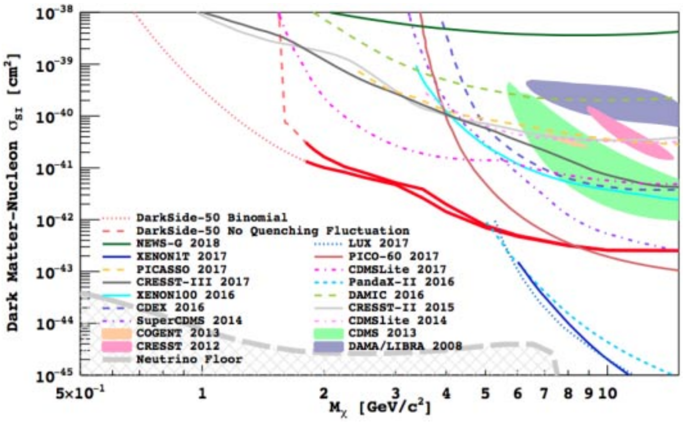

Fig. 1. – 90% C.L. upper limits on spin-indipendent DM-nucleus cross section from DarkSide-50 in the range above 1.8 GeV/c^2 (see the text).

so no drift time is available for z-fiducialization. The position of each event is then assigned as the center of the PMT receiving the largest number of S2 photoelectrons. The S2 photoelectron yield per extracted ionization electron η, is determined by studying single electron events obtained during a short period of time in which the inline argon purification system was turned off for maintenance purposes. The observation of strong time and space correlations of single-electrons events to preceding large ionization events, suggests that these events are from electrons captured and subsequently released from impurities in the argon [18, 19]. *In situ* calibration data from ^{241}Am^{13}C and ^{241}AmBe neutron sources and neutron beam scattering data from the SCENE [20] and ARIS [21] experiments, are used to determine the ionization yield from nuclear recoils Q_y. Upper limits on the WIMP-nucleon scattering cross-section are extracted from the observed N_{e^-} spectrum using a binned profile likelihood method. The 90% C.L. exclusion curves for the binomial fluctuation model (red dotted line) and the model with zero fluctuations in the energy quenching (red dashed line) are shown in fig. 1. For masses above 1.8 GeV/c^2, the 90% C.L. is insensitive to the choice of quenching fluctuation model, while below 1.8 GeV/c^2 the two exclusion curves rapidly diverge because of the effective threshold due to the absence of the fluctuations in the energy quenching process.

I presented here a background-free analysis of high-mass WIMP search, using more than 500 days of data taking of the DarkSide-50 detector, with the best exclusion limit from a LAr experiment for WIMP-nucleon cross section. Best sensitivity limit from the same experiment in low mass WIMP search in the range of 1.8-6 GeV/c^2 were also presented. Finally these results are extremely promising in view of the next DarkSide detectors generation (DarkSide-20k [22] and GADMC - Global Argon Dark Matter Collaboration).

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