2 Search for Cold Dark Matter Particles with CDMS-II

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(CDMS-II Collaboration)

The Cryogenic Dark Matter Search (CDMS-II) experiment operated in the Soudan Underground Laboratory a total of 19 Ge (∼230 g each) and 11 Si (∼105 g each) detectors at a temperature of ∼40 mK to search for signals from Weakly Interacting Massive Particles (WIMPs) scattering off the target nuclei. They were designed to detect the phonons and ionization from an interaction within the crystal. The ionization was lower for nuclear recoils, produced by WIMP candidates, than for electron recoils, caused mostly by background photons. Fewer than 10^{-4} of the electron recoils in the bulk of the detector were misidentified as nuclear recoils. The main source of misidentified electron recoils were events with interactions in the first few μm of the detector surfaces, which also constituted the dominant background for the CDMS-II experiment. Due to incomplete charge collection these surface events had reduced ionization. Hence, they could mimic a WIMP-nucleus interaction. Neutron background from cosmogenics and radioactive processes was much less significant.

In December 2009 the CDMS-II collaboration published the results from a WIMP search analysis that yielded the world's most stringent constraints on the spin-independent WIMP-nucleon cross section at that time [1]. Since then the collaboration has focussed on developing improved detector technologies and reanalyzing the available data with regard to WIMP models that require a refined approach in order to increase the sensitivity. We participated in the reanalysis efforts. In particular our group performed an improved search for inelastic dark matter (iDM) [2].

Inelastic dark matter scattering has been proposed as a way to resolve the tension between the DAMA claim, the observation of an annual modulation due to the movement of the Earth around the Sun [3], and results from other WIMP-search experiments [1; 4]. The inelastic scenario assumes that WIMPs can only scatter off baryonic matter by transition into an excited state at a certain energy above the ground state. The WIMP-mass splitting between the WIMP and its excited state enters the iDM scenario as an additional free parameter.

Initial constraints from CDMS on the iDM model interpretation of the DAMA claim were set using a recoil-energy range of 10–100 keV [1]. Last year we reanalysed the entire data set taken at Soudan for two main reasons: within the allowed parameter space of the iDM model the energy spectrum may reach significantly beyond the 100 keV upper threshold used in the analysis, hence an extension to 150 keV increases the sensitivity. Moreover, the expected rate drops to zero for low recoil energies, in contrast to the elastic-scattering case. Since most of the dominant surface-event background occurred at energies just above our

10 keV threshold [5], where no iDM signal is expected, the sensitivity could be further enhanced by defining a looser surface-event rejection cut based upon the estimated background with recoil energy between 25 keV and 150 keV. The final surface-event background was calculated to be $0.8^{+0.5}_{-0.3}$(stat.)$^{+0.3}_{-0.2}$(syst.) given the exposure of 969 kg·days.

After fixing all event selection criteria, the signal region was "unblinded". We observed three WIMP candidates between 25 keV and 150 keV, at 37.3 keV, 73.3 keV and 129.5 keV, the latter occuring above the analysis range from previous analyses. The probability to observe three or more background events in this energy range including the surface-event background and the much lower neutron background is 11%, which is low but not negligible. Thus, this analysis does not constitute a significant detection of WIMP scattering.

Constraints emerging from this analysis are shown in Fig. 2.1. The only remaining parameter space allowed by CDMS data is within a narrow region at WIMP masses of ~100 GeV/c^2 and WIMP-mass splittings between 85 keV and 135 keV. Due to the occurrence of the three candidate events between 25 keV and 150 keV the constraints on the iDM parameter space are slightly weaker than from our previous analysis for which no events were observed at intermediate energies where the rate is expected to peak. Though this analysis was performed with regard to the iDM scenario, the expansion of the analysis range to 150 keV could be useful to test other models predicting a signal at tens of keV recoil energy. A preprint discussing this analysis [6] was submitted to PRD.

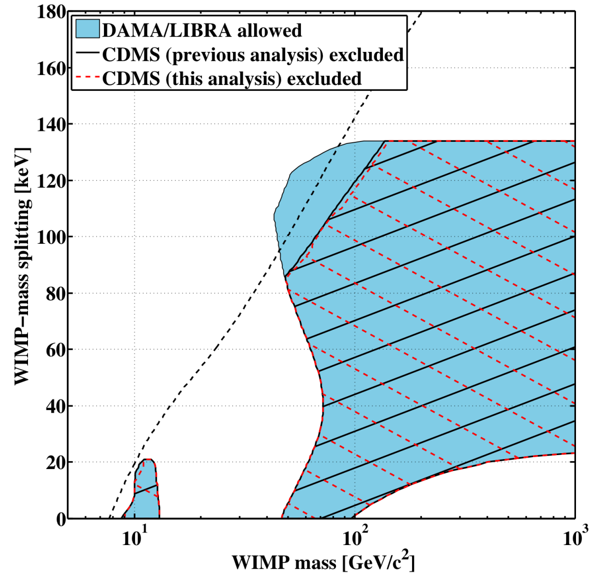

Fig. 2.1 – The blue/shaded regions represent WIMP masses and WIMP-mass splittings for which cross sections exist that are compatible with the modulation spectrum observed by DAMA/LIBRA at 90% C.L. The hatched regions show constraints on these parameters from the reanalysis (red/dashed) and from our previous analysis (black/solid) [1]. The black/dashed line represents the maximum reach of the CDMS-II experiment.

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