Towards the pair spectroscopy the Hoyle state

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Although it is well established that the source of carbon in the universe is the 3α (triple–alpha) nuclear reaction occurring in stars, the rate at which this process occurs, via the Hoyle state in ^{12}C, is surprisingly poorly known. The current uncertainty of ~12.5% on the radiative width of the 7.654 MeV E0 and 3.215 MeV E2 transitions de-exciting the Hoyle state limits our understanding of stellar evolution and nucleosynthesis. We propose to observe directly the electron–positron pairs of both transitions using the ANU superconducting solenoidal electron spectrometer, Super–e [1]. The Hoyle–state will be populated using the ^{12}C(p,p') reaction at 10.5 MeV resonant energy. Electron–positron pairs, with well-defined energy sharing, separation angles and time differences, will be transported onto an array of six Si(Li) detectors located at 40 cm from the target. In comparison to previous measurements based on bare scintillator detectors, the new magnetic pair spectrometer offers a much higher selectivity for electrons and positrons, combined with improved energy resolution. The radiative width of the Hoyle state will be deduced from the relative width of the E0 and E2 transitions, from the theoretical pair conversion coefficient of the E2 transition [2] and from the pair width of the 7.6 MeV E0 transition [3, 4].

In this talk we will focus on the development of a new pair spectrometer, and the analysis procedures required measuring relative pair yields of the 7.654 MeV E0 and 3.215 MeV E2 transitions with high precision. We will also report on the first experimental results obtained with the new magnetic pair spectrometer.

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