Measurement of alpha elastic scattering on ^{15}O

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The measurement of alpha elastic scattering on ^{15}O for studying the resonance states of ^{19}Ne was performed by using the CRIB (CNS Radioactive Ion Beam separator) at the Center for Nuclear Study, University of Tokyo. Alpha-cluster structures have been an interesting subjects of study. Several investigations of alpha-cluster structures have been conducted on 4N nuclei such as ^{8}Be, ^{12}C, ^{16}O, and ^{20}Ne.[1–3] In the case of ^{19}Ne, because the system of nuclei can be regarded as ^{20}Ne plus one hole, weakly coupled states of the alpha and hole have been studied theoretically in the low-excitation energy region, but limited experimental data are available, till date. Therefore, experimental study of alpha elastic scattering on ^{15}O is very crucial for understanding how alpha clustering is manifested in proton-rich nuclei. Unknown alpha-cluster states of ^{19}Ne from 1^- and 3^- members ($K^\pi = 0^-$ cluster band of ^{20}Ne) as well as 4^+ and 6^+ members ($K^\pi = 0^+$ cluster band of ^{20}Ne) can be identified by performing alpha elastic scattering on ^{15}O. Because the study of alpha cluster states of ^{19}Ne has been carried out theoretically, this experimental result can be used to confirm the alpha-cluster structure of Z>N nuclei of Ne isotopes.[4,5]

Moreover, astrophysically, the ^{18}F$(p,\alpha)^{15}$O reaction is very important because the amount of ^{18}F produced in a nova depends sensitively on the reaction rates of ^{18}F$(p,\alpha)^{15}$O and ^{18}F$(p,\gamma)^{19}$Ne.[6] To date, experimental studies using ^{18}F beams as well as theoretical works have been reported competitively. However, resonance parameters of relevant states above the proton threshold at $E_x = 6.411$ MeV have not been confirmed and remain controversial.[7–9] Therefore, if the resonance properties of ^{19}Ne using ^{15}O$(\alpha,p)^{18}$F are studied, which is a time reverse reaction of ^{18}F$(p,\alpha)^{15}$O, we can expect better results because the ^{15}O + α threshold energy is only 3.53 MeV(E_x of ^{19}Ne).

In this study, the ^{15}O$(\alpha,\alpha)^{15}$O reaction was measured in the energy range $E_{c.m.} = 1.5 - 7.1$ MeV, which corresponds to $E_x = 5.0 - 10.6$ MeV of ^{19}Ne. The primary beam, ^{15}N (7.0 MeV/u, 0.6 pμA), was transported from the AVF cyclotron and impinged on a hydrogen gas target with a thickness of 1.09 mg/cm^2. The secondary beam, ^{15}O, was obtained by the $p(^{15}\text{N},n)^{15}$O reaction. Fig. 1 shows beam identification for ^{15}O and other contaminations on the F2 focal plane. The main contamination of the secondary beam was ^{15}N, the primary beam. ^{15}O beams of 6×10^5 counts/s were collected at the F3 chamber which contains He gas and a Si telescope and the beams were 96 % pure after passing through a Wien filter. The energy of the ^{15}O beam was 34 MeV after the entrance window (Mylar 25 μm-thick) of the F3 chamber.

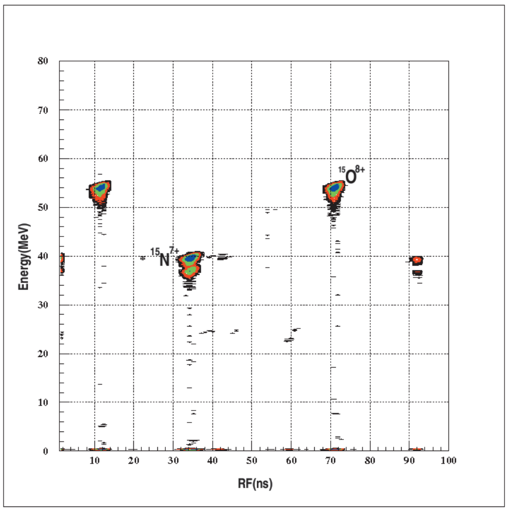

Fig. 1. Secondary beam identification on the F2 focal plane.

For inducing alpha elastic scattering, we filled He gas directly in the F3 chamber without a special gas cell. We installed the one-set telescope of consisting two Si layers (20 μm-thick and 480 μm-thick, respectively) at zero degrees; it was located at a distance of 200 mm from the entrance window of the chamber and the pressure of ^{4}He gas was 760 Torr at room temperature, which is equivalent to that for an effective thickness of 3.33 mg/cm^2. The data are currently being analyzed.

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References

1) K. Ikeda et al.: Prog. Theor. Phys. Suppl. **68**, 1 (1986)
2) H. Horiuch et al.: Suppl. Prog. Theor. Phys. **192**, 1 (2012)
3) M. Freer : Rep. Prog. Phys. **70**, 2149 (2007)
4) F. Nemoto and H. Bando: Prog. Theor. Phys. **47**, 1210(1972)
5) T. Sakuda and F. Nemoto: Prog. Theor. Phys. **62**, 1274 (1979)
6) M. Hernanz et al.: Astrophys. J. **526**, L97 (1999)
7) D. W. Bardayan et al.: Phys. Rev. C **70**, 015804 (2004)
8) H. Fortune et al.: Phys. Rev. C **73**, 024302 (2006)
9) A. St. J. Murphy et al.: Phys. Rev. C **79**, 058801 (2009)