Super-K Gd: Traking Supernova Relic Neutrinos with a Gd-loaded water Cherenkov detector

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Super-Kamiokande (Super-K) is an already successful experiment in neutrino research, involved in the discovery of the neutrino oscillations, and performing analysis on a large spectrum of the neutrino physics: from atmospheric neutrinos to solar neutrinos, including neutrino produced by the J-PARC beam in the T2K experiment. Since the supernova SN1987A, the neutrino production by supernovae has been demonstrated. According to the models, a rate of $1 \sim 3$ galactic supernovae per century can be expected. However, ~ 1 supernovae occur each second in the visible universe, which leads to a so-called Diffuse Supernova Neutrino Background (DSNB) or Supernova Relic Neutrino (SRN). This SRN signal is expected to be $0.3 \sim 1.5$ $\nu/\mathrm{cm}^2/\mathrm{s}$ (17.3 MeV threshold) but has so far not been obversed due to the high background level. The discovery of the SRN signal would be an important key to understand the history of star formations in the universe.

According to the models, supernovae release more than 99% of their energy by radiating the 6 standard neutrinos (ν_e, ν_μ, ν_τ, $\overline{\nu}_e$, $\overline{\nu}_\mu$, $\overline{\nu}_\tau$) in similar quantities (with an excess of ν_e). However, giving their energy and the interaction cross-sections, more than 90% of the supernova neutrino signal in a water Cherenkov detector would consist in $\overline{\nu}_e$ interacting through inverse β decay (IBD): $\overline{\nu}_e + p \rightarrow n + e^+$. Since most of the background affecting the SRN research does not produce neutrons, the use of a neutron tagging method would allow to improve the selection of this IBD signal over the background ratio. The use of Hydrogen neutron tagging allows only a neutron tagging efficiency of $\sim 20\%$, which is not enough to extract the signal. Loading Gadolinium at 0.1% in the Super-K water would allow to improve the neutron tagging efficiency to more than 80%. Sensitivity studies have shown that in 10 years of data taking with Gadolinium, the SRN signal could be extracted from the background. In this presentation the studies of the feasibility of the Gadolinium loading in Super-K are presented, as well as the other physics interests of this loading.