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Cross-sections of the 127I (n, n2) 126I nuclear reactions

An experimental search for a bound dineutron has been ongoing for decades, presenting the experiments for light and heavier nuclei masses as target nuclei. Our approach to indirectly observe a bound dineutron is based on the theoretical prediction by Migdal [1] and considers not light, but heavier nuclei in nuclear reactions, near which a bound dineutron can be formed in the outgoing channels as a product of (n,n2) nuclear reactions [2-4]. The possibility for two neutrons to populate a certain energy level comes from the solution of the quantum-mechanical problem in [1], resulted in the appearance of real levels within the potential well of some heavy nuclei outside of their volume in order to bind two identical particles in one nucleus. In our article [5], a set of medium and heavy weight target nuclei ($90 < A < 210$) was considered and ranked according to the criteria in [5, 6] to identify those of them that are acceptable for the (n,n2) nuclear reaction in order to form another heavy nucleus in the outgoing channel that is more susceptible to host a bound dineutron. With our earlier experiments [2-4], we mainly targeted at heavier nuclei like 159Tb, 175Lu, 197Au, while this phenomenon may also take place for nuclei with smaller masses, for instance, 127I. According to the ranking in [5], this isotope, like 174Lu nucleus, belongs to the "less-likely" category because only two criteria out of four are met. However, 127I is included in the "0"-category, for which none of the criteria reaches the required value, but can be considered as a candidate with, probably, lesser cross-sections, going down in the hierarchy of atomic masses. Then we may expand the boundaries, within which the dineutron can be observed with necessary statistical significance. Thus, it was our decision to design and perform experiments with neutron irradiation of potassium iodine (KI) samples in order to observe the formation of bound dineutrons under conditions that are not optimal, and to determine the cross-sections for the 127I(n,n2) nuclear reaction.

Therefore, in our new experiment to identify the potential nuclear reaction channel 127I(n,n2)126I within the energy range below the Eth = 9.217 MeV threshold energy of the 127I(n,2n)126I nuclear reaction, two KI samples were irradiated by neutrons generated via the DD reaction:

- with deuterons of Ed = 5.429 MeV that induced neutrons in the En = 7.20+0.13/-0.11 MeV neutron energy range with ⊠n = 1.12E+06 +18%/-27% n/(cm2•s) fluence rate;
- with deuterons of Ed = 6.812 MeV that induced neutrons in the En = 8.78+0.09/-0.09 MeV neutron energy range with ⊠n = 1.38E+06 +18%/-27% n/(cm2•s) fluence rate.

In both irradiations Nb foils were attached to the rear sides of the KI samples in order to check the presence of neutrons above the Eth = 8.927 MeV threshold energy of the 93Nb(n,2n)92mNb nuclear reaction.

After completion of the irradiations lasted about 36,000 s for each case, the KI samples as well as the Nb foils were counted on an HPGe Canberra detector. Both Nb foils showed no induced activity of 92mNb, but in both KI samples the full absorption peaks at Eg = 388 keV and Eg = 666 keV gamma-ray energies were detected due to the decay of 126I with peak areas from hundreds to several thousands of counts.

Taking the expression for cross-section calculations from [4], the estimated cross-sections are (0.25 ± 0.08) mb and (0.24 ± 0.07) mb for the first and second irradiations, respectively.

Thus, the dineutron in bound state was clearly observed in this study for the 127I (n, n2)126I nuclear reaction with corresponding cross-section estimates.

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