ELECTROMAGNETIC E2 TRANSITION PROBABILITIES IN ^{120}Xe AND ^{118}Te — N=66 NUCLEI*

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Lifetimes of the yrast states in ^{120}Xe and the ground state band below and above band crossing in ^{118}Te have been measured by DSAM in the ^{111}Cd(^{12}C,3n) reaction and by DSAM and RDM in the ^{109}Ag(^{13}C,$p3n$) reaction, respectively. The experimental data are compared with calculation done in the framework of the IBM1 model in the O(6) and SU(5) limits.

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1. Introduction

The motivation for the lifetime study of ^{120}Xe [1] and ^{118}Te [2] was our previous investigation of ^{119}I where lifetime of 60 levels in 10 bands have been measured [3,4]. The energy structure of the low-lying part of the yrast decoupled negative parity band built on the $h_{11/2}$ state in this nucleus is very similar to the yrast state band below the backbending in the neighbouring ^{120}Xe nucleus (Fig. 1). This figure also shows that the E2 $\Delta I=2$ transitions in the $g_{9/2}$ band have energies similar to the corresponding E2 transitions in the neighbouring ^{118}Te nuclei. The B(E2) values for the $h_{11/2}$ and $g_{9/2}$ bands of ^{119}I differ from each other [4], therefore, a comparison with corresponding values in ^{118}Te and ^{120}Xe can be helpful to explain this fact. Before this work was done, only a few experimental lifetime values in ^{120}Xe and ^{118}Te nuclei were known [5–7]. For ^{118}Te the only known data were given in [8] for the 8^+ and 10^+ levels: $1.3^{+0.5}_{-0.4}$ ps and $0.83^{+0.12}_{-0.08}$ ps, respectively.

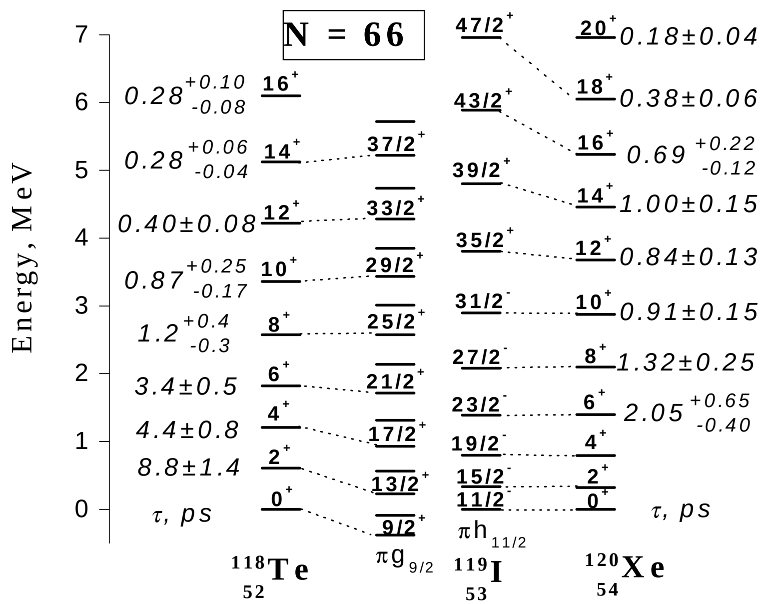

Fig. 1. Ground state band levels in ^{118}Te and ^{120}Xe in comparison with $\pi g_{9/2}$ and $\pi h_{11/2}$ bands of ^{119}I. Results of our lifetime measurements for ^{118}Te and ^{120}Xe are shown on the left and right part of figure, respectively.

2. Experiment

Lifetimes in ^{120}Xe have been measured by the Doppler Shift Attenuation method (DSA) in the ^{111}Cd(^{12}C,$3n$) reaction at the beam energy of E = 56 MeV [1]. The experiment was performed at the JAERI Tandem Accelerator (Japan). The $\gamma\gamma$ coincidences were collected by the GEMINI array. A thick target (30 mg/cm^2 metallic foil) has been used.

Lifetimes in ^{118}Te have been determined with the DSA and Recoil Distance (RD) methods using the ^{109}Ag(^{13}C,$p3n$) reaction at E = 54 MeV [2]. The experiment was performed at TAL NBI (Denmark). The $\gamma\gamma$ coincidences were collected by the NORDBALL array. For the DSA method a target of 5.7 mg/cm^2 has been used. RD measurements have been done using a self-supporting 0.82 mg/cm^2 target [3].

The analysis of experimental γ-lineshapes was carried out using updated versions of Monte-Carlo codes COMPA, GAMMA, SHAPE [3, 9]. The main features of the used approach are the following:

(a) The kinematical spread of the initial recoils is calculated on the basis of a statistical model taking into account, step by step, the evaporation of light particles from the compound nucleus.

(b) The slowing down and multiple scattering of the recoils can be calculated for several stopping layers. Recoil distance spectra are regarded as a special case of DSA with three layers: a target, a vacuum and a stopper. More details concerning the Recoil Distance Doppler Shift Attenuation (RDDSA) method can be found in Refs [3,11,12].

(c) The number, the solid angles and the arrangement of γ-detectors are not limited.

(d) The number of levels and branches of cascade feeding is not limited. Sidefeeding cascades from each state to the level of interest are included into the Monte-Carlo simulation. Any condition of $\gamma\gamma$-coincidence gating (“above”, “below” *etc.*) can be taken into account by the Monte-Carlo techniques.

(e) Overlapping Doppler broadened lines can be analysed using lifetimes as lineshape parameters.

The Lindhard correction factors for electronic ($f_{\rm e}$) and nuclear ($f_{\rm n}$) components of the stopping power of the recoils have been measured by lineshape analysis using the "emi-thick target" method [9, 10] and values of $f_{\rm e} = 1.27{\pm}0.07$ and $f_{\rm n} = 0.77{\pm}0.07$ have been obtained for the case of the ^{119}I recoils moving in the ^{109}Ag target [3, 11]. It follows from our measurements that for recoil velocities $v/c = 1\%$ the electronic stopping power taken from the tables of Ziegler *et al.* [12] (computer codes TRIM-95, SRIM-2000) can be two times smaller than the experimental values, whereas the nuclear stopping power is close the predicted one.

To extract lifetimes of high spin states the sum of spectra gated below the line of interest was used. The sidefeeding effective time $\tau_{\rm sf}$ is expected to be small in both nuclei [1, 2]. From the precise lineshape analysis of the 819 keV $18^+ \to 16^+$ transition in ^{120}Xe the value of $\tau_{\rm sf} = 0.040{\pm}0.015$ ps has been evaluated.

For the analysis of the high spin levels in ^{118}Te, the sum of the spectra taken from all 20 NORDBALL detectors have been used. Obtained in

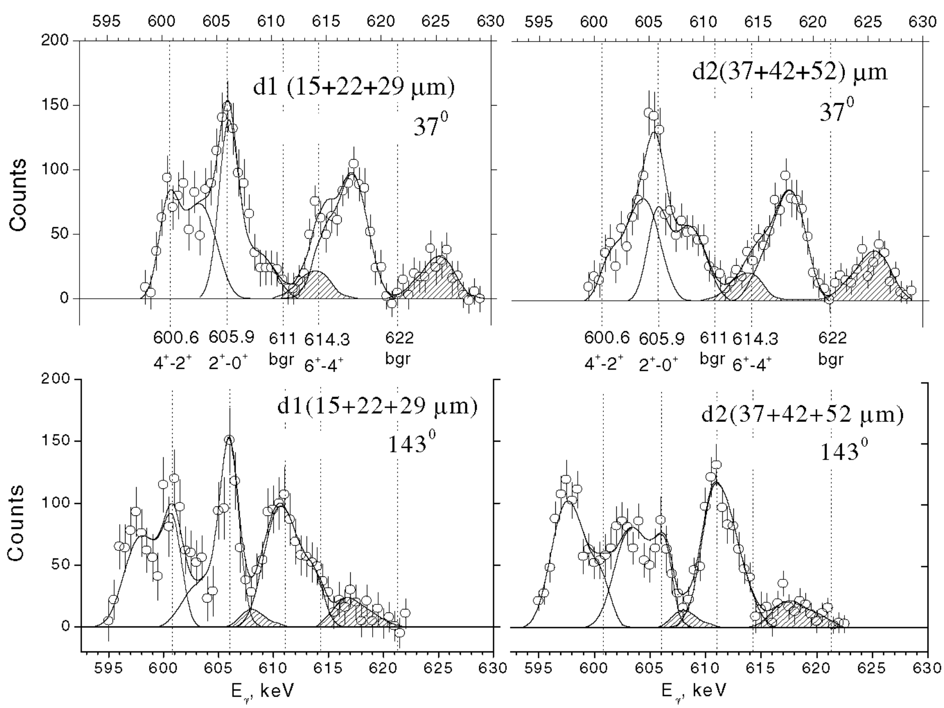

Fig. 2. Analysis of the multiplet consisting of the 600, 605, 611, 614 and 622 keV lines in ^{118}Te. "bgr" — background lines, d1, d2 – spectra being the sum of spectra obtained in the RD method for the target-stopper distances given in brackets.

this way symmetrical Doppler broadened γ lines (corresponding to relatively short lived levels) were analyzed [2]. In the case of ^{120}Xe the DSA lineshape analysis of spectra gated on the flight component of the 819 keV $18^+ \to 16^+$ γ line as well as on γ lines below the 10^+ state has been done. As a result, the lifetimes of the 16^+ and 10^+ levels from the unresolved 773 keV doublet consisting of the $16^+ \to 14^+$ and $10^+ \to 8^+$ transitions have been extracted [1].

Lifetimes of the 2^+, 4^+ and 6^+ levels in ^{118}Te have been evaluated from the RD spectra gated on the flight component of the 753 keV $8^+ \to 6^+$ line. Since the 615, 600, and 606 keV lines, corresponding to the $6^+ \to 4^+$, $4^+ \to 2^+$, and $2^+ \to 0^+$ transitions are overlapping each other, τ values were determined by the RDDSA method [2] (Fig. 2).

3. Discussion

One of the first attempts of describing the excitation energies and B(E2) values in the backbending region has been done using a model based on the IBM1 model, which involved high-spin phonons in addition to s- and d-bosons [13]. This approach has been improved by using microscopic calculations and was applied to ^{110}Cd and ^{126}Ba [14,15]. A detailed description of this model, named IBM+2qp, is presented in [15]. The last developments of this model applied to ^{118}Te and ^{120}Xe are presented in Refs [1,2,16]. Since only in a few cases the B(E2) values in backbending region are known, we compare the ^{120}Xe data with the recent information about the ^{128}Ba nucleus [17]. The results are presented in the left panel of Fig. 3. It is easy to see that in both nuclei corresponding O(6) limits overestimate the experimental B(E2) values near the backbending region.

It can be seen in Fig. 1 that energies of levels belonging to the decoupled $\pi h_{11/2}$ band in ^{119}I are similar to the yrast band states of ^{120}Xe. The B(E2) values presented in Fig. 3 (left panel) show that the collectivity of the $\pi h_{11/2}$ band is even higher than that of the yrast band in ^{120}Xe. It can be due to core polarization effects. The situation for the strongly coupled $g_{9/2}$ band in ^{119}I turns out to be more complex. Fig. 3 (right panel) shows that E2 transition probabilities for the $g_{9/2}$ band in ^{119}I are significantly smaller than the corresponding values for the low spin levels of ^{120}Xe and even ^{118}Te. Moreover, there is a difference in the spin-dependence of the B(E2) values for ^{119}I and ^{118}Te. Fig. 3 (right panel) shows that the B(E2) values for the ground state band in ^{118}Te increase with spin, in contradiction with the theoretical results of the IBM1 model in the O(6) limit, but they are close to the SU(5) limit. It is of interest, that in ^{119}I above backbending the B(E2) values and their spin-dependence drastically differ from the low-spin region of the ^{119}I band but are similar to those of the low spin states of ^{118}Te.

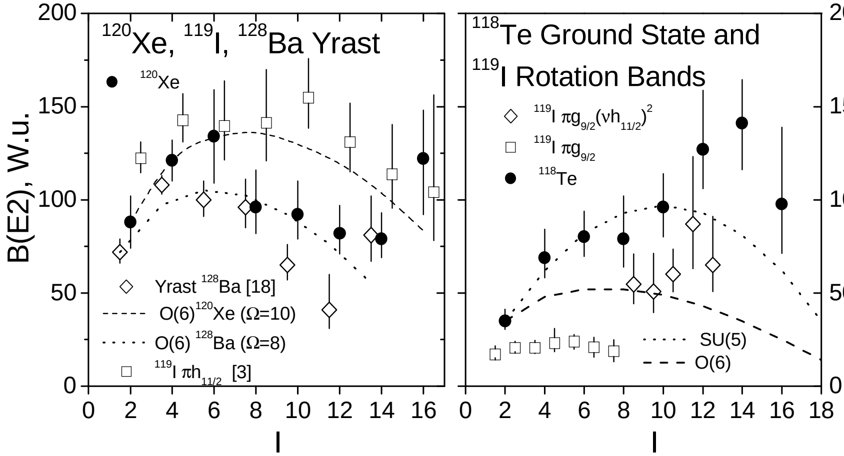

Fig. 3. Experimental spin dependence of B(E2) in ^{120}Xe, ^{128}Ba, ^{119}I (left panel) and ^{118}Te, ^{119}I (right panel). The spin values for bands containing the $\pi h_{11/2}$ and $\pi g_{9/2}$ orbitals are shifted by spin value of their bandheads.

4. Summary

The level energies in the $\pi h_{11/2}$ decoupled band of ^{119}I is similar to the ^{120}Xe core and collectivity of decoupled band seems to be higher than that in ^{120}Xe. The energies in the $\pi g_{9/2}$ rotational band of ^{119}I are similar to the ^{118}Te ground state band (Fig. 1) but the B(E2) values are drastically smaller than the corresponding values in ^{118}Te. The low collectivity of the $g_{9/2}$ band below backbending has to be accounted for and this is a challenge to the theory. It is worth adding that the lifetimes obtained for ^{118}Te give us the unique possibility to analyse B(E2) values in the collective ground state band above the band crossing. The interpretation of the B(E2) values, measured for ^{118}Te and ^{120}Xe, within the IBMF model with two interacting quasiparticles is presented in the paper of Efimov *et al.* [16].

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