Impact of transport processes on stellar evolution

Charbonnel[1,2], Eggenberger[1], Ekström[1], Georgy[1], Meynet[1], Maeder[1], Lagarde[1], Decressin[1] & Granada[1]

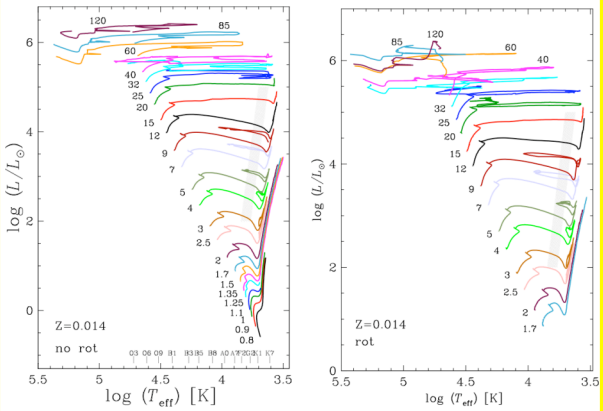
(1) Geneva Observatory, University of Geneva, Switzerland ; (2) CNRS UMR 5577, IRAP, Toulouse University, France

Processes transporting chemicals and angular momentum in stellar interiors are known to have non negligible impacts on the structure, properties, and evolution of stars. We present grids of solar metallicity models that were tailored to investigate the effects of rotation-induced mixing and of the double-diffusive thermohaline instability in stars over a large range in mass. We highlight specific results obtained in the case of low-mass stars.

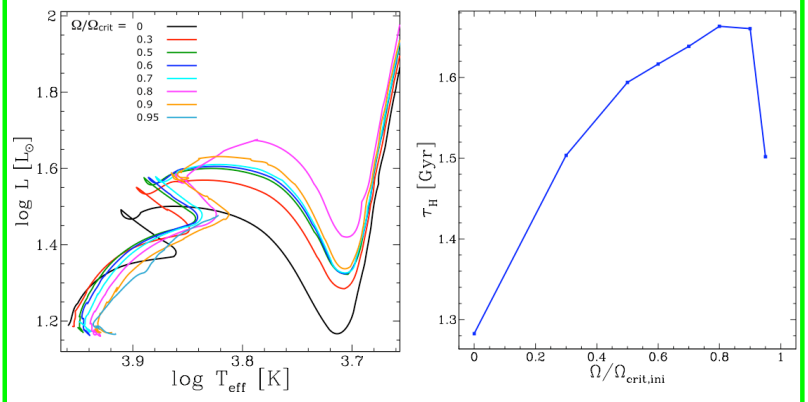
◆The evolution codes : GENEVA code and STAREVOL

- ✧ Models are computed using two different evolution codes: The GENEVA code (e.g. Eggenberger et al.08), and STAREVOL (e.g. Siess et al. 00)
- ✧ Here we focus on results at solar metallicity (assuming solar composition from Asplund et al. 05 with Ne from Cunha et al.06), although extended grids are available over a large metallicity domain.
- ✧ In both codes rotation-induced transport for angular momentum and chemicals is treated with the complete formalism by Zahn (1992) and Maeder & Zahn (1998) taking into account advection by meridional circulation and diffusion by shear turbulence (for details see Ekström et al.11, Charbonnel & Lagarde 10, and Lagarde et al.11).
- ✧ In STAREVOL thermohaline (or salt-finger) instability is also included using the prescription advocated by Ulrich (72) and Charbonnel & Zahn (07) that accounts for the behaviour of surface abundances in C ($^{12}C/^{13}C$), N, and Li in low-mass red giant stars.

◆ Impact of rotation on the evolution tracks and main sequence lifetimes - GENEVA extended grids

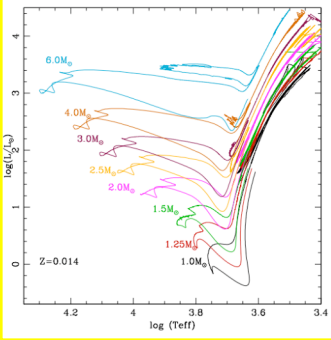


Standard models (left) and rotating models assuming Ω/Ω_{crit} =0.4 on the zams (right, low-mass stars currently under computation)

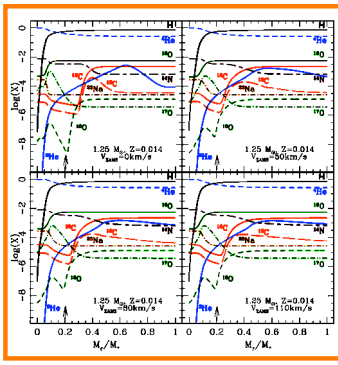


Impact of rotation on the evolution track up to the RGB tip (left) and on the lifetime on the main sequence (right) for $2M_{\odot}$ models (Geneva) assuming different initial values for Ω/Ω_{crit}

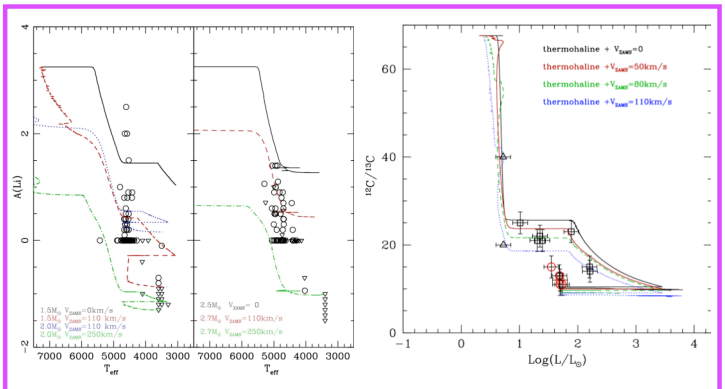
◆ Impact of rotation and thermohaline mixing on stellar surface abundances The testcase of low- and intermediate-mass stars - STAREVOL grids



Rotating models (STAREVOL) for low- and intermediate-mass stars computed up to the TP-AGB tip assuming Ω/Ω_{crit} =0.4 on the zams and including thermohaline mixing



Chemical structure at the turnoff for a $1.25M_{\odot}$ star computed with different initial rotation velocities



Impact of rotation and thermohaline mixing on the surface Li abundance and carbon isotopic ratio from the zams up to the end of the early-AGB. The interplay of both mechanisms leads to perfect agreement with data in low-mass field evolved stars (left, Charbonnel et al. 11) and in giant stars in the open cluster M67 (right, Gilroy & Brown 91)

References :

Asplund et al. 2005 ASPC 336,25
Charbonnel & Lagarde 2010 A&A 522, 10
Charbonnel & Zahn, 2007, A&A 467, L15
Charbonnel et al. 2011 in prep,
Cunha et al. 2006 ApJ 647, L143
Ekström et al. 2011 in prep.
Eggenberger et al. 2008 Ap&SS 316,43
Gilroy & Brown, 1991, ApJ 371, 578
Lagarde, Decressin & Charbonnel 2011 in prep
Maeder & Zahn, 1998, A&A 334, 1000
Ulrich, 1972, ApJ 172, 165
Zahn, J.-P. 1992, A&A, 265, 115