Stars on fire -- simulating astrophysical burning in stellar evolution and thermonuclear supernovae

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An essential process in stars is the nuclear processing of material. In several phases of stellar evolution and in the cataclysmic end stages, supernova explosions, the reactions are strongly coupled to fluid flows. Consequently, an appropriate description of such processes is in terms of reactive fluid dynamics. However, the wide range of relevant temporal and spatial scales and the different regimes of burning encountered under astrophysical conditions pose particular challenges. Numerical approaches have been very successful in the transonic regime as will be discussed on the example of thermonuclear supernova explosions. In contrast, low Mach number flows typically occurring in dynamical phases of stellar burning lead to severe problems when treated with traditional schemes. They require special treatment and suitable numerical techniques are currently under development. I will present a promising approach and first astrophysical applications.