Basics of the MESA evolution code

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Starting model

- According to Paxton et al. 2013
- `pre_ms_model` routine
- `create_pre_main_sequence_model = .true.`
- iterations on the starting conditions at the centre to find a model with a given M and central temperature T_c
- usability: $M \gtrsim 0.03\ M_\odot$
- for lower masses convergence problems

Starting model - very low M

- create_initial_model routine
- create_initial_model = .true.
- the routine builds a model of given M and radius R using an adiabatic temperature profile
- given the central pressure P_c and specific entropy S, the equation of hydrostatic balance is integrated outward, and the temperature at each step determined from the EOS using $T = T(P,S)$
- iterations on P_c and S in order to obtain the desired M and R

Starting model - very low M

- the luminosity profile is calculated with assumption that that *S* is constant in space for the fully convective planet
- *L(M)* is estimated with *R* and T_{eff} at $\tau = 2/3$ using a relation $L(M) = 4\pi R^2 \sigma T^4_{eff}$
- the procedure works down well to ~0.1 M_J

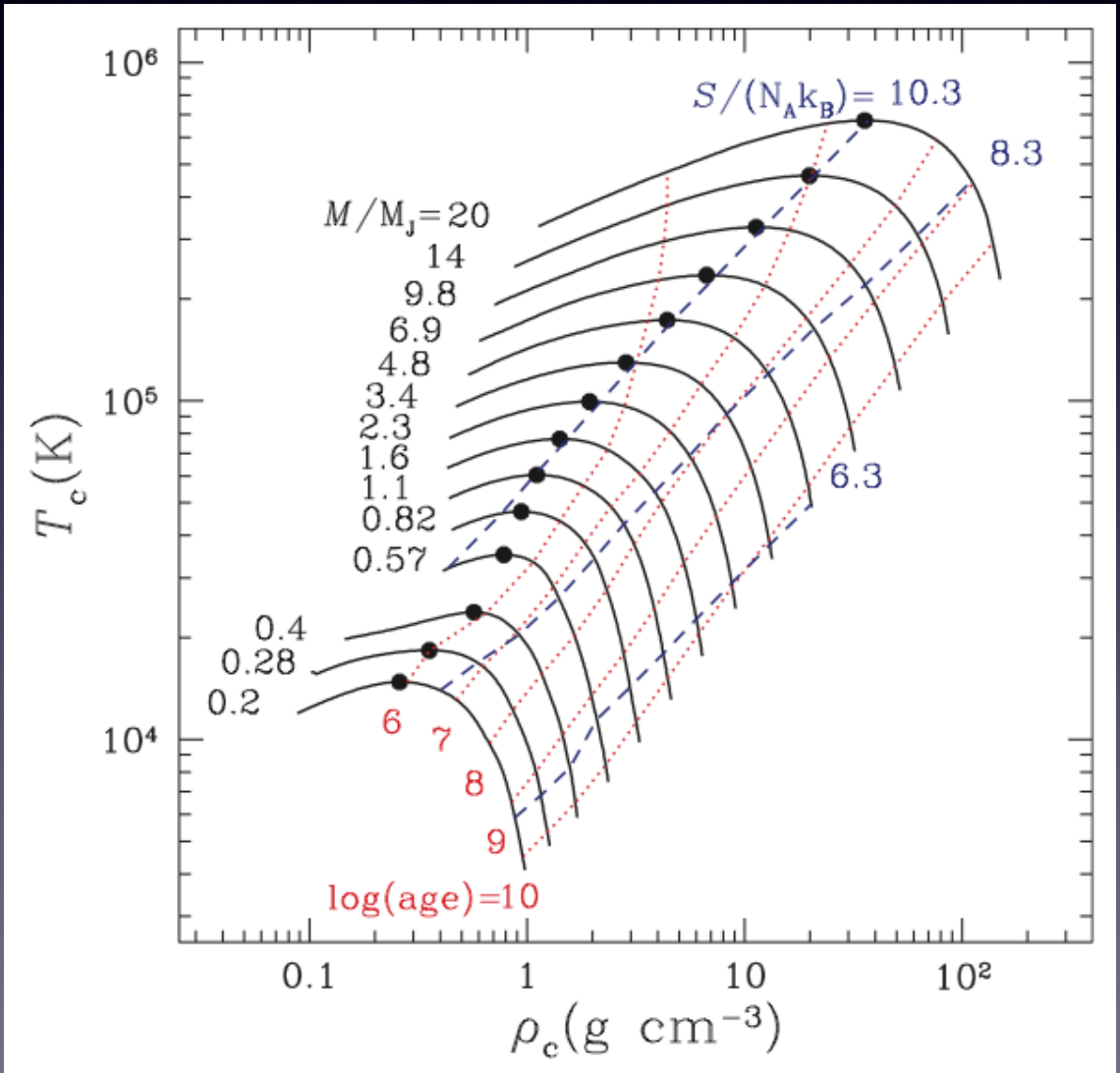
Starting model - very low M

$$\int_0^m dm'\, T(m')\frac{dS}{dt} \simeq \frac{dS}{dt}\int_0^m dm' T(m') = -L(m)$$

$$L(m) = L(M)\left(\frac{\int_0^m dm'\, T(m')}{\int_0^M dm'\, T(m')}\right)$$

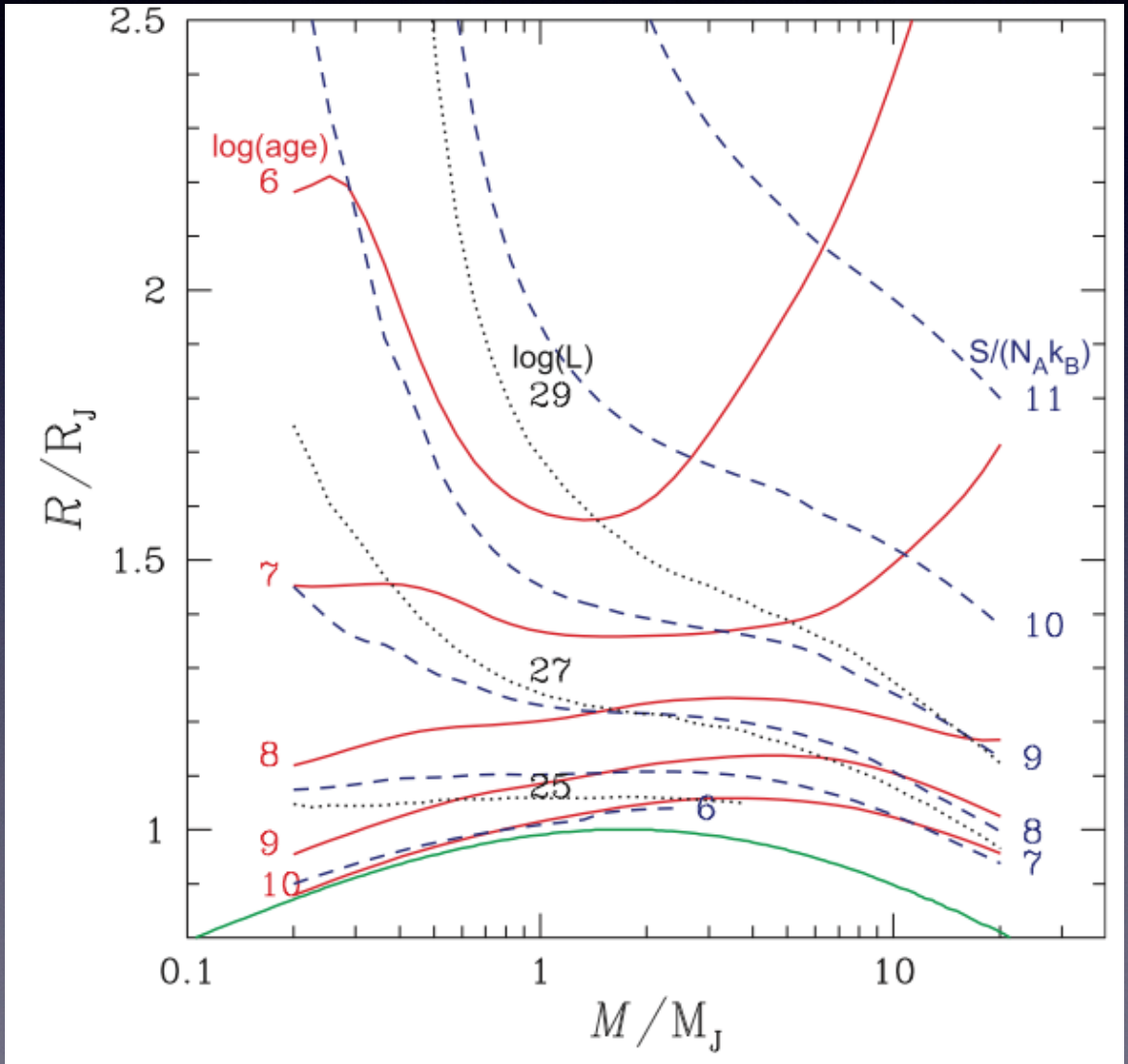
Paxton et al. 2013

Planets



Paxton et al. 2013

Planets



Paxton et al. 2013

Planets and low mass stars

- Additional materials:
- http://mesastar.org/results/mesa2/planets
- http://mesastar.org/documentation/mesa-summer-school-2013/pre-main-sequence-evolution-of-low-mass-stars