Search for Homologous States in ^{139,140}Pr by Means of the $(\vec{p},\alpha)$ Reaction

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The ^{142,143}Nd$(\vec{p},\alpha)^{139,140}$Pr reactions have been measured at 23.5 MeV incident proton energy from the Munich MP Tandem accelerator and the Stern-Gerlach atomic beam source of negative polarized hydrogen ions [1]. The proton beam current intensity was up to 1.5 μA and the beam polarization $\approx 60\,\%$. 82 μg/cm^2 thick ^{142,143}Nd$_2$O$_3$ isotopically enriched targets (98.26 %, 91.68 %, respectively) were evaporated on an 8 μg/cm^2 carbon backing. The reaction products were analyzed with the Q3D magnetic spectrograph and detected by the focal plane detector with cathode strip readout [2]. To provide the energy calibration of the ^{139,140}Pr spectra the ^{123}Sb$(\vec{p},\alpha)^{120}$Sn reaction has been used.

The target nuclei ^{142,143}Nd chosen for the present study are such that the lighter member of the pair has a magic neutron shell so that the additional neutron in the heavier member occupies a higher shell. Comparison of the cross sections and asymmetries of the (p,α) reactions on the two isotopes thus provides information on the role of the extra unpaired neutron. Previous studies of the (p,α) reaction on these nuclei, based on a low resolution experiment [3], showed that to a large extent this neutron acts as a spectator so that the reaction takes place mainly with the core. This explains the similarity between the spectra for the two reactions; they show almost the same structure, but are shifted by an energy value corresponding to the gap between the unpaired neutron and closed shell, i.e. between the 2f$_{7/2}$ neutron level above the N = 82 magic shell and 2d$_{3/2}$ level which completes this shell. This energy gap can be estimated from the excitation energy of the first $7/2^-$ excited state of ^{137}Ba which is strongly populated in the ^{136}Ba(d,p)^{137}Ba reaction and amounts to 1.798 MeV [4].

The aim is now to identify the ^{140}Pr states being homologous to the low excitation energy states of ^{139}Pr and to study the spectator role of the unpaired 2f$_{7/2}$ neutron of the ^{143}Nd target nucleus.

In Fig. 1 the energy spectra measured at $E_\mathrm{p} = 23.5$ MeV and $\theta = 20°$ of the ^{143}Nd$(\vec{p},\alpha)^{140}$Pr reaction up to $E_\mathrm{x} \simeq 3.300$ MeV and the ^{142}Nd$(\vec{p},\alpha)^{139}$Pr reaction up to $E_\mathrm{x} \simeq 1.500$ MeV are shown.

The excitation of low lying levels of ^{140}Pr below the energy gap of ≈ 1.8 MeV can be attributed to the unpaired 83^{rd} neutron of ^{143}Nd. Moreover, the similarity of the spectra of the two reactions [3] suggests that mostly the neutrons of the N = 82 shell are involved in the ^{143}Nd$(\vec{p},\alpha)^{140}$Pr reaction.

References

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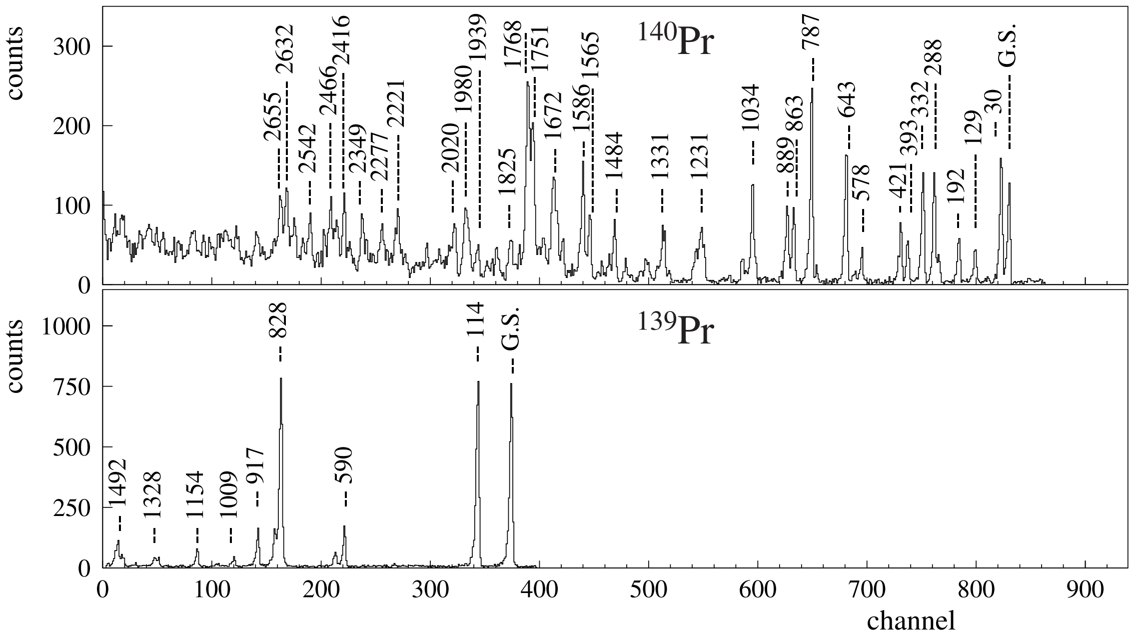

Fig. 1: α-spectra for the ^{143}Nd$(\vec{p},\alpha)^{140}$Pr (top) and the ^{142}Nd$(\vec{p},\alpha)^{139}$Pr reaction (bottom). Numbers: E_x in keV.