The variation of tidal dissipation in the convective envelope of low-mass stars along their evolution

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Abstract:

More than 1500 exoplanets have been discovered around a large diversity of host stars (from M- to A-type stars). Tidal dissipation in their convective envelope is a key actor that shapes the orbital architecture of short-period systems and that still remains unknown. Using a simplified two-layer assumption and grids of stellar models, we compute analytically the frequency-averaged tidal dissipation due to the conversion into heat of the kinetic energy of tidal waves because of the viscous friction applied by turbulent convection.

During their Pre-Main-Sequence (PMS), all low-mass stars have an increase of the frequency-averaged tidal dissipation for a fixed angular velocity in their convective envelope. Next, it evolves on the Main-Sequence to an asymptotic value that is maximum for K-type stars and that decreases by several orders of magnitude with increasing stellar mass. Finally, the rotational evolution of low-mass stars strengthens tidal dissipation during the PMS.

The studied set-up:

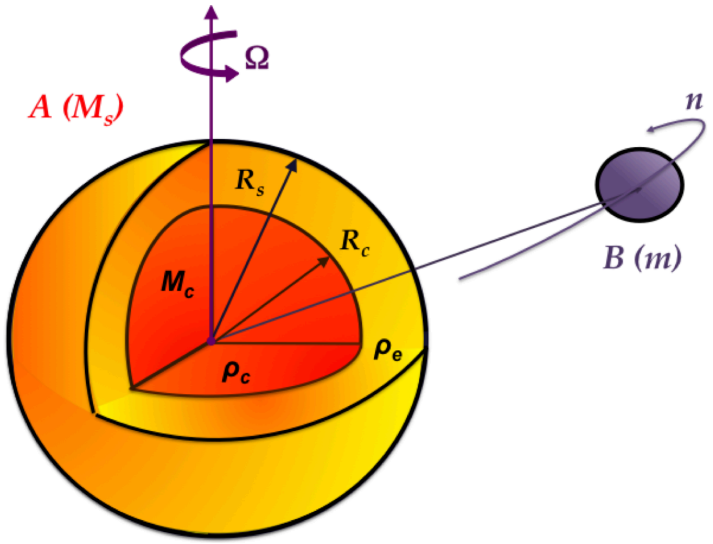

Fig 1: Two-layer low-mass rotating star A of mass M_s and mean radius R_s and point-mass tidal perturber B of mass m orbiting with a mean motion n. The radiative core of radius R_c, mass M_c and density ρ_c is surrounded by the dissipative convective envelope of density ρ_e.

Key results

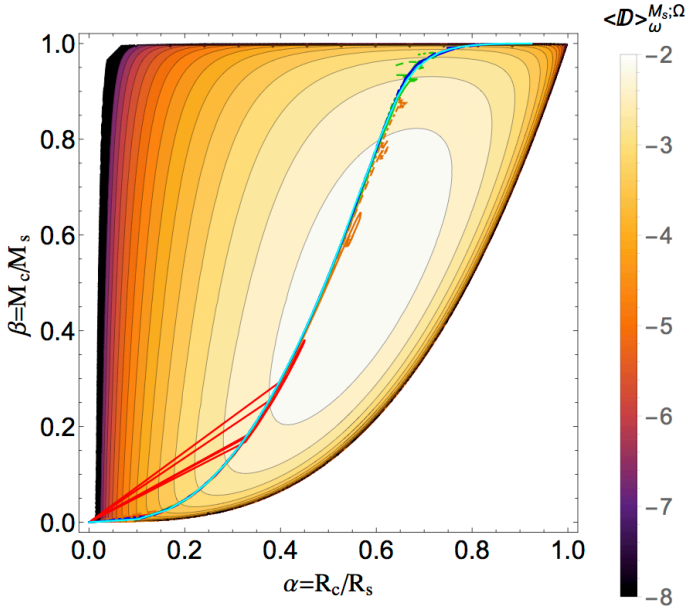

Fig 2: Variation of the frequency-averaged tidal dissipation at fixed angular velocity as a function of aspect and mass ratios ($\alpha=R_c/R_s$ and $\beta=M_c/M_s$ respectively) in color logarithmic scales. Evolutionary tracks of stars from 0.4 to 1.4$M_\odot$ in the (α,β) plane (red, orange, green, dark blue, cyan lines correspond to M, K, G, F and A-type stars respectively).

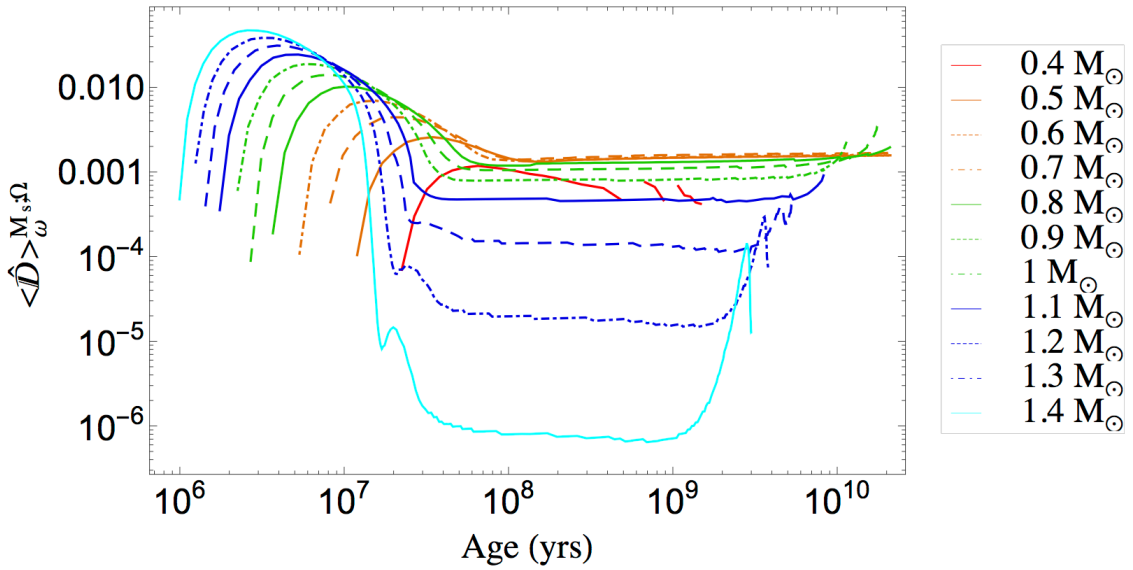

Fig3: Evolution of the frequency-averaged tidal dissipation at fixed angular velocity as a function of time for stars from 0.4 to 1.4$M_\odot$.

Conclusion:
- For all masses, tidal dissipation reaches a maximum during the PMS;
- On the Main-Sequence, it reaches an almost constant value that decreases from K to A type stars

Bibliography:

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Siess et al. 2000, A&A, 358, 593