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Cousin of the Hoyle state: Observation of a narrow resonance above 13N+2p threshold

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The existence of the Hoyle state is crucial for the nucleosynthesis of the chemical elements heavier than lithium. This state has been the subject of many theoretical studies and philosophical discussions (anthropic principle). The existence of this remarkable state could be explained by the Ikeda conjecture [1,2]. The latter can be formulated simply: The coupling to a nearby cluster decay channel induces cluster correlations in nuclear wave functions. The Hoyle state resides just above the threshold for decay into 8Be and an alpha particle. The Ikeda conjecture implies that the Hoyle state should have an alpha cluster structure.

We performed a study of the unbound nucleus 15F. Intense and pure radioactive beam of 14O, produced at GANIL (France) with the SPIRAL1 facility, was used to study the 15F low-lying states [3]. Exploiting resonant elastic scattering in inverse kinematics with a thick target, the resonance corresponding to the second excited state (J=1/2-) was measured with a width of only 36(5)(14) keV. This state is precisely located just above the two-proton threshold. The structure of this narrow above-barrier state in a nucleus located two neutrons beyond the proton drip line was investigated using the Gamow Shell Model in the coupled channel representation with a 12C core and three valence protons. It is found that it is an almost pure wave function of two-proton cluster.

[1] K. Ikeda et al., Prog. Theor. Phys. Suppl., Extra Number, 464(1968).
[2] J. Okołowicz, M. Płoszajczak and W. Nazarewicz. Progress of Theoretical Physics Supplement 196, 230 (2012). 65, 100
[3] F. de Grancey et al., Physics Letters B758 (2016)26–31

Primary author: Dr DE OLIVEIRA SANTOS, François (GANIL)

Presenter: Dr DE OLIVEIRA SANTOS, François (GANIL)

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