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Search for WIMP annual modulation signature: results from DAMA/NaI-3 and DAMA/NaI-4 and the global combined analysis

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Abstract

Data, collected by the $\simeq 100$ kg NaI(Tl) DAMA set-up at the Gran Sasso National Laboratory of I.N.F.N. during two further yearly cycles (DAMA/NaI-3 and DAMA/NaI-4; statistics of 38475 kg · day), have been analysed in terms of WIMP annual modulation signature. The results agree with those previously achieved. The cumulative analysis of all the available data (DAMA/NaI-1 to 4; statistics of 57986 kg · day) favours the possible presence of a WIMP with $M_w = (52^{+10}_{-8})$ GeV and $\xi\sigma_p = (7.2^{+0.4}_{-0.9}) \cdot 10^{-6}$ pb at 4 σ C.L., when standard astrophysical assumptions are considered. The allowed mass extends up to 105 GeV (1 σ) when the uncertainty on the mean value of the local velocity v_0 is taken into account and up to 132 GeV (1 σ) in case a possible bulk halo rotation is taken into account. Moreover, the allowed regions extend to lower $\xi\sigma_p$ values when the upper limits on the recoil differential counting rate obtained from DAMA/NaI-0 is included in the cumulative analysis (favouring, in case of standard assumptions, $M_w = (44^{+12}_{-9})$ GeV and $\xi\sigma_p = (5.4 \pm 1.0) \cdot 10^{-6}$ pb at $\simeq 4$ σ C.L.). The 3 σ C.L. allowed regions in the $\xi\sigma_p$, M_w plane summarize the obtained main physical results.

1. Introduction

The $\simeq 100$ kg NaI(Tl) DAMA set-up is running at the Gran Sasso National Laboratory of I.N.F.N. [1–11]; its main goal is to search for Weakly Interacting Massive Particles (WIMPs). According to standard models, these particles would have in the galactic halo a Maxwellian velocity distribution with a cut-off at the galactic escape velocity; therefore, a WIMP ''wind'' would continuously hit the Earth. WIMPs can be detected by investigating their elastic scattering on the target nuclei of a detector. The nuclear recoil energy in the keV range is the measured quantity. The best way to single out the possible presence of a WIMP signal from the background is to look for the so-called *annual modulation signature* [4–6,12,13]. In fact, since the Earth rotates around the Sun, it would be invested by a larger WIMP flux in June (when its rotational velocity adds up to the velocity of the whole solar system in the

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