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Background simulation and evaluation of the XMASS experiment for the detection of low energy solar neutrinos*

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The solar neutrino problem is now commonly thought to be caused by neutrino oscillations. Indeed, the measured deficit of the atmospheric muon neutrino flux, the latest solar neutrino data from the Super-Kamiokande and SNO detectors and results of the LSND accelerator experiment, all could be explained by means of neutrino oscillations, requiring nonzero neutrino masses and demonstrating the existence of new physical effects beyond the Standard Model of particle physics. However, high energy ^{8}B neutrinos measured by SK and SNO are a tiny fraction ($\approx 10^{-4}$) of the total solar neutrino spectrum calculated by the Standard Solar Model (SSM), while ≈98% of the solar ν's flux constitute neutrinos with energies below 1 MeV: $p-p$ (≈91%) and ^{7}Be (≈7%) neutrinos. Note that the SSM prediction of the $p-p$ flux is almost model independent and closely tied with the solar luminosity. Moreover, different theoretical schemes for the neutrino masses and mixing, based on the available oscillation data, all predict a strong influence of oscillation on the low energy electron neutrinos.

The XMASS project is designed for the observation of low energy solar neutrinos with the help of a liquid Xe scintillation detector with a 10 t inner fiducial volume (total mass of 23.3 t). The liquid Xe is contained in a vacuum cryostat shielded by high purity water. The Monte Carlo simulation of the XMASS set up (performed with GEANT and DECAY4 codes) evidently proves the feasibility of this project, which would be able to measure the flux and energy spectrum of the $p-p$ solar neutrinos. It may allow one to establish the oscillation phenomena with low energy solar neutrinos.

The second aim of the XMASS project is the search for the 2β decay of ^{136}Xe. By using 1.6 t inner volume of the detector filled with enriched ^{136}Xe, it may be possible to reach a half-life limit of $T_{1/2}^{0\nu} \geq 10^{27}$ yr, which translates to the neutrino mass bound $m_\nu \leq 0.05$ eV and would be of great interest for modern astroparticle physics.

Another and very important issue of the XMASS experiment is the dark matter particle quest. Its projected sensitivity with a fiducial volume of 6.7 t (80 cm $< r <$ 100 cm) and for an energy threshold of 10 keV will be compared with those of other challenging projects. It is demonstrated that the large part of the parameter space, predicted by the constrained minimal supersymmetric standard model, would be tested by the XMASS detector. Besides, it would be possible to identify the dark matter signal by detection of its seasonal modulation.

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