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Sensitivity Study of Type-I X-ray Burst To Nuclear Reaction Rates

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Neutron stars in low-mass X-ray binaries, accreting hydrogen- or helium-rich material from a companion star, frequently exhibit thermonuclear runaways on their surfaces known as Type-I X- ray bursts (XRBs). These bursts are powered by nuclear processes, such as the triple-α process, the αp process, and rapid proton capture process, which play a critical role in model-observation comparisons. In this study, we investigate the impact of nuclear reaction uncertainties on XRBs using the ONEZONE model (Cyburt et al., 2016), considering different accreted compositions and accretion rates for the binary systems that are within the range of observed burst sources. The study is carried out in two stages. First, we determine the burst ignition conditions by simulating the settling of the accreted material with a full reaction network and a semi-analytical model. Second, we perform a sensitivity analysis by varying proton- and alpha-induced reaction rates in JINA REACLIBV2.2 within their estimated uncertainties. We explore the influence of these reactions on the XRBs light curve and the neutron star crust composition. The findings highlight key nuclear reactions that significantly affect XRB observables and the final abundances produced, offering guidance for future experimental efforts to improve our understanding of the uncertainties in the reaction rates involved in XRBs.
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