DIRECT DETERMINATION OF THE RADIATIVE WIDTH OF THE HOYLE STATE FROM PAIR CONVERSION

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Stellar formation of carbon occurs when three alpha particles fuse and form the excited 7654 keV 0^+ "Hoyle" state in ^{12}C. Stable carbon is only formed if the excited nucleus decays to the ground state. The Hoyle state is located above the 3α threshold, which makes the triple alpha process very unlikely as the excited carbon nucleus decays back to three alpha particles 99.96% of the time. The process is therefore a bottleneck in nuclear astrophysics, and good knowledge about the production rate is imperative for proper modelling of carbon formation in the universe. Since the formation of stable carbon depends on electromagnetic decay from the Hoyle state, the 3α rate is directly related to its radiative transition probabilities. The internal decay of the Hoyle state occurs either by a 7654 keV $E0$ transition to the 0^+ ground state, or by a 3215 keV $E2$ transition to the first excited 2^+ state. The current value of the radiative width has been determined in an indirect way, resulting in a ≈12.5% uncertainty on the 3α rate.

The Hoyle state also offers a unique opportunity to test our understanding of light nuclei. For example, the ^{12}C nuclear system is on the limits of the *ab initio* shell model. Furthermore, aspects of the structure of ^{12}C can be explained using the alpha cluster model. Additionally, the 7654 keV $E0$ transition has the largest known $E0$ matrix element and precise determination of $E0/E2$ transition rates will allow tests of nuclear models.

By obtaining the E0/E2 branching ratio from the relative $E0$ and $E2$ pair transition intensities the radiative width can be deduced. In order to achieve this goal in a single experiment, the ANU Super-e spectrometer has been upgraded and optimized for pair spectroscopy. Further, the Hoyle state is easily populated via the ^{12}C(p, p') reaction at 10.5 MeV. Our earlier experiments show a clear 7654 keV $E0$ pair transition and our current focus is on the isolation of the less intense 3215 keV $E2$ pair transition.