The Joint Institute for Nuclear Astrophysics

Activation Measurement of the $^{19}F(n,\gamma)^{20}F$ Cross Section at kT=25 keV

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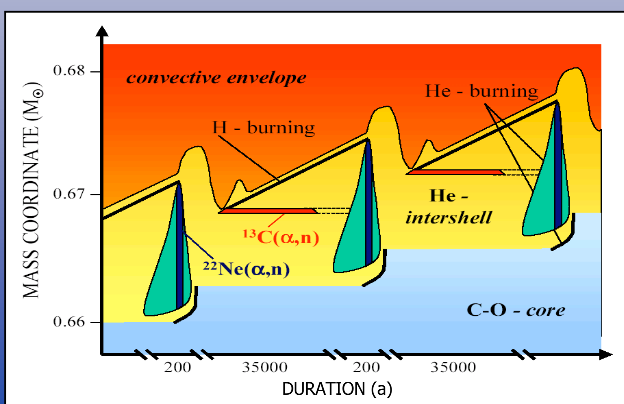
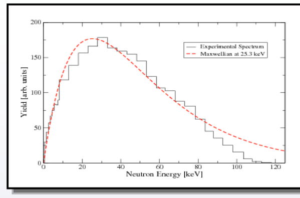
Fluorine in Asymptotic Giant Branch (AGB) Stars

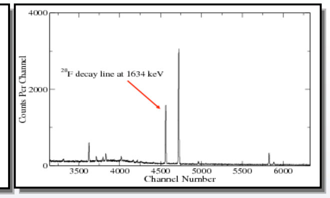
The observation of an ^{19}F overabundance at the surface of AGBs has led to much research concerning the nucleosynthetic path of fluorine in these stars. Presently, fluorine production has been attributed to the region of thermal instability in AGBs characterized by intermittent periods of H and He shell burning. During this evolutionary phase, (α,n) reactions generate a high neutron flux within the He intershell. The liberated neutrons are necessary to initiate the proposed reaction sequence that results in the production of ^{19}F, though $^{19}F(n,\gamma)^{20}F$ acts to destroy fluorine prior to being dredged up to the surface. To quantify this effect, a precise neutron capture cross section is needed for use in current stellar models.

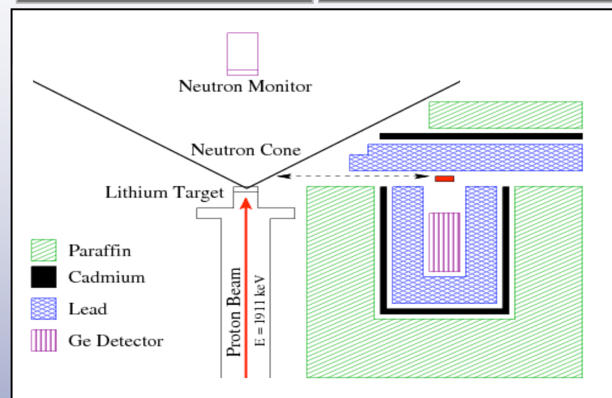
$^{14}N(n,p)^{14}C(\alpha,\gamma)^{18}O$
$^{14}N(\alpha,\gamma)^{18}F(\beta^{+}\nu)^{18}O$ → $^{18}O(p,\alpha)^{15}N(\alpha,\gamma)^{19}F$ → $^{19}F(n,\gamma)^{20}F$
$^{19}F(\alpha,p)^{22}Ne$



Above: Visualization of the He intershell during AGB thermal pulses







Top Left: Neutron spectrum produced by $^{7}Li(p,n)^{7}Be$ at E_p = 1911 keV
Top Right: Gamma spectrum obtained from the HPGe detector
Above: Experimental setup for the cyclic activation

Cyclic Activation

The short half-life of ^{20}F ($t_{1/2}$=11 s) required the employment of the cyclic activation technique. The sample was irradiated for 30 s intervals in a quasi-stellar neutron spectrum approximating a thermal distribution at kT=25 keV. The neutron spectrum was produced via the $^{7}Li(p,n)^{7}Be$ reaction at E_p=1911 keV. Following each irradiation phase, the ^{20}F decay line at 1634 keV was counted for an equal period using a HPGe detector. An automatic beamstop blocked the proton beam during the counting phase, and the data acquisition system was gated to prevent the recording of gamma events throughout the beam-on period. A pneumatic slide transported the samples alternately between the two positions.

Preliminary Maxwellian Averaged Cross Sections [mbarn]

	kT [keV] =	5	10	15	20	25	30	40	50	60	80	100
^{19}F	Present	1.24	4.13	4.61	4.26	**3.76 ± 0.19**	3.30	2.57	2.06	1.69	1.24	0.97
	Bao et al.	2.0	6.7	7.8	7.4	6.6	5.8 ± 1.2	4.6	3.8	3.2	2.5	2.2

- Present results show a **43% reduction** in the MACS at kT = 25 KeV and an **improvement in the uncertainty by a factor of four** when compared with the value given in the Bao compilation.
- Such a reduced cross section for $^{19}F(n,\gamma)^{20}F$ indicates increased survival of ^{19}F throughout the thermal pulses of AGB stars. Detailed stellar model calculations are needed to precisely quantify the effect of the present cross section on AGB surface abundances.

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