α–capture and elastic scattering on p-nuclei for the improvement of the optical model potential

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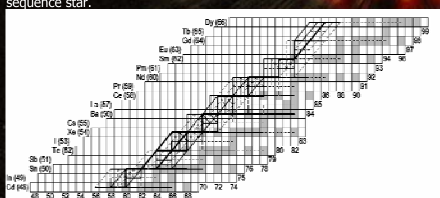
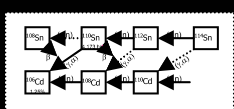
Introduction

P-nuclei are thought to form through photodisintegration reactions on seed r- or s- nuclei of mainly the (γ,n) (γ,α) and (γ,p) types. This requires high temperatures of T_9 = 2-3. Possible production sites may include Type II supernovae or x-ray bursts in a binary system that is accreting mass from a main sequence star.



Synthesis trail of the proton rich nuclei when the supernova shock front passes the O/Ne layer

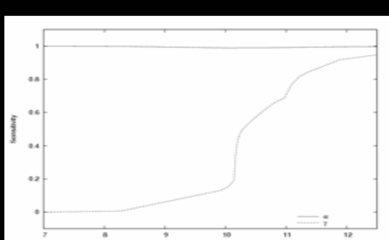
Abundance calculations for the p-nuclei involve an extended network of about 20,000 nuclear reactions of almost 2000 nuclei with masses ranging from 12 to 210. These rates are calculated with the statistical Hauser Feshbach Model (HF-Model) which is based on the reliability of the α–optical nucleus potentials.



P-process reaction flow at the Cd-Sn region. For simplicity, only even-even isotopes are shown, hence the (γ,n) arrow indicates two subsequent neutron emissions. The solid arrows show the main reaction flow path while dashed arrows indicate weaker branchings.

$$\sigma^{\mu}_{\alpha\gamma} = \frac{\lambda_\alpha^2}{4\pi}\frac{1}{(2J_i^\mu+1)}\sum_{J^\pi}(2J+1)\frac{T_\alpha(J^\pi)T_\gamma(J^\pi)}{T_{tot}(J^\pi)}$$

T_α: measures probability for forming the compound nucleus
T_γ: decay of compound nuclear state into the residual nucleus and a γ
T_{tot}: total transmission coefficient for the decay of the compound state

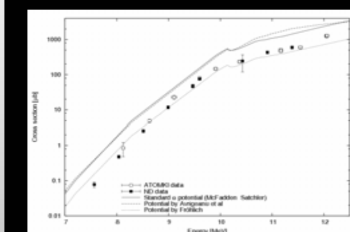


Sensitivity of the (α,γ) cross section to a variation in the α and γ widths, respectively. The sensitivity is given as a function of the alpha c.m. energy. It ranges from 0 (no change) to 1 (the cross section is changed by the same factor as the width).

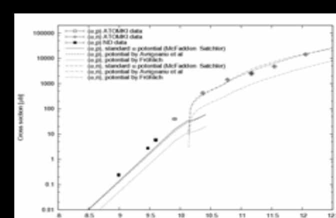
Comparison of Experiment to Theory

There is a discrepancy between the experimental cross section measurements and the theoretical values (NON_SMOKER). This is largely due to the lack of experimental data. Currently, only a few α-induced reaction rates have been measured.

Two ND clover detectors in close geometry (9mm between detector and target).



Experimental cross sections of the $^{106}Cd(\alpha,\gamma)^{110}Sn$ reaction compared to NON-SMOKER predictions, using three different α+nucleus potentials: McFadden and Satchler [1], Avrigeanu et al. [2], and by Fröhlich[3,4].



The same as above figure except it is the $^{106}Cd(\alpha,n)^{109}Sn$ and $^{106}Cd(\alpha,p)^{109}In$ reactions.

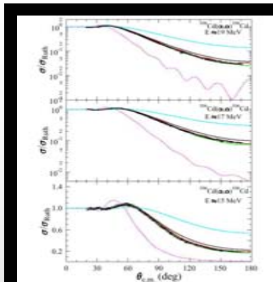
(α,α) experiments at low energies

Alpha Optical Potential

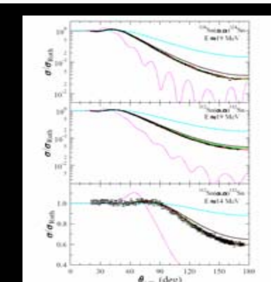
$$U(r) = V_c(r) + V_R(r) + iW(r)$$

$V_c(r)$: Coulomb potential
$V_R(r)$: Real part of nuclear potential
$iW(r)$: Imaginary part of nuclear potential

Experimental Cross Section ↕ Theoretical Cross Section ↑ Experimental Optical Potential (extrapolated)



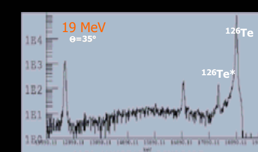
Experimental Rutherford-normalized cross section for $^{106}Cd(\alpha,\alpha)^{106}Cd$ versus $\Theta_{c.m.}$[5]



Experimental Rutherford-normalized cross section for $^{110}Sn(\alpha,\alpha)^{110}Sn$ and $^{124}Sn(\alpha,\alpha)^{124}Sn$ versus $\Theta_{c.m.}$

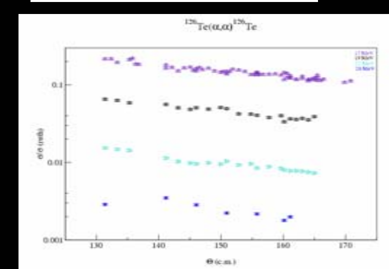
Future Experiments

Temperature dependent models of the optical potential take into account a variation in energy and mass along an isotopic chain[6]. Future work includes alpha scattering on ^{120}Te, ^{124}Te, ^{126}Te, ^{130}Te.



Rutherford normalized cross section

$$d\sigma/d\Omega\ (\vartheta) = (d\sigma/d\Omega)_M\ (\vartheta{=}35°)\ N(\vartheta)/N_M(\vartheta{=}35°)\ \Delta\Omega_M/\Delta\Omega$$



Experimental Rutherford-normalized cross section for $^{126}Te(\alpha,\alpha)^{126}Te$

References

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This project is funded by the NSF through grant PHY0216783, and the Universities of JINA.