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Report on the measurement of geoneutrinos by KamLAND in the reactor-off period in Japan

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The decay of radioactive isotopes (U, K, Th) in the Earth is an important heat source that drives the evolution of the Earth and is crucial for understanding the history and dynamics of the Earth. Anti-neutrinos emitted from the decay, geo-neutrinos, bring unique and direct information on the Earth's chemical composition, which related to the fundamental mysteries of its heat balance.

KamLAND, which is the world-largest liquid-scintillator anti-neutrino detector, has been operated in Japan from 2002. Anti-electron neutrinos are detected via the inverse-beta decay reaction on hydrogen nuclei in the liquid scintillator. The delayed coincidence method of two spatially and temporally correlated events can significantly reduce non-neutrino background events.

KamLAND was originally designed to verify properties of neutrinos and has succeeded in observing reactor neutrino oscillations over three cycles. On the other hand, reactor neutrinos are one of dominant backgrounds for the geo-neutrino observation because of the shared energy range. However, the shutdown of commercial nuclear reactors in Japan due to the Great East Japan Earthquake in 2011 gave us an opportunity to observe the geo-neutrinos with the low reactor neutrino background rate. In particular, the structure of the geo-neutrino energy spectrum could determine the information on the contributions from U and Th separately. The geo-neutrino measurement results were translated into the U and Th abundance ratio in the Earth, which could be a tool to constraint the chemical composition of the Earth independent of the geoscientific methods. Furthermore, the amount of the radiogenic heat from U and Th could be estimated from our measurement results assuming the U/Th ratio from geoscientific studies.

Assuming a uniform distribution of radioactive materials in the mantle, our measurement result could constraint on the amount of radiogenic heat in the mantle. The Earth's engine is powered by an unknown balance of primordial and radiogenic heats. The precision of our geo-neutrino measurement has started to be able to give a gauge informing us as to how much radiogenic heat in the Earth together with geoscientific assumptions.

In this talk, I will report the newest results from KamLAND with about 20-year geo-neutrino observation data.