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 strengths 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.

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 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].](image)

![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].](image)

References