# Recycling neutrons in the s-process: determining the $^{17}O+\alpha$ reaction rates

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The $^{20}Ne(d,p)^{21}Ne$ reaction is capable of providing information on excitation energies, spins and parities, and neutron widths but one major important piece of information needed for the $^{17}O+\alpha$ reaction

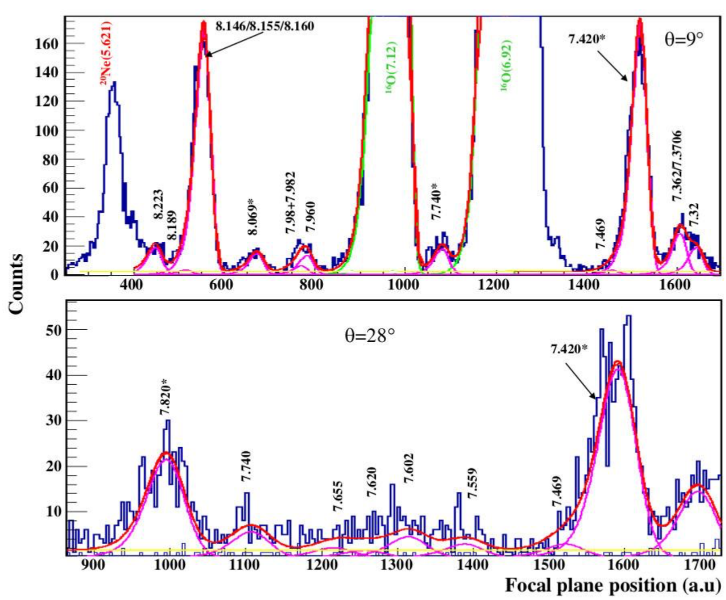


**Fig. 1**. Two focal-plane spectra taken at (top) 9 and (bottom) 28 degrees. The red line shows the total fit, the pink, yellow and green show individual contributions from $^{21}Ne$, $^{20}Ne$ and $^{16}O$ states, respectively. The $^{21}Ne$ state excitation energies (in MeV) are labelled in black, the $^{20}Ne$ in red and the $^{16}O$ in green.

rates, the $\alpha$-particle partial widths of the excited levels in $^{21}$Ne, are unknown. $\alpha$-particle transfer reactions such as $^{17}$O($^{7}$Li,t)$^{21}$Ne can be used to deduce these partial widths from the magnitude of the transfer cross sections. In order to do this, we performed a measurement of this reaction using the Munich Q3D spectrograph. The targets were enriched tungsten oxide deposited on a carbon backing. The beam energy, $E_{7Li}$ = 42 MeV, was low enough that the reactions between the lithium and the tungsten were suppressed due to the Coulomb barrier and so only reactions on the oxygen and carbon (and other contaminants in the targets) took place. Example focal-plane spectra are shown in Fig. 1.

From the spectroscopic information obtained in this reaction, the $^{17}$O+$\alpha$ reactions were again recalculated. This supports the previous calculations which favoured a stronger neutron recycling from the $^{17}$O+$\alpha$ reactions and a stronger s-process in rotating metal-poor stars. Fig. 2 shows the ratios of the reaction rates obtained in this work compared to previous rate evaluations, and additionally the $^{17}$O($\alpha$,n)/$^{17}$O($\alpha$,$\gamma$) reaction-rate ratio. This work has been submitted and is under review.

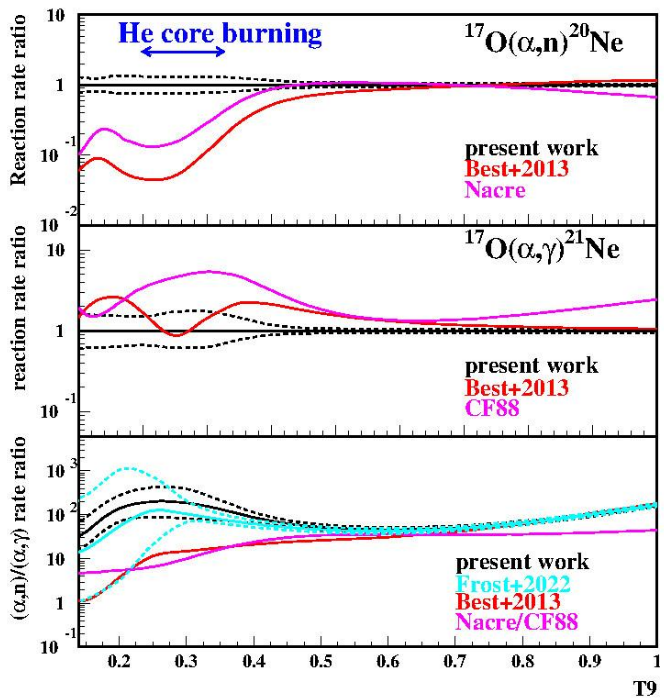


**Fig. 2**. The top two panels show the ratio of the reaction rates described in this work compared to those from previous evaluations. The bottom panel shows the ratio of the $^{17}$O($\alpha$,n)/$^{17}$O($\alpha$,$\gamma$) reaction rates, a measure of the efficiency of the neutron recycling. Ratios above 1 mean that most of the neutrons are recycled.