

r-process


$$\tau_{ng} \sim 10^{-4} \text{ s} \rightarrow N_n \sim 10^{21} \text{ cm}^{-3}$$

HOW TO FIND?

$$N_r(A, Z) = N_0(A, Z) - N_s(A, Z)$$

FORM IN $(\gamma, n) - (n, \gamma)$ equil.

WAIT FOR β^{\pm} decay

$$\frac{dN(Z, A)}{dt} = -N_n \cdot N(Z, A) \langle \sigma v \rangle_{Z, A} + N(Z, A, A+1) \lambda_{\gamma}(Z, A+1)$$


IN EQ.

$$\frac{N(Z, A+1)}{N(Z, A)} = N_n \left(\frac{\hbar^2}{2\mu_{A,n} K T} \right)^{3/2} \frac{(2j_{Z, A+1} + 1)}{(2j_{Z, A} + 1)}$$

$$\frac{G_{Z, A+1}^{\text{NORN}}}{G_{Z, A}^{\text{NORN}}} e^{-Q_{ng}/K T} \left| \begin{array}{l} G_{Z, A+1}^{\text{NORN}} \\ G_{Z, A}^{\text{NORN}} \end{array} \right. = \frac{g_i}{g_j} = \frac{\sum_k g_k e^{-E_k}}{g_i}$$

→ typical very narrow peak!

BOTTLENECK environment
to make seeds



S-process BRANCHING POINTS

Cosmic Ray "NUCLEOSYNTHESIS"

SPALLATION OF HEAVY NUCLEI

COSMIC RAY ACCELERATION IN SN SHOCK

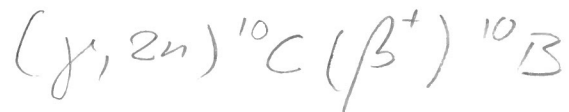
→ FERMION - MECHANISM

"COLLISION-LESS SHOCK"



in MAGNETIZED PLASMA

E.g.



$$\text{CR: } {}^{11}\text{B} / {}^{10}\text{B} \sim 2.2 - 2.4$$

$$\text{Solar: } {}^{11}\text{B} / {}^{10}\text{B} \sim 4$$

→ CONTRIBUTION BY γ -process in SNe!

Exercise: find T-exponent n for

$$\lambda \sim N_A \langle \sigma v \rangle = N_A \left(\frac{4}{3} \right)^{3/2} \frac{\hbar}{\bar{u}} \frac{N_A}{m_{o1} z_0 z_1 e^2} S_0 \tau^2 e^{-\tau}$$

such that $\lambda \sim T^n$

$$\tau = \frac{3E_0}{kT}$$

$$E_0 = \left[\left(\frac{\bar{u}}{\hbar} \right)^2 (z_0 z_1 e^2)^2 \left(\frac{m_{o1}}{2} \right) (kT)^2 \right]^{1/3}$$

Find

$$\rightarrow n = \frac{\tau - 2}{3}$$

GENERATIONS OF NUCLEOSYNTHESIS PROCESSES

BBN

"Primary" — JUST FROM INITIAL BBN
COMPOSITION $\sim [Z]$
 r, α

"Secondary" — REQUIRES INITIAL
"PRIMARY" ELEMENTS
 $\sim [Z]^2$
S

"Tertiary" — REQUIRES INITIAL
"SECONDARY" ELEMENTS
 $\sim [Z]^3$
S \rightarrow P