

Transport processes in 1D stellar evolution models

WP 121 200

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Lack of response due to lack of animation over the past year.

Need for other people willing to contribute ?

Transport processes in 1D stellar evolution models

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Census of codes and methods : requested inventory form sent to WP participants

Name

Code used

Transport processes for chemicals

Process 1

Nature of the process

Formalism used

Physical quantity to which it applies (concentrations, mass fractions, abundances)

Numerical scheme used

Reference

...

Transport processes for angular momentum

Process 1

Nature of the process

Formalism used

Numerical Scheme used

Reference

...

+ update on developments done by these people on the front of transport processes

Transport processes in 1D stellar evolution models

Code	Nucleides Transport	AM Transport
STAREVOL (Decressin et al. 2009, Charbonnel et al. 2013, Amard et al. 2016)	Atomic diffusion (Paquette+86, MM78) Shellular rotation (MC + shear) (MZ98,CZ95) Thermohaline instability (CZ07) Diffusive overshoot (Herwig 2000)	Shellular rotation (MZ98, MZ05) IGW (TZ99, Charbonnel+2013)
GENEC (Maeder & Meynet 2004, Eggenberger et al. 2008, Ekström et al. 2012)	Atomic diffusion (CC70, Paquette+86) Shellular rotation (MC + shear) (MZ98,CZ95) Tayler-Spruit dynamo (S02,MM04)	Shellular rotation (MC + shear) (Z92, MZ98) Tayler-Spruit dynamo (S02,MM04)
MoMo (Turcotte et al. 1998B, Richard et al. 2001, Vick et al. 2010)	Atomic diffusion (Turcotte+88) Mass loss (Vick+10) Double-diffusive convection (Brown+13)	
CESTAM (Marques et al. 2013)	Atomic diffusion (CC70, Paquette+86) Shellular rotation (MZ98,CZ95)	Shellular rotation (MZ98, MZ05) Mixed modes (Belkacem+2015a,b) IGW (not functioning yet)
STARS (Eggleton 1971, Pols+ 1995, Stancliffe 2006)	Atomic diffusion Diffusive overshoot (Herwig 2000)	
YREC	Atomic diffusion Hydrodynamical instabilities (Heger+00) Thermohaline instability	Meridional circulation (ES76,ES78) Hydrodynamical instabilities (Heger+00)

PUBLIC

Transport of angular momentum in other codes

FRANEC STERN MESA ATON TGEC

Endal & Sofia (1978) Formalism

Zahn (1992) Maeder & Zahn (1998), Théado & Vauclair (2001) Formalism

Transport processes in 1D stellar evolution models

Recent developments among the community

- ❏ Impact of rotation on global asteroseismic quantities
(Lagarde et al. 2015, 2016)

- ❏ Double-diffusive convection (thermohaline)
 - interplay with atomic diffusion (Deal et al. 2016b)
 - interplay with accretion (Deal et al. 2016a)
 - modelling (Lattanzio et al. 2014)

- ❏ Internal gravity waves (Charbonnel et al. 2013, Alvan et al. 2014, 2015)

- ❏ Overshooting (Viallet et al. 2015, Stancliffe et al. 2015)

- ❏ Transport by mixed modes (Belkacem et al. 2015a,b)

- ❏ Vertical shear turbulence (Prat et al. 2016)

- ❏ Torques exerted by magnetized winds (braking on PMS) (Amard et al. 2016)

- ❏ Tidal interactions (stars / star and star / planet) (Mathis 2015, Mathis et al. 2016 , Privitera et al. 2016)

Transport processes in 1D stellar evolution models

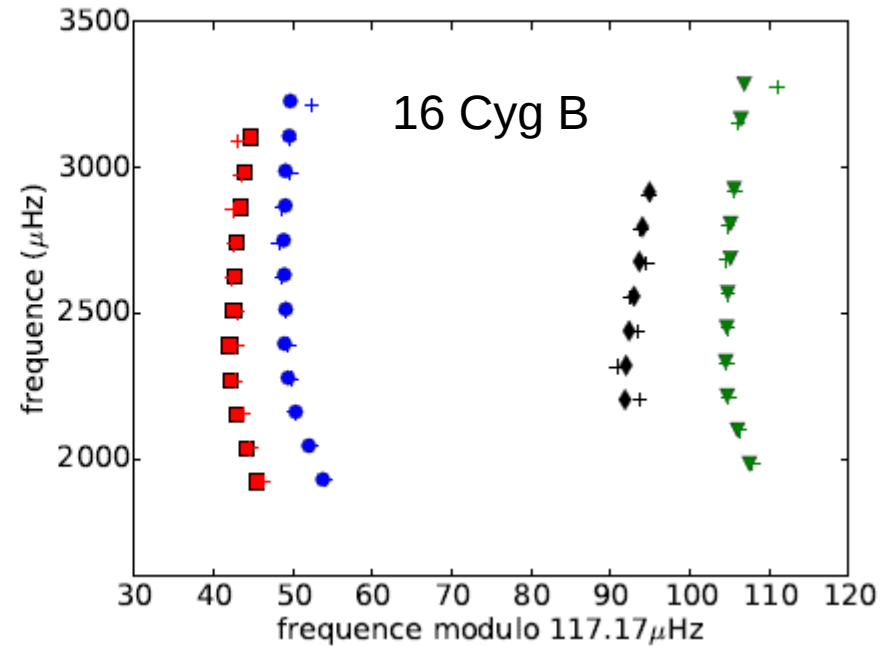
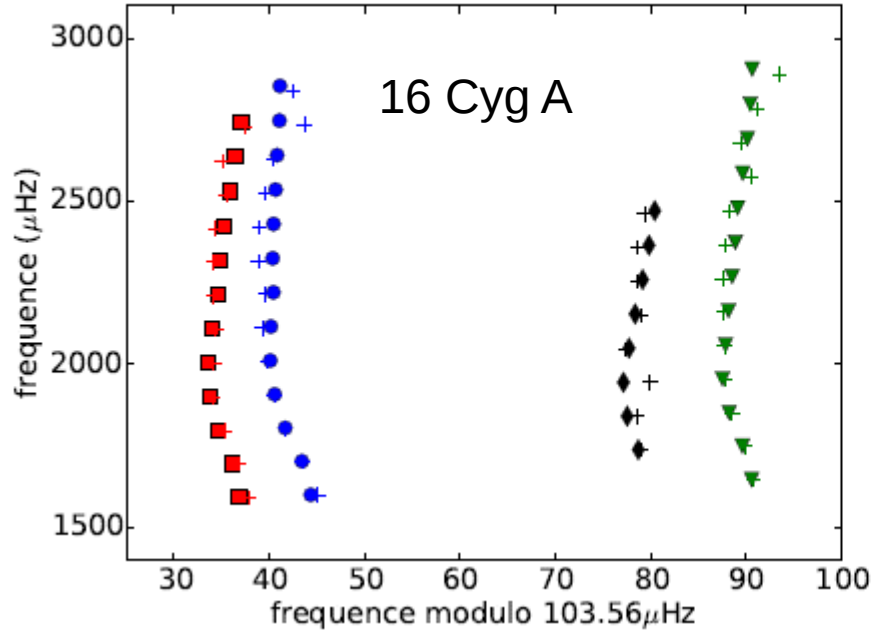
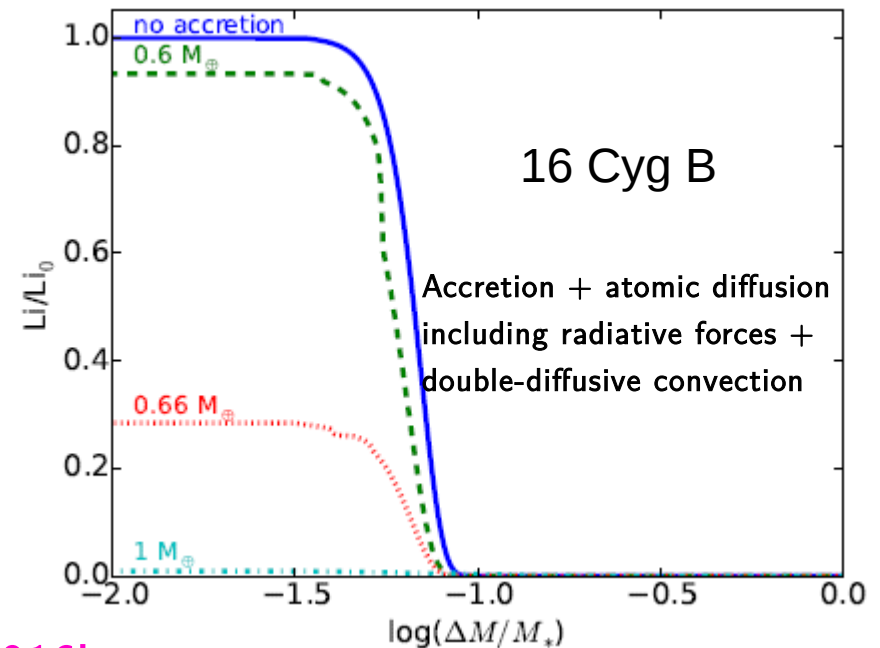


Table 2. Properties of 16 Cygni A and B from this work

	16 Cygni A	16 Cygni B
T_{eff} (K)	5821 ± 25	5747 ± 25
$\log g$	4.29 ± 0.01	4.36 ± 0.01
Mass (M_{\odot})	1.10 ± 0.01	1.06 ± 0.01
Radius (R_{\odot})	1.24 ± 0.01	1.13 ± 0.01
Luminosity (L_{\odot})	1.58 ± 0.03	1.25 ± 0.03
Age (Gyr)	6.4 ± 0.4	6.4 ± 0.4
Z_i	0.024	0.024
Y_i	0.26	0.26
Z_{surf}^a	0.0221	0.0223
Y_{surf}^a	0.2226	0.2265

Notes. ^(a) Values at the age of best models



Deal et al 2016b

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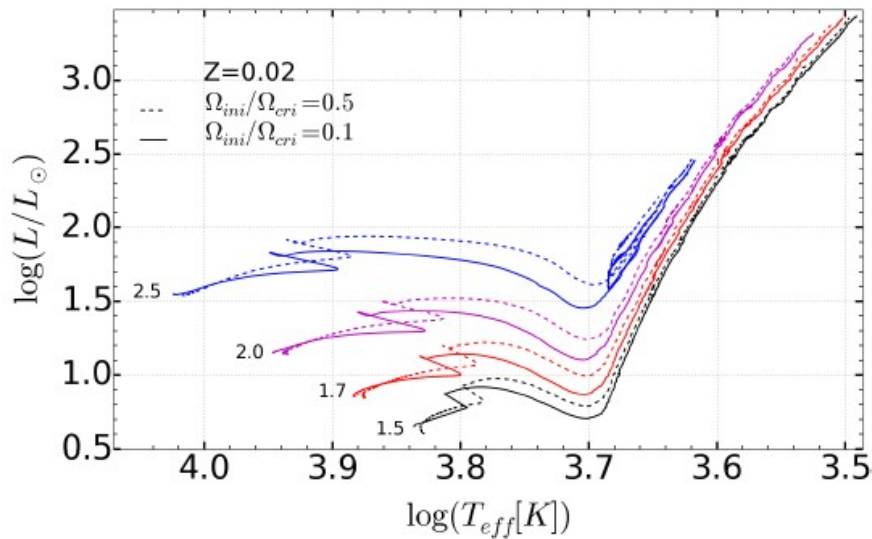
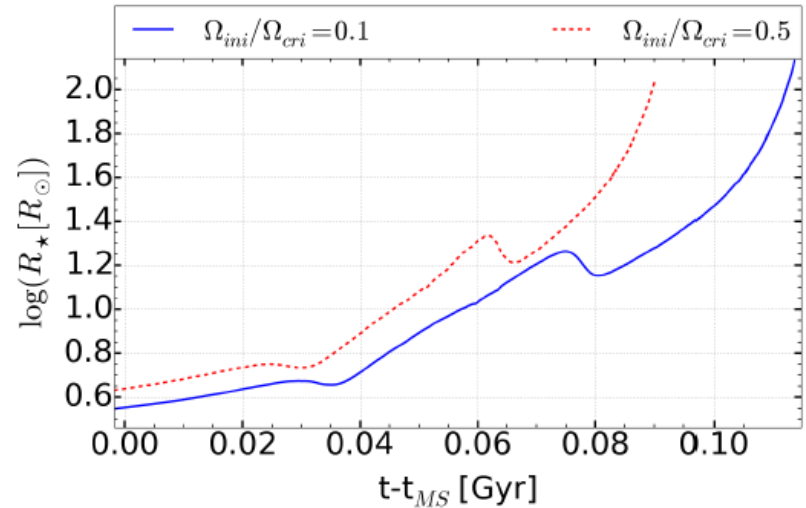
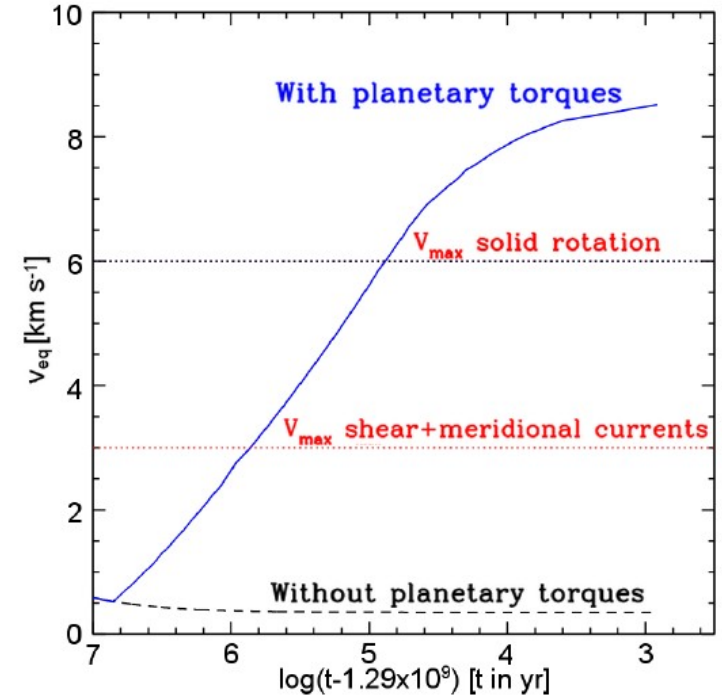
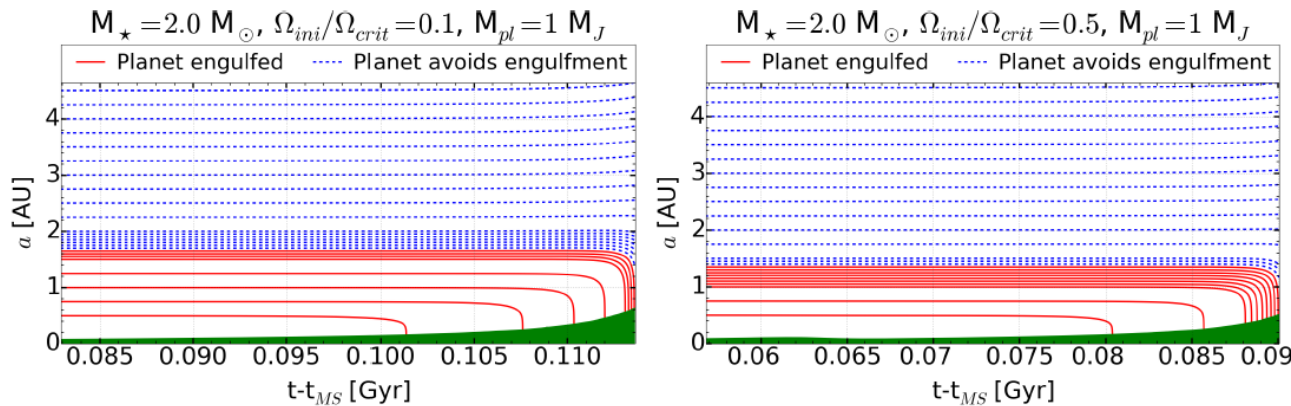


Fig. 2. Evolutionary tracks in the Hertzsprung-Russell diagram for rotating models of 1.5, 1.7, 2.0 and 2.5 M_{\odot} . The solid and dashed lines indicate models with $\Omega_{ini}/\Omega_{crit} = 0.1$ and 0.5, respectively.



Star-planet interactions Privitera + 2016



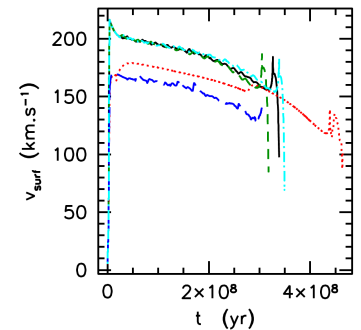
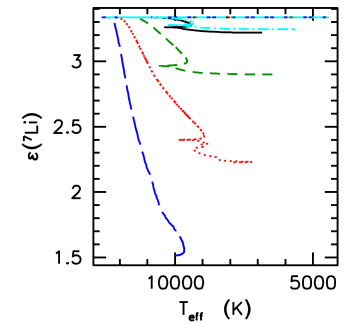
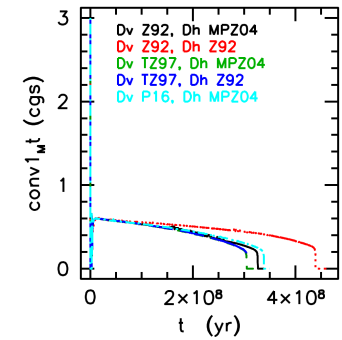
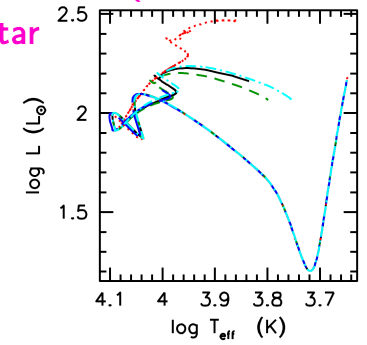
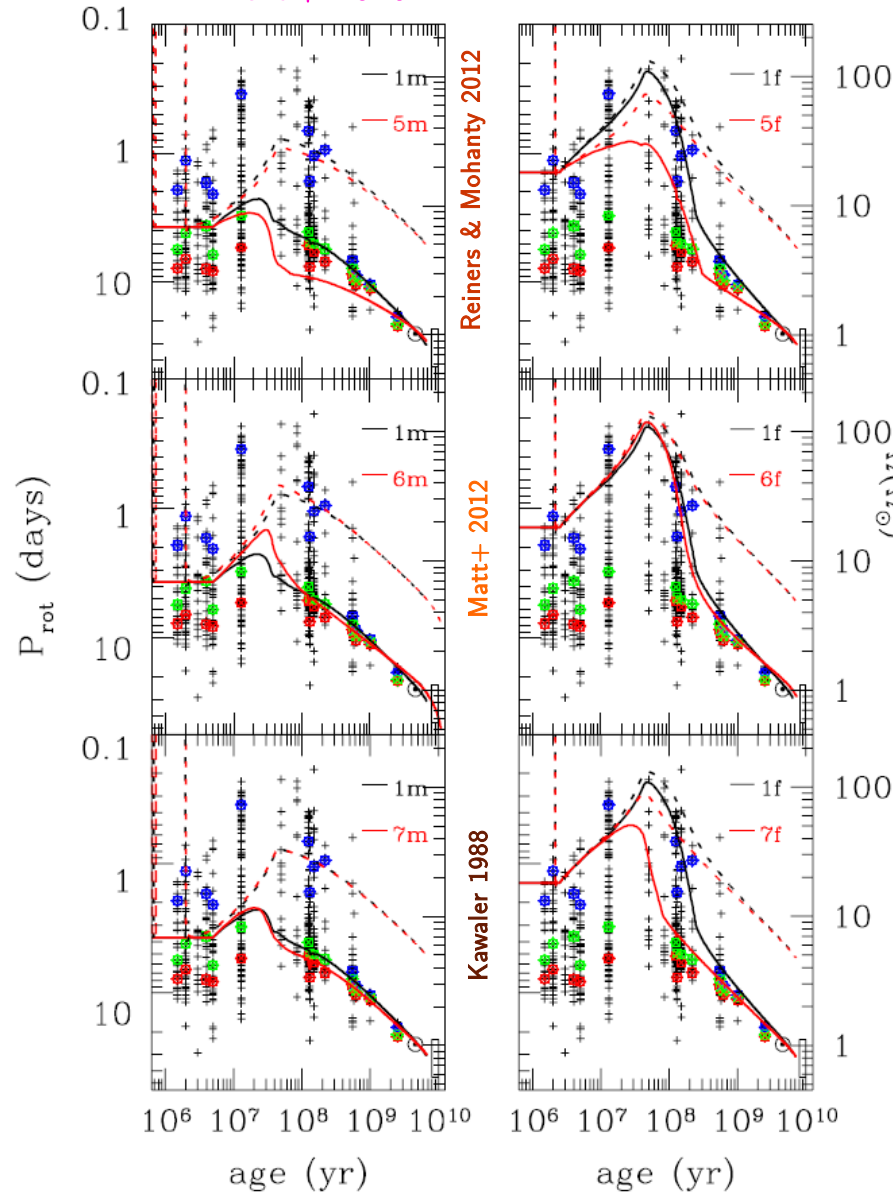
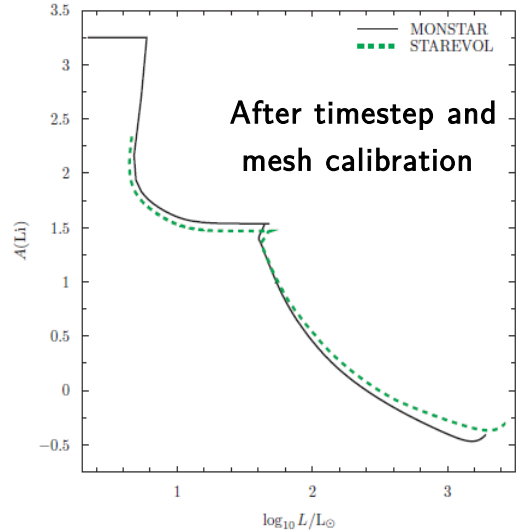
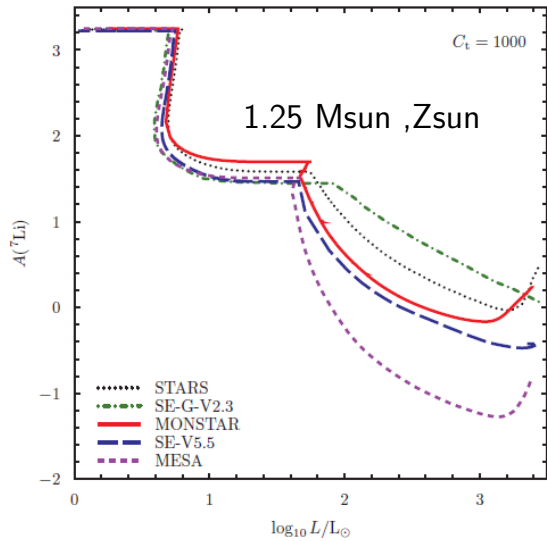
Transport processes in 1D stellar evolution models

Impact of formalisms and numerical schemes

Treatment of thermohaline mixing
Lattanzio+ 2013

Surface torque in solar-type stars
Amar+ 2016

Shear turbulence (vertical and horizontal)
3 Msun star



Transport processes in 1D stellar evolution models

To be done for PLATO

❏ Identify mandatory processes to be included in final models for grid production

❏ Select numerical schemes

❏ Select prescriptions



Benchmarking ?