A METHOD FOR AN UNAMBIGUOUS DETECTION OF A HYPOTHETICAL BOUND TWO-NEUTRON SYSTEM

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A recent announcement of a discovery of bound dineutrons existing in loosely bound nuclei [1] revived interest to these hypothetical electrically neutral light nuclei despite it was clear that the observed effect is, probably, due to emission of a correlated pair of neutrons originating from an anti-bound singlet spin state: negative value of the scattering length $^1a_{nn} = -18.7$ fm was used to interpret the measured data. The phenomenon is very similar to the so called nn final state interaction (nn-FSI) peak observed frequently in many nuclear reactions in a specific kinematical configuration where the neutron pair with low relative momentum is emitted back-to-back with the recoiling system. Among them are neutron induced breakup reactions on deuterium and other light nuclei, radiative μ^- capture on deuterium and ordinary π^- absorption on helium isotopes. The shape of the FSI peak was astonishingly well modeled by K.M. Watson and A.B. Migdal already in 1952 [2] and is dependent on $|^1a_{nn}|$. The sign of $^1a_{nn}$ which is decisive for the existence or non-existence of a bound state must be established from a coherent neutron-neutron scattering. Since such an experiment has not been done yet, the negative sign of $^1a_{nn}$ is mainly motivated by lack of observation of bound multi-neutron systems, consistency in the description of the experimental data by the model nucleon-nucleon forces and isospin conservation in strong interactions. As all these arguments give only limited confidence (see e.g. [3]), the non-existence of bound dineutrons is still an open question.

In the presentation, we will propose an experiment aiming at an unambiguous detection of mass $A = 2$ neutral particles via elastic scattering and neutron exchange reaction on protons in a plastic scintillating fiber detector. Dineutrons would be produced in an ordinary π^- absorption on ^{3}He and ^{4}He isotopes together with tagging charged particles (p and d, respectively). The basic advantages of the proposed process are the strict collinearity and opposite, and constant momenta of dineutrons and recoiling particles in LAB reference system. Moreover, the detection cross sections ($(2n) + p \to p + (2n)$, $(2n) + p \to d + n$) are calculable with three-nucleon codes based on $^1a_{nn}$ dependent nn interactions.

[1] A. Spyrou et al., Phys. Rev. Lett. 108, 102501 (2012).

[2] K.M. Watson, Phys. Rev. 88, 1163 (1952), A.B. Migdal, JETP (Sov. Phys.) 1 (1955) 2.

[3] H. Witala and W. Gloeckle, Phys. Rev. C 85, 064003 (2012).

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