Alpha Emission Near ^{100}Sn and the Termination of the rp Process

The astrophysical rp-process is thought to reach a termination point in the region of ^{100}Sn, via the Sn(p,γ)□Sb(p,γ)□Te(γ,α) cycle, due to changing mass surface above the closed Z=50 shell. By measuring the decay properties of nuclei in this region, information can be provided to determine the actual endpoint for the rp-process, as well as measure single particle states near ^{100}Sn.

We have identified a small alpha branch in the decay of ^{109}I to ^{105}Sb, resulting in a $Q_\alpha(^{109}I)$ of 3.92 MeV. This result when combined with $Q_p(^{109}I)$ and Q_α (^{108}Te) shows ^{105}Sb to be 130 keV more bound than the previously reported. This result suggests that the astrophysical rp process terminates in the $^{105}Sn \xrightarrow{p} {}^{106}Sb \xrightarrow{p} {}^{107}Te \xrightarrow{\alpha} {}^{103}Sn$ cycle.

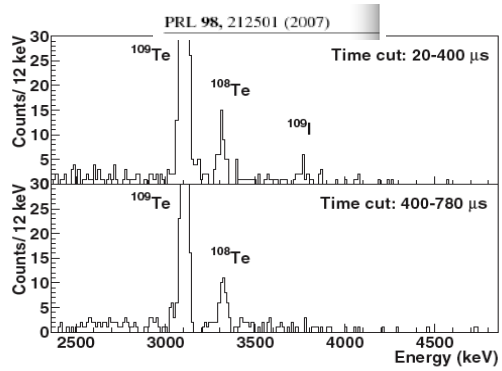

FIG. 2. Portion of the energy spectrum of decay events following implantation of an ion between 20 and 400 μs (upper panel) and in the 400–780 μs time interval (lower panel). The peaks are labeled with their precursor. The spectra are vetoed by the SiBox and SiLi detector signals to suppress escape signals and β particles and β-delayed protons.

The study of nuclei around shell closures is vital for the determination of the single particle energies and nucleon nucleon effective interactions, which are then used to extrapolate out to more exotic regions. Recently UNIRIB has observed, for the first time, the single-particle structure and decay energies of ^{109}Xe and ^{105}Te were via their alpha decay. Fine structure in the decay of ^{109}Xe has allowed measurement of the energy difference between two low-lying neutron single-particle states ($d_{5/2}$ and $g_{7/2}$) in ^{105}Te. The very fast submicrosecond decay of ^{105}Te can be interpreted as the presence of superallowed alpha transition.

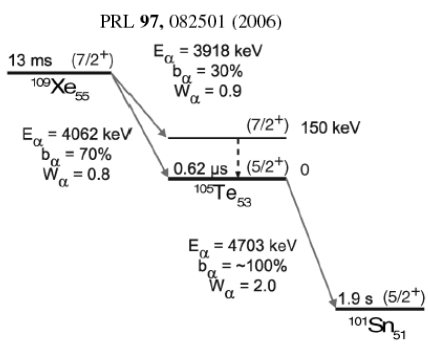

FIG. 3. Alpha decay scheme for the $^{109}Xe \rightarrow {}^{105}Te \rightarrow {}^{101}Sn$ decay chain. Figure is not to scale. See text for uncertainties on half-lives, energies, branching ratios, and W_α.

" Alpha Decay of ^{109}I and Its Implications for the Proton Decay of ^{105}Sb and the Astrophysical Rapid Proton-Capture Process"
C. Mazzocchi, et al., Phys. Rev. Lett. **98**, 212501 (2007).

"Discovery of ^{109}Xe and ^{105}Te: Superallowed α Decay near Doubly Magic ^{100}Sn"
S. N. Liddick, et al., Phys. Rev Lett. **97**, 082501 (2006).