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Identification of Excited States in ^{117}Xe

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Excited states of ^{117}Xe were populated via the reaction ^{92}Mo(^{28}Si,2pn) at beam energy 115 MeV. The emitted prompt γ-rays were measured by using in beam γ-ray experimental techniques. Five bands of ^{117}Xe have been identified, two of them are observed for the first time, and the three known bands are extended to higher spins.

Key words: in beam γ-ray spectroscopy, ^{117}Xe levels, γ-γ coincidence.

In recent years, a lot of studies have been carried out for the high excited energy and high spin nuclear structure of the transitional neutron deficient nuclei I, Xe, Cs and Ba via (HI,ypxn) fusion evaporation reaction with in beam γ experimental setup. Experimental phenomena such as bandcrossing, triaxial deformation and the shape coexistence of collective prolate and noncollective oblate ($\gamma = 60°$) have been observed. But studies on the neutron very deficient isotope ^{117}Xe remain rarely seen. Only the negative parity $h_{11/2}$ band was observed in the research by Chowdhury [1], and a positive parity $g_{7/2}$ band consisting of 5 transitions was reported by Tormannen [2]. The low spin levels of ^{117}Xe were established in the ^{117}Cs decay study by Marguier [3], and similarities between the low energy levels in ^{117}Xe, ^{119}Xe and ^{121}Xe were shown there. In this paper we report some new experimental results of the excited states in ^{117}Xe.

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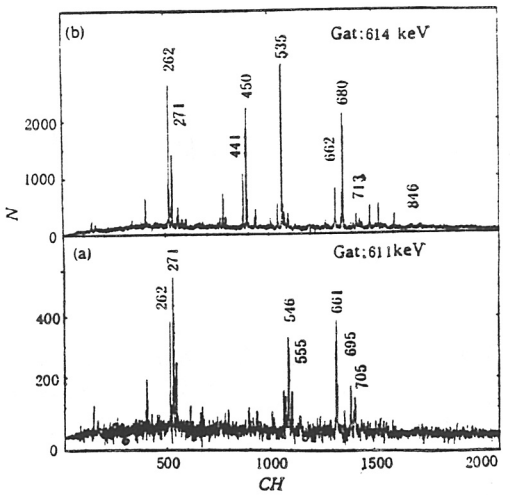

Fig. 1
Typical γ-γ coincidence gated spectra obtained via the ^{92}Mo(^{28}Si,2pn) reaction at beam energy 115 MeV.

The experiment was carried out at the HI-13MV tandem accelerator, Beijing, using a 2 mg/cm^2 ^{92}Mo (isotopically enriched to 94.1%) target with a lead backing of 6 mg/cm^2. Excitation functions were measured at ^{28}Si beam energy of 100-120 MeV with a 5 MeV step and an optimal bombarding energy of 115 MeV was chosen for the γ-γ coincidence data taking. Seven BGO Compton suppressed HPGe detectors and a 14-element BGO crystal ball were used to detect γ rays and a total of 90 million γ-γ coincidence events were recorded on tapes. Figure 1 gives two typical gated spectra and Fig. 2 shows the part of level scheme proposed from this work.

Bands 4 and 5 represent the favored ($\alpha = -1/2$) and unfavored ($\alpha = +1/2$) Signature member of the $h_{11/2}$ neutron band. Band 4 is populated most and is pushed four levels higher from the result of [1], but the 990 keV transition on the top is different from the latest result [4] reported after our experiment. Coincident with the other members in band 5, two new transitions 793 and 803 keV are added above the 25/2-level [1,4].

Band 2 is populated only a bit weaker than band 4. No interband transition is observed between bands 1, 2 and bands 4, 5. The six transitions 262, 271, 441, 450, 546, 555 keV in band 1 and 2 were identified in ^{117}Cs decay study [3] and their coincidence relations are the same as that observed there. Anisotropies of 262, 271 keV transitions support that they are of $\Delta I = 1$ character, in agreement with the measured conversion electron coefficients [3]. Typical coincidence relations in bands 1 and 2 are shown in Fig. 1. In this measurement, band 1 is established for the first time and band 2 pushed two important levels higher than that of [2].

Band 3 is also observed for the first time and assigned to ^{117}Xe based on the five interband transitions from band 3 to band 4. The anisotropy of 481 keV transition manifests its $\Delta I = 2$ ($E2$) character, and the interband transitions are from the levels above 481 keV transition in band 3 to corresponding levels in band 4. Therefore, band 3 is a $\Delta I = 2$ band. The absolute spin values and parity of band 3 remain to be determined.

A $\Delta I = 1$ band similar to that observed in ^{119,121}Xe, was expected on top of the 205, 188 keV transitions [3]. But results from our work are far from the expectation, and the details will be discussed later. However, a $\Delta I = 1$ band consisting of 193, 237, 275, 308, 334, 359, 374 keV transitions together with their corresponding crossover transitions are observed. It looks like the expected band.

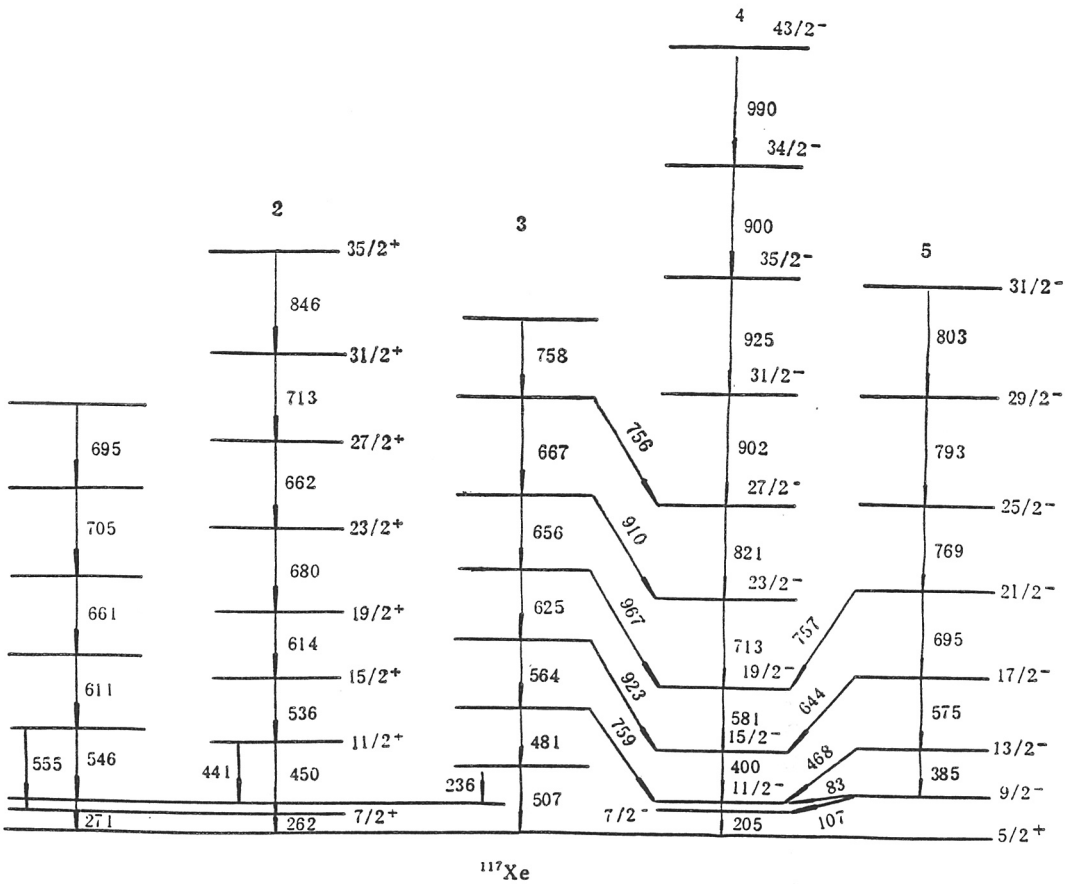

Fig. 2
Part of level scheme of ^{117}Xe proposed from this work.

No connection between this band and the known transitions of other bands has been found, so at present, this band is not able to be assigned firmly to ^{117}Xe yet.

Bands 4 and 5 are the $\nu h_{11/2}$ bands with Signature $\alpha = -1/2$ and $\alpha = 1/2$, and were compared with the CSM (Cranking Shell Model) calculations in [4]. The bandcrossing observed at rotational frequency $\hbar\omega = 0.45$ MeV in band 4 can not be caused by alignment of the lowest pair of neutrons due to blocking effect. The alignment of angular momentum 5-6h is produced by alignment of a pair of $h_{11/2}$ protons. It was noticed in [4] that the last transition of band 5, $25/2^- \rightarrow 21/2^-$ transition shows a onset of upbend, whereas the theoretical calculations predicted that bandcrossing would occur at $\hbar\omega = 0.42$ MeV, a frequency lower than that in band 4. In the present work two new transitions are extended, and they demonstrate that in band 5 a bandcrossing really occurs at a lower frequency $\hbar\omega = 0.41$ MeV. It is noticed that only upbend of the two corresponding bands in ^{119}Xe [6] were observed, and the frequencies of the upbends are similar to the crossing frequencies observed in ^{117}Xe.

Band 2 is built on the $g_{7/2}$ orbital. This can be seen clearly from a comparison with the $g_{7/2}$ band of ^{119}Xe. The alignments of band 2 and the $g_{7/2}$ band of ^{119}Xe are plotted in Fig. 3. Harris parameters $J_0 = 12\hbar^2$ MeV^{-1}, $J_1 = 45\ \hbar^4$ MeV^{-3} are extracted from levels of ^{119}Xe [6]. These two $g_{7/2}$ bands are very similar to each other and experience a sudden increase in alignment at $\hbar\omega = 0.33$ MeV. The CSM calculations show that this is caused by alignment of the lowest pair of $h_{11/2}$ neutrons.

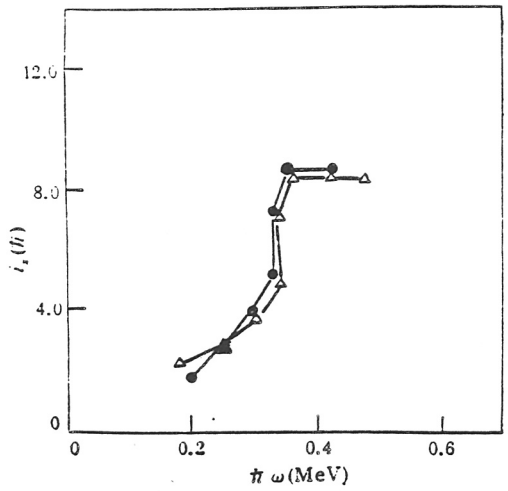

Fig. 3
Comparison of the alignments of band 2 in ^{117}Xe (•) with that of the $g_{7/2}$ band in ^{119}Xe (Δ).

Bands 1 and 3 are first observed in this work, and there are several transitions decaying from band 3 to band 4, which have never been found in heavier odd-A Xe isotopes. The nuclear structure involved in these new bands will be discussed and a more complete scheme will be given later.

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