Mass Chain Evaluations at ORNL

Caroline D. Nesaraja,
Michael S. Smith
ORNL
Physics Division
**Responsibility: Actinide Evaluations A=241 – 249**

- **A=152** evaluation in progress  
  (Murray Martin)

- **A=69** evaluation in progress  
  (Caroline Nesaraja) * also for astrophysics

- **A=121** follow up on review  
  (Murray Martin & Caroline Nesaraja)

- **A=125** reviewed  
  (Murray Martin)

- **A=58** published  
  (Caroline Nesaraja, Scott Geraedts, Balraj Singh)
Astrophysics Motivation: $S_p(^{69}\text{Br})$ essential for studying the rp-process waiting point nucleus $^{68}\text{Se}$ in X-ray burst

**Waiting point nuclei:**
Nuclides along the rp process path that hinder or delay the abundance flow to heavier masses are called waiting point nuclei ($^{64}\text{Ge}$, $^{68}\text{Se}$, $^{72}\text{Kr}$ ...)

Since $^{69}\text{Br}$ is proton-unbound, proton capture is inhibited, and the process must wait for the long ($t_{1/2}=35.5$ s) $\beta$ decay of $^{68}\text{Se}$, essentially terminating the path to heavier masses.

It is possible to bypass the waiting point by sequential 2p capture through $^{69}\text{Br}$

This depends exponentially on the proton separation energy $^{69}\text{Br}$

H. Schatz et al., 1998

\[ \lambda_{eff} = \lambda_{p} + Y_p \rho^2 N_A^2 \left( \frac{2\pi \hbar^2 k}{kT} \right)^{3/2} \frac{C_{Br}(T)}{2C_{Se}(T)} \exp \left( \frac{S_{p}}{kT} \right) \langle \sigma v \rangle_{Br}. \]

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Work in progress:
- include in ENSDF
- generate statistical model cross section for $^{68}\text{Se}(p,\gamma)^{69}\text{Br}$
- convert to reaction rate with CINA
- perform post processing element synthesis
- X-Ray bursts calculations with new CINA rate

Range of $S_p$ where $t_{1/2}^{eff}$ is significantly below its beta decay $t_{1/2}$ value

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The Q value of \(^{68}\text{Se}(p,\gamma)^{69}\text{Br}\) is crucial in nucleosynthesis calculations. A change in the Qp-value of 200 keV in \(^{68}\text{Se}\) can vary the effective halflife of \(^{68}\text{Se}\) by a factor of 5.

The exact value of the binding energy of nucleus \((Z + 1, N)\) \(^{69}\text{Br}\) has to be known to determine the effective stellar lifetime of nucleus \((Z, N)\) \(^{68}\text{Se}\) and thus its effect on the rp-process.

Comprehensive series of post processing calculations for sensitive studies of type 1 X-ray burst to uncertainties in reaction Q values. \(^{68}\text{Se}(p,\gamma)^{69}\text{Br}\) Q = -450 ± \(\Delta Q = 100\) keV; \(\Delta Q\) significantly affect XRB nucleosynthesis calculations.

For the most unbound Sp, no \(^{69}\text{Br}\) will be produced through proton capture with \(\tau_{\text{ff}} = 35.5\) s. As Sp become more positive, the exponential begins to dominate rapidly destroying \(^{68}\text{Se}\).

Experimental determination of reaction Q values (Sp) needed to better constrain the reaction rates in XRB nucleosynthesis calculations.