HIGH-SPIN SPECTROSCOPY OF $^{124,125,126}$Xe*

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High-spin states in $^{124,125,126}$Xe have been populated in the reaction $^{82}$Se ($^{48}$Ca, xn)$^{130-17}$Xe and γ-ray coincidences were measured with the GAMMASPHERE spectrometer. Twelve new bands extending into the spin 50–60 $h$ region are identified in $^{125}$Xe and $^{126}$Xe and previously known rotational bands at low spins are confirmed and extended. Earlier known structures in $^{124}$Xe are confirmed and a new band is observed. Irregular structures are identified at the top of the yrast and a side band in this nucleus. Configuration assignments for the different structures are suggested.

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1. Introduction

The main aim of the investigation of $^{124,125,126}$Xe was to search for hyperdeformed structures at very high spin. Up to date no statistically significant discrete-line hyperdeformed bands have been discovered, but the analysis of the $\gamma$-ray continuum shows ridge structures with small energy spacings which may result from rotational bands with very large moments of inertia [1–3]. In the present paper, we report on an analysis of the normal-deformed level structure of these isotopes. Results on $^{126}$Xe have been reported at a previous conference [2].

2. Experimental details

High-spin states in $^{124,125,126}$Xe were populated in the $^{82}$Se($^{48}$Ca, xn) reaction. The $^{48}$Ca beam of 205 MeV was provided by the ATLAS accelerator at ANL. The target consisted of a 0.5 mg/cm$^2$ foil of $^{82}$Se evaporated on a 0.5 mg/cm$^2$ Au backing, and the Se was protected by a thin Au layer. Since the Au backing faced the beam, the beam energy at mid-target was about 199 MeV. For heat dissipation, the target was mounted on a rotating wheel and the beam was wobbled horizontally by about 5 mm. With these precautions, a beam current of about 4 pnA could be used. Gamma-ray coincidences were measured with the GAMMASPHERE spectrometer. With a Ge-detector fold selection of $\geq 5$, a total of $2.8 \times 10^9$ events were recorded in a beam time of 7 days.

The $\gamma$-ray coincidence events were sorted into three- and four-dimensional arrays and were analysed using the RADWARE program package [4]. Matrices and $\gamma$-ray-gated matrices were created for an analysis of angular correlation ratios. This work and a complete determination of $\gamma$-ray intensities are in progress.

3. Results and discussion

The level structures of $^{124,125,126}$Xe were previously studied up to a spin of about 20 $\hbar$ [5–8]. The present work extends the level schemes of $^{125,126}$Xe into the region of 50–60 $\hbar$. As $^{124}$Xe is populated in the 6n reaction channel, its level scheme can only be moderately extended. The level schemes of $^{124}$Xe and $^{125}$Xe are presented in Figs. 1 and 2, respectively. The level scheme of $^{126}$Xe was given in a previous publication [2]. The most prominent features of the level schemes of $^{125,126}$Xe are the long regular cascades extending to high angular momenta. An example of the spectra of one of these bands in $^{125}$Xe is shown in Fig. 3, together with the spectrum of a new band found in $^{124}$Xe.

Due to the short lifetimes of the transitions within the high-spin bands in $^{125,126}$Xe, Doppler shifts could be observed even with the thin target used in the experiment. Following the method suggested by Cederwall [9], spectra
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Fig. 1. Level scheme of $^{124}$Xe based on present work and previous results [6].

were sorted for the strongest band in $^{126}$Xe, band a [2], for different recoil velocities $v/c$, and the widths of the $\gamma$-ray peaks were determined in each of these spectra. An $F(\tau)$ curve was obtained adopting the $v/c$ values for which the width of a given peak was a minimum. For band L4 in $^{125}$Xe, see Fig. 2, spectra were sorted for different Ge-detector angles relative to the beam direction, from which $v/c$ and $F(\tau)$ values were determined. Due to the thin target, Doppler shifts could be determined for 12 transitions in each band and the change in $F(\tau)$ is about 6%. Therefore, only estimates of the transition quadrupole moments are obtained from fits to the $F(\tau)$ curves, resulting in $Q_t \approx 5.0-5.5$ b for both bands. These quadrupole moments are significantly larger than those for low-spin states in these nuclei [10] and probably correspond to highly deformed prolate minima ($\varepsilon \approx 0.35, \gamma \approx 5^\circ$) in the potential energy calculations using the Ultimate Cranker (UC) code.

To assign configurations to the bands, we compare excitation energies, moments of inertia, quadrupole moments, aligned angular momenta and band-crossing frequencies to UC calculations [11]. In the lower-spin region, where the deformation is small and the shape is fluctuating, the configurations are dominated by $h_{11/2}$ and $g_{7/2}$ neutrons and $h_{11/2}$ and $g_{7/2}$ protons.
Fig. 2. Partial level scheme of $^{125}$Xe deduced from this work. The low-spin part is taken from [5].

According to the calculations, strongly prolate-driving intruder configurations are responsible for the observed properties of the new high-spin bands. They are of neutron $j_{13/2}$ origin, but also further $h_{11/2}$ and $g_{7/2}$ proton orbitals play a role.

A sharp crossing and strong alignment gain is observed at a frequency of 1.15 MeV in several of the high-spin bands in $^{125,126}$Xe. The calculations suggest that it is caused by the strongly shape-driving $j_{15/2}$ neutron orbital. As pairing is probably quenched for multi-particle excitations at such high
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Fig. 3. Examples of $\gamma$-ray coincidence spectra in $^{124}$Xe and $^{125}$Xe. The peaks marked by a single asterisk belong to the ground and yrast bands and those marked by two asterisks are decay-out transitions.

frequencies, crossings with unpaired bands may also occur. It should be pointed out, however, that several of the high-spin bands are still not linked to low-spin states and final configuration assignments have to await firm spin determinations. This work is in progress.

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