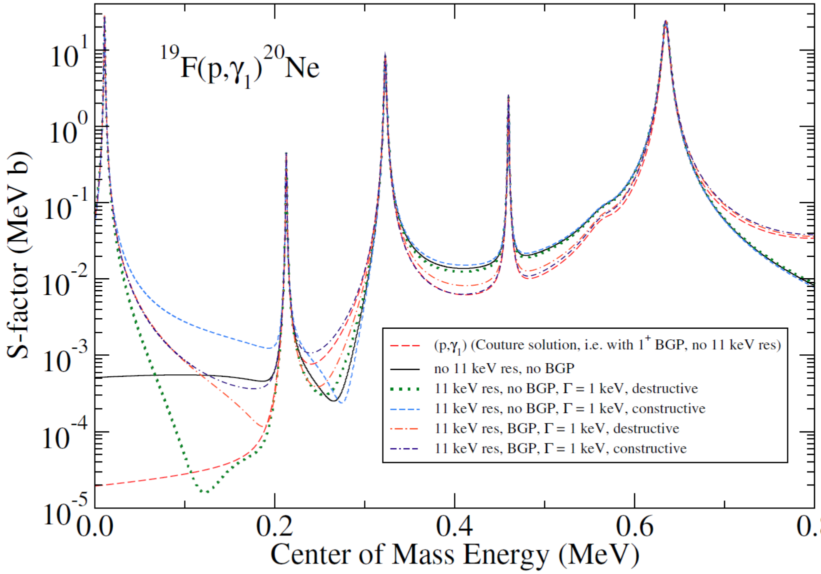
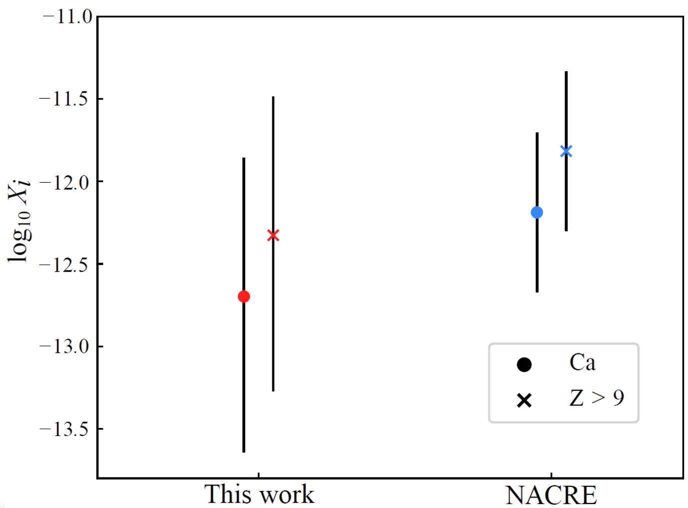
$^{19}F(p,\gamma)^{20}Ne$ and $^{19}F(p,\alpha)^{16}O$ reaction rates and their effect on calcium production in Population III stars from hot CNO breakout

First generation stars have a different evolution than those of later generations owing to their initial primordial abundance composition. Most notably, the lack of carbon, oxygen, and nitrogen, means that the CNO cycles occur at higher temperature compared to later stellar generations. It is currently controversial if the observed enhanced abundances of Ca in the most metal-poor stars could be a result of the high temperature H-burning under these conditions. The level of this enrichment depends on the hot breakout path from the CNO cycles via the $^{19}F(p,\gamma)^{20}Ne$ reaction. In this work, the rates of both the $^{19}F(p,\gamma)^{20}Ne$ and competing $^{19}F(p,\alpha)^{16}O$ reactions are re-evaluated using the phenomenological R-matrix approach. It was found that the rate uncertainty for $^{19}F(p,\gamma)^{20}Ne$ reaction is considerably larger than previously estimated. This is the result of undetermined interferences between observed resonances, a possible threshold state, possible subthreshold states, direct capture, and background levels. Additional experimental measurements are suggested to resolve the open question of Ca production in early stars.





deBoer *et al.* PRC **103**, 055815 (2021)

NSF Grant No. **PHY-2011890** and PHY-1430152 (JINA-CEE)