Medium and High-spin Structures near N=82: ^{135}Cs and ^{138}La

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Abstract

In a previously approved experiment, we performed γ-γ coincidence measurements at the IFIN-HH Tandem by the ^{130}Te(^{11}B, 3n γ)^{138}La and ^{130}Te(^{11}B, α2n γ)^{135}Cs reactions and proposed preliminary level schemes for these two nuclei. A new γ-γ coincidence experiment is proposed now with the ROSPHERE array, with emphasis on low-energy de-excitation gamma-rays, in order to extend the level schemes with respect to the number of excited states, their decay schemes and spin parity assignments.

I Scientific motivation

The isotopes with valence protons outside the Z=50 shell closure have attracted considerable interest because they exhibit a transition from more collective nature in the middle of the neutron shell to spherical shell model structure as the number of neutrons increases toward the N=82 closed shell.

The odd-odd transitional nuclei in this region are interesting because both odd nucleons span the same Z,N =50-82 subshell space, providing a good opportunity to study the role of the p-n interaction and its influence on both the collective rotation as well as the single particle motion. We expect that nuclear structure configurations for ^{135}Cs and ^{138}La come from the proton 1 $g_{7/2}$ and $2d_{5/2}$ and the neutron $3s_{1/2}$, $2d_{5/2}$, and $1h_{11/2}$ orbitals at lower excitations, while the role at higher excitations. The missing information on the structure of these two nuclei may also be of astrophysical interest.

The ^{135}Cs nucleus has been identified as an important branch point in nucleosynthesis theory for the slow neutron capture [1,2]. R. Takashima *et al.* evaluated the possibility of photo-transmutation of long lived nuclide by ultra short ultra intense laser [3]. The origin of the rare ^{138}La nuclide remains one of the key questions that nucleosynthesis theory is still trying to answer. The p-process nucleosynthesis in the ^{138}La region is further complicated by the theoretical difficulty of estimating the reaction rates in the hot astrophysics plasma [4].The existing information on the low levels for ^{135}Cs and ^{138}La was obtained by β decay and by transfer reactions using p, d, ^{3}He, α projectiles, respectively [5].

Very recently, it was reported the first identification of high-spin states in ^{135}Cs, produced as fusion-fission fragment in the reaction ^{18}O(91MeV)+^{208}Pb studied with the Gammasphere array[6], and of ^{138}La [7] produced as fission fragment in the reaction ^{12}C(90MeV)+^{238}U studied with the Euroball array. The identification of transitions depopulating high-spin levels which are completely unknown is based on the fact that the prompt γ-rays emitted by complementary fragments are detected in coincidence. The statistics for ^{135}Cs and ^{138}La was too low to perform γ- γ angular correlation analyses. The spin assignments of all states (given in parentheses), are based on several arguments, such as previous experimental information and comparison of the experimental and calculated shell model states.

We are proposing an alternative way to study these two neutron-rich nuclei by prompt γ-ray spectroscopy following the fusion-evaporation ^{130}Te(^{11}B, 3n γ)^{138}La and ^{130}Te(^{11}B, α2n γ) ^{135}Cs reactions at 40 MeV (see Figure 1). More experimental information to determine unambiguously spin and parity assignments of the states is needed to confirm or modify the interpretation suggested in previous works.

II Motivation of the proposal

In a previous beam time scheduled at the Bucharest van de Graaf Tandem accelerator, we performed an experiment to study for the first time high spin states of the odd-odd ^{138}La , unknown at the time of the experiment proposal. We also obtained new data on the level structure of ^{135}Cs nucleus populated in the (α2n) channel (see Figure 2). A number of excited states could be established from these experiments in agreement with very recently published results from fusion-fission experiments [6,7].

Our present data support a reversed sequence for the 882KeV and 189KeV transitions connected by new 1050 KeV transition in ^{135}Cs, compared the previous tentative ordering in the level scheme. We observed for the first time a new band built on the $5/2^+$ state at 249 KeV in ^{135}Cs (see Figure 3). The experimental measurements of the γ-γ coincidences in the 130Te+11B reaction was performed with a 7 HPGe detector array of the lab, supplemented with one planar detector for the measurements of low-energy γ-rays. However, as our investigated level schemes contain many low-energy γ-rays, and the efficiency of the HPGe detectors at such energies was rather low, these results could only be taken as preliminary. Therefore, it is desirable to repeat the experiment with a better efficiency with the ROSPHERE array provided with a larger number of detectors.

III Summary of beam time request

Target: 1.0 mg/cm^2 ^{130}Te on Au (or Pb) backing

Beam: ^{11}B, 40MeV, ~10 pnA

Detectors: ROSPHERE array: 14 HPGe, 2-4 planar HPGe, 7-9 $LaBr_3$ detectors

Beam time requested : 9 days (based on the statistics of the old experiment)

The proposed experiment is similar with the previous one, except for the improved efficiency of due to larger number of big HPGE detectors, and 2 to 4 planar detectors. The multipolarity of the observed transitions will be deduced from Directional Correlation Orientation (DCO) ratios ,with events recorded in the 90^0 detectors and those recorded in the minimum 3 detectors at $+37^0$ and other minimum 3 detectors at -37^0. The parallel collection of energy and time spectra with the existing $LaBr_3$ detectors may lead to measurements of lifetimes of some excited states in the region from about 50ps to 10ns. As an outcome of this experiment, we expect to extend the level and decay schemes for the ^{135}Cs and ^{138}La nuclei and make γ-ray multipolarity experimental assignments.

References

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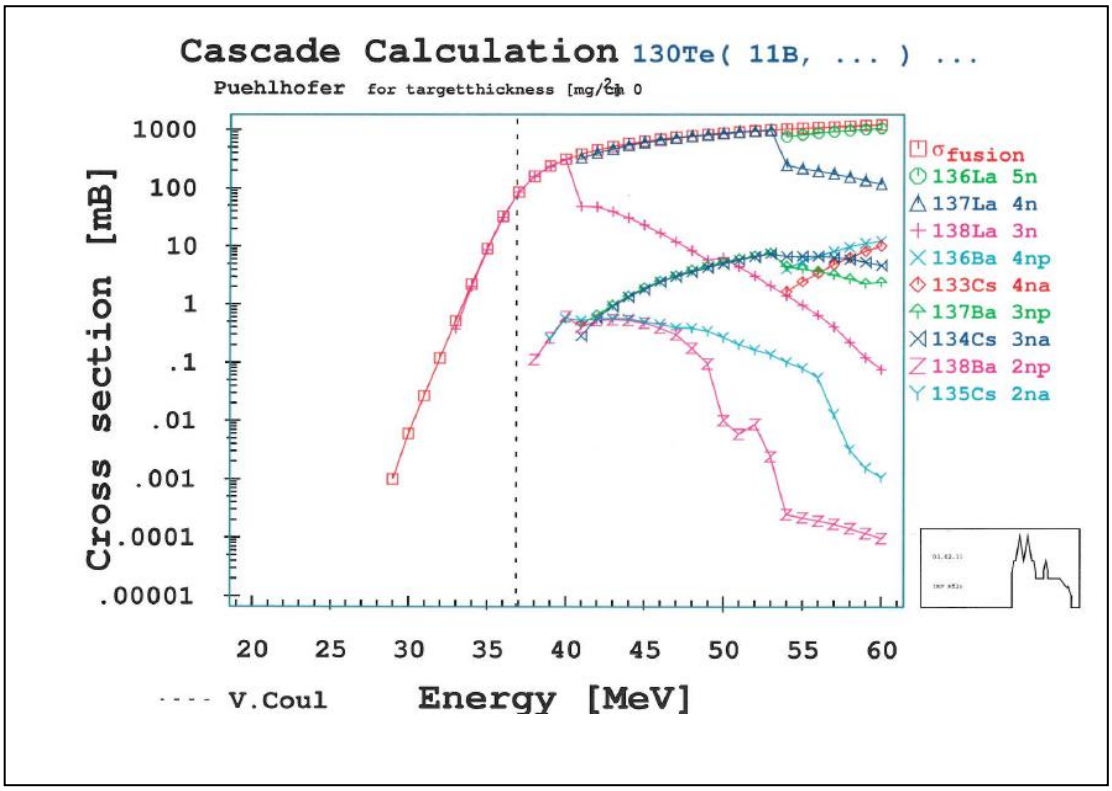
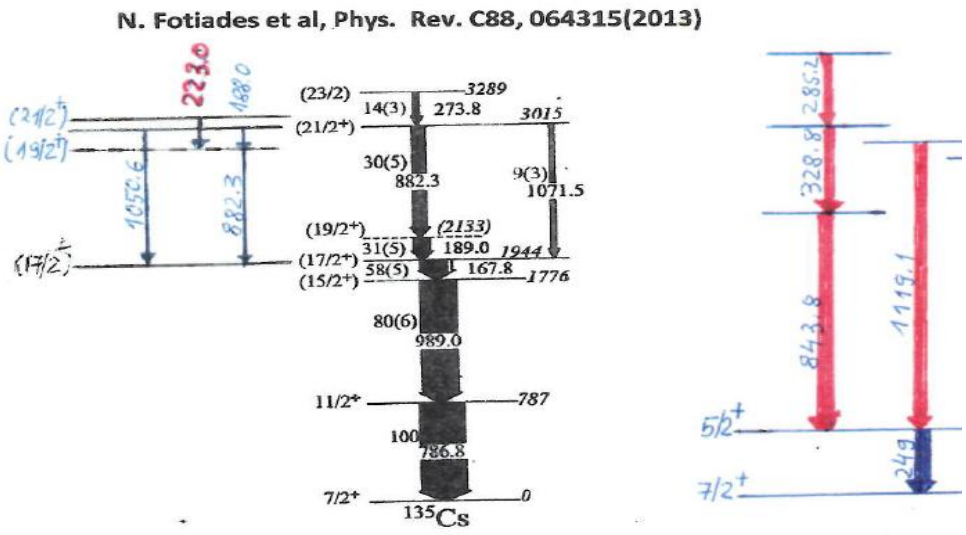


Figure 1: Calculated (CASCADE) excitation functions.

Figure 2:



Known levels (left) and newly assigned levels (our work – right) in ^{135}Cs

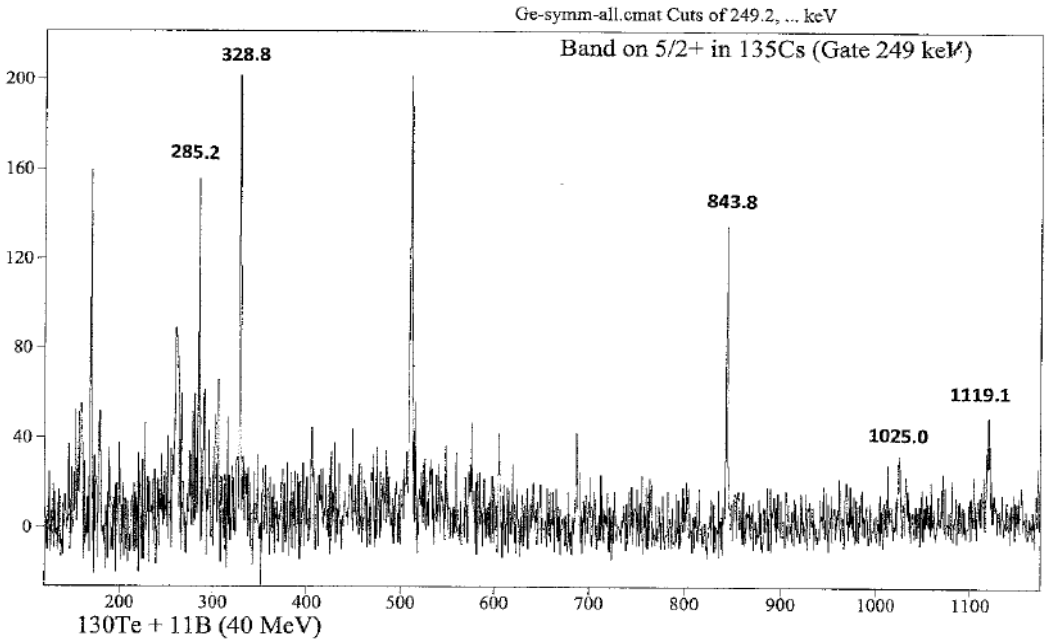


Figure 3: Example of γγ-coincidence spectrum from our previous experiment, illustrating the new level sequence (Fig. 2) from ^{135}Cs.