2 - 17 Experimental Study of Key Astrophysical $^{18}Ne(\alpha,p)^{21}Na$ Reaction

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A nuclear astrophysics experiment was performed at CRIB (CNS low-energy Radioactive-Ion Beam separator) on Mar. 2011. The goal of this experiment is to study the reaction rate of $^{18}Ne(\alpha,p)^{21}Na$ reaction, which might be a key breakout reaction from the hot CNO cycle to rp-process in X-ray burst and nova. Yet its reaction rate is poorly known.

Explosive hydrogen burning is thought to be the main source of energy generation and a source of nucleo synthesis in X-ray burst and nova[1,2]. In X-ray burst, for example, under its typical temperature 0.4 ~2 GK, the hydrogen burning occurs from the hot CNO cycle:

$$^{12}C(p,\gamma)^{13}N(p,\gamma)^{14}O(e^+\ \nu)^{14}N(p,\gamma)^{15}O(e^+\ \nu)^{15}N\ (p,\alpha)^{12}C,$$

while the reaction $^{13}N(e^+\ \nu)^{13}C$ in CNO cycle is bypassed by $^{13}N(p,\gamma)^{14}O$. As the compressing and exothermic nuclear reactions proceeding, the temperature of the accretion disk becomes higher. When it reaches about 0.4 GK, the second hot CNO cycle becomes dominant:

$$^{12}C(p,\gamma)^{13}N(p,\gamma)^{14}O(\alpha,\ p)^{17}F(p,\gamma)^{18}Ne(e^+\ \nu)^{18}F(p,\alpha)^{15}O(e^+\ \nu)^{15}N(p,\alpha)^{12}C,$$

It is predicted[1,2] that the ^{18}Ne waiting point in the second hot CNO cycle can be bypassed by the $^{18}Ne(\alpha,p)^{21}Na$ reaction at $T\sim0.6$ GK, and subsequently the reaction-chain breaks out to the rp-process, so it is very important to study this reaction rate.

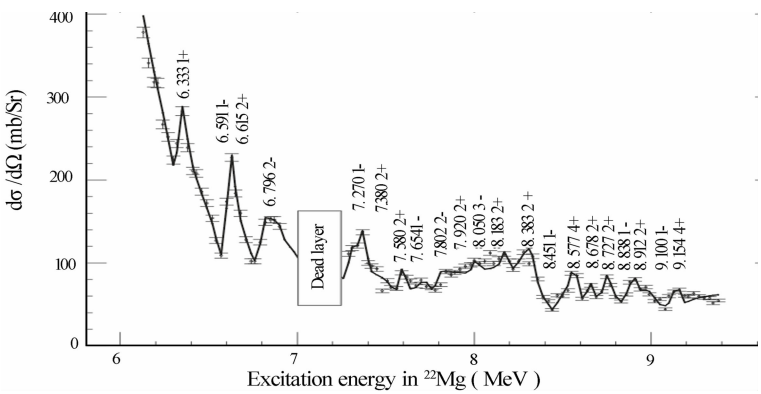

Fig. 1 Elastic-scattering proton spectrum with a typical *R*-matrix fitting (preliminary).

The experimental setup and data analysing was illustrated in Ref. [3], we will mainly discuss the most present result here. In this work, totally 21 levels in ^{22}Mg were observed, and their spin-parities and proton widths have been determined by fitting the $^{21}Na+p$ elastic-scattering data with an *R*-matrix code MULTI[4]. The doublet at 8.451 and 8.577 MeV is confirmed, and new spin-parity assignments for states above the α threshold, i.e., 8.383, 8.451, 8.678 and 8.727 MeV, were given based on the present *R*-Matrix analyses. Fig. 3 shows a typical *R*-matrix fitting for the c.m. differential cross section of the resonant elastic scattering of $^{21}Na+p$ measured at $E_{c.m.}\approx175°$. Nowadays, the data analysis is still going on. The impact of our new J^π values on the $^{18}Ne(\alpha,p)^{21}Na$ reaction rate, as well as on the nucleosynthesis in X-ray burst will be studied later on.

References

[1] A. E. Champage, M. Wiescher, Annu. Rev. Nucl. Part. Sci., 42(1992)39.
[2] M. Wiescher, et al., J. Phys., G25(1999)R133.
[3] Zhang Liyong, et al., IMP & HIRFL Annual Report, (2012)52.
[4] R. O. Nelson, et al., Nucl. Instr. and Meth., A236(1985)128.