Stellar Modelling for Nuclear Astrophysics: Constraining the Astrophysical Origin of the p-nuclei

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The production of the p-process nuclides that we observe today in the Solar System is still uncertain. Recent Galactic Chemical Evolution (GCE) calculations, showed that explaining the inventory of the p-nuclides by the contribution from Core collapse supernovae (ccSNe) alone is challenging, thus requiring a complementary contribution from thermonuclear supernovae (SNe Ia), assuming in this last case an s-process rich pre-explosive seeds distribution, built by neutron captures during the accretion phase. Presently there are no complete stellar models calculating these abundances. We calculate accreting white dwarfs (WDs) models with five different initial masses using the stellar code MESA. We then focus on the nucleosynthesis calculating the full abundance distribution. In these models the dominant neutron source are ^{22}Ne(α,n)^{25}Mg, activated at the bottom of the convective thermal pulse driven by the Helium flashes along the accretion phase, for WD masses lower than 1.26 $M_\odot$, and ^{13}C(α,n)^{16}O for WD masses equal or higher than 1.26 $M_\odot$. We found neutron densities up to few 10^{15} cm^{-3} in the most massive WDs. In particular, we obtain a strong production by neutron captures up to the Pb region, showing how the classic assumption of a neutron-capture rich pre-explosive seeds distribution is justified. Using these results, we compute the resulting explosive nucleosynthesis of proton rich heavy stable isotopes using a multi-D SNe Ia model, and discuss the uncertainties affecting our results, focusing in particular on the nuclear reaction-rates which provide the dominant contribution to the production uncertainty, highlighting which of the identified key reactions are realistic candidates for future experiments.