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Cover Story (Issue 7, 2025) Evidence of the negative parity linear chain states in ^{16}C

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The linear-chain structure in which three alpha particles are arranged in a straight line was initially proposed by H. Morinaga [1] as the structure of the Hoyle state of carbon-12 [2]. This unique idea attracted much attention, but it was rejected because it could not explain the lifetime of the Hoyle state. Half a century later, the concept of the linear chain structure was revived in the physics of unstable nuclei, and experimental and theoretical research have demonstrated that this structure exists in carbon-14 and 16. The authors have conducted internationally recognized experimental research on the linear-chain structure of carbon-14 and carbon-16. This paper is the latest report of a series of these experimental studies [3-8]. While the existence of positive-parity linear-chain states has been demonstrated in carbon-14 and 16 in previous studies, the search for negative-parity linear-chain states has been very sparse. It is known that in parity-asymmetric systems (for example, $\pi 2\sigma 2$ bonding systems), a parity-inversion doublet emerges; hence, establishing the negative-parity band is crucial evidence supporting the existence of the linear chain.

With improved detection efficiency, the authors were able to more clearly observe the state around 21.6 MeV by resolving it into three states at 20.9 MeV, 21.9 MeV, and 22.9 MeV. The newly observed states at 21.9 MeV, 22.9 MeV, 25.4 MeV, and 27.9 MeV were tentatively assigned as a negative-parity linear-chain band. These states serve as strong evidence for the existence of an exotic linear-chain structure in the neutron-rich carbon-16 nucleus. However, the assignments of these observed resonance states are still provisional, and further collaborative research through experiments and theory is highly expected.

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