Research Result Report ICRR Inter-University Research Program 2023

Research Subject: Study of supernova neutrinos in Super-Kamiokande

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Summary of Research Result :

The purpose of this research is detection of the supernova neutrino in SK-Gd. There are two targets, one is neutrinos from nearby supernova explosion, the other is diffuse neutrinos from the past supernovae called 'Supernova Relic Neutrinos (SRN)'. The SK-Gd project is gadolinium (Gd) loading into Super-Kamiokande (SK) to increase inverse beta decay interactions of anti-electron neutrinos.

In 2020 summer, we've doped 13 tons of gadolinium sulfate into Super-Kamiokande, which is equivalent to 0.01% Gd mass concentration, and the SK-Gd experiment officially started. The neutron capture efficiency showed the expected performance, and the detector was operated stably. In 2022 summer, an additional 26 tons of gadolinium sulfate was introduced to the detection. (0.03% Gd mass concentration) The SK-Gd data taking is currently working well.

In FY2023, we reported the first result of supernova relic neutrino in SK-Gd with 0.01% mass concentration gadolinium loaded water in SK-Gd [2]. Though no significant signals were observed (left figure), the data showed that similar sensitivity was achieved with 20% live time data compared to the pure water period. We also showed the atmospheric neutrino – oxygen neutral-current quasielastic (NCQE) cross section [1] (right figure), which is main background events for supernova relic neutrino search (magenta in left figure). From this analysis, we obtained new knowledge about the interaction of neutrons with oxygen nuclei.

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Published paper

[1] S.Sakai et al., Measurement of the neutrino-oxygen neutral-current quasielastic cross section using atmospheric neutrinos in the SK-Gd experiment, Phys. Rev. D 109, L011101 (2023).

[2] M.Harada et al., Search for astrophysical electron antineutrinos in Super-Kamiokande with 0.01wt% gadolinium-loaded water, The Astrophysical Journal Letters, 951, L27 (2023).

Presentations

- (1) M. Harada, First result of a search for diffuse supernova neutrino background in SK-Gd experiment, TAUP23, Wienna, Austria, August 28 Sep. 1, 2023.
- (2) S. Sakai, Measurement of the neutrino-oxygen neutral-current quasielastic cross section using atmospheric neutrinos in the SK-Gd experiment, TAUP23, Wienna, Austria, August, 28 Sep. 1, 2023.
- (3) Y. Hino, Status and prospect of the SK-Gd project, ICRC2023, Nagoya, Japan, July26 August 3, 2023.
- (4) F. Nakanishi, Evaluation of neutron tagging efficiency on 0.03% Gd mass concentration in SK-Gd experiment, ICRC2023, Nagoya, Japan, July26 – August 3, 2023.
- (5) Y. Koshio, Supernova neutrino detection in Super-Kamiokande and Hyper-Kamiokande, 3rd New Physics Opportunities at Neutrino Facilities Workshop: Astrophysical Neutrinos, SLAC, USA, June 11-13, 2023.

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