Experimental study of the ^{208}Pb($\vec{p}, 2p$)^{207}Tl reaction at 392 MeV

T. Ishida,[a] S. Asaji,[a] K. Fujita,[b] Y. Hagihara,[a] K. Hatanaka,[b] G. C. Hillhouse,[c] J. Kamiya,[d] S. Kishi,[e] T. Kudoh,[a] T. Noro,[a] K. Sagara,[a] H. Sakaguchi,[e] Y. Sakemi,[b] Y. Shimizu,[b] S. Shimomoto, M. Shiota, H. Takeda,[f] Y. Tameshige,[b] S. Terashima,[e] M. Uchida,[e] T. Wakasa,[a] Y. Yasuda,[e] T. Yonemura and H. P. Yoshida,[b]

[a]*Department of Physics, Kyushu University, Hakozaki, Fukuoka 812-8581, Japan*
[b]*Research Center for Nuclear Physics (RCNP), Ibaraki, Osaka 567-0047, Japan*
[c]*Department of Physics, University of Stellenbosch, Matieland 7602, South Africa*
[d]*Japan Atomic Energy Research Institute (JAERI), Naka, Ibaraki 319-1195, Japan*
[e]*Department of Physics, Kyoto University Kyoto 606-8502, Japan*
[f]*Institute for Chemical and Physical Research (RIKEN), Wako, Saitama 351-0106, Japan*

Measurement of the differential cross section and the analyzing power for ^{208}Pb ($\vec{p}, 2p$) ^{207}Tl reaction is in progress at an incident beam energy of 392 MeV. The purpose of the study is to examine a relativistic effect on quasi-free scattering at intermediate energies by comparing the experimental data with relativistic and non-relativistic calculations with distorted wave impulse approximation (DWIA). In order to avoid theoretical difficulties in handling the recoil effect, a heavy nucleus, ^{208}Pb, is used as a target for this study.

On the same nuclear reaction, a South Africa group has compared their experimental data with various kinds of theoretical calculations at an incident energy of 202 MeV. In their analysis, they have also shown that the relativistic DWIA calculation, which gives better result than non-relativistic one for some measuremental conditions and worse result for other conditions. But from a view-point to examine the relativistic effects, studies at higher energy is preferable. In addition, the energy resolution of their measurement is comparable with separations of adjacent peaks and they separate them by using peak fitting only for a part of their data.

In order to separate the $3s_{1/2}$ ground state of ^{207}Tl from the $2d_{3/2}$ first excited state (351 keV) and the $2d_{5/2}$ (1683 keV) third excited state from the $1h_{11/2}$ (1348 keV) second excited state, we have made an effort to improve energy resolution of the measurement, especially energy measurement by using the spectrometer LAS. Momentum of each particle detected at focal plane of LAS are deduced by using a polynomial function of the horizontal position x, the vertical position y, the horizontal angle θ and the vertical angle ϕ as

$$\delta = \sum_{ijkl} a_{ijkl} x^i y^j \theta^k \phi^l,$$

where $\delta = (p - p_0)/p_0$ is a deviation of the particle momentum from the value corresponding to the central orbit of LAS, and a_{ijkl} represents a coefficient of the polynomial. However, as the coefficients used presently were determined by using calibration data when the energy spread of the beam was significantly larger than the present beam. Accordingly, we revised them by using newly taken data of $p + {}^{40}$Ca elastic scattering at $E_p = 200$MeV varying magnetic field so as to place the peak at $-13.5, -8, 0, 8, 17\%$ of δ. In addition, we also made a measurement in order to revise the coefficients of a polynomial function for reconstruction of the scattering angle of the detected particle. For this purpose, a slit with an aperture of ± 5 mrad was placed at $0, \pm 25, \pm 50$ mrad of the entrance angle of LAS.

In the actual analysis of the $(p, 2p)$ data, the separation energies for each event was calculated with additional correction terms which are introduced and determined purely phenomenologically as functions of energy E_{gr}, the horizontal angle θ_{gr} measured by GR, and θ_{las} measured by LAS. Contributions of this correction terms were less than $\sim$ 400 keV.

Until now, we measured momentum distribution of cross section and analyzing power of the ^{208}Pb$(\vec{p}, 2p)^{207}$Tl reaction under a condition where the setting angles of GR and LAS were fixed at 32.5° and 50.0° respectively.

Figure 1 shows the separation energy spectrum of the reaction. The widths of the peaks are 194 $\sim$ 272 keV in FWHM. Now improvement of energy resolution has been achieved and further analysis for cross section and analyzing power is in progress.

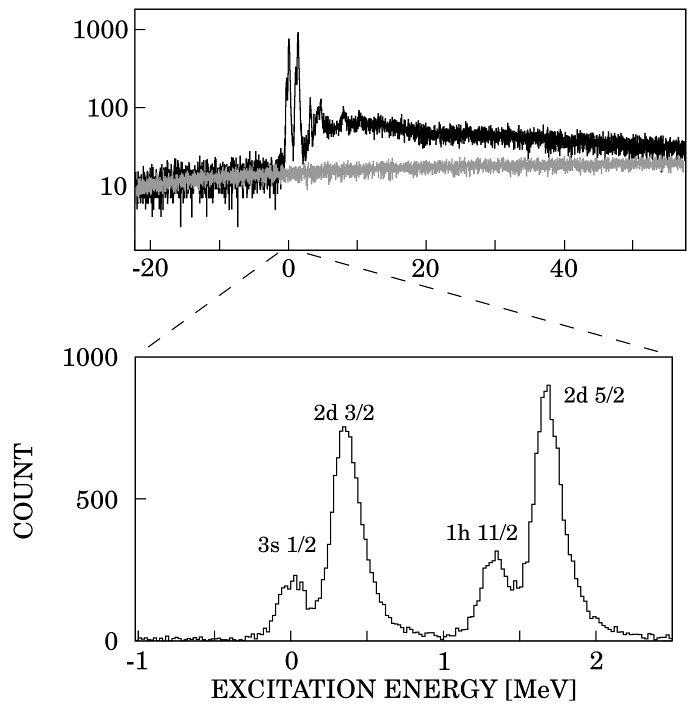

Figure 1: The separation energy spectrum of ^{208}Pb$(\vec{p}, 2p)^{207}$Tl reaction at 392 MeV reconstructed with newly determined coefficients. On a top figure, the separation energy spectrum including accidental coincidence events is plotted with a black line in logarithmic scale. The contribution of the accidental events is also shown with a gray line. An expanded spectrum, after the subtraction of the accidental contribution, is shown on the bottom of the figure in a linear scale. Four different stats of our interest are reasonably well resolved.

References

[1] R. Neveling *et al.*, Phys. Rev. **C66** (2002) 034602.