Probing the $Z = 6$ spin-orbit shell gap with $(p, 2p)$ quasi-free scattering reactions

jizheng Bo, junzhe Liu

October 30, 2022

Main points(Abstract)

- Provide key spectroscopic information
- The structure of exotic nuclei, the shell evolution
- The $Z = 6$ spin-orbit shell gap towards the neutron dripline
- $N(p, 2p)C$ quasi-free scattering reactions
- A moderate reducion of the proton $1p_{1/2} - 1p_{3/2}$ spin-orbit splitting

Some concepts

1. The isospin dependence of the nucleon-nucleon(NN) residual interaction $\rightarrow$ the magic numbers near the stability line are not necessarily the same for exotic nuclei (which have large neutron-proton asymmetry)
2. The spin-orbit shell gap originates from the splitting of the $1p_{1/2} - 1p_{3/2}$ orbits.
3. The tensor and 2-body spin-orbit forces acting on the 1p protons $\rightarrow$ a quenching of the splitting (when neutrons are added in the $d_{5/2}$ and $s_{1/2}$ orbits)
4. Results show the increase in the proton component (which signals a quenching of the $Z = 6$ $1p_{1/2} - 1p_{3/2}$ gap towards the dripline)

Experimental details

setup

- A beam of Ar bombarded Be target $\rightarrow$ products
- FRS: the fragment separator
- $R^3B/LAND$: the setup which enables a kinetically complete measurement of QFS(p,2p) reactions in inverse kinematics
- The Crystal Ball (XB) detector array: the QFS reactions and γ rays from the decay of excited states are detected

Experimental details

data → PID (the particle-identification plots)

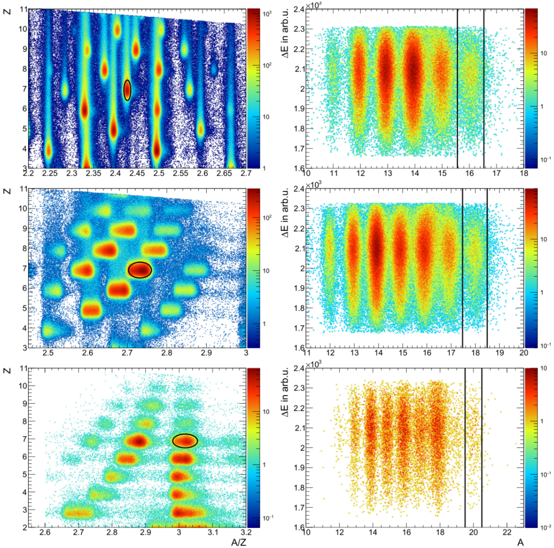


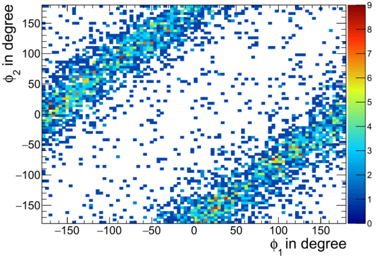
Fig. 1. Incoming (all Z) (left) and outgoing (Z = 6) (right) PID plots for the reaction $^{17}N(p,2p)^{16}C$ (first row), $^{19}N(p,2p)^{18}C$ (second row), and $^{21}N(p,2p)^{20}C$ (third row) using a CH_2 reaction target. The gates on the isotopes of interest are marked with an ellipsoid (incoming PID plots) and two straight lines (outgoing PID plots).

Experimental details

Table 1
Incoming beam and target properties.

Beam	Energy [MeV/nucleon]	Total # of ions	Target	Thickness [g/cm^2]
^{17}N	438	3.533×10^7	CH_2	0.458
		1.131×10^7	C	0.558
^{19}N	430	2.534×10^7	CH_2	0.922
		1.034×10^7	C	0.935
^{21}N	422	1.693×10^6	CH_2	0.922
		5.127×10^5	C	0.935

Figure: The target properties as well as the energy of the incoming isotopes



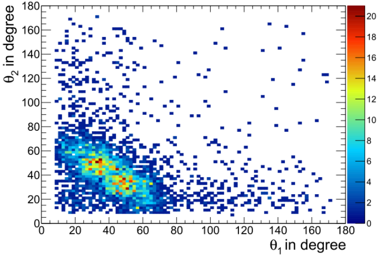


Figure: The distribution of the protons in the laboratory frame

Thank you for your listening!