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Structure of the exotic neutron-rich nuclei 42Si, 52Ti, and 54Ti

INGO WIEDENHOEVER, Florida State University

The modification of magic numbers and the shell structure of very neutron-rich systems is one of the most intriguing subjects to be studied with present and future exotic beam facilities. In a number of recent experiments, the modification of shell structure for both the neutron and proton-systems was studied for the very neutron-abundant nuclides ^{52,54}Ti and ^{42}Si; The excited level structure of ^{52,54}Ti show evidence for a sub-shell closure at N=32 [1], while a recent measurement of Coulomb excitation of the 2_1^+ in ^{56}Ti [2] shows that the sub-shell closure at N=34 is weaker than expected. In order to investigate the character of ^{42}Si, we performed an experiment using a ^{44}S beam, generated in fragmentation of 140 MeV/u ^{48}Ca at the Coupled-Cyclotron Facility at the NSCL. This beam was delivered to the target position of the S800 spectrograph, where secondary reactions occurred. The one-proton and two-proton knockout reaction products, ^{43}P and ^{42}Si, were identified using the S800 spectrograph and coincident γ rays were detected with the segmented Germanium array, SeGA, surrounding the S800 target position. We measured one-proton knockout populating the ground and first excited state of ^{43}P. The direct reaction character of one-proton [3] knockout and two-proton knockout [4] allows to compare the observed cross-section to calculations using the eikonal-approach. We find large cross sections for the single-proton knockout, corresponding to single-particle spectroscopic factors for the $^{43}\mathrm{P} = {}^{42}\mathrm{Si} + \mathrm{p}$ system. Simultaneously, the measured two-proton knockout cross section corresponds to a Z=14 closed shell ^{42}Si. Both of these aspects support the magic character of ^{42}Si. [1] R.V.F. Janssens *et al.* Phys. Lett. B 546 (2002) [2] D.C. Dinca *et al.* Phys. Rev. C**71**, 041302R (2005) [3] Hansen, P.G. & Tostevin, J.A., Direct Reactions with Exotic Nuclei. Annu. Rev. Nucl. Part. Sci. 53, 219-261 (2003). [4] D. Bazin *et al.* Phys. Rev. Lett. **91** 012501 (2003)