Study of ^{49}Ca in One-Neutron Transfer Reactions ◇

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1. Introduction

Recent interest in the Calcium region arises from new shell model calculations which predict a shell closure in the Calcium region at N=34 [2]. Since neutron-rich Ca isotopes beyond ^{48}Ca are only avaliable at low intensity, only knockout reactions could be studied with sufficient statistics. An experiment to study single neutron knockout on ^{52}Ca and ^{50}Ca at the fragment separator FRS at GSI is in preparation.

Due to the fact, that knockout reactions in the A≈50 region are no established method, the results have to be compared to transfer reactions. Single-nucleon transfer reactions are well established from many studies with stable nuclei, see [1]. We performed two different single-neutron pickup experiments with ^{48}Ca in normal and inverse kinematics. The inverse kinematic method is essential for the study of radioactive nuclei which are only avaliable as beam.

In the ^{50}Ca single neutron knockout, the $7/2^{-}$-^{49}Ca state, will be one of the strongest reaction channels. Special effort was devoted in the normal kinematics reaction to search for this so far unobserved state.

2. d(^{48}Ca,^{49}Ca)p

A d(^{48}Ca,^{49}Ca)p experiment was carried out using a deuterated Titanium target (0.7 mg/cm^2) and a 105 MeV ^{48}Ca beam (2.19 MeV per nucleon) from the Cologne Tandem. The γ-rays were detected with 18 six-fold segmented HPGe crystals of the MINIBALL array grouped in six clusters. Three of these clusters were positioned at $\theta \approx 45°$ and three at $\approx 135°$ with respect to the beam direction. The light reaction products, protons from the pickup reaction, deuterons from elastic scattering, were detected in a 300 μm thick CD-shaped double sided silicon strip detector (DSSSD) segmented in 48 rings on the front side (pitch 0.5 mm) and 16 sectors on the back side. The particle detector covered $\theta = 30°$ to $\theta = 60°$ in the laboratory system. Scattered Titanium or Calcium nuclei were stopped in a 30 μm thick Aluminium foil covering the active area of the DSSSD.

Because the emitting nucleus was moving in the laboratory frame with $\beta = 0.06$, a Doppler correction of the γ-ray energies is important. Correcting with respect to the position of the segments of the crystals, a relative resolution of ≈ 0.7 % (15.7 keV FWHM at 2023 keV, 30.5 keV FWHM at 4424 keV) was achieved. Figure 1 shows the Doppler corrected γ-spectrum. All lines in the spectrum are identified, four assignments are shown. The protons will be used to determine angular distributions of the different exited states in ^{49}Ca. The yield of the elastic scattered deuterons will allow us to determine the absolute cross sections.

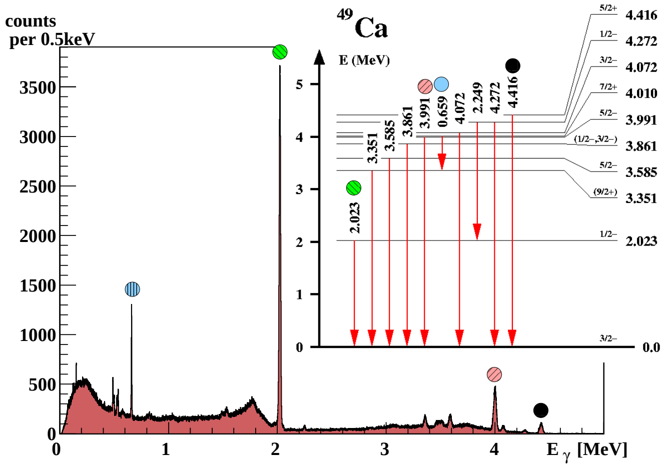

Fig. 1: Doppler corrected γ-energy from the d(^{48}Ca,^{49}Ca)p reaction (E(^{48}Ca)=105 MeV) detected with the MINIBALL spectrometer

3. ^{48}Ca($\vec{d}$,p)^{49}Ca

A second experiment was performed in normal kinematics at the MLL. This provides the possility to compare the data obtained in inverse kinematics involving γ-spectroscopy with data obtained in normal kinematics involving particle spectroscopy.

For this experiment, the MLL Tandem provided a polarized deuteron beam with an energy of 14 MeV. A 130 μg/cm^2 thick metallic ^{48}Ca target was used. The outgoing protons of the ($\vec{d}$,p) reaction were detected with the Q3D spectrometer using a light ion detector [3]. Seven different angular positions were measured from 5° to 50° covering an excitation energy range from 0 MeV to 7.5 MeV. Angular distributions of all populated states in ^{49}Ca will provide the orbital momentum of these states. The asymmetry of measurements with different spin polarities allows us to determine the spin orientation and hence the total angular momentum of the exited state. A first candidate for the $7/2^{-}$ state has been identified with statistics of ≈300 counts from three days beam on target.

References

[1] N. Glendenning, Direct nuclear reactions, Acad. Press, 1983
[2] M. Honma *et al.*, Phys. Rev. C **65** (2002) 061301
[3] H. Wirth, Ph.D. thesis, TU München, 2001

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