# Confirmation of the astrophysically important 6.15-MeV, $1^-$ state in $^{18}$Ne via resonant proton scattering of $^{17}$F+$p$

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The $^{14}$O($\alpha$, $p$)$^{17}$F reaction is important during the ignition phase of X-ray bursts. However, thus far, the rate of this reaction remains unknown. Therefore, studies on this reaction are of great importance in researching explosive stellar environments in a nuclear astrophysics context. The $^{14}$O($\alpha$, $p$)$^{17}$F reaction is mainly resonant, and its reaction rate depends on the resonant properties of the excited states that are above the $\alpha$ threshold in the compound nucleus $^{18}$Ne. A state observed in $^{18}$Ne at $E_x$ = 6.15 MeV has been tentatively identified as the important state, which could be dominated at low temperatures.

The experiment was performed using the CNS radioactive ion beam separator (CRIB)[1]. A primary beam of $^{16}$O$^{6+}$ was accelerated up to 6.6 MeV/nucleon with an average intensity of 560 $e$nA. A $D_2$ gas target was bombarded with the primary beam, resulting in the production of a secondary beam of $^{17}$F via the $^{16}$O($d$, $n$)$^{17}$F reaction in inverse kinematics. The $^{17}$F beam, with a mean energy of 61.9 MeV and an average intensity of 2.5×10$^5$ pps, was then delivered to the F3 experimental chamber where it bombarded a thick $H_2$ gas target. The recoiled light particles were measured by using three sets of $\Delta E$-$E$ Si telescopes at averaged angles of $\theta_{\rm lab} \approx 3°$, 10°, and 18°, respectively.

The excitation function of $^{17}$F+$p$ elastic scattering cross sections at different scattering angle regions are shown in Fig. 1(a)–(b). Five resonances, *i.e.*, at $E_x$ = 6.15, 6.28, 6.35, 6.85, and 7.05 MeV, all of which with the exception of 6.85 MeV had been observed previously in other ways, were analyzed using the multichannel $R$-matrix calculations.[2] The most probable fitting curves are shown in Fig. 1(a)–(b). As shown in the figure, the fitting results at different scattering angle regions are consistent with each other.

According to our $R$-matrix analysis, see Fig. 1(c), a dip structure around $E_{\rm c.m.}$ = 2.21 MeV corresponding to the 6.15-MeV level in $^{18}$Ne can be fitted as $1^-$ ($s$ = $2^+$, $\ell$ = 1), $\Gamma$ = 50 keV very well. The shape of the dip structure is clear, in contrast to the bump shape

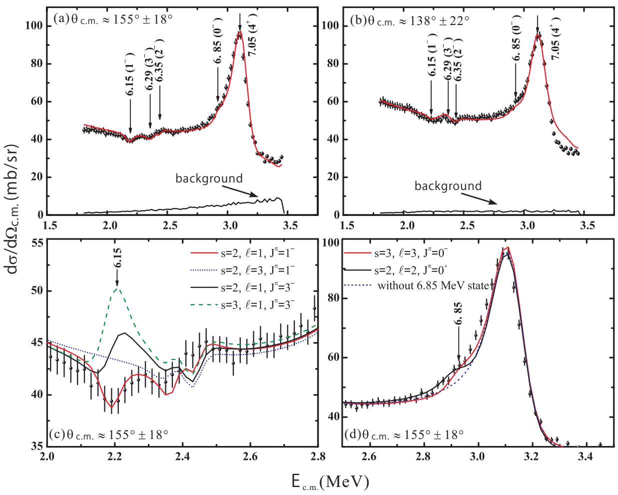


Fig. 1. The center of mass differential cross sections for elastically scattered protons. The curves represent the $R$-matrix fits to the data.

reported previously.[3] The $1^-$ assignment with high statistics in this work firmly maintains the significant position of 6.15-MeV state at low temperatures.

Moreover, a shoulder-like structure around $E_{\rm c.m.}$ = 2.93 MeV was observed (Fig. 1(a) and (b)). This may imply that a new state was discovered at $E_x$ = 6.85 MeV in $^{18}$Ne. Both $0^-$or $0^+$ resonances can reproduce the observed shape, as shown in Fig. 1(d). Because of the small energy shift for the negative-parity states in this excitation energy region[4], this new state is possibly the analog state of $^{18}$O at $E_x$ = 6.88 MeV ($0^-$). Another possibility also exists: This new state could be a candidate of the $0^+$ state, a band-head state of the six-particle four-hole (6p-4h) band.[5]

A more comprehensive analysis and the inclusion of $\alpha$ particle information are in progress.

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