Direct Observation of the Second 2^+ State in ^{12}C

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A low-lying 2^+ state in ^{12}C was predicted over fifty years ago to exist as an excitation of the Hoyle state. The exact energy, width, and electromagnetic transition probability of this state is related to the structure of the Hoyle state, and measuring these parameters will help to constrain the various models which attempt to describe the clustering phenomenon in light nuclei. The second 2+ state in ^{12}C was directly observed in the $^{12}C(\gamma,\alpha)^{8}Be$ reaction using the intense, nearly monoenergetic gamma-ray beams available at the High Intensity Gamma-ray Source (HIGS) facility. The alpha particles produced by the photodisintegration of ^{12}C were detected using an optical time projection chamber (OTPC), which allowed for the complete angular distributions necessary to definitively confirm the 2^+ nature of the state. This unique combination of a Compton-backscattered gamma-ray beam and and an active-target system made possible the unambiguous identification of this 2^+ state. This state increases astrophysical helium-burning reaction rates at the high temperatures which are thought to occur during core-collapse supernovae. New triple-alpha reaction rates have been calculated based on these results, and simulations of explosive nucleosynthesis reveal their possible impact on the production of heavy elements during core-collapse supernovae.