Results from single-neutron adding reactions on light neutron-rich nuclei with HELIOS*

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The distribution of the single-neutron strength in the sd shell was investigated through a series of neutron-adding experiments utilizing radioactive beams produced by the Argonne National Laboratory ATLAS in-flight facility[1]. The ^{19}O(d,p) and ^{17}N(d,p) direct reactions at beam energies of 6.6 MeV/u ($\sim 10^5$ pps) and 13.5 MeV/u ($\sim 10^4$ pps), respectively, were carried out in inverse kinematics. Outgoing protons were measured in coincidence with heavy-ion recoils by the helical orbit spectrometer (HELIOS)[2]. Eight levels in ^{20}O up to an excitation energy of ~ 6 MeV, including a previously unobserved $J^\pi = 3^+$ level at $E^* = 5.23$ MeV, were observed. In addition, three strongly populated states in ^{18}N below S$_n = 2.8$ MeV, including a previously unobserved $J^\pi = 1^-$ level at $E^* = 1.2$ MeV, were measured. Spectroscopic factors have been extracted from angular distributions through a distorted wave Born approximation.

Information from the ^{19}O$(d,p)^{20}$O reaction has established empirical $\ell = 0$ and 2 strength distributions in this region ($Z = 8, N = 12$). The measurements are well reproduced by shell model calculations confined only to the sd shell. Furthermore, the data has allowed for a determination of the $J = 0, 2$ and 4, $T = 1$ $\langle (0d_{5/2})^2 J|V|(0d_{5/2})^2 J\rangle$ empirical two-body matrix elements of the NN interaction which showed consistency with those previously deduced from ^{17}O$(d,p)^{18}$O data and a global survey. The $J^\pi = 2^-$ and 3^- levels in ^{18}N at 0.12 MeV and 0.74 MeV, respectively, were identified in the present work as having dominant $\nu(0d_{5/2})^3_{J=5/2}$ neutron configurations coupled to an unpaired $\pi(0p_{1/2})^{-1}$ proton configuration. These levels, along with a newly found $J^\pi = 1^-$ level at 1.2 MeV, provide a glimpse of the energy centroid evolution for the neutron $(0d_{5/2})^3_{J=5/2,J=3/2}$ and $(0d_{5/2})^2(1s_{1/2})^1_{J=1/2}$ configurations along the $N = 11$ isotones. This region runs from ^{19}O, which has a $J^\pi = 5/2^+$ ground state, a high lying $1/2^+$ excited state, and a nearly filled proton $0p_{1/2}$ orbital, to the exotic ^{17}C nucleus having a ground state $J^\pi = 3/2^+$ spin-parity and an almost vacant $0p_{1/2}$ proton orbital. Additional discussion will take place on these data in terms of modern shell-model calculations using interactions confined to the $0p$-$1s0d$ and $1s0d$ orbitals.

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