Study of deep hole states by ^{40}Ca$(p,2p)^{39}$K reaction

Y. Yasuda, H. Sakaguchi, T. Noro[a], O. V. Miklukho[b], V. A. Andreev[b], M. N. Andronenko[b],
G. M. Amalsky[b], S. L. Belostotski[b], O. A. Domchenkov[b], O. Ya. Fedorov[b], K. Hatanaka[c],
M. Itoh, A. A. Izotov[b], A. A. Jgoun[b], J. Kamiya[c], T. Kawabata[c], A. Yu. Kisselev[b],
Y. Kitamura[c], M. A. Kopytin[b], E. Obayashi[c], A. N. Prokofiev[b], D. A. Prokofiev[b],
V. V. Sulimov[b], A. V. Shvedchikov[b], H. Takeda, S. I. Trush[b], M. Uchida, V. V. Vikhrov[b],
T. Wakasa[c], H. P. Yoshida[c], M. Yosoi, and A. A. Zhdanov[b]

Department of Physics, Kyoto University, Kyoto 606-8502, Japan
[a]*Department of Physics, Kyushu University, Fukuoka 812-8581, Japan*
[b]*Petersburg Nuclear Physics Institute, Gatchina 188350, Russia*
[c]*Research Center for Nuclear Physics, Osaka University, Ibaraki 567-0047, Japan*

The spectroscopic factor and the width of the deep orbital states attract many people, since they are related to short range correlations between nucleons, and the residual interactions inside the nucleus. Most of the nuclear physicists thought the width of the deep hole states too broad to be observed as a peak.

According to the report of the high resolution $(e,e'p)$ experiments at NIKHEF, the sum of spectroscopic factors for orbits close to the Fermi surface decreases to about 60~70% of $(2j+1)$ which is the shell model limit[1]. It is thought as an effect of short range correlations, since the reduction factor seems to be explained by the nuclear matter calculation. On the other hand spectroscopic factors for deep orbital states have not been measured until now. It is due to the difficulty to observe deep hole states. Because nucleons in deep orbital states feel higher density rather than near surface, the short range correlation might affect the spectroscopic factor more strongly in deep orbital states. Hence, it is interesting to investigate spectroscopic factors for deep orbital states.

Until now no one except people at Petersburg Nuclear Physics Institute(PNPI) has successfully observed the deep hole 1s states for medium and heavy nuclei[2]. They showed separation energy spectra of $(p,2p)$ and (p,np) reaction at 1 GeV. They used a detector pair of a magnetic spectrometer and an array of plastic scintillators to measure two scattered nucleons. They reported also the 1s state energy spectra of the heavy nuclei, like ^{90}Zr and ^{208}Pb [3]. However they did not report the cross section value of the spectra. In order to discuss spectroscopic factors, it is necessary to measure the absolute cross section.

In March 2000 and March 2001 we performed $(p,2p)$ experiment with 1 GeV proton beam from PNPI synchrocyclotron. We have used a two-arm magnetic spectrometer for momentum analysis of two scattered protons and have measured absolute cross sections with a newly calibrated luminosity monitor. The two-arm spectrometer consists of a high-momentum (MAP) and a low-momentum (NES) spectrometer arms and MWPC polarimeters at the focal planes of the both spectrometers. The cross section of $(p,2p)$ reaction strongly depend on the recoil momentum of the nucleus which approximately reflect the momentum of the knock-out proton before the scattering. At zero recoil momenta of the nucleus, cross section for the p or d states has a minimum, and that of s(l=0) state becomes maximum. Thus we have chosen the condition that $1s_{1/2}$ state enhances and 1p states are suppressed. One of the secondary protons was detected by the spectrometer MAP at the angle $\theta_1 = 13$ deg. with a magnetic field for the 875 MeV proton in the central orbit, and the other was detected by the spectrometer NES at the angle $\theta_2 = 64$ deg. with a magnetic field for the 75 MeV proton in the central orbit. Besides, we reduced the vertical angular acceptance of spectrometers by

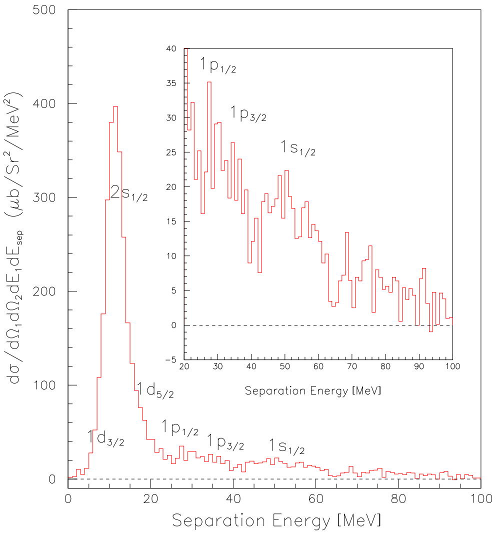

Figure 1: Separation Energy Spectrum for ^{40}Ca$(p,2p)^{39}$K reaction at 1 GeV initial proton energy.

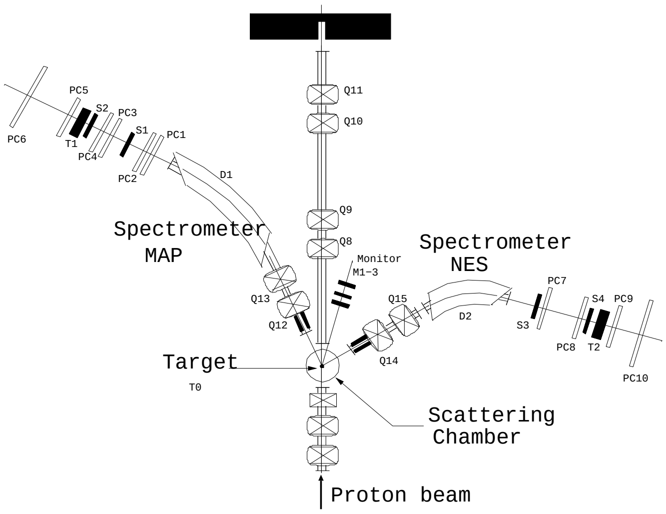

Figure 2: Setup of this experiment.

the slits to limit the recoil momentum of the nucleus.

The separation energy spectrum for ^{40}Ca$(p,2p)^{39}$K reaction which we have obtained in this experiment is shown in Fig.1. We notice the bump structure of $1s_{1/2}$ state at about 50 MeV is showing. This is consistent to the result of the previous experiment at PNPI. Assignment of orbital states is according to S. S. Volkov *et al.*[2]. Detailed analysis of spectroscopic factor for $1s_{1/2}$ is in progress. In order to obtain more accurate data, further experiments with good statistic and low background are necessary.

We also performed ^{40}Ca$(p,2p)^{39}$K experiment with 392 MeV proton beam from the ring cychrotron of Research Center for Nuclear Physics (RCNP). For this experiment, we installed slits at the front of both spectrometers to limit the angular acceptance and the recoil momentum of residual nuclei and chose the condition in such a way that 1p states are suppressed. However protons which lost the energy at the slits or somewhere in the york came into detectors and became a background in this experiment. In order to reduce the background and to limit the recoil momentum, we are now preparing new slits and counter system in front of spectrometers to tag scattering angles of protons accurately.

References

[1] L. Lapikás, Nucl. Phys. **A533** 297c (1993).
[2] S. S. Volkov *et al.*, Yad. FHz. **52** 1339 (1990).
[3] A. A. Vorob'ev *et al.*, Phys. Atom. Nucl. **57** 1 (1994)