Contribution ID: **39** Type: **not specified**

Test of nuclear collectivity above 100 Sn

Thursday, 11 April 2019 10:00 (15 minutes)

Collectivity in nuclei in the vicinity of the N = Z line may be enhanced by neutron-proton interactions occupying similar orbits near the Fermi level. Therefore, information on single-particle energies and residual interactions with respect to the 100 Sn core are extremely important. The region of 100 Sn has been extensively investigated due to unusual B(E2;0 + ⟶2 +) values observed for light Sn isotopes. But the direct study of the properties of 2 + state neutron-deficient Sn-isotopes is challenging due to presence of long-lived isomers up to the range of nanoseconds.

In the proposed experiment we propose to probe the collectivity in the neighbouring light Sb nuclei. The dominant feature of low-energy levels of the odd-mass Sb nuclides with 54<N<82 is the dramatic monopole shift of the d 5/2 and g 7/2 levels in which the g7/2 level moves from a position 852 keV above the d 5/2 in 111 Sb to a position 963 keV below the d 5/2 level in 133 Sb [1]. The monopole effect how spherical single-particle energies are shifted as protons or neutrons occupy certain orbits is postulated in ref. [2]: it arises as a consequence of spin-orbit interaction that diminishes as N/Z ration increases.

Another peculiarity for odd-A Sb isotopes is the presence of two 9/2+ states. One of 9/2+ 1 is interpreted as the result of the coupling a d 5/2 proton to the 2+ state of adjacent even-even Sn core. As follow from this simple approach for a pure particle-vibration coupled state B(E2;9/2+⟶ 5/2+) = B(E2;2+⟶0+), see the Eq. (6-467) of volume II of Bohr-Mottelson. Indeed, the full shell-model calculations using the CD-Bonn interaction [3] performed by Chong Qi [4], confirm the trend. However for heavier Sb (A>113) due to the monopole shift the proton is moved to g7/2 and as a result, the mixing between d5/2 and g7/2 orbitals which leads to the significant drop in the calculated B(E2; 9/2+⟶g.s.) transition strength. The energy of 9/2+ 1 is relatively insensitive to the neutron number and remains in close proximity to 2 + level in the underlying Sn core. The second 9/2+ 2 might be due the promotion of a g 9/2 proton into a higher orbital, which gives 2p1hconfiguration. Both 9/2+ states, which have different intrinsic configuration, are closely spaced and, therefore, may be mixed with each other. The situation is similar to one observed near Z = 28 shell [5].

We propose to study lifetime of the low-lying states in 105,107,109 Sb, by using a 1n and 2n knock-out reaction from 106,108,110 Sb, respectively. The 106,108,110 Sb fragments will be produced from the fragmentation of a primary 124 Xe beam at 345 MeV/A on a Be target. The reaction fragments will be separated and identified by he BigRIPS separator. The fragments of interest will impinge on a 9 Be target surrounded by a high-purity germanium array (MINIBALL). The final reaction products will be identified by the ZeroDegree spectrometer.

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Session Classification: Proposals