The radiative width of the Hoyle state from cascading gamma-ray measurements

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It is well known that carbon is produced in the universe by the triple-alpha reaction in helium-burning red giant stars. In 1953, Fred Hoyle realised that the fact that there is any significant carbon in the Universe requires a resonant state in ^{12}C very near 7.7 MeV. The subsequent observation of this state [1], known as the Hoyle state, is often cited as the beginning of experimental nuclear astrophysics.

The rate for the triple-alpha reaction can be written as $r_{3\alpha} \approx \Gamma_{rad} \exp(-Q_{3\alpha} kT)$, where T is the temperature, $Q_{3\alpha}$ is the energy released in the ^{12}C(7.654MeV) $\rightarrow 3\alpha$ decay and Γ_{rad} is the radiative width. The largest contribution to the uncertainty on $r_{3\alpha}$ comes from Γ_{rad}, which is usually [2] determined as $\Gamma_{rad} = (\Gamma_{rad} \backslash \Gamma)(\Gamma \backslash \Gamma_{pair}) \Gamma_{pair}$.

Here we report on a new measurement to determine $\Gamma_{rad} \backslash \Gamma$ ratio from the observation of cascade γ radiations from the Hoyle state. This decay branch is responsible for more than 98% of Γ_{rad}. The Hoyle state was excited with proton bombardment of natural carbon target at the Oslo Cyclotron Laboratory (OCL). Cascade gamma rays of E2 multipolarity and energies of 3.215 MeV and 4.439 MeV were observed using the CACTUS array [3] comprising twenty six 5″ x 5″ sodium iodide (NaI) detectors. Scattered protons in singles and in coincidence with γ-ray cascades were recorded with the Silicon Ring (SiRi) array [4] consisting of eight ΔE-E telescopes, where the front detector is segmented into eight strips.

In this talk we will report on the preliminary analysis and will compare our results with the only previous measurement performed by Obst and Braithwaite more than 35 years ago [5]. This study complements our project to determine the radiative width from pair conversion measurement of the E0 and E2 transitions deexciting the Hoyle state [6].

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