# Measurement of γ rays from the giant resonances in $^{12}C$ and $^{16}O$

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Oxygen ($^{16}O$) and Carbon ($^{12}C$) are the most abundant isotopes by mass in the solar system after hydrogen, helium. Thus, they have been used as the target materials in the form of water and organic liquid scintillators, respectively, in many large-scale neutrino experiments designed to detect low-energy neutrinos ($E_\nu$<100 MeV). One of the most interesting applications is the detection of neutrinos from supernova explosion in our Galaxy. The main reaction for neutrino detection is the charged-current (CC) anti-neutrino reaction with a proton ($\bar{\nu}_e + p \rightarrow e^+ + n$), also known as the inverse β-decay reaction (IBD). Of special interest is the neutral-current (NC) neutrino or anti-neutrino inelastic scattering with $^{16}O$ and $^{12}C$, followed by the emission of γ rays that can be observed with the detector.

The γ-ray emission probability ($\Gamma_\gamma/\Gamma$) of excited states of $^{16}O$ and $^{12}C$ below the proton separation energy ($S_p$ = 12.1 MeV for $^{16}O$ and $S_p$ = 16.0 MeV for $^{12}C$) has been well measured [1]. However, the giant resonances appear above the separation energy and they decay mainly hadronically via particle emission (p, n, d and α) to the daughter nuclei. Although they decay mainly to the ground state of the daughter nuclei, some of these decays are to the excited states. If these excited states are below the particle emission threshold in daughter nucleus, they decay by γ-ray emissions [2]. The detection of $\gamma$-rays from giant resonances of these nuclei can be identified as NC event. However, there are no experimental measurements of γ rays from the giant resonances of $^{16}O$ and $^{12}C$.

An experiment(E398) was carried out at RCNP, Osaka University to measure the energy and emission probabilities ($R_\gamma$) of γ rays from the giant resonances in $^{16}O$ and $^{12}C$ using 392-MeV proton beam, high-resolution magnetic spectrometer “Grand Raiden" and an array of NaI(Tl) scintillators. The maximum value of $R_\gamma$ was measured to be (59.7 ± 0.9 ± 6)% at $E_x$ =25 MeV for $^{16}O$ and (47.9 ± 0.5 ± 3.5)% at $E_x$ =27 MeV for $^{12}C$. This is the first systematic measurement of its kind. In this presentation, we will discuss the analysis method, results and the comparison with the simple statistical decay model.

[1] Table of Isotopes, 1999 Update with CD-ROM, edited by R. B. Firestone, C. M. Baglin, and S. Y. F. Chu (Wiley, New York, 1999), 8th ed.
[2] E. Kolbe, K. Langanke, S. Krewald, and F. K. Thielemann, Nucl. Phys. A540, 599 (1992).