Gamow-Teller Strengths in Ni Isotopes and Electron Capture in Gravitational Core-Collapse of Massive Stars

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Electron capture reactions play the most essential roles in the core-collapse processes at the end of the life-cycle of massive stars. Accurate evaluations of the electron capture rates at high densities and temperatures are important to determine the initial conditions for the nucleosynthesis in supernova explosions [1].

Gamow-Teller (GT) transition strengths in Ni isotopes are studied by shell model calculations with the use of a new Hamiltonian in *fp*-shell, GXPF1J [2]. The GT strengths obtained are used to evaluate electron capture rates at stellar environments [1]. Calculated GT strength for ^{58}Ni and ^{60}Ni as well as the experimental data[3,4] are shown in Fig. 1. Calculated sum of the GT strengths obtained by GXPF1J is in fair agreement with observation for both ^{58}Ni and ^{60}Ni. Calculated electron capture rates for ^{58}Ni and ^{60}Ni are shown in Figs. 2.

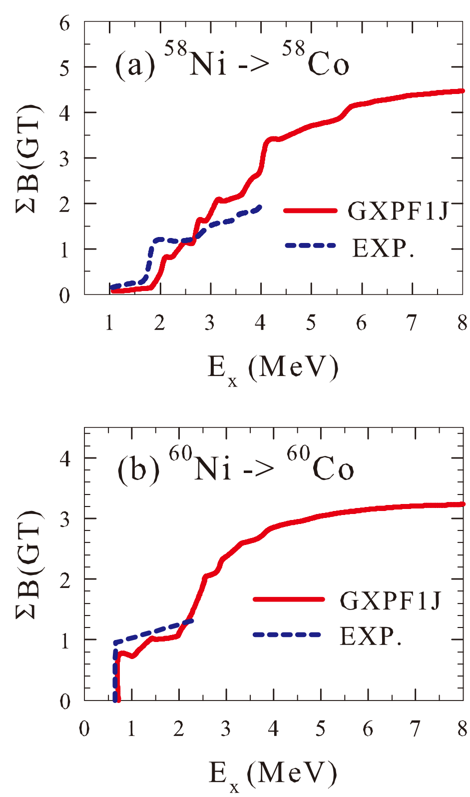

Figure 1: The sum of GT strengths in (a) ^{58}Ni and (b) ^{60}Ni up to the excitation energies (E_x) of ^{58}Co and ^{60}Co. Experimental data are taken from Refs. [3,4].

The calculated capture rates in ^{58}Ni and ^{60}Ni are found to reproduce well the rates obtained by using the experimental GT strengths [3,4]. Better evaluations of the capture rates have been obtained compared with previous calculations [3,4] as well as those by KB3G [5].

The capture rates for ^{56}Ni, and neutron-rich ^{62}Ni and ^{64}Ni isotopes as well as Co and Mn isotopes are also investigated [6]. The GT strengths for GXPF1J are generally more fragmented compared to those of conventional Hamiltonians such as KB3G. The GT distribution in ^{56}Ni obtained by GXPF1 is found to reproduce the recent (p, n) reaction data [7].

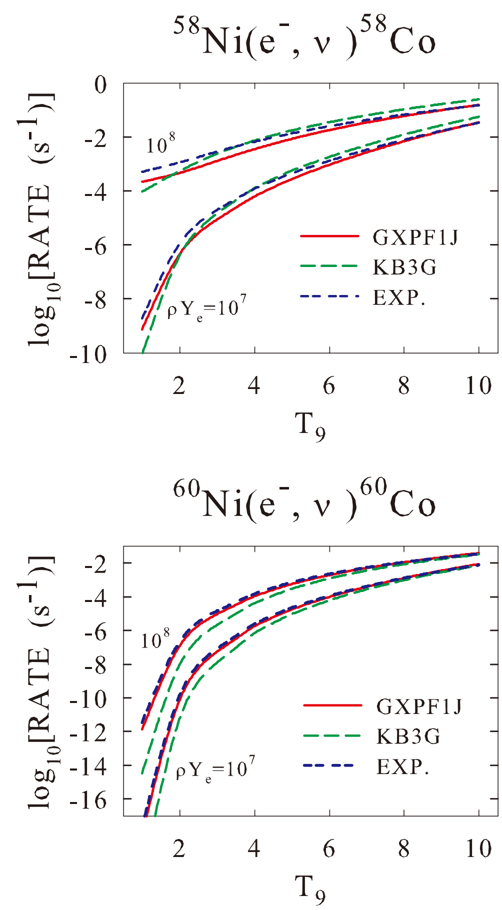

Figure 2: Electron capture rates on ^{58}Ni and ^{60}Ni obtained for GXPF1J and KB3G [5] as well as those obtained by experimental GT strength [3,4].

References

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