

Nuclear Physics I: Nuclear Astrophysics

PHYS 8801

Alexander Heger¹

¹Minnesota Institute for Astrophysics
School of Physics and Astronomy
University of Minnesota

Nuclear Physics I: Nuclear Astrophysics, Spring 2012

Agenda

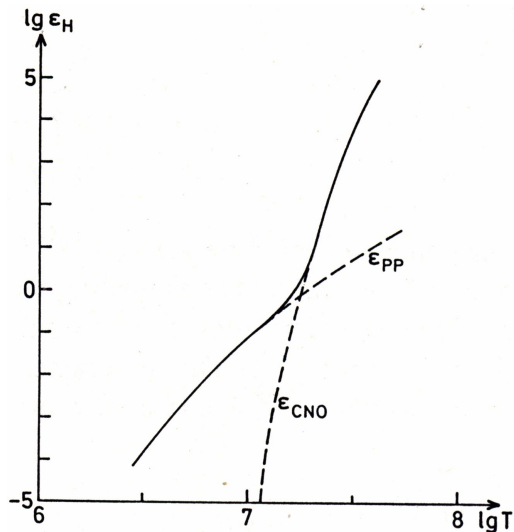
- 1 Nuclear Reaction Rates
- 2 Hydrogen Burning
- 3 Helium Burning
- 4 The Final Stages

Overview - Burning Phases in Stars

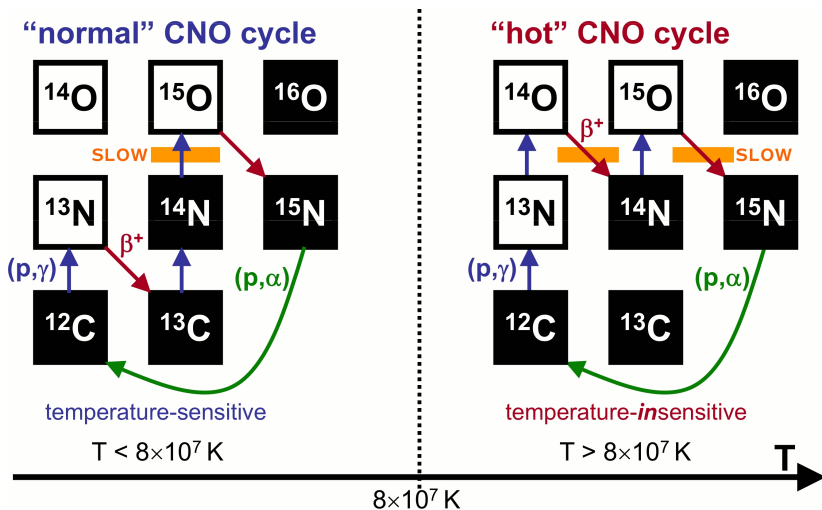
20 M_☉ star

Fuel	Main Product	Secondary Product	T (10 ⁹ K)	Time (yr)	Main Reaction
H	He	¹⁴ N	0.02	10 ⁷	^{CNO} 4 H → ⁴ He
He	O, C	¹⁸ O, ²² Ne s-process	0.2	10 ⁶	3 He ⁴ → ¹² C ¹² C(α,γ) ¹⁶ O
C	Ne, Mg	Na	0.8	10 ³	¹² C + ¹² C
Ne	O, Mg	Al, P	1.5	3	²⁰ Ne(γ,α) ¹⁶ O ²⁰ Ne(α,γ) ²⁴ Mg
O	Si, S	Cl, Ar, K, Ca	2.0	0.8	¹⁶ O + ¹⁶ O
Si, S	Fe	Ti, V, Cr, Mn, Co, Ni	3.5	0.02	²⁸ Si(γ,α)...

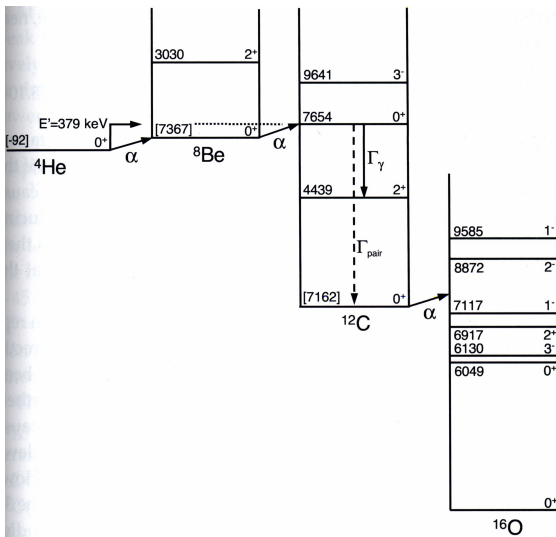
Competition of Hydrogen-Burning Modes



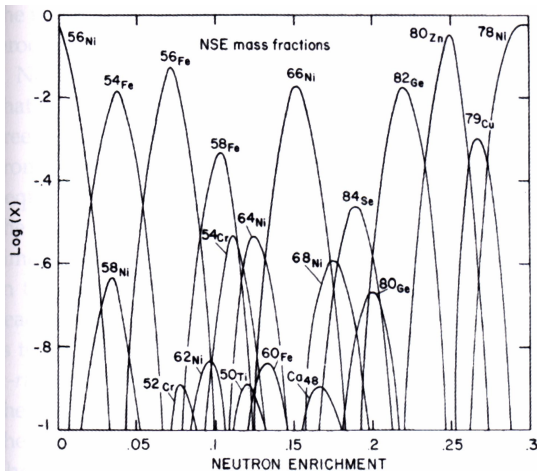
Normal and Hot CNO Cycles



Helium Burning level scheme



Beyond Silicon/Sulfur Burning



NSE distribution for
 $T = 3.5 \times 10^9 \text{ K}$,
 $\rho = 10^7 \text{ g/cm}^3$