Joint Institute for Nuclear Astrophysics

Indirect Measurements of (α,p) Reaction Rates along the αp-Process

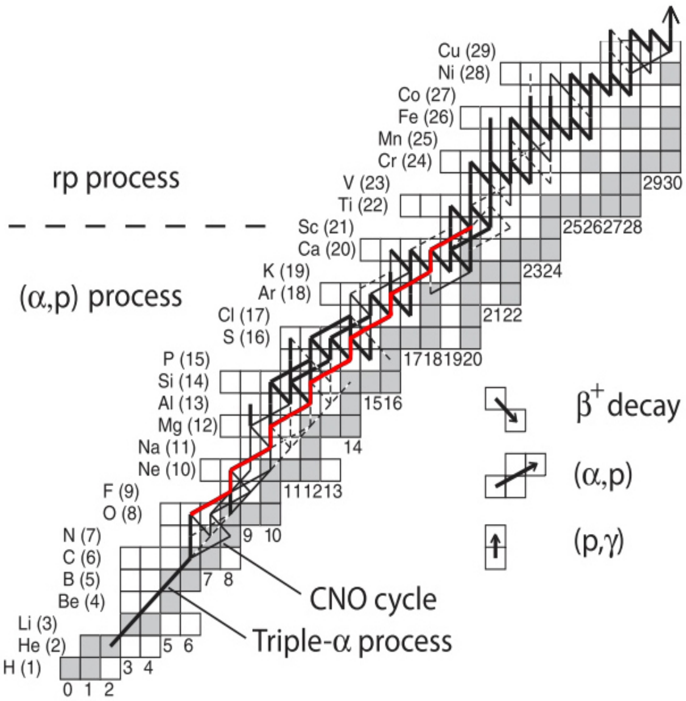

Figure 1: The time-integrated reaction flow during a thermonuclear runaway at the surface of an accreting neutron star.

Type 1 X-ray Bursts (XRB) are identified as thermonuclear runaways on the surface of accreting neutron stars. This thermonuclear runaway occurs with the breakout of the HCNO cycle and is powered mainly by the rp-process (Fig. 1). For lighter nuclei (up to A ≈ 40), (α,p) reactions (αp-process) can become an effective bypass of the slower β+ decay waiting points in the rp-process. Much effort has been made to experimentally measure the (α,p) rates along the αp-process for input into XRB models, as the αp-process is thought to shape the early phase of an XRB light-curve. Hauser-Feschbach reaction rates often used in XRB models assume high level densities. This assumption may not be a good representation for a particular compound nucleus.

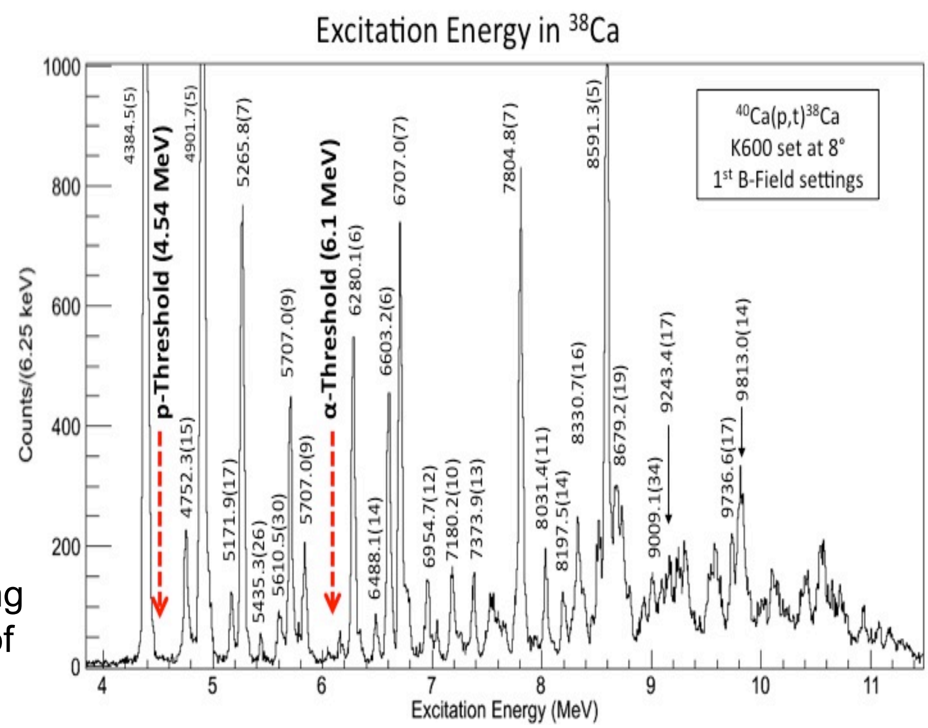

Figure 2: Focal plane triton spectrum of ^{38}Ca taken with the K600 positioned at 8° from the incident proton beam. Average energy resolution in the focal plane ≈ 40keV. Particle thresholds and selected states identified have been labeled up ~ 10 MeV .

Three indirect studies of (α,p) reaction rates were performed at iThemba LABS with the K600 magnetic spectrometer: ^{14}O(α,p)^{17}F, ^{26}Si(α,p)^{29}P, and ^{34}Ar(α,p)^{37}K. Resonance states were populated in the compound nucleus (^{18}Ne, ^{30}S, and ^{38}Ca, respectively) using the (p,t) reaction. A sample spectrum of ^{40}Ca(p,t)^{38}Ca is shown is Fig. 2.

With resonance states in the compound nucleus identified, reaction rates were calculated using narrow resonance formalism. Initial calculation of ^{26}Si(α,p)^{29}P, and ^{34}Ar(α,p)^{37}K reactions suggest an over-estimation of rates calculated from Hauser-Feschbach models.

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