A Future Lead-based Supernova Detector at LNGS

C.J. Virtue, Laurentian University / SNOLAB

Lead is known to be an interesting target material for supernova neutrino detectors due to its large neutrino cross-sections, abundance, and modest cost [1]. Its neutron excess leads to Pauli blocking which greatly suppresses $\overline{\nu_e}$ charged current interactions. Its high Z value Coulomb-enhances ν_e charged current interactions and further suppresses $\overline{\nu_e}$ ones leading to a dominant ν_e sensitivity that is complementary to water Cherenkov and liquid scintillator detectors. Since information on supernova dynamics and neutrino properties is encoded into the ν_e, $\overline{\nu_e}$, and $\nu_{\mu\tau}$ signals differently, the ability to disentangle these channels, enhanced by the existence of a lead-based supernova detector, will likely lead to the extraction of more physics from the next galactic supernova [2]. Charged and neutral current neutrino-nucleus interactions may leave the lead nucleus in an excited state from which one or two neutron emission occurs with or without an accompanying charged lepton. With few MeV thresholds for one and two neutron emission the production rate of neutrons in lead is about one neutron per tonne per 10 kpc supernova [3], though this is a strong function of the supernova neutrinos' temperature. The Helium and Lead Observatory (HALO) at SNOLAB was constructed with 80 tonnes of lead and instrumented with ^{3}He neutron detectors available from the third phase of the SNO experiment. Members of the HALO Collaboration are very interested in the opportunity to create a significantly improved kT-scale lead-based supernova detector employing the OPERA lead now available at LNGS and other resources currently part of HALO at SNOLAB. Initial contacts with members of LVD and OPERA also indicate an interest. Together we would like to explore the formation of a larger collaboration and pursue design studies of a larger and more capable supernova detector at LNGS. The timescale for a full proposal could be as short as two years.

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[2] Väänänen, D. and Volpe, C., JCAP **10** (2011) 019
[3] Engel, J. McLaughlin, G.C. and Volpe, C., Phys. Rev. **D 67**, (2003) 013005