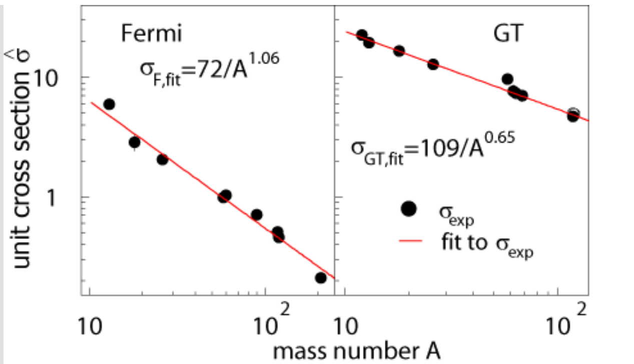
The Joint Institute for Nuclear Astrophysics

Calibrating the extraction of Gamow-Teller strengths with the (^{3}He,t) reaction.



Experimentally extracted unit cross sections for Fermi (left panel) and Gamow-Teller (right panel) transitions (solid dots). These unit cross section are important for extracting weak transition strengths from (^{3}He,^{3}H) and (^{3}H,^{3}He) charge-exchange reactions in cases where direct calibration using known strengths from β-decay is not possible. The simple trends that are observed and fitted are important for extracting reaction rates of relevance for understanding the evolution of massive stars just before they explode as supernovae.

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, for example, important for describing the late stellar evolution of thermonuclear and core-collapse supernovae. The (^{3}He,^{3}H) and (^{3}H,^{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.

The (^{3}He,^{3}H) and (^{3}H,^{3}He) reactions have the advantage over (proton,neutron) and (neutron,proton) reactions that better resolutions can be achieved, thereby providing more detailed information to test the nuclear models. However, the reactions involving ^{3}He and ^{3}H are more complex than those with protons and neutrons and a convincing systematic evaluation of the reliability of the extraction of transition strengths using the (^{3}He,^{3}H) and (^{3}H,^{3}He) reaction was lacking so far.

To fill this gap, the charge-exchange group of the National Superconducting Cyclotron Laboratory (NSCL), together with collaborators from Japan and Europe, performed a detailed study of the (^{3}He,^{3}H) reaction at the Research Center for Nuclear Physics (RCNP) in Osaka. The experimenters measured reaction rates to energy levels in specific nuclei for which the transition strength associated with electron-capture and β decay are known. They then showed that the so-called unit cross sections, which relate the measured reaction rates in the (^{3}He,^{3}H) experiments to these strengths, follow very simple trends as a function of mass number of the target nucleus. These simple trends are now available for extracting the transitions strengths in nuclei for which the unit cross section cannot be calibrated directly using a transition of known strength. Because of the similarity of the (^{3}He,^{3}H) and (^{3}H,^{3}He) reactions, these trends can also be employed in the analysis of (^{3}H,^{3}He) experiments at the NSCL.

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

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