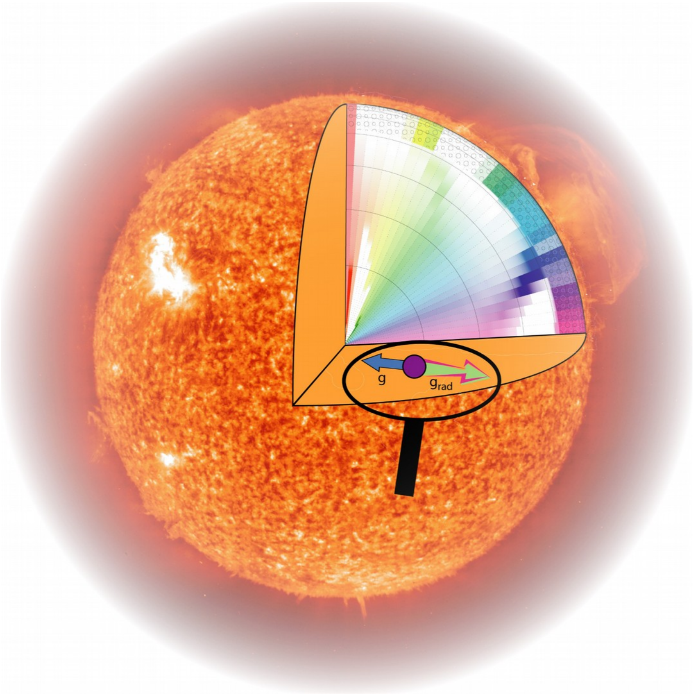
Impact of atomic diffusion on the structure and surface abundances of G and F type stars:

stellar parameter determinations and effects of rotation



Morgan Deal
LESIA

Prospective PNPS - 27 mars 2018

PNPS

Etude soutenue par le PNPS:

Processus de transport dans les étoiles en rotation lente (2018):
G. Alecian, M. Deal, F. Delahaye, A. Hui-Bon-Hoa, G. Massacrier, O. Richard (**PI**), G. Vauclair, S. Vauclair, C. Zeippen

Etude détaillée des variations de composition chimique à l'intérieur des étoiles : la diffusion des éléments et ses conséquences hydrodynamiques (2015-2017):
G. Alecian, M. Deal, F. Delahaye, A. Hui-Bon-Hoa, G. Massacrier, O. Richard (**PI**), G. Vauclair, S. Vauclair

Transport of elements inside stars

Diffusion velocity of element E (trace element case):

$$V_E = D_{E,p}\left[-\frac{\partial \ln c_E}{\partial r} + \frac{A_E m_p}{k_B T}\left(g_{rad,E} - g\right) + \frac{Z_E m_p g}{2 k_B T} + \kappa_T \frac{\partial \ln T}{\partial r}\right] + \sum D_{turb}\left[-\frac{\partial \ln c_E}{\partial r}\right]$$

Radiative acceleration term

Gravitational settling term

Macroscopic transport processes

Continuity equation :

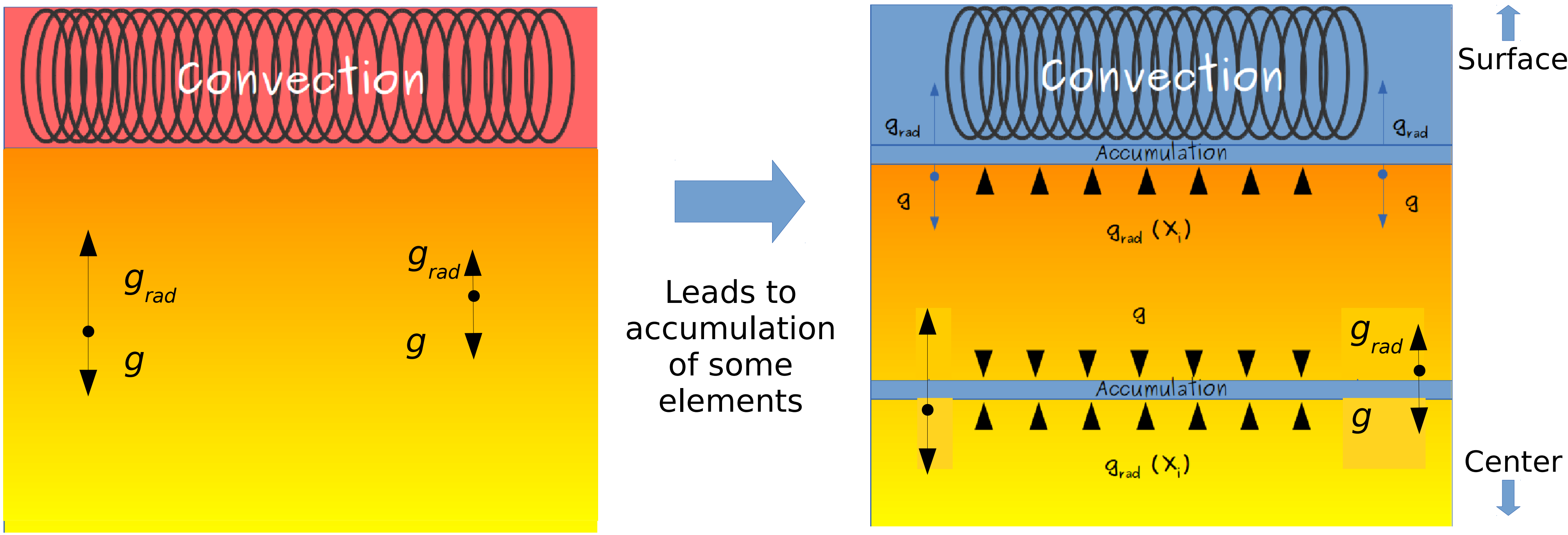
$$\frac{\partial \rho c_E}{\partial t} = -\nabla . \left(\rho V_E c_E\right)$$

The sign of the velocity mainly depends on the one of (if **D_{turb} is negligible**)

$$\left(g_{rad,E} - g\right)$$

Two main computational methods in stellar evolution codes: **Burgers method** and **Chapman & Cowling method**

Atomic diffusion inside stars

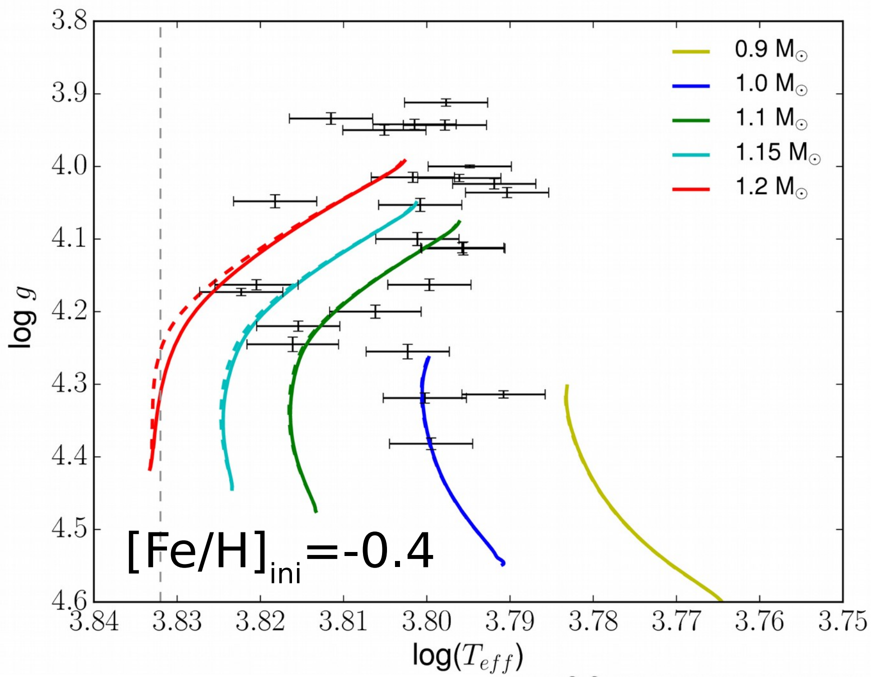


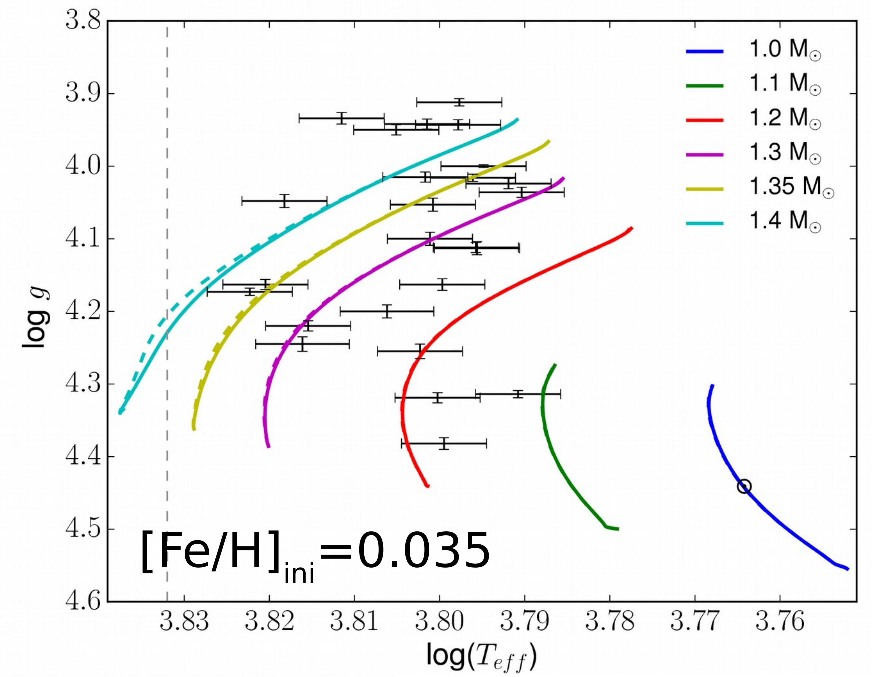
These effects are different **for each element** and depend on :

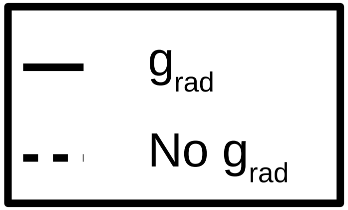
- the **abundance** of the element
- the **ionisation state**
- the **photon flux**

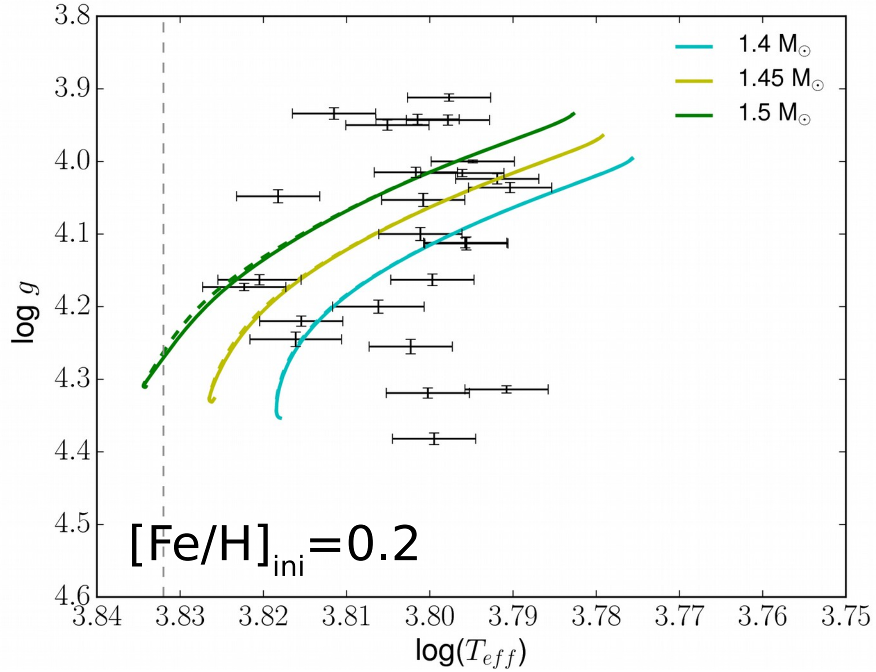
→ **Direct influence** on stellar **structure** and **hydrodynamics**

Evolution

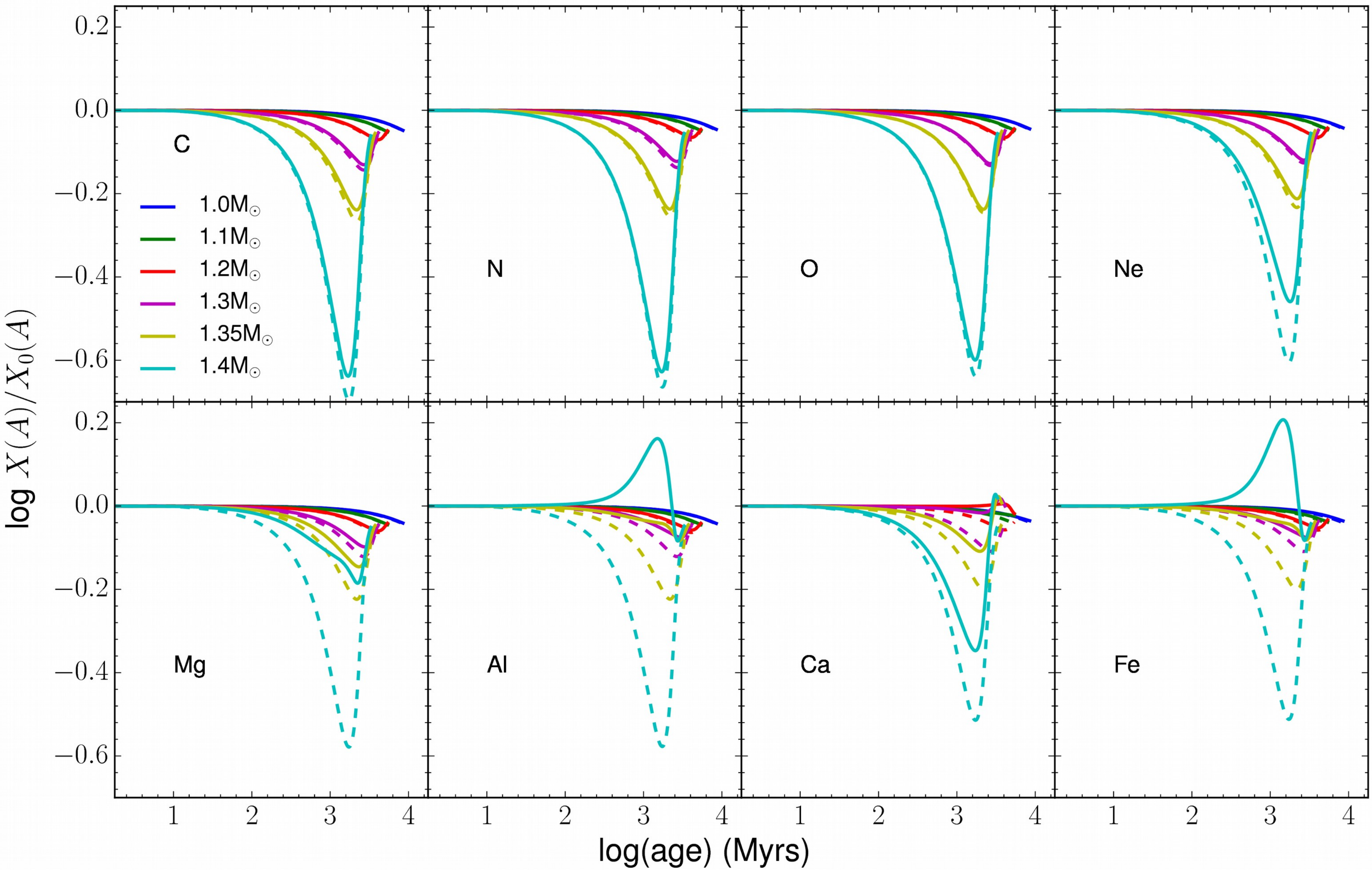

0.9 M☉
1.0 M☉
1.1 M☉
1.15 M☉
1.2 M☉
[Fe/H]ini=-0.4
log g
log(Teff)


1.0 M☉
1.1 M☉
1.2 M☉
1.3 M☉
1.35 M☉
1.4 M☉
[Fe/H]ini=0.035
log g
log(Teff)


grad
No grad

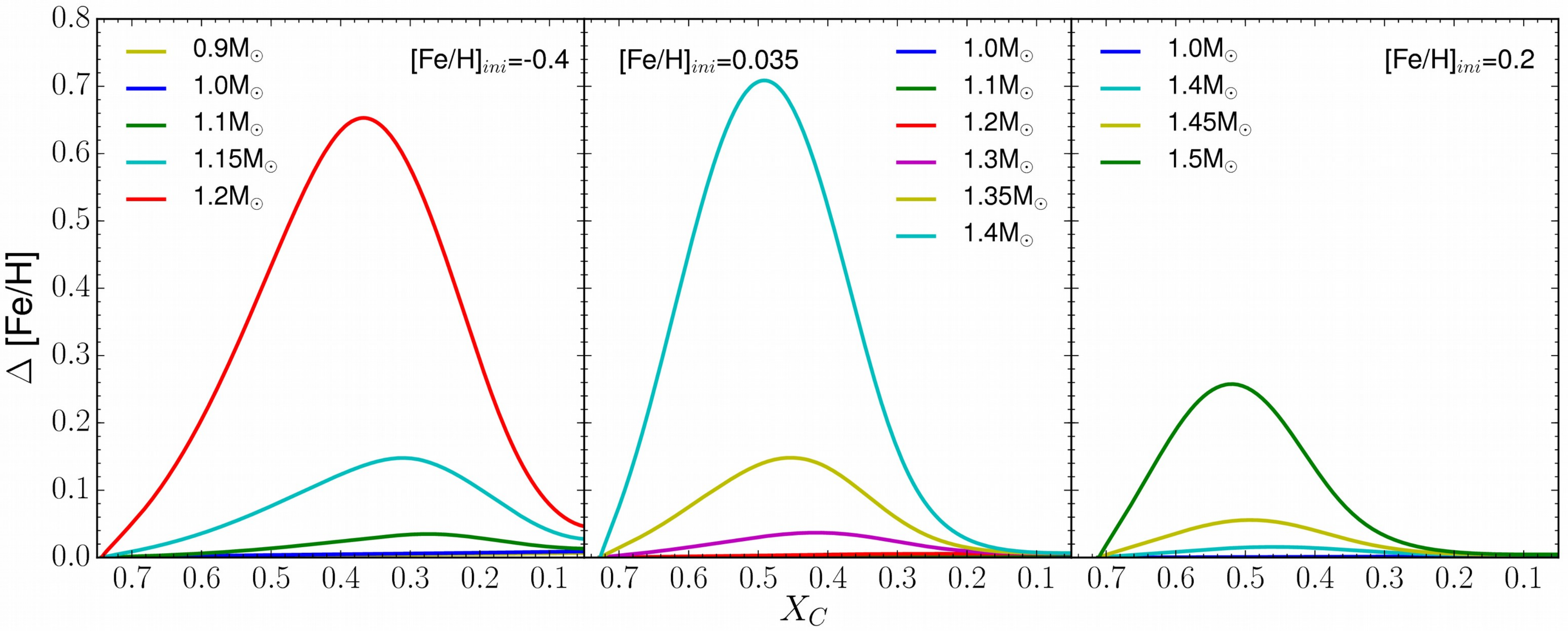

1.4 M☉
1.45 M☉
1.5 M☉
[Fe/H]ini=0.2
log g
log(Teff)

Surface abundances



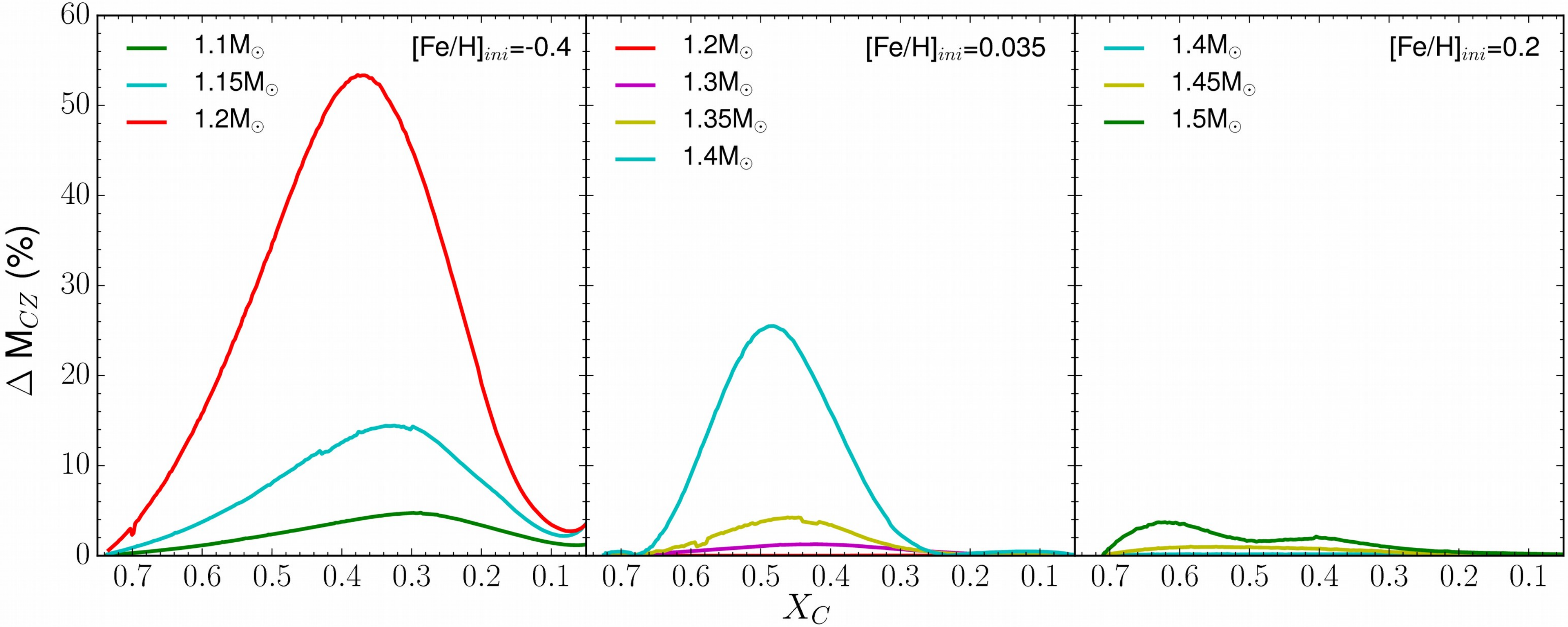
Surface abundances

Difference of [Fe/H] between models with and without radiative accelerations



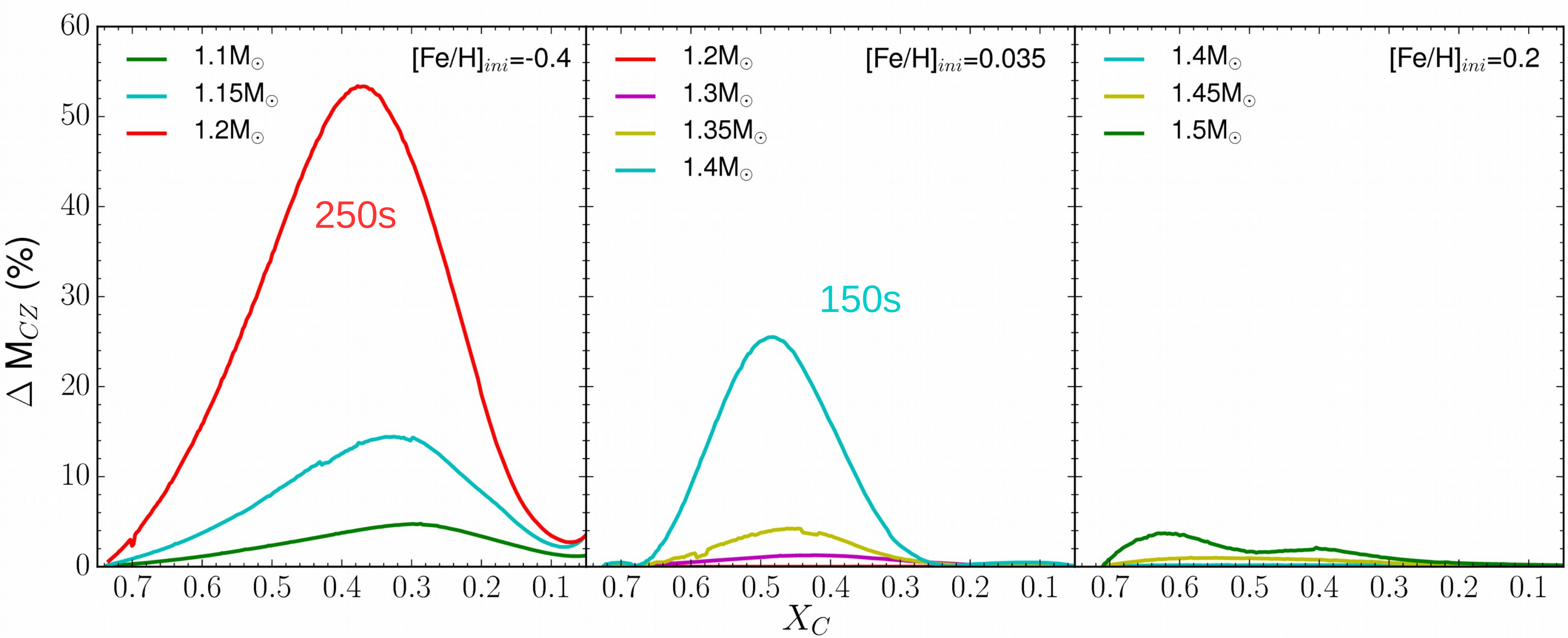
Surface convective zone

Difference of M_{cz} between models with and without radiative accelerations



Surface convective zone

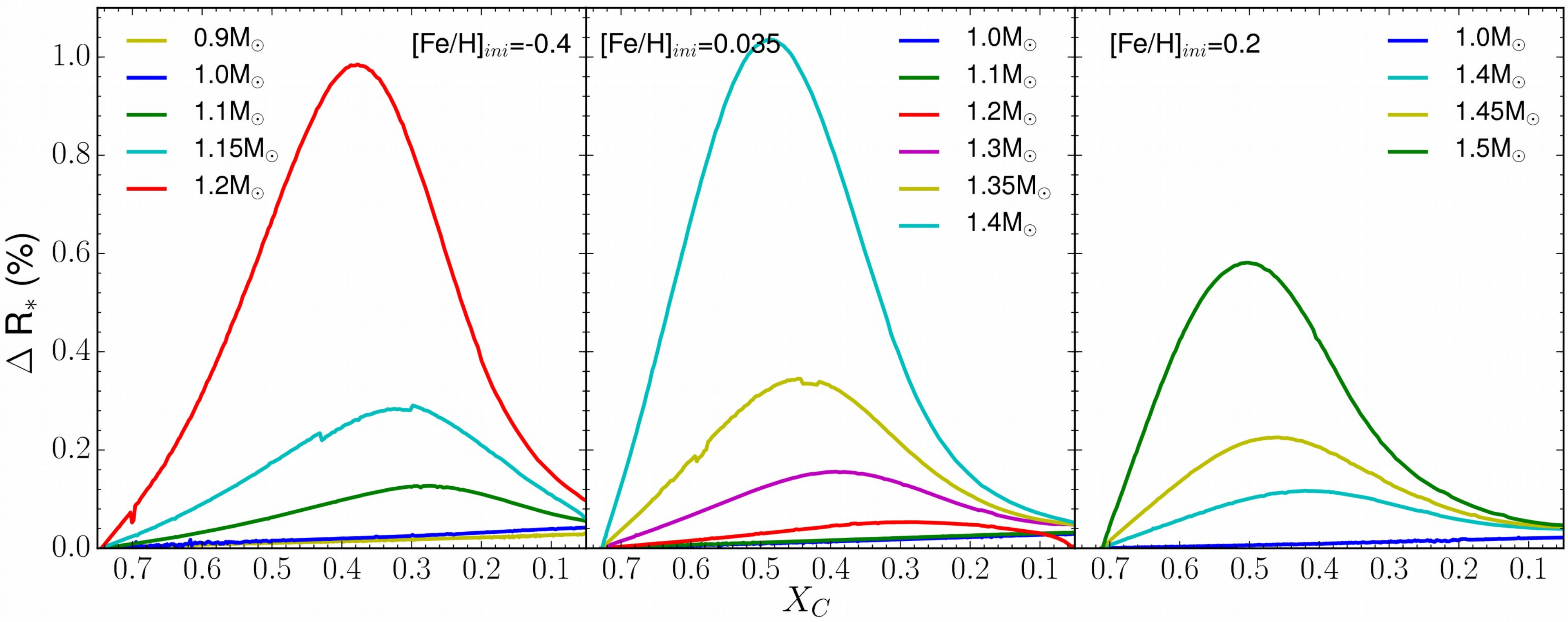
Difference of M_{cz} between models with and without radiative accelerations



Larger than the uncertainty on the **acoustic depth** of surface convective zone of some F type stars from ***Kepler*** (Verma+ 2017)

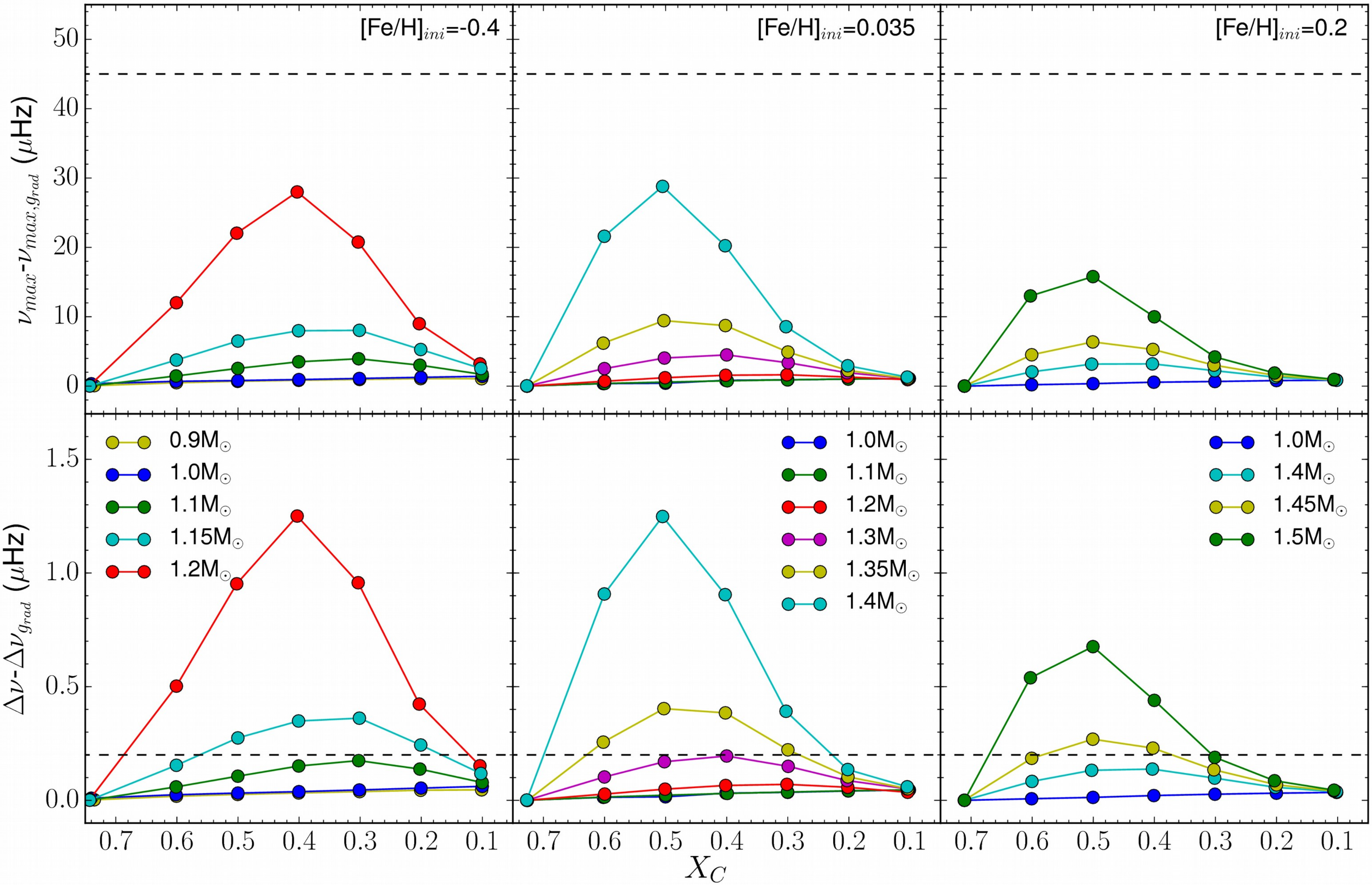
Radius

Difference of radius between models with and without radiative accelerations

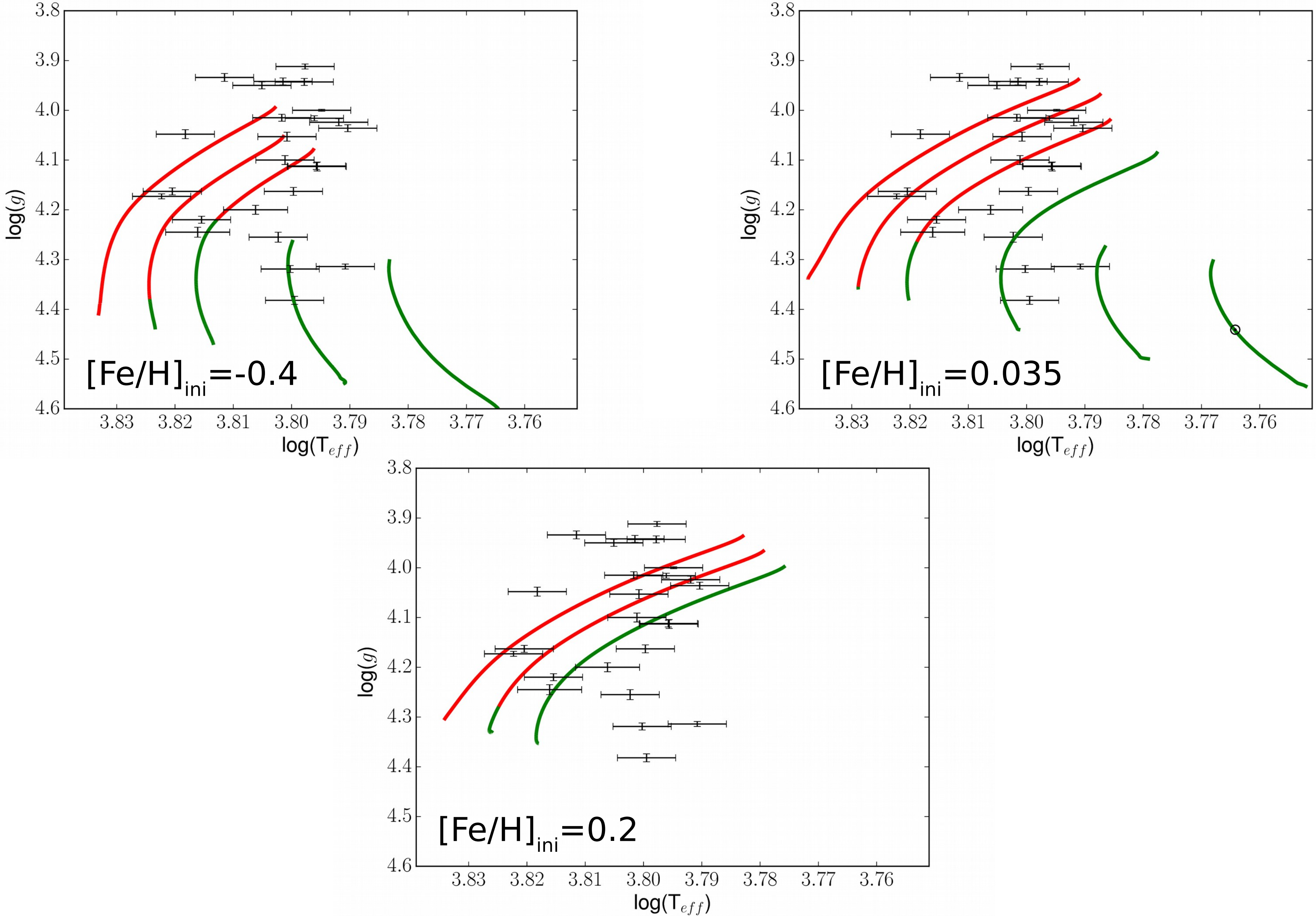


1% in radius at maximum

$\Delta\nu_0$ and ν_{max}



Δv_0 and v_{max}



$\Delta\nu_0$ and ν_{max}

	1	2	3
[Fe/H]$_{ini}$	-0.4	0.035	0.2
Limit Mass ($M_\odot$)	1.1	1.3	1.43

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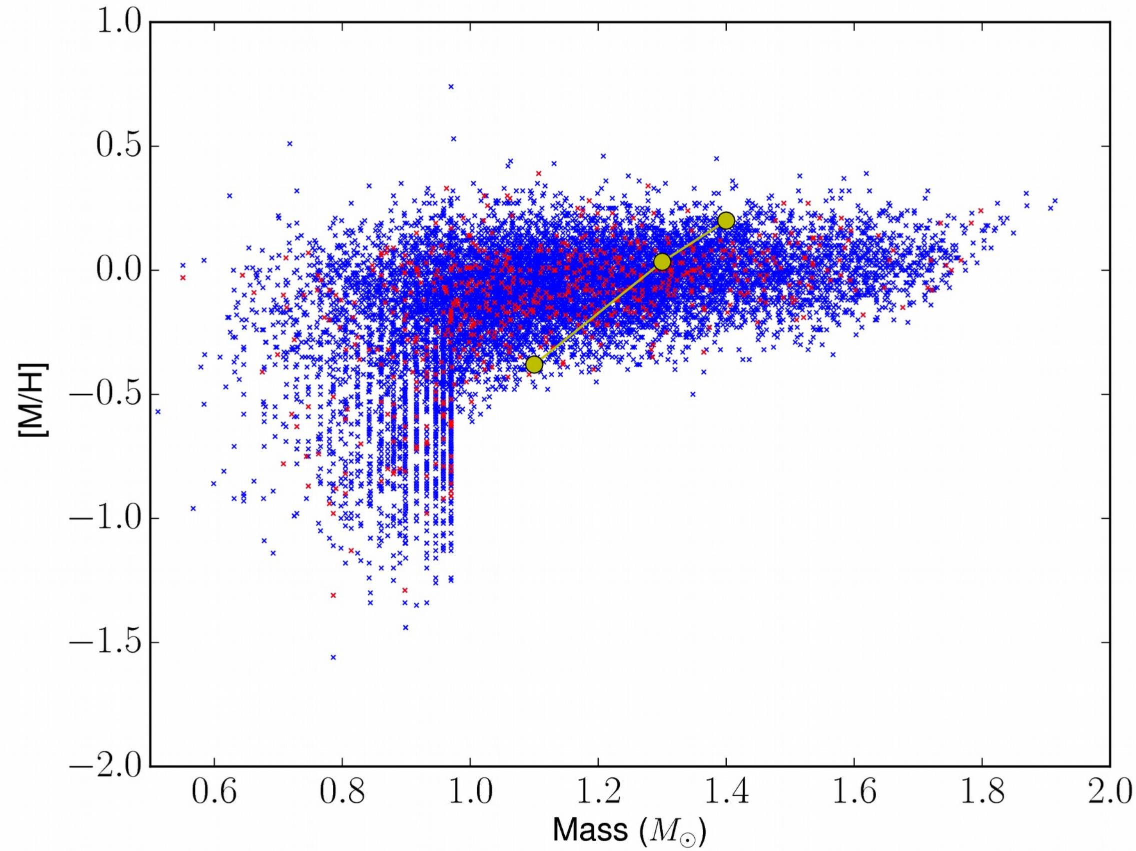
Kepler

PLATO



Simulation of stellar population from the Besançon code (A. Robin)

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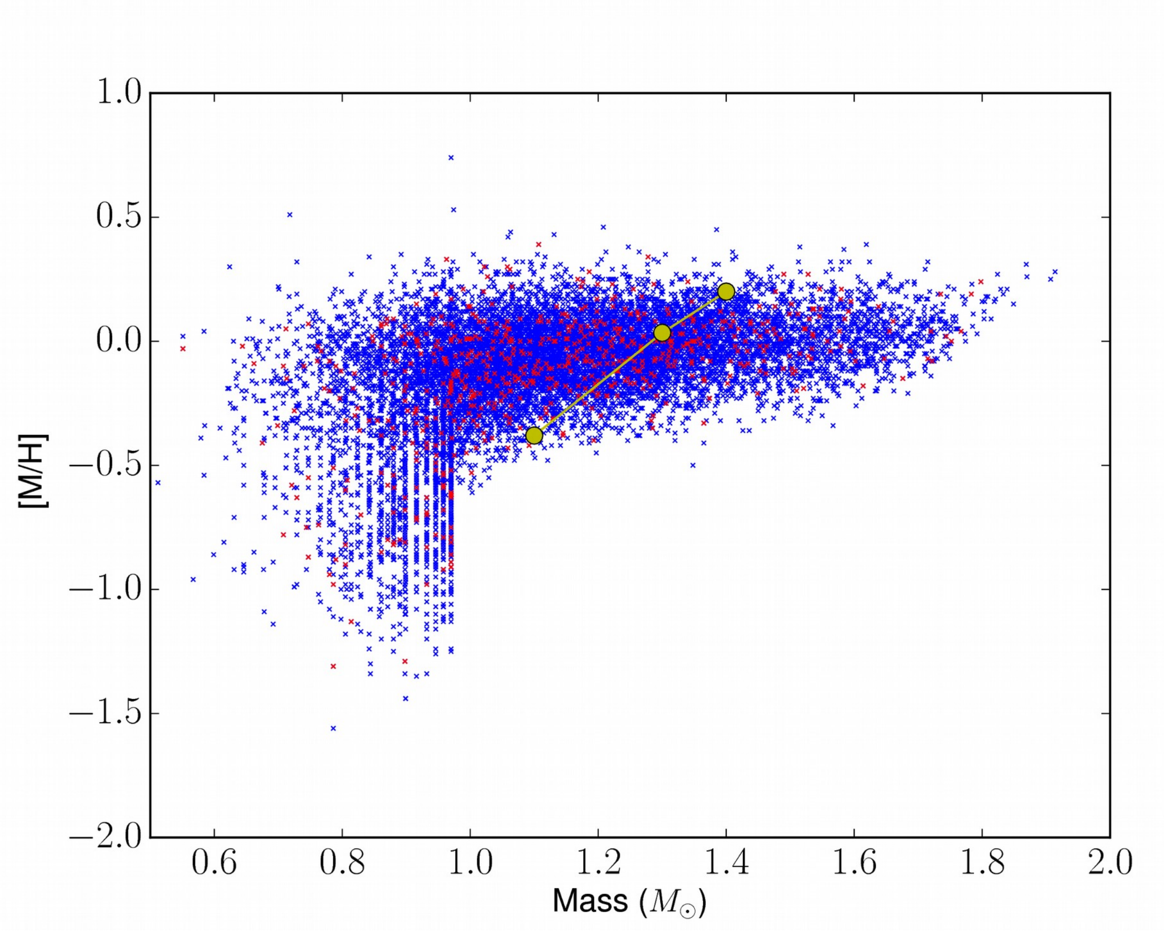
Kepler

PLATO



Simulation of stellar population from the Besançon code (A. Robin)

***28%** of core program stars*

Parameter determinations

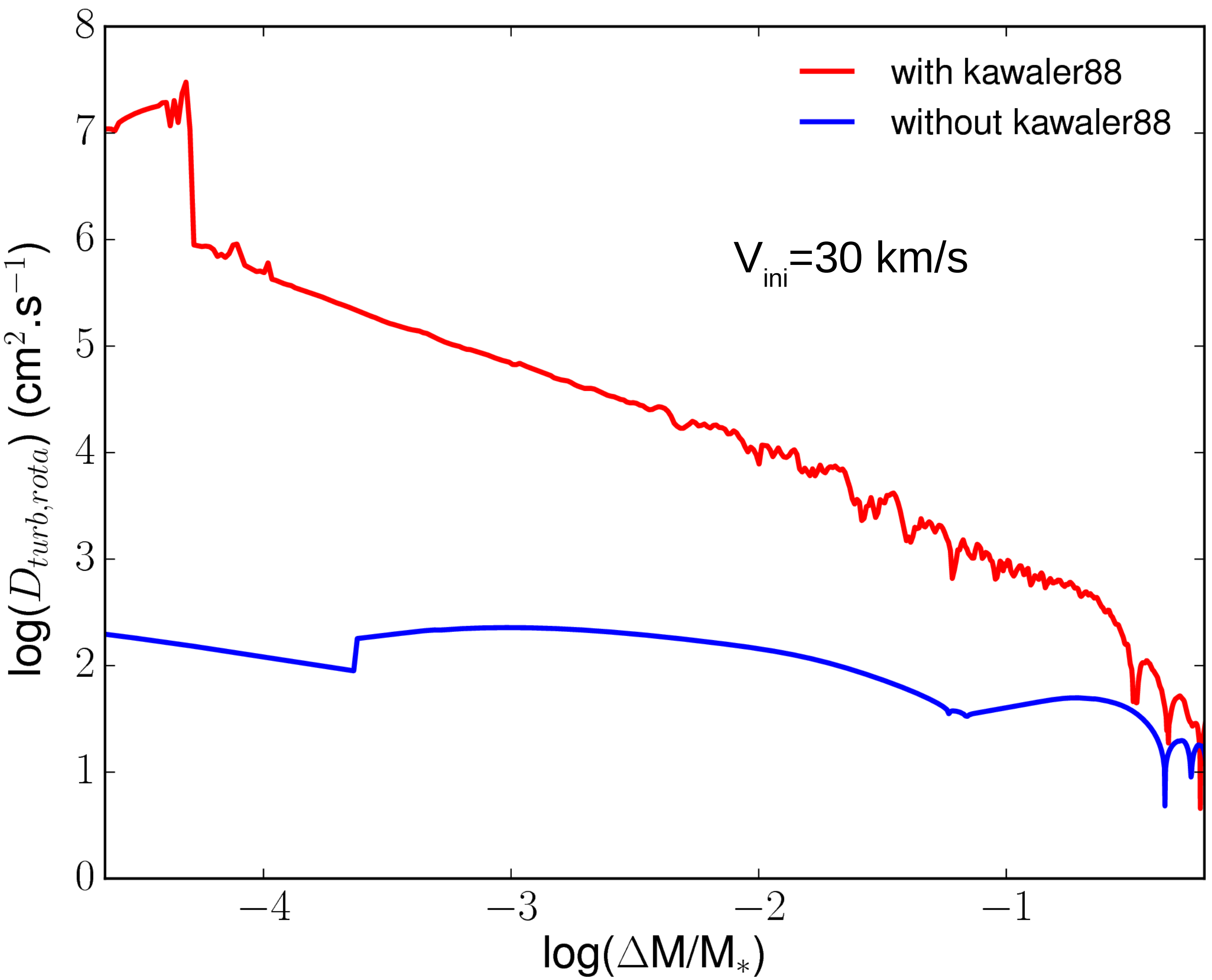
94 Ceti A: age difference of 4% (Deal et al. 2017)

1.4 $M_{\odot}$ at solar metallicity: age difference of 12%, mass difference 4% using AIMS (Deal et al. In prep.)

Impact of rotation

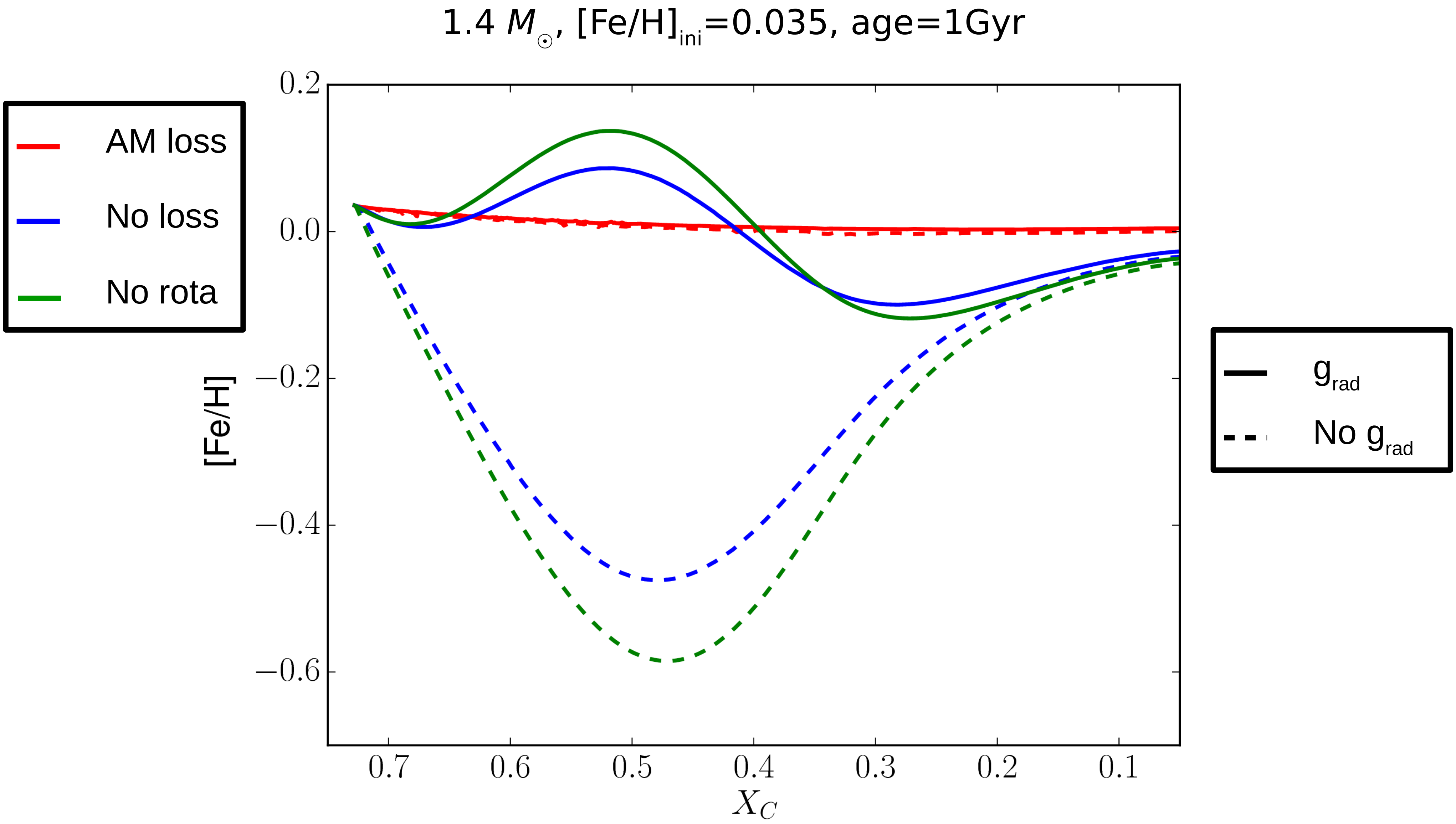
Angular momentum loss at the surface

1.4 $M_{\odot}$, [Fe/H]$_{ini}$=0.035, age=1Gyr



Impact of rotation

Angular momentum loss at the surface



Perspective

- Continue the study of the coupling between atomic diffusion and rotation, and other transport processes

- Impact of g_{rad} and other transport processes in the case of the optimisation of stellar parameters

- Study the impact of atomic diffusion on glitches (size of surface convective zones)

- Study the ionisation zone of heavy elements (Brito+ 2017,2018)