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On the long-standing quest for the tetra-neutron system: a recent observation of four-neutron correlations and future perspectives

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The search for chargeless nuclei consisting only of neutrons has been a long-lasting challenge in nuclear physics, dating more than six decades back (see Ref. [1] for a recent review). The tetraneutron, in particular, has attracted a lot of experimental and theoretical attention. Most models agree that nuclear forces cannot bind four neutrons together without destroying many of the other successful predictions for light nuclei. The theoretical models, however, struggle to provide reliable and consistent predictions regarding the possibility of four neutrons forming a resonance system. On the other hand, no solid experimental information on possible correlations between four neutrons was available until recently as experiments suffered from low statistics and/or large background. The possibility of the tetraneutron forming a resonance state is still an open and fascinating question, which can now be probed theoretically with state-of-the-art ab-initio calculations and studied experimentally by employing new techniques in the upgraded, high-intensity, radioactive-ion beam facilities. In this talk, I will present a brief overview of this long-standing quest and discuss some recent, high-quality results from a novel experiment that was performed at the SAMURAI setup in RIKEN, Japan. This experiment probes the correlation energy between the four remaining neutrons after the quasi-elastic removal of alpha cluster from 8He projectiles and has provided for the first time a notably clean experimental signature. The results have been recently published in Nature [2]. The quest now continues with renewed interest as theoretical models attempt to reproduce the experimental result and new experiments aim to confirm and refine the measurement; hence, this talk will conclude with a brief discussion of these new perspectives.

[1] Marqués, F. M. & Carbonell, J. The quest for light multineutron systems. Eur. Phys. J. A 57, 105 (2021).

[2] Duer, M., Aumann, T., Gernhäuser, R., Panin, V., Paschalis, S., Rossi, D. M., et al. Observation of a correlated free four-neutron system. Nature 606, 678–682 (2022). https://doi.org/10.1038/s41586-022-04827-6

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