From Lithium to Uranium: Elemental Tracers of Early Cosmic Evolution
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Fast rotating first stars

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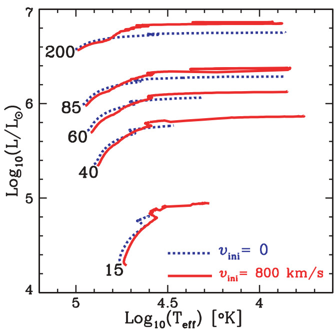
Abstract. In order to study the effects of fast rotation on primordial stars, we present the evolution and the chemical yields of zero metallicity models with masses between 15 to 200 $M_\odot$.

Keywords. Stars: abundances, stars: rotation, early universe

Because of the peculiarities of physics at Z= 0, primordial stars are more compact than non-zero-metallicity stars, and thus for a given mass the radius is smaller. If one admits that the angular momentum contained in a primordial star-forming cloud has no reason to be lower than the angular momentum observed in present-day star-forming clouds (see Abel *et al.* (2002)), one can suppose that primordial stars will present high equatorial velocities on the ZAMS. It is therefore interesting to study the effects of fast rotation on the first stars of the Universe.



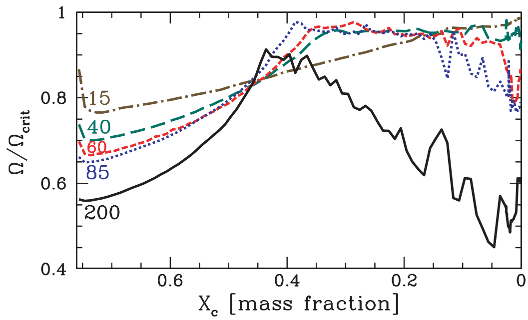


Figure 1. Left: HR diagram for Z= 0 models. **Right:** Ω/Ω_c evolution during core H-burning.

For this purpose, we have computed zero-metallicity models with masses ranging from 15 to 200 $M_\odot$. For each chosen mass, we have computed a fast rotating model (υ_{ini}= 800 km/s) and a non rotating one (see Fig. 1 left). The evolution has been followed until core helium exhaustion for the highest masses (85 and 200 $M_\odot$) and until core carbon depletion for the others. We refer the reader to Meynet & Maeder (2002) concerning the main physical ingredients of the calculations. In agreement with Meynet & Maeder (2002), all the models reach break-up limit during MS (see Fig. 1 right), but the mechanically experienced mass loss remains modest. Striking differences between rotating and non-rotating models appear in the internal profiles (see Fig. 2). Steep Ω gradients induce very strong internal mixing and early surface enrichment, whereas the surface of non rotating models remains metal-free at least until the end of our calculations.

The ejected masses presented here (see Table 1) have been computed according to the supposed fate of the stars (see Heger & Woosley (2002)). The 200 $M_\odot$ models are expected to be totally disrupted by pair-instability supernovae and to return to the ISM all the heavy elements processed during their life. The 85, 60 and 40 $M_\odot$ models will be

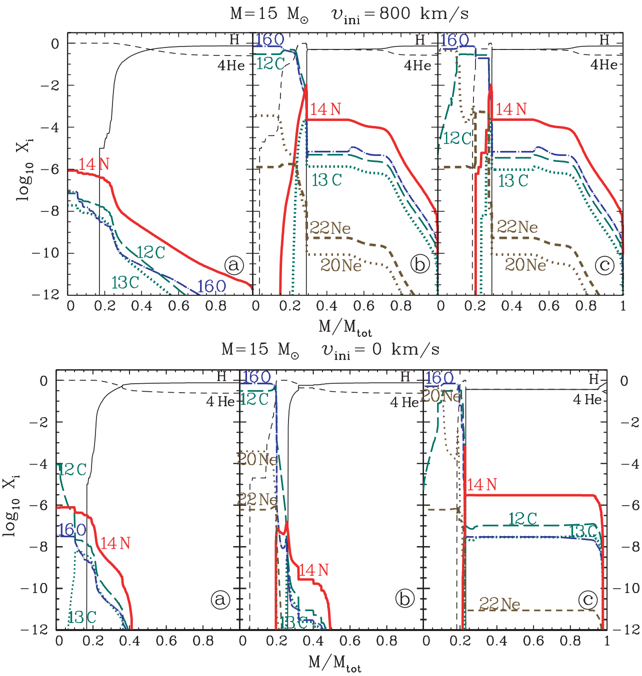


Figure 2. Top: internal abundances profiles at the end of (a) core H-burning, (b) core He-burning and (c) core C-burning in the 15 $M_\odot$ with $\upsilon_{\rm ini}$= 800 km/s. **Bottom:** for comparison, same as above but in the non-rotating model.

Table 1. Ejected masses of He and CNO elements by the Z= 0 models, computed according to the assumed fate of the star (see text).

$M_{\rm ini}$ $M_\odot$	$\upsilon_{\rm ini}$ km/s	**end of He-b** $M_{\rm fin}$	$M_{\rm CO}$	**ejected masses** in $M_\odot$(end of He-b) ^{4}He	^{12}C	^{13}C	^{14}N	^{16}O
200	0	199.95	98.82	57.88	6.29	7.75e-07	4.33e-05	81.45
	800	181.42	121.27	55.31	7.64	5.33e-02	5.17e-01	103.55
85	0	84.94	38.43	1.44e-02	0	0	0	0
	800	78.29	41.09	2.35	2.53e-06	6.33e-07	8.23e-05	1.55e-06
60	0	60.00	25.10	2.40e-05	0	0	0	0
	800	57.72	28.13	0.58	3.56e-12	9.82e-13	3.66e-10	9.57e-12
40	0	40.00	14.66	0	0	0	0	0
	800	38.99	16.33	0.25	6.98e-13	1.92e-13	7.62e-11	2.11e-12
15	0	15.00	2.96	4.63	0.46	2.98e-10	6.61e-08	0.85
	800	14.82	3.38	5.22	0.77	8.52e-05	3.03e-03	0.90

completely swallowed in a black-hole, contributing to the enrichment of the medium only through their winds, if any. In this case, only the rotating models have a contribution, very modest but non zero. The 15 $M_\odot$ models end their life as SNII and the differences in the rotating and non rotating profiles lead to a difference of 5 orders of magnitude in the values of ^{13}C or ^{14}N pre-SN yields.

References

Abel T., Bryan G.L. & Norman M.L. 2002, *Science* 295, 93
Heger A. & Woosley S.E. 2002, *ApJ* 567, 532
Meynet G. & Maeder A. 2002, *A&A* 390, 561

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