Observation of Unbound States in ^{16}Ne / ^{15}Ne via 1n- / 2n-Knockout on ^{17}Ne *

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In recent years, experiments investigating the driplines have unearthed rich evidence on the peculiarities of the nuclear force, in particular those connected to weak binding and large proton-neutron asymmetry. While for very neutron-rich systems, e.g., various manifestations for 1n and 2n halo systems are found, the existence of the dripline is known only up to $Z = 8$. Quite reversed due to the additional presence of the Coulomb barrier, the proton dripline is sharp and known up to $Z = 91$, whereas halo formation is suppressed and just a few case exist. In the recent past we have investigated proton-knockout reactions studying the borromean 2p-halo nucleus ^{17}Ne [1, 2], and here we have used the dataset from the same experiment as a stepping stone to reach beyond the proton dripline and explore yet unknown regions of the nuclear landscape.

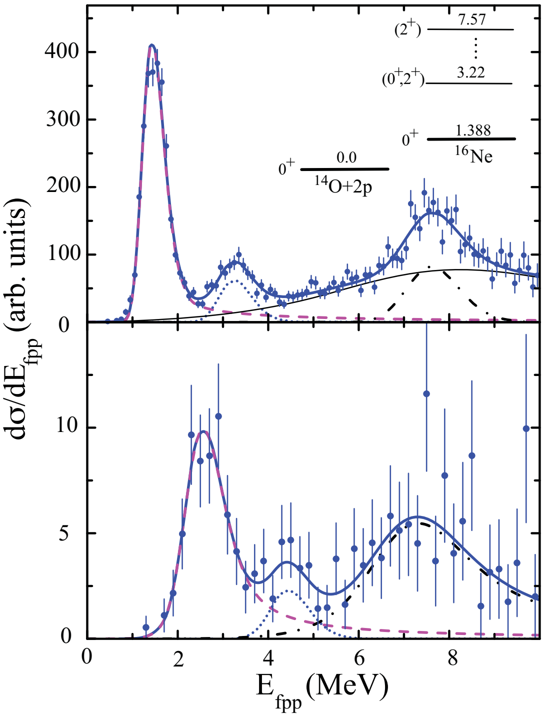

Fig. 1: Relative-energy (E_{fpp}) of ^{16}Ne (top) and ^{15}Ne (bottom), after 1n-/2n-knockout from ^{17}Ne projectiles.

This report presents data of 1n- and 2n- knockout reactions on ^{17}Ne projectiles in light targets (C, CH$_2$), populating states in the unbound nuclei ^{16}Ne and the yet unobserved ^{15}Ne. In a simple picture, the respective neutrons were removed from the ^{17}Ne core, ^{15}O, thus creating ^{14,13}O fragments coupled to the two remaining s^2/d^2 protons, all travelling under forward angles and being detected in coincidence. The data analysis procedure, via 4-momentum reconstruction and invariant-mass technique, is equivalent to the description in [1]. The excitation spectra, in terms of f-2p relative-energy spectra, of the ^{16}Ne and ^{15}Ne systems are shown in Fig. 1. The shown data (full dots with errorbars) have been corrected for experimental acceptance, and the peaks have been fitted by Coulomb-Breit-Wigner functions (dashed, dotted lines) folded with the experimental resolution, and in the case of ^{16}Ne in addition by a non-resonant background (full line). The experimental acceptance and the E_{rel} calibration and resolution have been obtained from R3BROOT-based simulations [2] in combination with the width and position of the known $5/2^-$ state in the ^{15}O+2p continuum of ^{17}Ne as a reference.

For ^{16}Ne (^{14}O+2p) we have extracted the positions and widths of the ground state and the first two excited states as E_r(g.s.) = 1.388(15) MeV, Γ_r(g.s.) = 0.082(15) MeV; E_r(1.x.) = 3.22(5) MeV, Γ_r(1.x.) $\leq$ 0.05 MeV; E_r(2.x.) = 7.57(6) MeV, Γ_r(2.x.) $\leq$ 0.1 MeV. These values are in good agreement with previous publications on ^{16}Ne, e.g. [4], and confirm the validity of our technique and calibrations.

For the first time, the unbound isotope ^{15}Ne has been observed, as coincidences between ^{13}O and two beam-like protons (see Fig. 1(bottom)). The same type of analysis as for the ^{16}Ne case has been performed for the ^{15}Ne (E_{fpp}) spectrum. We identified the ground state and the first excited state with parameters of E_r(g.s.) = 2.522(66) MeV, Γ_r(g.s) = 0.59(23) MeV; E_r(1.x.) = 4.42(4) MeV, Γ_r(1.x.) $\leq$ 0.1 MeV. The observed position of the ^{15}Ne ground state at S_{2p} = -2.522(66)MeV is in good agreement to a recent model prediction [5].

References

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