The impact of ^{17}O+alpha uncertainties on the s-process

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The s-process (the slow capture of neutrons on seed nuclei) is responsible for the production of half of the elements heavier than iron. The s-process occurs when alpha-particle capture reactions on the neutron sources ^{13}C and ^{22}Ne produce neutrons which capture on seed nuclei, typically iron-peak elements, building up the heavier elements. There are two main sites for the s-process, thermally pulsing AGB stars which cause the "main" s-process and the "weak" s-process occurring in massive stars. Rapidly rotating metal-poort massive stars can also play host to an s-process, the so-called "enhanced" s-process. This enhanced s-process is strongly dependent on not only the neutron source reactions but also the presence of ^{16}O which captures neutrons to produce ^{17}O. The competing ^{17}O(alpha,gamma) and ^{17}O(alpha,n) reactions can then either permanently absorb neutrons or release them, enabling s-process nuclei synthesis, respectively. The relative strengths of the ^{17}O+alpha reactions critically influences the neutron recycling and therefore the possible nucleosynthesis in the enhanced s-process.

An experiment using the ^{20}Ne(d,p)^{21}Ne reaction was performed using the TUNL Split-pole Enge spectrograph and the resulting differential cross sections were used to assign spins and parities, and extract neutron widths, of the ^{21}Ne states which control the ^{17}O+alpha reactions. As a result of this experiment, new ^{17}O+alpha reaction rates were computed with associated uncertainties for the first time. These new results show that the enhanced s-process is expected to produce heavy elements up to at least barium and, under extreme assumptions as to the reaction rates and the mixing of CNO material into the helium-burning region, up to around lead. This may help to explain some of the history of galactic chemical evolution since massive stars will enrich the Universe in s-process elements much sooner than AGB stars, and may provide an alternative site to the production of heavy elements before neutron-star mergers can contribute to chemical evolution.

This research was recently accepted for publication in the Monthly Notices of the Royal Astronomical Society https://doi.org/10.1093/mnras/stac1373

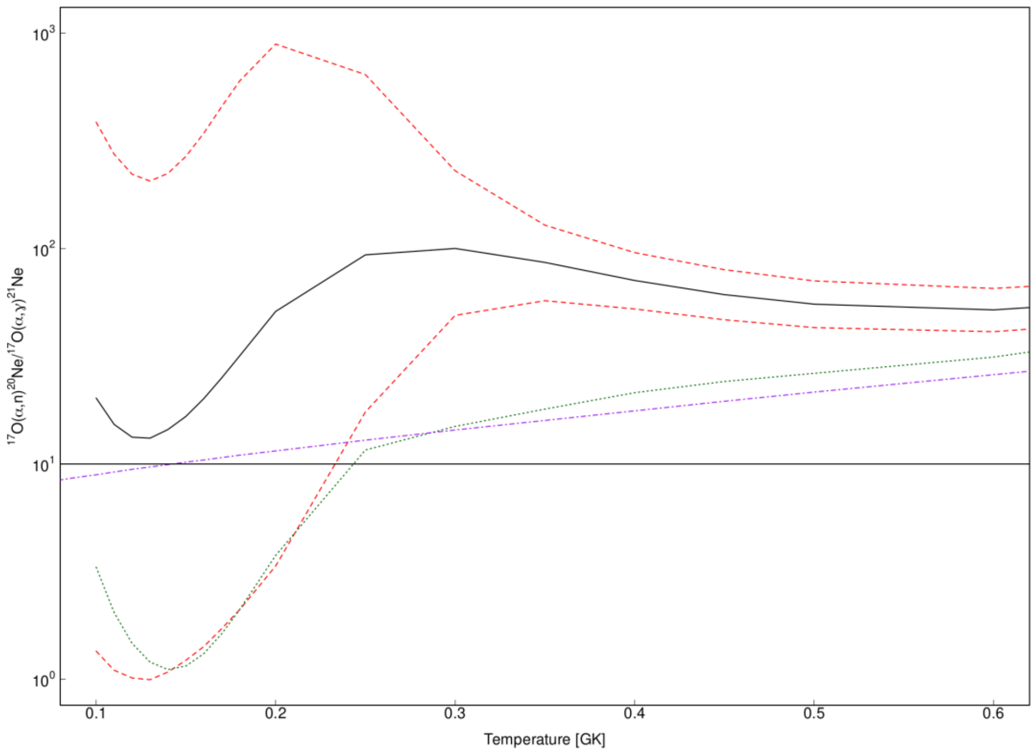

Fig. 1. The ratio of the $^{17}O(alpha,n)^{20}Ne/^{17}O(alpha,gamma)^{21}Ne$ reaction rates as a function of temperature. The green line is the previous ratio from Best (), the purple is the estimate from Caughlan and Fowler '88. The black is the ratio of the median rates from the current work. The red lines are the ratios of the 68% upper (lower) $^{17}O(alpha,n)^{20}Ne$ rate to the 68% lower (upper) $^{17}O(alpha,gamma)^{21}Ne$ rate.