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Dark Matter Searches with Low-Radioactivity Argon

We present the case for the DarkSide-Argo program for direct dark matter searches with low-radioactivity argon from underground sources.

The immediate objective is the DarkSide-20k two-phase liquid argon detector, currently under construction at the Gran Sasso laboratory (LNGS). DarkSide-20k will have ultra-low backgrounds, with the ability to measure its backgrounds in situ, and sensitivity to WIMP-nucleon cross sections of 5.1 × 10−48 cmˆ2 (4.8 × 10−47 cmˆ2) for WIMPs of $1\ \mathrm{TeV/c^2}$ ($10\ \mathrm{TeV/c^2}$) mass, to be achieved during a 10 yr run with exposure of 460 t y. This projected sensitivity is a factor of > 40 better than currently-published results above $1\ \mathrm{TeV/c^2}$. DarkSide-20k is foreseen to start taking data in 2028 and will either detect WIMP dark matter or exclude a large fraction of the parameter space complementary to LHC experiments.

An important element for this program will be the searches for low-mass WIMP candidates and dark matter candidates beyond the WIMP using the ionization-only technique. Based on demonstrated ultra-low threshold and world-leading sensitivity achieved with DarkSide-50, DarkSide-20k will improve existing constraints at $1\ \mathrm{GeV/c^2}$ dark matter mass by two orders of magnitude. The same technique can also deliver valuable insight in case of a galactic core-collapse supernovae detection using the flavor blind CEνNS reaction.
In parallel, a dedicated experiment specifically optimized for the observation of the electroluminescence signal, coupled to ^{39}Ar reduction by the large cryogenic distillation plant (Aria) meant to purify the DarkSide-20k target, will be able to reach through the so-called "neutrino floor" in the low-mass search region.

The final objective will be the construction of the ultimate Argo detector with a 300 t fiducial mass to push the sensitivity to the region where neutrino background will be a limitation in detectors without directional capability.
The WIMP detection sensitivity will only be limited by systematic uncertainties in nuclear recoil background from Coherent Neutrino Scattering of Atmospheric neutrinos. The strong electron recoil rejection will eliminate background from solar neutrinos and some
residual internal backgrounds such as radon. This unique property of argon extends the sensitivity with respect to technologies with more limited electron recoils discrimination, enabling a broad physics program which includes the observation of ultra-rare solar neutrino
sources (CNO, hep).

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