Rotation Evolution in Intermediate-Mass Stars

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The aim of our work is to study the evolution of rotation and its effects in massive, intermediate- and low-mass stars. To do so, we run models with both MESA and GENEC (with and without magnetic fields) for a broad initial mass range, and compare the results to observational constraints.
The first aspect we focussed on is the evolution of rotation in intermediate-mass stars. This poster presents the preliminary results of our study, showing the angular momentum evolution of 3 solar mass models calculated with MESA. We included magnetic torques according to the Taylor-Spruit dynamo (Spruit 2002) in our MESA models and the final rotation rates are still higher than observed WD spins, confirming the results obtained by Suijs (2008). Our next step is to investigate additional mixing processes that would be able to reproduce observations of WD spins and to study the impact of rotation on the s-process production.

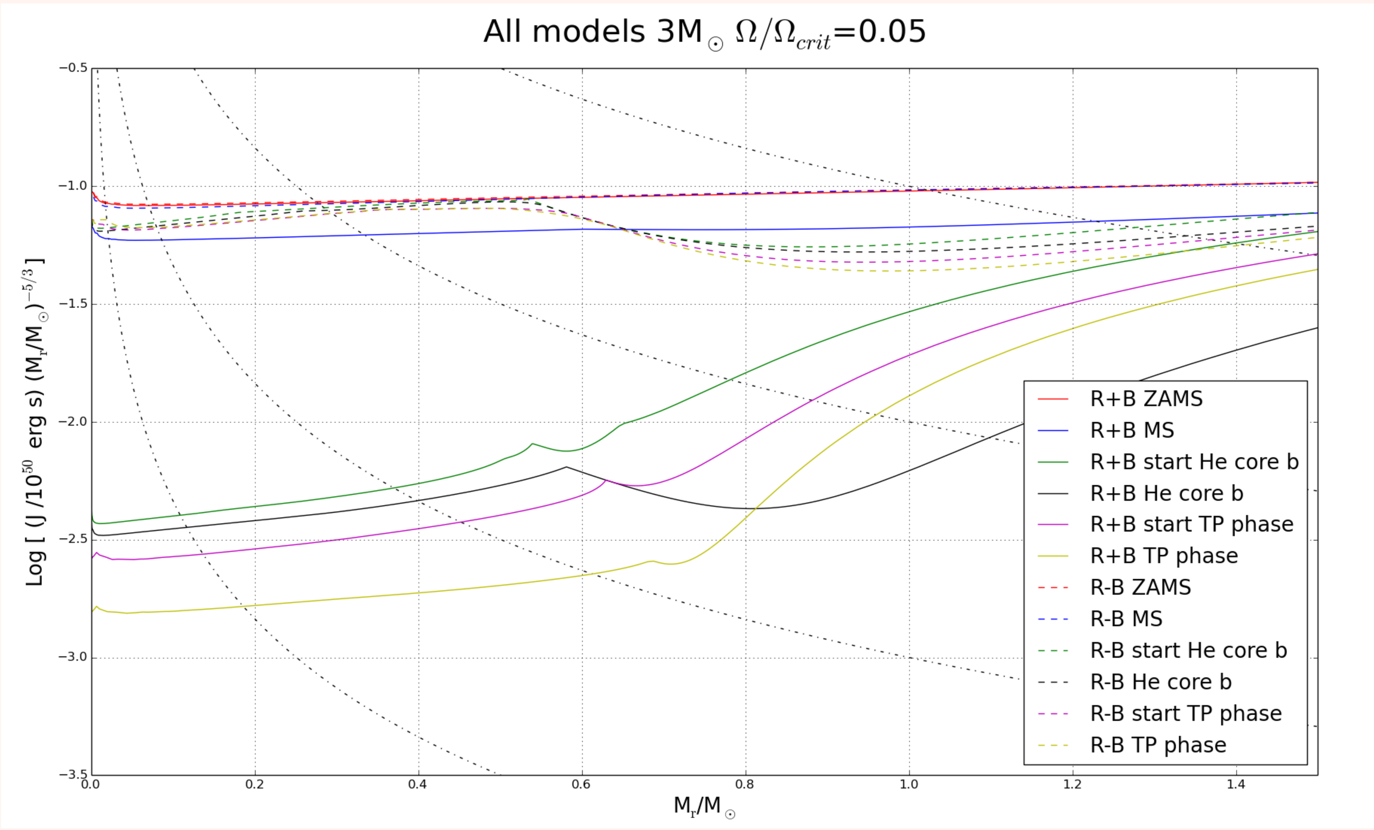

Fig. 1: Integrated angular momentum divided by $M^{5/3}$, as a function of mass for all 6 models of the sequences of Ω/Ω_{crit}=0.05 both with and without magnetic torques. The dashed-dotted lines are levels of constant J, with J=10^{49-46} from top to bottom.

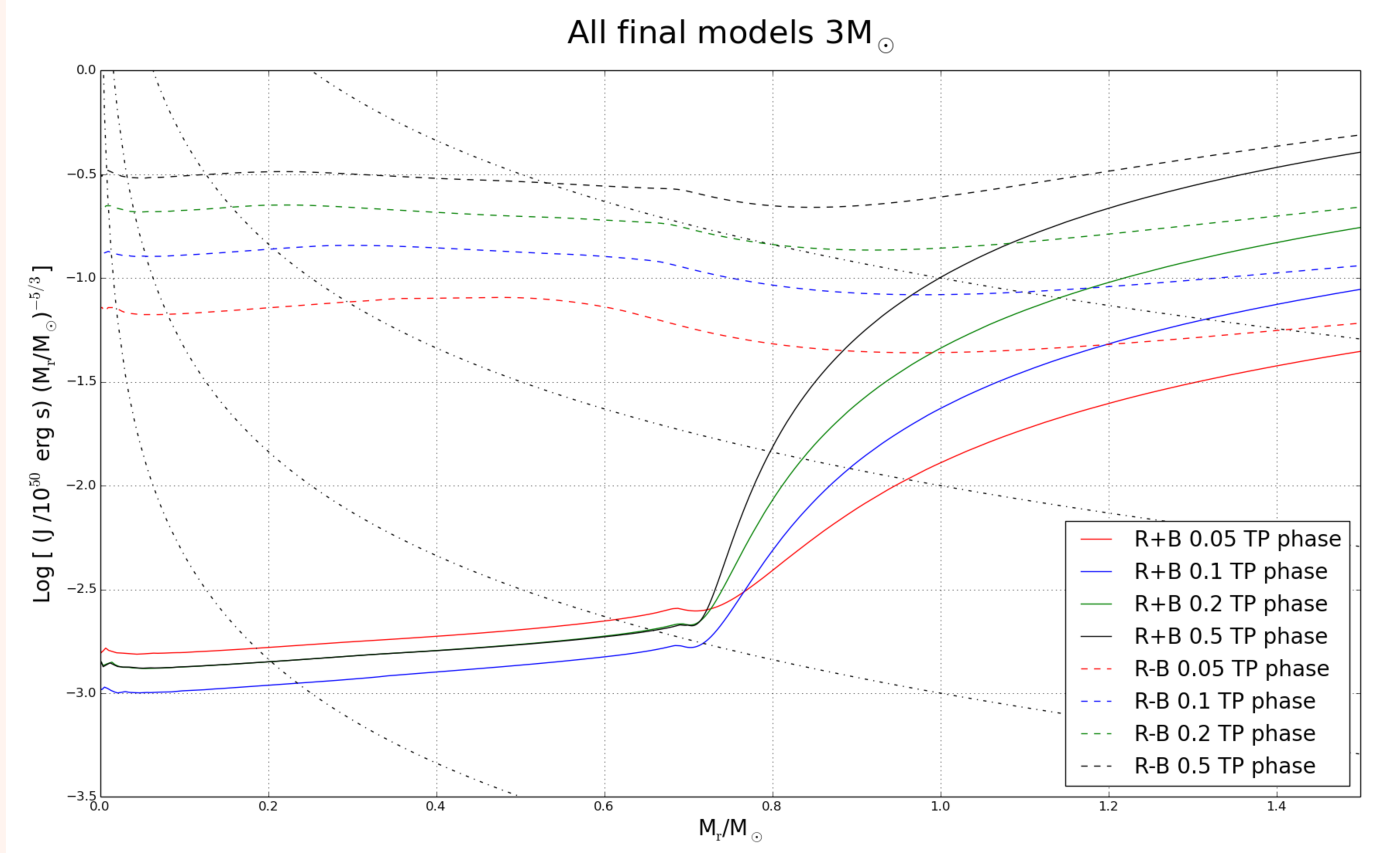

Fig. 2: Integrated angular momentum divided by $M^{5/3}$, as a function of mass for the final models of all the sequences: Ω/Ω_{crit}=0.05;0.1;0.2;0.5, all with and without magnetic torques. Contour lines represent levels of constant J, like in fig. 1.

The biggest drop of core angular momentum occurs during the giant phase, as predicted by Spruit (1998). This drop is larger in the models including magnetic fields, due to the magnetic fields enforcing close-to-rigid rotation. This situation is similar for higher initial Ω/Ω_{crit} values.

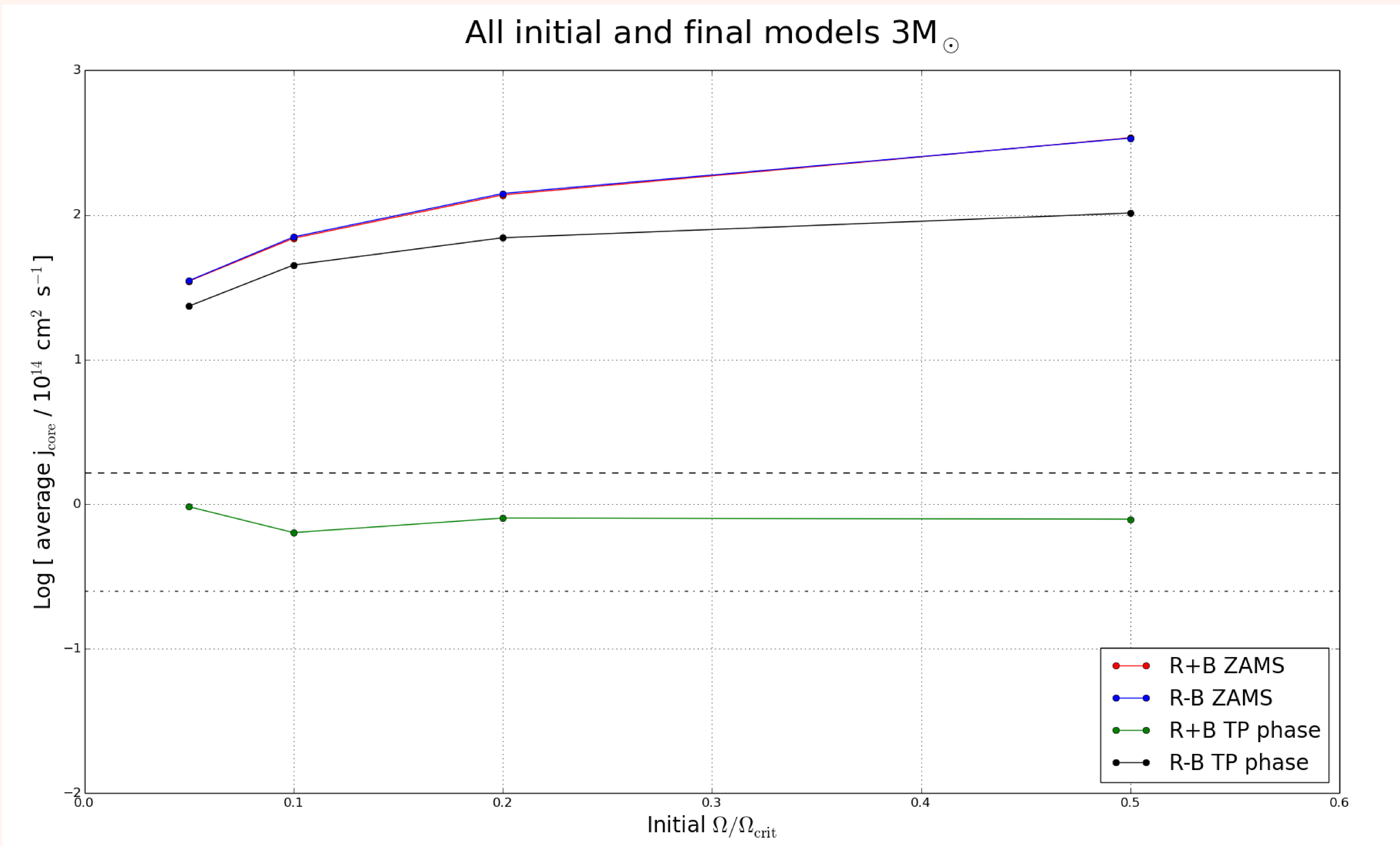

Fig. 3: Average core specific angular momentum of the initial and final models of the sequences described in the caption of fig. 2 versus the initial Ω/Ω_{crit} values. The dashed horizontal line is the spectroscopic upper limit of the white dwarfs spins obtained by Berger (2005). The dashed-dotted line is the asteroseismic upper limit, see Kawaler (2003). Only the sequences include magnetic fields are below the spectroscopic limit, yet still higher than the asteroseismic upper limit.

Asteroseismic observations find spins of an order of magnitude lower than predicted by Suijs (2008) and our models. Therefore, an unmodeled angular momentum transport process must be operating, see also Cantiello (2014).
We have started studying the impact of rotation and magnetic fields on the C13-pocket in our models. The initial tests confirm that rotation and magnetic fields strongly affect the pocket formation and evolution as already found in Herwig (2003) and Piersanti (2013). Successful models need to be able to reproduce both nucleosynthesis and rotation properties of stars.

Extra angular momentum transport process needed:
- MRI?
- gravity waves?
- …?

Observations wanted:
- spin periods
- stellar abundances
- asteroseismology
- ...

as many as possible

References

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