Theoretical $\Delta Y/\Delta Z$ in the early Universe

Sylvia Ekström

in collaboration with
G. Meynet, A. Maeder, C. Chiappini, C. Georgy
and R. Hirschi (Keele)

IAUS 268, Geneva
12th of November 2009

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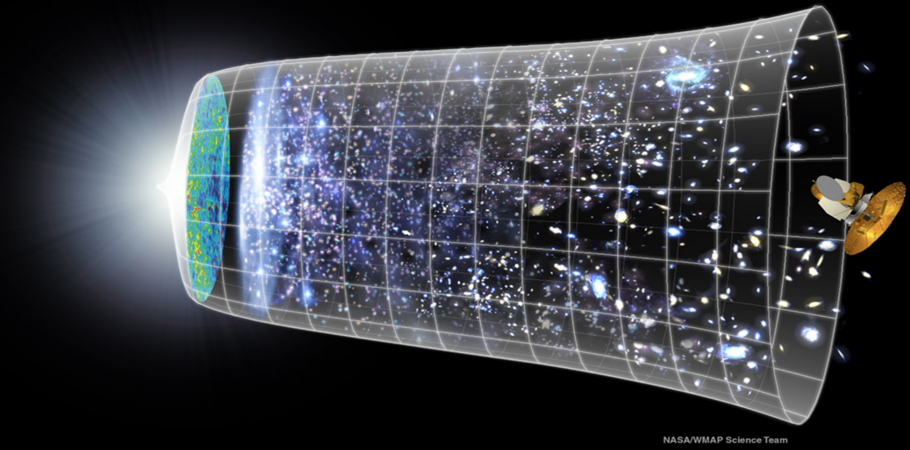
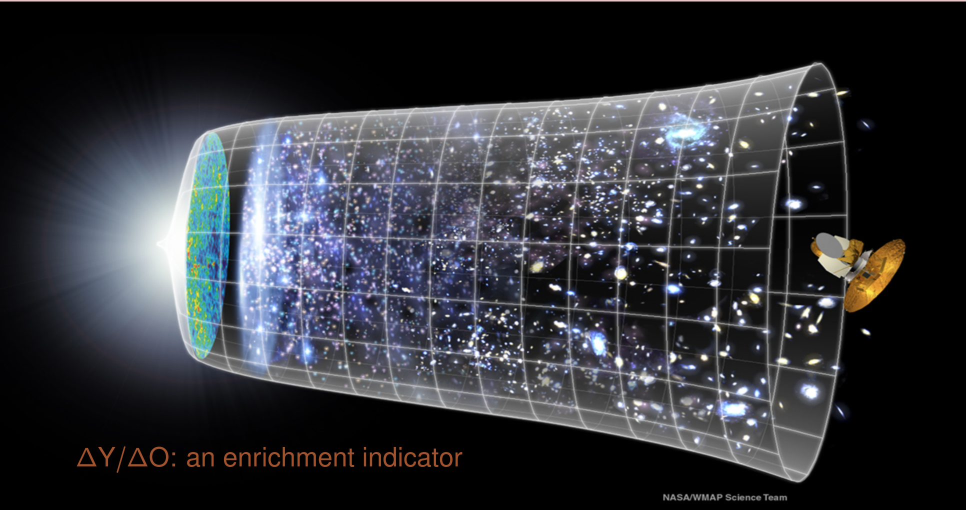
Introduction



Introduction

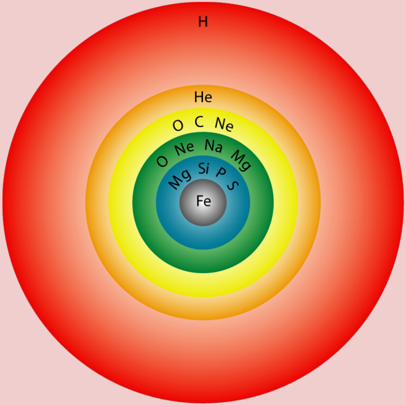


ΔY/ΔO: an enrichment indicator

Nucleosynthesis in stars

H → He

He → C,O
C → Ne, Na, Mg
Ne → O, Mg, P, S
O → Mg, P, S, Si
Si → Ni, Fe



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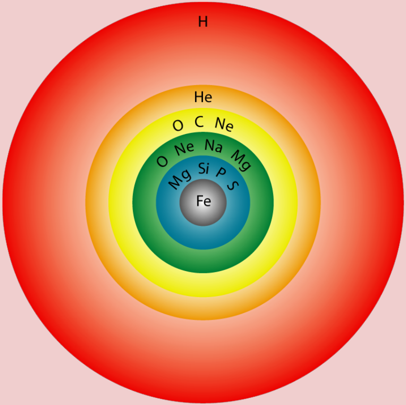
Enrichment by winds
SN



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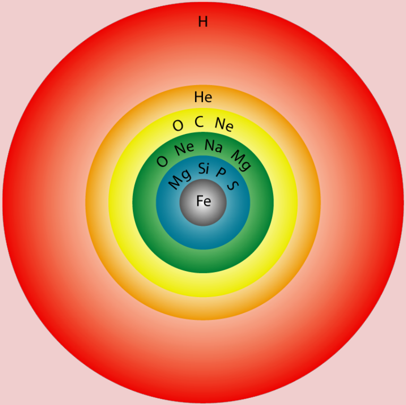
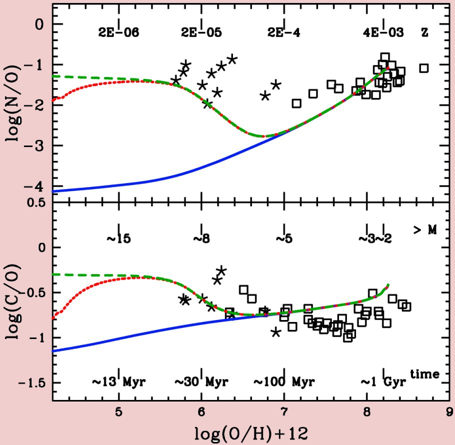
cf. contribution by *G. Meynet*



□ *Israelian et al. (2004)*

⋆ *Spite et al. (2005)*



Chiappini et al. 2006, 2008, Ekström et al. 2008:

N/O and C/O best fitted
by low-*Z* fast-rotating models

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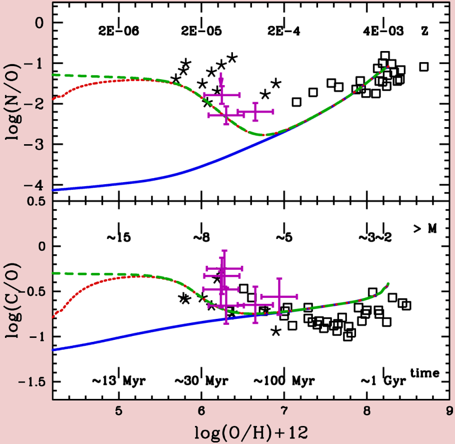


Chiappini et al. 2006, 2008, Ekström et al. 2008:

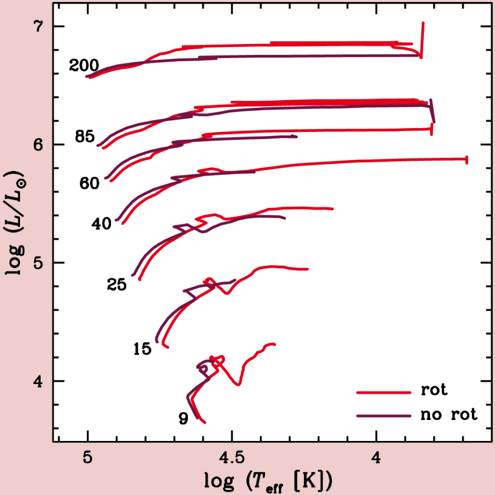
N/O and C/O best fitted
by low-Z fast-rotating models

Physical ingredients

- Geneva code in the version *Hirschi et al. (2004)*
- 2 x 7 Pop III models, with and without rotation
- radiative mass loss prescription from *Kudritzki (2002)*
  same adaptations to $Z = 0$ case as in *Marigo & al. (2003)*
- treatment of mechanical mass loss as described in *Meynet & al. (2006)*

Metal free models

mass	$v/v_{\rm crit}$
9	0.54
15	0.72
25	0.63
40	0.56
60	0.52
85	0.48
200	0.40



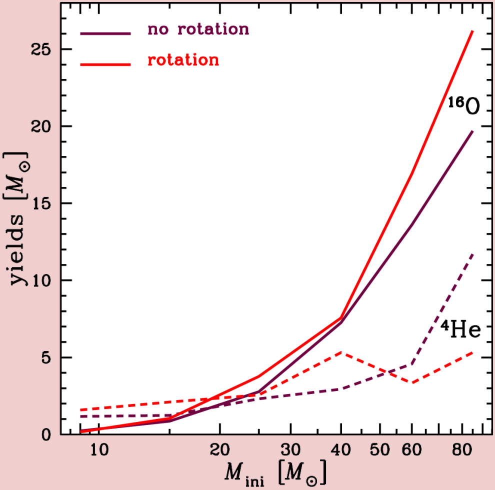
Yields of Pop III models

no rotation

	^{4}He	^{16}O
9 $M_\odot$	1.17	0.24
15 $M_\odot$	1.24	0.86
25 $M_\odot$	2.32	2.78
40 $M_\odot$	2.94	7.25
60 $M_\odot$	4.58	13.6
85 $M_\odot$	11.70	19.7

rotation

	^{4}He	^{16}O
9 $M_\odot$	1.59	0.17
15 $M_\odot$	2.10	1.05
25 $M_\odot$	2.57	3.76
40 $M_\odot$	5.32	7.57
60 $M_\odot$	3.37	16.9
85 $M_\odot$	7.09	26.2



ΔY/ΔO calculation

$$\frac{\Delta Y}{\Delta O} = \frac{\int_{M_{\rm down}}^{M_{\rm up}} \Delta Y\, \Phi(M)\, dM}{\int_{M_{\rm down}}^{M_{\rm up}} \Delta O\, \Phi(M)\, dM}$$

where $\Phi(M) = AM^{-(1+x)}$ is the IMF

With $M_{\rm down} = 9\ M_\odot$ et $M_{\rm up} = 120\ M_\odot$:

no rotation	1.22
rotation	1.39

Effects of the IMF

Salpeter (1955): $x = 1.35$

Miller & Scalo (1979): $x = 1.00$ from 1 to 2 $M_{\odot}$
$x = 1.30$ from 2 to 10 $M_{\odot}$
$x = 2.30$ above 10 $M_{\odot}$

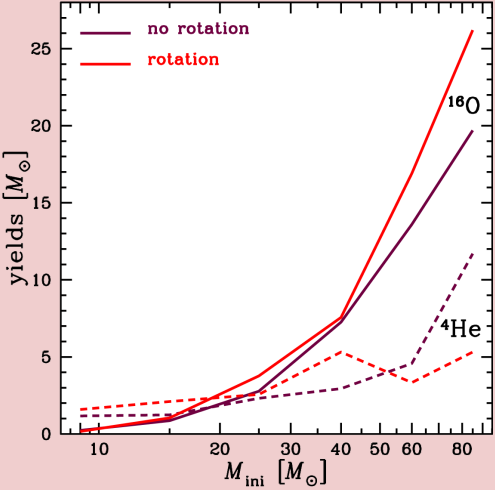
Nakamura & Umemura (2001): $x = 1.35$ for both M_{peak}

	S55	*MS79*	*NU01* (1 - 50 $M_{\odot}$)	*NU01* (1 - 100 $M_{\odot}$)
no rot.	1.22	1.77	0.52	0.86
rot.	1.39	2.14	0.29	0.37

Effects of metallicity

Rotating models at $Z = 10^{-8}$ from *Hirschi 2007*

	S55	MS79
$Z = 0$ no rot.	1.22	1.77
$Z = 0$ rot.	1.39	2.14
$Z = 10^{-8}$ rot.	2.82	4.18



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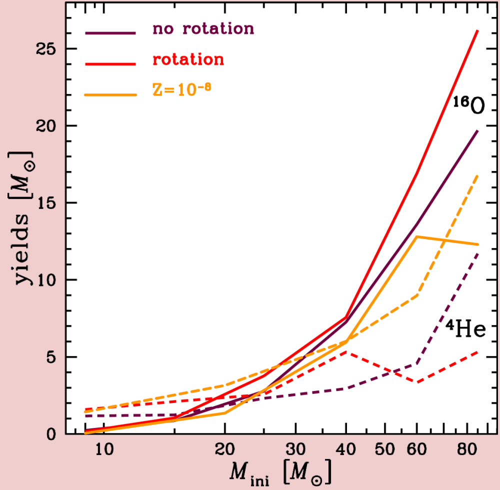
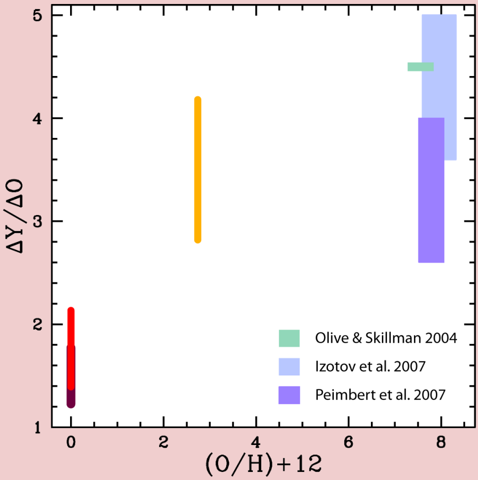


Comparison with observations

Olive & Skillman 2004:
- reanalysis of 7 extragalactic HII regions from *Izotov & Thuan 1998*
- metallicities between $O_\odot/24$ and $O_\odot/6$

Izotov et al. 2007:
- 86 extragalactic HII regions
- metallicities between $O_\odot/11$ and $O_\odot/2$

Peimbert et al. 2007:
- 5 extragalactic HII regions
- metallicities between $O_\odot/14$ and $O_\odot/4$



Summary

Pop III models:

- prediction of low $\Delta Y/\Delta O$
- rotation: higher $\Delta Y/\Delta O$ (but still low)

$Z = 10^{-8}$: better agreement with observations

Questions:

- Evolution of $\Delta Y/\Delta O$?
- How long does the Pop III chemical signature last?