Pair spectroscopy of the Hoyle state

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The second excited state of ^{12}C at 7.654 MeV, the Hoyle state is particularly important for understanding the formation of carbon in the universe. At the late stage of the evolution of red giant stars, when hydrogen in the central core has been largely converted into helium, gravitational contraction raises the central temperature to $\sim 10^8$ K and the density to $\sim 10^5$ g/cm^3. The triple-alpha process then plays a crucial role in the energy generation and in the synthesis of the elements: $3 \times {}^4$He $\leftrightarrow {}^{12}$C(7.654 MeV) $\rightarrow {}^{12}$C + γ. Central to a quantitive knowledge of stellar evolution is the radiative width of the Hoyle state, Γ_{rad}, which is the sum of the decay widths of photon, internal pair conversion and conversion electron emissions. Recently we proposed a new approach to determine the radiative width of the electromagnetic transitions from the Hoyle state [1]. In this approach the radiative width will be evaluated from the ratio of the pair conversion intensities of the 7.654 MeV E0 and the 3.215 MeV E2 transitions, from the E2 pair conversion coefficient and from the absolute E0 transition rate.

In this paper we report on the development of a new magnetic pair spectrometer, which combines the ANU Super-e electron spectrometer [2] and an array of six Si(Li) detectors. The results of the first experiments and the progress in pair spectroscopy will be presented.

[1] T. Kibédi, et al, AIP Conf. Proc. **1109** (2009) 66.

[2] T. Kibédi, et al., Nucl. Inst. Meth. Phys. Res. **A294** (1990) 523.