Lifetime measurements in ^{125,127}I

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Abstract:
The proposed experiment aims to measure the lifetimes of the same structure in ^{127}I and to re-measure the lifetimes of the exited states with three quasipartical structure in ^{125}I. The high spin structure of the iodine nuclei, when approaching the N = 82 shell closure, is insufficiently studied. Excited states in the nuclei of interest will be populated in the ^{122}Sn(^{6}Li,4n) and ^{124}Sn(^{6}Li,4n) fusion-evaporation reactions. To do the proposed measurement we ask for ten days of beam time.

1 Motivation

The high spin structure of the iodine nuclei, when approaching the N = 82 shell closure, is insufficiently studied. The relatively neutron-rich ^{125,127}I are difficult to populate up to high spins and are less studied compared to the lighter ones.

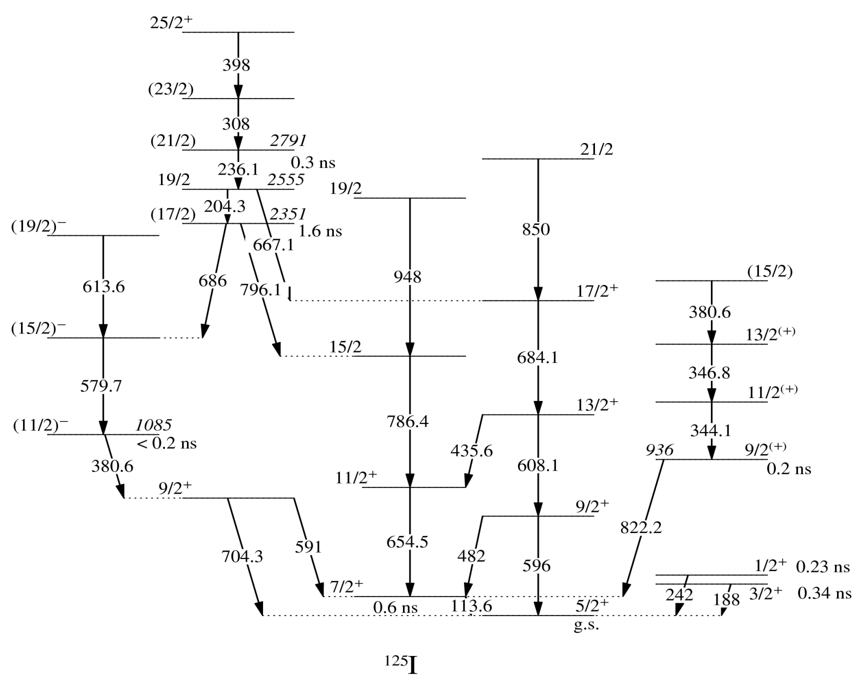

Fig 1. Partial level scheme of ^{125}I [1]

The lifetimes of five levels in ^{125}I are measured so far with the centroid-shift method, using Ge detectors and the upper limit is given for 2 more states (see fig. 1). The spin and parity assignments of the high spin states are mostly based on the systematics of similar bands in neighboring nuclei and remain uncertain. The lifetime of 3/2+ level at 188.4 keV is $T_{1/2}$= 0.34 (2) ns and the lifetime of $1/2^+$ level at 243.4 keV is $T_{1/2}$= 0.230 (10) ns, both obtained in ε decay [1]. The lifetimes of the levels with higher energy are measured in (α, 2n) reaction [2]. The lifetime of 188.4 keV state in that study was obtained $T_{1/2}$= 0.2 (1) ns, the 243.4 keV level was not populated. The lifetime of 935.8 keV state with spin of $9/2^{(+)}$ is $T_{1/2}$= 0.2 (1) ns. Only a upper limit is given for the $T_{1/2}$(1084.9 keV) ≤ 0.2 ns.

The 2350.3 keV state with $T_{1/2}$= 1.6 (3) ns with a tentative spin of (17/2) and a sequence of states up to 3497.0 keV is built upon this level. For the next 2554.8 keV, 19/2 level in the sequence an upper limit of the $T_{1/2}$ ≤ 0.2 ns is given. The next one has energy of 2791 keV, spin (21/2) and $T_{1/2}$ = 0.3 (1) ns. The parities of these levels have not been determined. A cascade of low energy transitions, which have been reported as likely M1, from gamma-ray angular distributions and conversion electron measurements [3], populates these states.

Three-quasiparticle bands have been previously reported in several odd mass iodine and ceasium nuclei [4,5], built upon an excited isomeric state. The bandhead energies are all above 2 MeV and the spin varies from 17/2 to 23/2. The sequence was also tentatively described to have a threequasiparticle structure as in the other neighboring odd mass I and Cs nuclei.

Based on the irregular level spacings according to the level scheme of Ref. [3] and transition probabilities deduced from the lifetime data it was suggested three different quasiparticle configurations for the structure of the three lowest states of this band [2]. The configurations suggested for the three states involve the $\pi d_{5/2}$ or $\pi g_{7/2}$ protons coupled to the neutron configurations of the type $\nu(h_{11/2}\ d_{3/2})$ or $\nu(h_{11/2}\ s_{1/2})$. Later the ordering of the 204.3 and 236.5 keV transitions was reversed and it was noticed that the transitions follows approximately the I(I+1) rule for rotational bands [6]. Also the excited sequence of states built on the 2350.3 keV was found to be similar to three-quasiparticle bands observed in $^{119,121}I$ [4] and ^{125}Cs [5] and it was suggested three-quasiparticle configuration $\pi h_{11/2}(\nu g_{7/2}\nu_{h11/2})$ [6].

In ^{127}I lifetime of only low lying states with spin I < 9/2 are measured [7].

In this experiment we want to re-measure the known lifetimes in ^{125}I and to measure the lifetime of the same structures in ^{127}I.

2 Experiment

The life-times of the excited states will be measured by using the Bucharest detector array, a specially designed system for in-beam fast-timing measurements. It consists of fast $LaBr_3$(Ce) scintillator detectors and HpGe detectors working in coincidence. The system is triggered by two $LaBr_3$(Ce) fired in coincidence with one HpGe detector. (Thus the triple γγγ coincidences will be collected and analyzed.) The use of HpGe detectors in coincidence helps to clean up the spectrum from the scintillator detectors in case of many close lying transitions in the nuclei produced in-beam. The life-times of the excited states will be estimated using centroid shift method, the delayed coincidence technique recently established at NIPNE [9]. The life-time of level of interest is measured by using the time interval between the feeding and de-exciting gamma-rays detected by two $LaBr_3$(Ce) detectors. It has been demonstrated that the method can be used down to the life-time range of tens of picoseconds.

The lower limit of the lifetime depends on statistics of the measurement, which determines the error of the extracted centroids. In our case the transitions of interest have relatively low intensities.

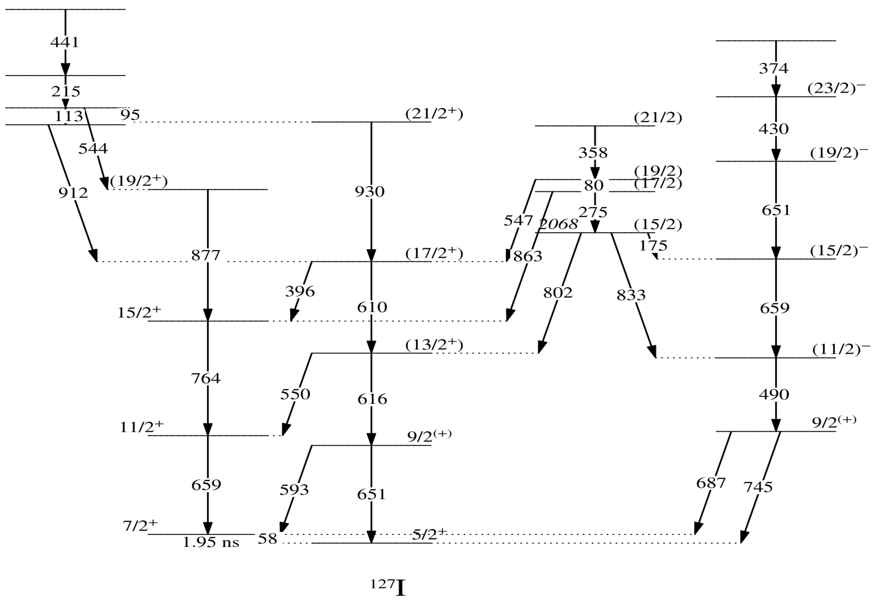

Fig 1. Partial level scheme of ^{127}I [7-8]

We suggest to use the ^{6}Li + ^{122}Sn fusion-evaporation reaction at 29 MeV to populate the excited states of ^{125}I and ^{6}Li + ^{124}Sn at 27 MeV to populate the excited states of ^{127}I. The reaction cross-section of the first reaction obtained with PACE code is about 740 mb and for the second one about 610 mb.

The values of the life-times we want to measure are within the range limit of the fast-timing setup. We want five days of beam time for each nucleus.

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