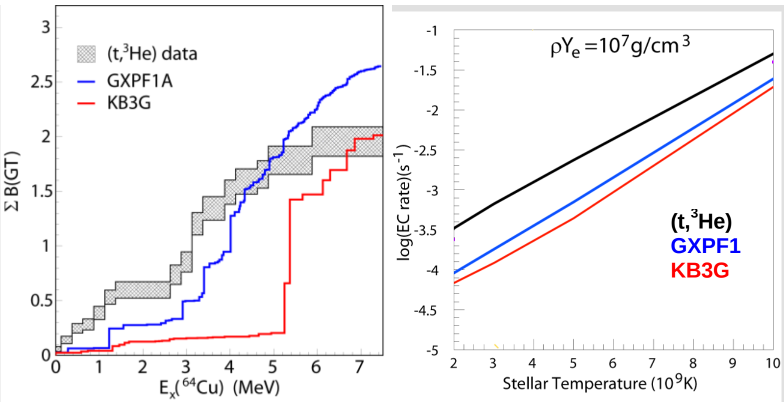
The Joint Institute for Nuclear Astrophysics

Gamow-Teller transitions to ^{64}Cu measured with the ^{64}Zn(t,^{3}He) reaction



Comparison between experimentally extracted Gamow-Teller strengths from the ^{64}Zn(t,^{3}He) data and theoretical predictions in the shell-model using the GXPF1 and KB3G interactions (left panel). Significantly more low-lying strength is found in the data than in the theory, resulting in significant underestimates of electron capture (EC) rates if theoretical strengths are used (right panel).

Electron-capture and β decays processes play significant roles in the evolution of stars. An accurate description of the reaction rates of these processes is important for describing the late stellar evolution of thermonuclear and core-collapse supernovae, as well as the properties of neutron-star crusts. The (t,^{3}He) charge-exchange reactions are excellent probes for studying the relevant nuclear processes, in particular so-called Gamow-Teller transitions. Experiments employing these reactions provide testing ground for theorists who calculate the electron-capture and β decay rates in the stellar environment.

In this work, G.W. Hitt and collaborators focused on the measurement of the ^{64}Zn(t,^{3}He) reaction using the S800 spectrometer at the NSCL. The Gamow-Teller strength distribution for transitions from ^{64}Zn to ^{64}Cu was extracted.

The experimental results were compared with theoretical predictions made in the shell-model using GXPF1 and KB3G interactions. The new shell-model code NuShellX was used, which allowed for calculations without truncations. Although the total Gamow-Teller strength found in the experiment was in reasonable agreement with the theory, the distributions of the strength over excitation energy did not match well; more Gamow-Teller strength was found at low excitation energies in the data. Consequently, electron-capture rates at stellar densities and temperatures calculated based on theoretical and experimental results differ by a factor of ~4. Therefore, further refinement of the theory is warranted. A possible explanation for the discrepancy is the influence of the $g_{9/2}$ orbit on the nuclear structure of the upper pf-shell.

This work formed the basis for the Ph.D. thesis of Wes Hitt.

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Related Web Sites:
http://groups.nscl.msu.edu/charge_exchange/

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