EXPERIMENT PROPOSAL

RDDS lifetime measurements in the ground state band of ^{120}Te

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Abstract

We propose to measure lifetimes of excited states in ^{120}Te using the Recoil Distance Doppler Shift (RDDS) method in the ^{110}Pd(^{13}C, 3n) ^{120}Te reaction at a beam energy of 52 MeV. The γ-rays will be detected using the HPGe array installed on the first beam line of the TANDEM accelerator.

1. Scientific motivation

The low lying energy spectra in the tellurium isotopic chain displays a variety of collective properties, characteristic of the U(5)-O(6) leg of the symmetry triangle. The lighter ^{118,120}Te isotopes have a spherical shape and are considered to be good examples of anarhmonic spherical vibrator, while the shape evolves towards a quadrupole deformed, γ soft shape in heavier isotopes up to ^{128}Te. The collective behavior in this mass region is blurred by the strong role of intruder and two quasi-particle proton configurations.

The occurrence of an intruder configuration based on the g9/2 orbital is expected in the Te isotopic chain, based on the analogy with Cd, Sn, Sb and I isotopes were this configurations were previously observed. Low-lying rotational bands build on the g9/2 orbital are well known on Sn and Sb, but in Te they were assigned only at high spin were the band structure is well defined. An extended study of the behavior of this "intruder states" in the Te isotopes predict strong mixing between the "normal" and intruder configuration for the low-lying non-yrast states.

In order to correctly distinguish between states with strong intruder character and "normal" configuration states, one needs comprehensive information regarding the transition probabilities between low-lying non-yrast states and also the transition probabilities in the yrast band. This was emphasized by the recent study of ^{118}Te [1], at the Bucharest TANDEM, that showed the low-lying decay scheme is consistent with the anharmonic vibrator picture, the influence of the intruder configuration being negligible. In the case of ^{120}Te, lifetimes for both non-yrast and higher lying high spin states were measured by the Doppler shift attenuation method (DSAM) at the Bucharest TANDEM in the ^{117}Sn(α,n)^{120}Te and ^{110}Pd(^{13}C, 3n) reactions.

In the α-induced reaction, lifetimes or upper limits for 32 levels (mostly non-yrast) were measured by the DSAM method by analyzing the specific lineshapes of the γ-rays emitted during the stopping process of the recoil nuclei. The issue of side-feeding times comparable to the level lifetimes was treated using the method described in Ref. [3]. This information, combined with the results from the angular distribution analysis will enable an analysis of the structure from the point of view of vibrational multiplets structure and intruder contribution.

In the heavy-ion reaction, lifetimes were measured in the yrast band from I=8^+ up to I=18^+, again employing the DSAM method and the lineshape analysis technique. The reaction used in this case was ^{110}Pd(^{13}C, 3n) ^{120}Te at 52 MeV beam energy, induced on a 20 mg/cm^2 thick target with a beam intensity of about 1pnA. The lifetime of the 8^+_1 states was measured in both DSAM experiments, thus providing a cross-check of the parameters used in both cases.

The results from the previous experiment seems to indicate a sizeable intruder contribution to the structure of the 0^+_2 and 2^+_3 states, analogue to the case of ^{122}Te [4]. However, the fact that the lifetimes of the yrast states up to I=6^+ are unknown prohibits a quantitative comparison between the experiment and the predictions of collective models. The expected values for the lifetimes of the 2^+, 4^+, 6^+ states in ^{120}Te are from a few picoseconds up to 10 ps, thus suitable to be measured by the Recoil Distance Doppler Shifts (RDDS) method.

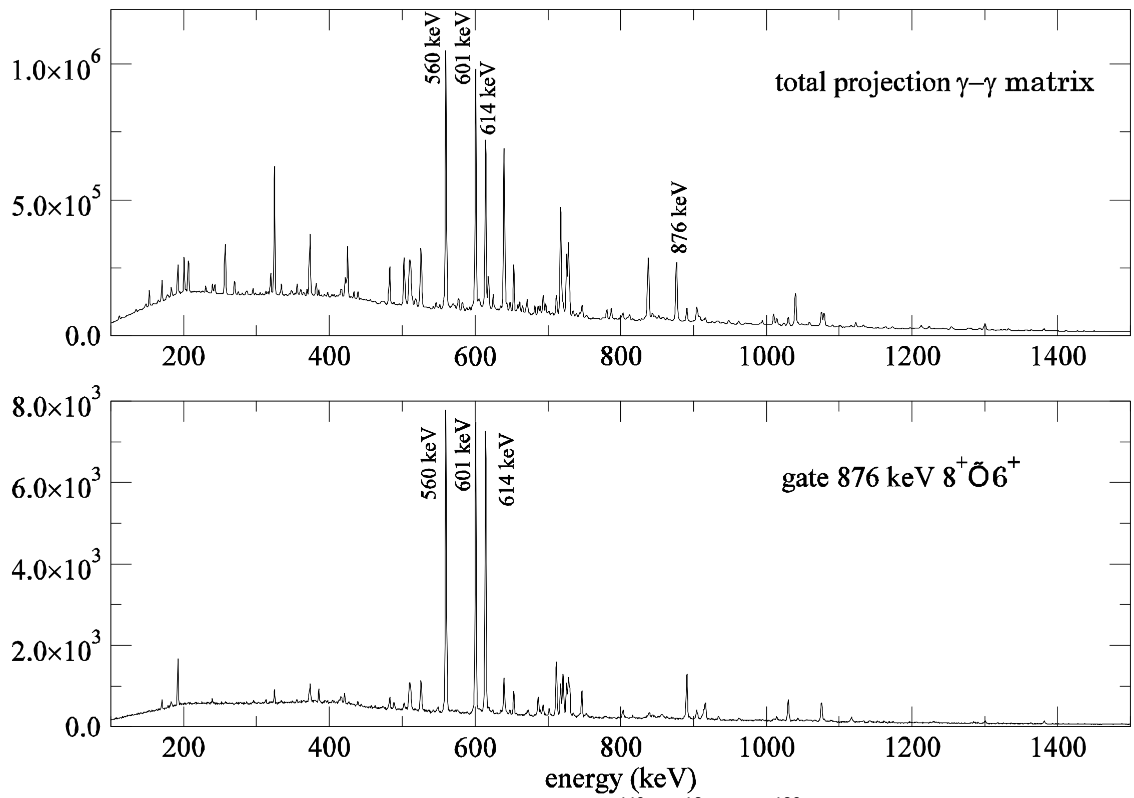

Figure 1. γ-ray spectra measured following the ^{110}Pd(^{13}C, 3n) ^{120}Te reaction at 52 MeV

2. Experimental Setup

We propose an heavy ion experiment using the $^{110}Pd(^{13}C, 3n)\,^{120}Te$ reaction at 52 MeV beam energy, to measure the lifetimes of the 2^+, 4^+, 6^+ states in the yrast band of ^{120}Te using the Bucharest plunger device. We plan to use a self-supported 0.6 mg/cm^2 palladium target, 99% enriched in ^{110}Pd in which the recoiling nuclei will be produced and a 8 mg/cm^{2}gold foil to stop the nuclei after a variable distance. The γ-rays will be detected in the Ge array installed on the first beam line of the TANDEM accelerator, comprising of 8 GeHP detectors, 5 placed in a ring at 143 degrees and 3 placed in a ring at 35 degrees. The lifetime will be extracted by the Differential Decay Curve Method (DDCM) by direct gating on the Doppler shifted component of a γ transition that feeds the level of interest.

The proposed reaction was already used in the DSAM experiment, in Fig. 1 being presented spectra following the $^{110}Pd(^{13}C, 3n)\,^{120}Te$ reaction at 52 MeV. The yrast transitions up to the 876 keV transition deexciting the 8^+ yrast state are marked by their energy, the reaction channel of interest being dominant. The target thickness was different in the DSAM experiment, nevertheless we can reach the same counting rates on the HPGe by increasing the beam intensity up to several pnA. Thus, we can use this data to estimate the beam time requirements. In the two days long DSAM experiment a total of $2.7*10^4$ coincidences between the 876 keV and 614 keV transitions (corresponding to the cascade 8^+-6^+-4^+). Because in the RDDS method the gate is set on the shifted component of the feeding transition (876 keV in this case), the total number of coincidences will be decreased with a factor corresponding to the intensity of the shifted component (20-90% depending on the distance, $\tau(8^+)$=0.46(8) ps). Thus, we estimate to have between $5*10^3$ and $2.5*10^4$ coincidences corresponding to the cascade 8^+-6^+-4^+ if we measure for 2 days/distance, thus assuring that the lifetime of the 6^+ state will be determined with ~10% error. In the case of the 4^+ and 2^+ states, the intensities will be higher, thus assuring smaller errors.

Because we estimate that the lifetimes of interest are confined to a relatively small interval between 3 ps and 10 ps, we propose to measure at 5 distances between 2 and 50 microns. Thus we estimate that 10 days of beam time are needed to perform RDDS measurements in the yrast band of ^{120}Te.

References

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