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Short note

The low-spin structure of ^{115}Xe

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Abstract. The low-spin band structure of neutron-deficient $^{115}_{54}$Xe has been studied following a low-energy (212.3 MeV) ^{60}Ni(^{58}Ni,2pnγ) reaction performed at IReS, Strasbourg, with the GAREL$^+$ spectrometer. The relative excitation energies of $\nu h_{11/2}$ (isomeric), $\nu g_{7/2}$, and $\nu d_{5/2}$ bandheads have been established.

PACS. 23.20.Lv Gamma transitions and level energies – 21.10.Re Collective levels – 27.60+j 90 ≤A≤ 149

It is important to experimentally establish the spectrum of single-particle states in nuclei at low spin, especially at the extremes of isospin, in order to provide constraints for current theoretical models. For example, phenomenological nuclear models often include parameters fitted to experimental data of nuclei near the valley of stability, but are then extrapolated to nuclei far from stability. In this regard, recent experiments have established the low-spin structure of ^{113}Xe [1], currently the lightest odd-A xenon isotope with known excited states, while the present Short Note elucidates the low-spin structure of ^{115}Xe [2]. Relative excitation energies of $\nu h_{11/2}$, $\nu g_{7/2}$, and $\nu d_{5/2}$ single-particle levels have been established in ^{115}Xe.

Data for ^{115}Xe were collected as part of a systematic study of the fusion of ^{58}Ni with ^{60}Ni at beam energies around the classical Coulomb barrier [3]; the data used here, in which states in ^{115}Xe were populated via the ^{60}Ni(^{58}Ni,2pnγ) reaction, correspond to a beam energy of 212.3 MeV. A beam of ^{58}Ni, of intensity 10 pnA, was provided by the Vivitron electrostatic accelerator of the Institut de Recherches Subatomiques (IReS), Strasbourg. The high beam intensity was necessary to offset the low fusion cross section at this beam energy. The target consisted of a thin self-supporting foil of ^{60}Ni of thickness 230 μg/cm^2. Escape-suppressed, coincident γ-ray events were detected with the GAREL$^+$ spectrometer, consisting of 13 EUROGAM-type HPGe detectors [4] and a single LEPS detector. The coincidence events from the HPGe detectors were unfolded off-line into a RADWARE-format [5] matrix ($\gamma\gamma$) and cube ($\gamma\gamma\gamma$) for subsequent level-scheme construction. Given the relatively weak population intensity of ^{115}Xe, which involved neutron emission from the ^{118}Ba* compound system, the ability of a triple-coincidence analysis ($\gamma\gamma\gamma$) was crucial in building the current level scheme.

The level scheme deduced for ^{115}Xe from this work is shown in Fig. 1; previously only the leftmost (negative-parity) band was known [2]. Relative spin/parity assignments were inferred through an angular correlation analysis, while the absolute spin/parity assignments of Fig. 1 are based on systematics. The bands are labelled by the usual single-particle labels, namely e ($\nu h_{11/2}$, α=–1/2), and a/b ($\nu g_{7/2}$, α=±1/2). Similar to the ^{113}Xe isotope [1], the I^π=11/2$^-$ bandhead of band e appears isomeric, which is also consistent with the systematics of heavier odd-A xenon isotopes. Moreover, band e is linked to a positive-parity sideband (eEB) which becomes yrast at high spin, and which in turn decays down to bands a and b, again similar to ^{113}Xe. The 5/2$^+$ and 7/2$^+$ bandheads of bands a and b decay down to a proposed I^π=5/2$^+$ ground state, which may be associated with a $\nu d_{5/2}$ orbital from systematics. The structure of the eEB band, namely the 3-quasiparticle $\nu h_{11/2} \otimes \pi h_{11/2} g_{7/2}$ configuration, follows from systematic comparison with the heavier ^{117,119}Xe isotopes [7,8]. A corresponding strongly populated positive-

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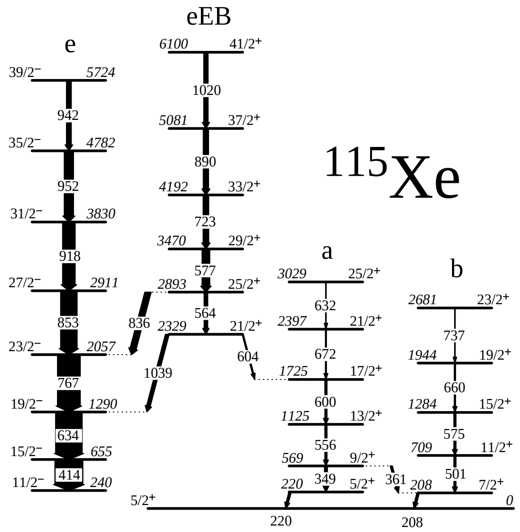

Fig. 1. Low-spin level scheme deduced for ^{115}Xe from this work. The transition energies and level energies are given in keV. Relative intensities are proportional to the widths of the arrows.

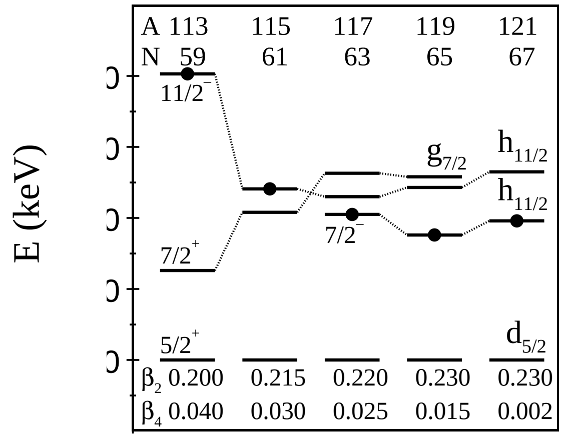

Fig. 2. Systematics of single-particle energy levels in light xenon isotopes. The solid circles denote the lowest-energy negative-parity state in each isotope. Average theoretical (TRS) deformation parameters (β_2, β_4) are also included. For each isotope, triaxiality is predicted to be in the range $-5^\circ \leq \gamma \leq 0^\circ$, i.e. very near prolate.

parity sideband is also observed in the lighter odd-A ^{113}Xe isotope [1], while a low-lying $\pi h_{11/2} g_{7/2}$ sideband (EB) is observed in the intermediate even-even ^{114}Xe isotope [6].

Systematics of $\nu h_{11/2}$ and $\nu g_{7/2}$ bandhead energies, relative to the respective $\nu d_{5/2}$ ground states, are shown in Fig. 2 for light odd-A xenon isotopes [1,7–9]. For the heavier ^{117,119,121}Xe isotopes, the $7/2^-$ level represents the bandhead of the $\nu h_{11/2}$ band e, which is based on an Ω=5/2 Nilsson orbital. For the lighter ^{113,115}Xe isotopes, it is the Ω=3/2 projection of the $\nu h_{11/2}$ orbital that is occupied, and hence the $11/2^-$ (I=j) state represents the lowest-energy state, or bandhead, being even lower in energy than the $7/2^-$ state. Indeed, no evidence has been found for low-lying $7/2^-$ states in ^{113,115}Xe.

Maximum quadrupole deformation is expected in the xenon isotopes near the neutron midshell at N≈64. This causes the $\nu h_{11/2}$ intruder orbital ($dE/d\beta_2<0$) to be lowest in energy for the $^{119}_{54}Xe_{65}$ isotope (the $7/2^-$ level). The new $11/2^-$ bandhead in ^{115}Xe is at a similar excitation energy to the $11/2^-$ levels in ^{117,119}Xe, while that of ^{113}Xe rapidly rises due to a decreasing deformation. In contrast, the energy of the high-Ω ($dE/d\beta_2>0$) $\nu g_{7/2}$ bandhead is lowered with decreasing deformation. Average, self-consistent, deformation parameters, obtained from Total Routhian Surface (TRS) calculations with a Woods-Saxon potential [10–12], are included in Fig. 2. With decreasing neutron number, the quadrupole deformation (β_2) is predicted to decrease, while the hexadecapole deformation (β_4) is predicted to increase.

In summary, low-spin single-particle bandhead energies have been established in ^{115}Xe, for which an I^π=$5/2^+$ $\nu d_{5/2}$ ground state is proposed. Taken with recent results for ^{113}Xe [1], these experimental energies can be used to provide constraints for theoretical models.

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