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p-process from Slow White Dwarf Mergers

Thursday 17 October 2024 10:00 (20 minutes)

The astrophysical origins of the heaviest stable elements that we observe today in the Solar System are still not fully understood. Recent studies have demonstrated that H-accreting white dwarfs (WDs) in a binary system exploding as type Ia supernovae could be an efficient p-process source beyond iron. However, both observational evidence and stellar models challenge the required frequency of these events. In this work, we calculate the evolution and nucleosynthesis in slowly merging carbon-oxygen WDs, exploring the impact of different accretion rates, mixing properties and compositions of both the primary and secondary white dwarf. As our models approach the Chandrasekhar mass during the merger phase, the ^{22}Ne(α,n)^{25}Mg neutron source reaction is activated in the external layers of the primary WD, where the carbon-rich material accreted from the secondary WD is burned via the ^{12}C+^{12}C reaction, which provides the necessary α-particles via the ^{12}C(^{12}C,α)^{12}Ne channel. Most importantly, surface carbon-burning is ignited in all our models, once the accretion rate onto the primary is larger than 2 10^{-6} $M_\odot$ yr^{-1}. The resulting neutron capture abundance distribution closely resembles a weak s-process one and peaks at Kr-Rb-Sr-Y-Zr, which are overproduced by a factor of 1000 compared to solar. The mass of the most external layers enriched in first-peak s-process elements crucially depends on the accretion rate of the CO-rich material from the secondary white dwarf, ranging between 0.05 M and ˜0.1 M . These results indicate that slow white dwarf mergers could potentially produce the lightest p-process isotopes (such as ^{74}Se, ^{78}Kr, ^{84}Sr, ^{92}Mo and ^{94}Mo) in significant abundance via γ-induced reactions, if they explode via a delayed detonation mechanism. Alternatively, they may eject the unburned external layers highly enriched in first peak s-process elements in the case of a pure deflagration. In both cases, we propose for the first time that slow WD mergers in binary systems may be a new relevant source for elements heavier than iron.

Length of presentation requested

Oral presentation: 17 min + 3 min questions

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Stellar Models and Galactic Chemical Evolution

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