Microscopic diffusion in the TGEC

by

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TGEC: non-standard physics

- Microscopic diffusion
- Accretion (over/under-metallic material)
- Rotational mixing
- Turbulent mixing (tachocline, thermohaline instability)
- Evolution of angular momentum
- Over/undershooting
- Mass-loss

Diffusion: basic assumptions

- Chapman & Cowling approach
- Diffusion velocity

$$V_{pi} = D_{pi} \left[-\nabla \ln c_i + k_p \nabla \ln p + \alpha_{pi} \nabla \ln T - \frac{f_i}{k_{\rm B} T} \right]$$

- D_{pi}, α_{pi} from Paquette et al. (1986)

Present implementation

- H, He, Li, Be, B, C, N, O, Ne, Mg
  - Total ionization
- Concentration gradient
- Gravitational settling
- Thermal diffusion
- Radiative forces in progress (Alecian & LeBlanc method)

Abudance evolution

- Continuity equation $\rho \frac{\partial c}{\partial t} = -\frac{1}{r^2}\frac{\partial}{\partial r}(r^2 V_{pi} \rho c) - \lambda \rho c$
- Resolution for each species (except H) → $\frac{\partial \boldsymbol{C}}{\partial t} = \boldsymbol{MC}$
- Crank-Nicholson method for time integration

$$\frac{\boldsymbol{C}^{l+1} - \boldsymbol{C}^{l}}{\Delta t} = \eta \boldsymbol{MC}^{l+1} + (1-\eta)\boldsymbol{MC}^{l}$$

- Typically 20 diffusion iter. per structure iter.
- H abundance from X+Y+Z=1

Some applications

- F stars in galactic clusters (Charbonnel et al. 1992)
- The Sun (Richard et al. 1996, 2004)
- He settling and rotation mixing in MS stars (Théado & Vauclair 2003)
- Ap stars and asteroseismology (Théado, Vauclair, Cunha 2004, 2005)
- Planet hosting stars (Bazot et al. 2004, 2005)
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