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Search for the rare gamma-decay mode in 12C

The triple α reaction is one of the most important reactions for the nucleosynthesis in the universe because it is a doorway reaction to synthesize heavier elements. An α particle is captured by ^{8}Be, which is a two α resonant state, to form a triple α resonant state. Most of such triple α resonant states decay back to 3α particles, but a tiny fraction of those states decay to the ground state in ^{12}C by emitting γ rays. The branching ratio between the γ and α decays of the triple α resonant states is a key parameter to decide the triple α reaction rate.

The triple α reaction proceeds via the Hoyle state at normal stellar temperature, but the high-energy triple α resonant states such as the 3^-_1 and 2^+_2 states in ^{12}C play a very important role at higher temperature $T_9 > 1$ like supernovae, first stars, and so on. Nevertheless, the γ-decay probability of the 3^-_1 state is still unknown.

Recently, we measured the inelastic proton scattering off ^{12}C under the inverse kinematic condition in order to determine the γ decay width of the 3^-_1 state in ^{12}C. The γ-decay probability of the 3^-_1 state is quite as small as 10^{-7}, therefore we introduced a thin solid hydrogen target and the recoil proton counter “Gion” to realize the low background measurement. We successfully identified the γ-decay events by measuring the recoil proton and ^{12}C in coincidence instead of detecting the γ ray.
With the careful data analysis, we finally determined the γ decay width of the 3^-_1 state for the first time.

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