Ab initio calculations of nuclear reactions important for astrophysics

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The description of nuclei starting from the constituent nucleons and the fundamental interactions among them has been a long-standing goal in nuclear physics. In addition to the complex nature of nuclear forces with two-nucleon, three-nucleon and possibly even four-nucleon components, one faces the quantum-mechanical many-nucleon problem governed by an interplay between bound and continuum states. In recent years, significant progress has been made in ab initio nuclear structure and reaction calculations based on input from QCD employing Hamiltonians constructed within chiral effective field theory. Among the newly developed methods is the No-Core Shell Model with continuum (NCSMC) capable to describe simultaneously bound and unbound states of light nuclei. I will present NCSMC results for reactions important for astrophysics that are difficult to measure, such as $^7\text{Be}(p,\gamma)^8\text{B}$, $^3\text{He}(\alpha,\gamma)^7\text{Be}$ and $^3\text{H}(\alpha,\gamma)^7\text{Li}$ radiative capture, and the $^3\text{H}(d,n)^4\text{He}$ and $^3\text{He}(d,p)^4\text{He}$ fusion. I will also highlight our recent studies of the exotic $^{11}\text{Be}$ and $^{11}\text{N}$ nuclei and address prospects of calculations of $^{11}\text{C}(p,\gamma)^{12}\text{N}$, $^2\text{H}(\alpha,\gamma)^6\text{Li}$ and $^4\text{He}(nn,\gamma)^6\text{He}$ capture reactions.