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In February of 1987, the Kamiokande detector detected the world’s first neutrinos from a supernova burst. Since then, no supernova explosion has occurred in or near our galaxy, so we have not observed any neutrinos from a supernova burst since then. Supernova explosions in our galaxy may be fairly rare, but supernovae themselves are not. On average, there is one core collapse supernova somewhere in the universe each second. The neutrinos emitted from all of these since the onset of stellar formation have suffused the universe. We refer to this thus-far unobserved flux as the Diffuse Supernova Neutrino Background [ ], also known as the “relic” supernova neutrinos. The detection of the supernova relic neutrinos enables us to investigate the history of star formation, a key factor in cosmology, nucleosynthesis, and stellar evolution. Furthermore, the study of supernova bursts, which produce and disperse elements heavier than helium, is vital to understand many aspects of the present universe.

Supernova bursts generate all types of neutrinos, however, because of its larger cross section, anti-electron neutrinos are the most copiously detected neutrinos in a water Cherenkov detector like Super-Kamiokande (Nobel Prize in physics, 2015). About 80% of the detectable supernova neutrino events are inverse beta interactions: an anti-electron neutrino interacts with a proton, ending up with a positron and a neutron in the final state. Super-K can detect the relativistic positron because it emits Cherenkov light. But to identify the signal as coming from an anti-electron neutrino, we need to detect not only the positron but also the neutron.

We will dissolve a 0.2% concentration of a gadolinium compound in the Super-Kamiokande detector in order to detect the neutron. The cross section of gadolinium to capture neutrons is very large, and the gadolinium then emits a cascade of observable gamma rays after the capture reaction. The coincident detection of a positron’s Cerenkov light, followed shortly thereafter in roughly the same place by a shower of gamma rays, will serve to positively identify inverse beta reactions in the detector.

Once we add gadolinium to Super-Kamiokande, we expect to record relic neutrino signals with almost no background. The same coincidence technique will also allow Super-K to make a very high statistics measurement of the anti-electron neutrino flux and spectrum from all of Japan's nuclear power reactors, yielding the world's most accurate determination of the mixing parameters connecting the first two generations of neutrinos.

This thesis offers the unique opportunity to participate to some outstanding project in the field of high energy in addition to the discovery of the Japanese culture.

The future Ph.D. student will first participate in the final stage of operation of adding gadolinium in the Super-K detector, in the participation of Monte Carlo simulations and finally in the analysis of the first data.

The student is expected to spend some significant fraction of his time in Japan, in particular during the first year for the hardware operations and commissioning. Most of the time, he will be accompanied during his stay by members of our group Neutrinos.

In parallel to these activities, Monte-Carlo simulations will be carry out in order to estimate the different sources of background and detection efficiencies for the "relic" neutrinos. It is expected that the Ph.D. student will play a leading role in the performance studies and optimization of background reduction.

First data with the new detector Super-Kamiokande will be taken middle of 2019. The Ph. D. student will participate actively in the first analysis. The defense of his thesis is foreseen by summer 2021.

- Master 2 in particle physics

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Super-Kamiokande: http://www-sk.icrr.u-tokyo.ac.jp/sk/sk/srn-e.html