

# Precision pair conversion spectroscopy of the Hoyle state

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Carbon is a major player in the evolutionary scheme of the universe because of its abundance and its ability to form complex molecules. Although it is well established that the source of carbon is the  $3\alpha$  (triple-alpha) nuclear reaction, the rate at which this process occurs in stars, via the Hoyle state in  $^{12}\text{C}$ , is surprisingly poorly known. The current uncertainty of  $\sim 12.5\%$  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 directly observe the electron-positron pairs of both electromagnetic transitions from the Hoyle state using the ANU superconducting electron spectrometer, Super-e [1]. The radiative width of the Hoyle state will be deduced from the relative intensity of the E0 and E2 transitions, from the theoretical pair conversion coefficient of the E2 transition and from the pair-width of the 7.6 MeV E0 transition. The spectrometer was significantly modified to detect high energy electron-positron pairs with well defined energy-sharing and separation angle. The key component of the measurements is an array of six Si(Li) detectors, each 9 mm thick to fully absorb electrons and positrons up to 3.5 MeV energy. The detector is well shielded from the intense photon background produced in the  $^{12}\text{C}(\text{p},\text{p}')$  reaction at 10.5 MeV resonant energy. 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 latest results from the new pair spectrometer on the pair decay of the Hoyle state will be discussed.

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[1] T. Kibédi, G.D. Dracoulis, A.P. Byrne, Nucl. Instr. and Meth. in Phys. Res. **A294** (1990) 523.

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