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# Forbidden transitions in nuclear weak processes relevant to neutrino detection, nucleosynthesis and evolution of stars

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Important roles of Gamow-Teller transitions have been studied for electron-capture and $\beta$-decay processes at stellar environments [1, 2] as well as $\nu$-nucleus reactions [3]. Importance of first-forbidden transitions in $\beta$-decay rates of N=126 isotones have been shown, and the short half-lives obtained were used to study r-process nucleosynthesis in core-collapse supernova explosions (SNe) and binary neutron-star mergers [4]. Here, we focus more on the roles of forbidden transitions in nuclear weak processes. $\nu$-induced reactions on $^{16}$O, where spin-dipole transitions are dominant, are studied with new shell-model Hamiltonians [5] and SN$\nu$ detection and $\nu$ mass hierarchy dependence of the cross sections [6] as well as nucleosynthesis of light elements such as $^{11}$B and $^{11}$C in SNe [5] are discussed.
Next, we study e-capture processes on $^{20}$Ne which become important in late stage of the evolution of O-Ne-Mg cores in stars. The transition to the ground state in $^{20}$F ($2^+$) is a second-forbidden transition and is important in certain ranges of densities and temperatures [7]. Electron-capture rates for the transition are evaluated with the multipole expansion method, and compared with a simple evaluation using a constant parametrized strength obtained from the beta-decay experiment [8]. Energy dependence of the second-forbidden transition strength is found to lead to a significant difference in the capture rates from the simple parametrized method.

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