A next-generation liquid-scintillator neutrino observatory

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Abstract

We propose a liquid-scintillator detector on the scale of 50 to 100 kiloton as a next-generation experiment for low energy neutrino physics, nucleon decay search, and long-baseline neutrino oscillations.

The outstanding successes of the Borexino and KamLAND experiments demonstrate the large potential of liquid-scintillator detectors (LSDs) as low-energy neutrino observatories. Low-energy threshold, good energy resolution and potent background discrimination are inherent to the liquid-scintillator technique. A 50-100 kton detector offers a substantial increase in detection sensitivity. This provides the opportunity to observe low-energy neutrinos from various astrophysical and terrestrial origins: High-statistics measurements of already established neutrino sources like a galactic Supernova (SN) explosion, the Sun or the Earth's interior will resolve energy spectra and the time development of the ν signals in unprecedented detail. Reactor neutrino enable a high-precision measurement of solar mixing parameters. At the same time, the search for very rare events becomes possible, as the excellent background rejection allows to identify a handful of events out of several years of data taking. Thus, the faint flux of the Diffuse Supernova Neutrino Background (DSNB) is well within reach. Similarly, observation of rare annihilation neutrinos allows for indirect dark matter search.

Recent studies indicate that a large-volume LSD can resolve both momentum and energy of GeV particles on a level of a few percent. Moreover, Monte Carlo (MC) simulations studying the reconstruction capability of a LSD for the complex event topologies of charged-current neutrino interactions show promising results. These techniques offer the opportunity to complement the rich low-energy physics program of LENA by long-baseline neutrino oscillation experiments, either from atmospheric neutrinos or an accelerator-produced neutrino beam. Moreover, an increase in sensitivity for proton decay search is expected, the new lifetime limits for the $K^+\bar{\nu}$ decay channel surpassing current limits by more than an order of magnitude.

A next-generation LSD is expected to equal or to outperform a water-Čerenkov detector of several times its size in most respects, being at the same time largely complementary to the capabilities of a liquid-argon TPC. An LSD's low-energy neutrino program and its versatility are unrivaled. Due to the high level of expertise built up in several European and international research groups and dedicated R&D activities over the last years, the technique can be regarded as sufficiently mature to allow for a prompt start of the detector realization. A finalization of the construction within the next decade seems feasible, allowing for the first detection of low-energy neutrinos before the year 2020.

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2.6 Indirect dark matter search

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Coordinator: Y. Novikov
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3 GeV physics

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3.3 Atmospheric neutrinos

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4 Technical Aspects

4.1 Detector design

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4.2 Liquid scintillator

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4.4 Read-out electronics

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4.5 Event reconstruction/tracking

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