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Direct Observation of the Second $J^\pi = 2^+$ State in ^{12}C and New Triple-α Thermonuclear Reaction Rates[1]

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During core-collapse supernovae, the triple-α thermonuclear reaction rates at high temperatures can affect the outcome of explosive nucleosynthesis and the production of heavy elements. The question of the existence of a second $J^\pi = 2^+$ state in ^{12}C has led to a long-standing disagreement in the triple-α thermonuclear reaction rates at high temperatures. This 2_2^+ state has been directly observed in the $^{12}C(\gamma,\alpha)^8$Be reaction using the intense, nearly monoenergetic γ-ray beams available at the High Intensity γ Source (HIγS) facility. The α particles produced by the photodisintegration of ^{12}C were detected using an optical time projection chamber (OTPC). This allowed for the measurement of complete angular distributions which were used to determine the $E1$ and $E2$ amplitudes and their relative phases. The 2_2^+ state was observed in the $E2$ cross section and confirmed in the behavior of the relative phases. This unique combination of a Compton-backscattered γ-ray beam and an active-target system made possible the first unambiguous identification of this 2^+ state. New triple-α thermonuclear reaction rates have been calculated based on the results of this experiment, and simulations based on the νp process [1] have been performed illustrating the effect of the second 2^+ state in ^{12}C on the outcome of explosive nucleosynthesis.

[1] A. Arcones, C. Fröhlich, and G. Martínez-Pinedo, ApJ **750**, 18 (2012)

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