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Intruder States in Neutron Rich Phosphorus Isotopes Near N=28

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Understanding the evolution of shell structure as a function of N/Z is one main focus of current nuclear structure studies. The force behind the migration of orbitals is the monopole part of the tensor interaction. Refinement of this monopole term to increase the predictive powers of shell model calculations underscores the need for more experimental information, specially for excited states in exotic nuclei. Odd Z and odd-odd nuclei provide one of the most stringent tests of shell model predictions as many more degrees of freedom are available.
The structure of odd Z phosphorus isotopes (N = 22 − 25) were investigated at the National Superconducting Cyclotron Laboratory via the beta decay of Si isotopes. Following allowed beta decay, intruder states were populated in the P isotopes which could be identified based on the measured logft values. First gamma transitions in 38,40P were observed de-exciting the strongly populated 1+ states. These 1+ states at relatively low energy (~2MeV) with parity opposite to the 2- ground state are core excited 1p-1h states (1). The occurrence of intruder states at low energies highlights the
importance of pairing and quadrupole correlation energies in lowering the intruder states despite the N = 20 shell gap. Configuration interaction shell model calculations with the state-of-art SDPF-MU effective interaction were performed to understand the structure of these 1p1h states in the even-A Phosphorus isotopes. States in 40P with N = 25 were found to have very complex configurations involving all the fp orbitals leading to deformed
states as seen in neutron rich nuclei with N ~ 28. The calculated GT matrix elements for the beta decay highlight the dominance of the decay of core neutrons over the valence neutrons in neutron rich nuclei when neutrons and protons occupy shells of opposite parity. Unlike the even A isotopes, for the odd A isotopes the negative parity intruder states lie at higher excitation energies and the beta decay strength was found to be fragmented. Systematic discussion of the results for 37-40P will be presented highlighting the effects of adding neutrons on the shell structure.
References:
1) V. Tripathi et al., accepted in PRC, 1/24/2017

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