Exotic phenomena studies in radioactive nuclei of the experimental group of nuclear reaction and structure from Peking University

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The experimental group of nuclear reaction and structure from Peking University has been dedicated to the researches of exotic phenomena in light neutron-rich nuclei for several decades, and has developed a large number of professor teams, detection devices and research methods. Dr. Zhu Hongyu from this group studies new magic numbers, shell evolutions, spectroscopic factors, halo structures and clusters through methods like the transfer, elastic/inelastic reactions and more.

Spectroscopic factors are generally quenched relative to the occupancy numbers predicted by the independent particle model(IPM) due to nucleon-nucleon correlations, which is quantified by the reduction/quenching factor *Rs*. *Rs* extracted from knock-out reactions were found to be strongly dependent on the isospin asymmetry ($\Delta S = Sn - Sp$ / $Sp - Sn$ for neutron/proton removing reaction) . However, *Rs* deduced from the transfer reactions induced by stable nuclei were found to be independent of ΔS. How about unstable nuclei with larger absolute values of ΔS in transfer reactions?

In order to answer this question, a combined experiment with radioactive beams of ^{15}C and ^{16}N was performed at Radioactive Beam Line in Lanzhou (RIBLL), China in 2022. The differential cross sections of the single-nucleon transfer reactions ^{15}C(p, d)^{14}C, ^{15}C(d, ^{3}He)^{14}B, ^{16}N(p, d) ^{15}N, and ^{16}N(d, ^{3}He)^{15}C were obtained. By comparing the experimental angular distributions to the DWBA theoretical calculations, the spectroscopic factors and the corresponding *Rs* with ΔS = -19.86-20.14 MeV were extracted. Significant dependencies of *Rs* on ΔS were found in the present experiment.

In the same experiment, a new measurement of the ^{2}H(^{15}C,^{3}He)^{14}B reaction was conducted to investigate the proton shell evolution in neutron-rich carbon and boron isotopes. The experiment employed a radioactive beam of ^{15}C with a higher energy at 28.3 MeV/u and a large acceptance charged particle detector array LACPU, enabling coincident measurement of high-lying unbound states in ^{14}B that include $\pi 0p_{1/2}$-$\pi 0p_{3/2}$ transitions. A newly observed 3.69(41)-MeV resonance with a statistical significance of 3.4σ in 14B exhibits $\pi 0_{p1/2}$ rather than π0p3/2-dominant character according to structural model predictions. The extracted proton spectroscopic factor of 0.14 ± 0.06 for $^{15}C_{g.s.}$ not only follows the systematic decreasing trend in neutron-rich carbon isotopes but also agrees with theoretical predictions, providing clear evidence for the Z = 6 magicity in ^{15}C.
In the future, Peking University and FLNR will be committed to leverage each other's advantages to carry out more and deeper cooperation and experiments in China and Russia.