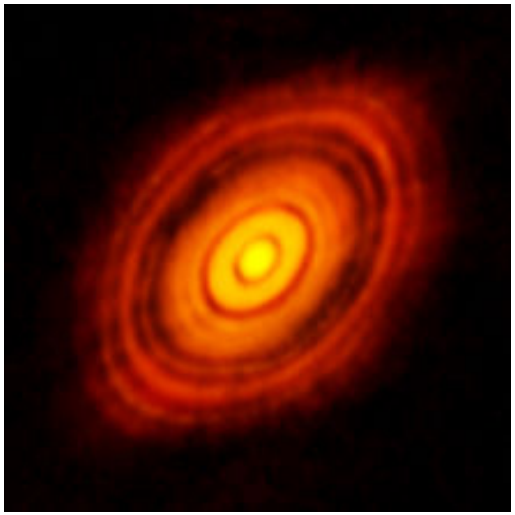
MCFOST - Radiative transfer code for protoplanetary disks

Héloïse Méheut

Radiative transfer day - 29/05/2019

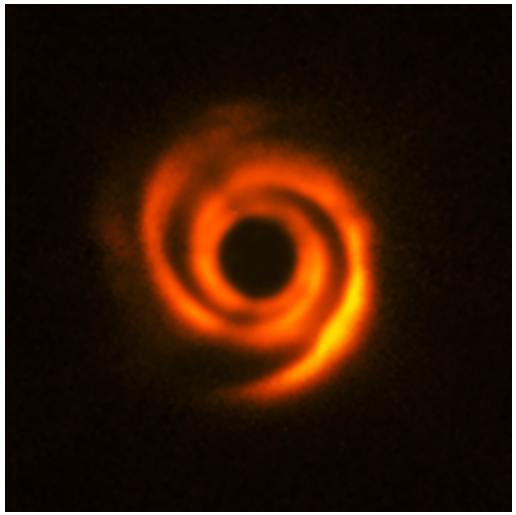
Structures in protoplanetary disks

Rings



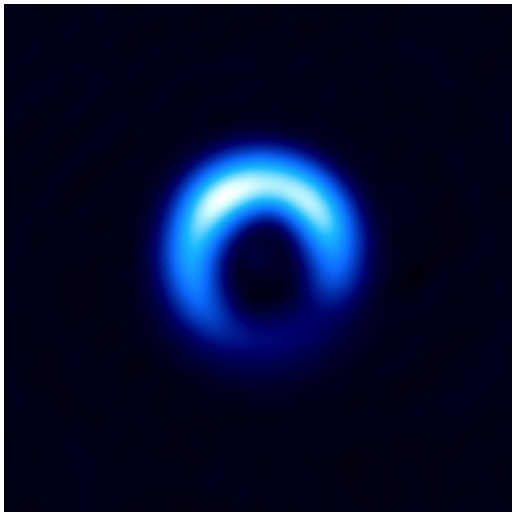
HL Tau (ALMA)

Spirals



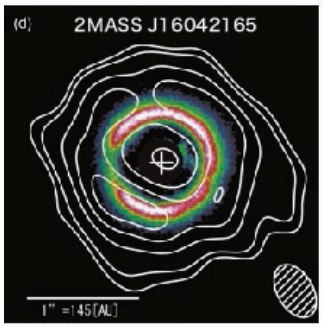
HD135344b (SPHERE)

Crescents

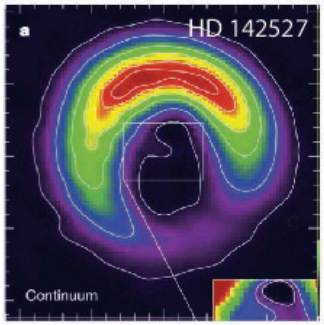


HD142527 (ALMA)

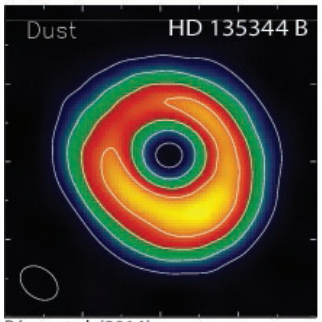
Crescents
Vortices ?



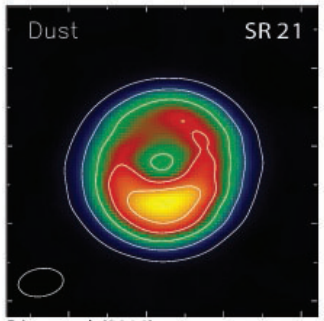
Mayama et al. (2012)



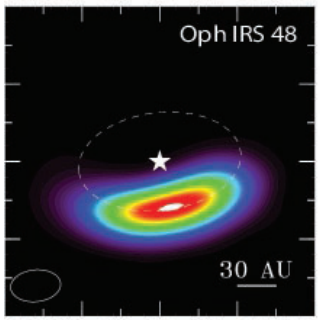
Casassus et al. (2013)



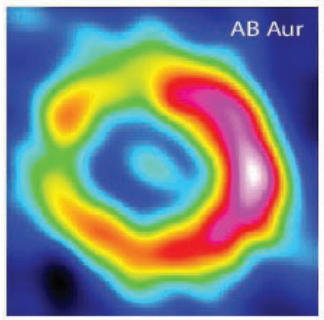
Pérez et al. (2014)



Pérez et al. (2014)

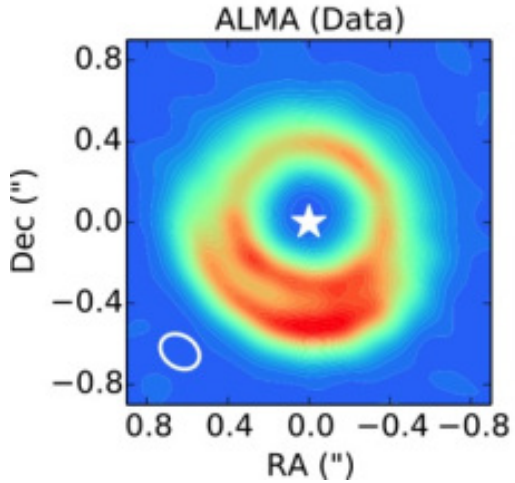


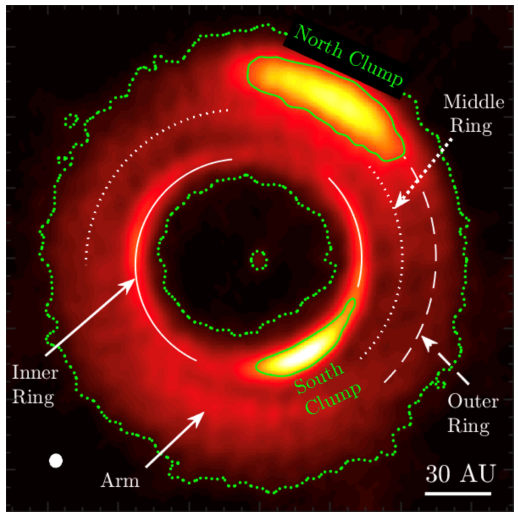
van der Marel et al. (2013)



Rodrigez et al. (2014)

HD 135344B





MWC 658

Adaptive Mesh Refinement Versatile Advection Code

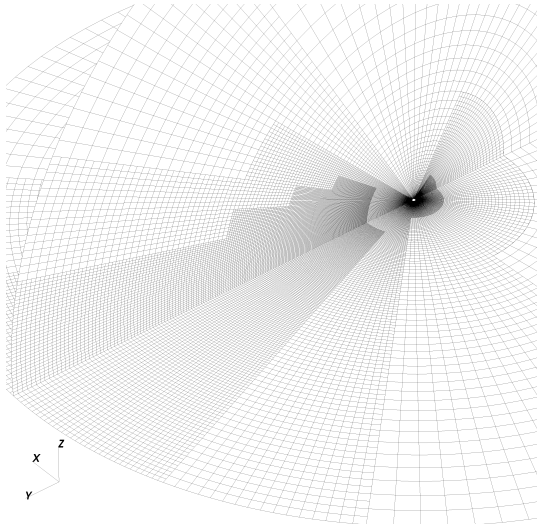
- AMR + **stretched grid**
- 1/**2**/3D, Cartesian, cylindrical, **polar**, spherical grids
- Spatial discretizations : central difference, finite difference, **finite volume, Riemann solvers**
- Temporal discretizations : Euler, **predictor-corrector**, RK4

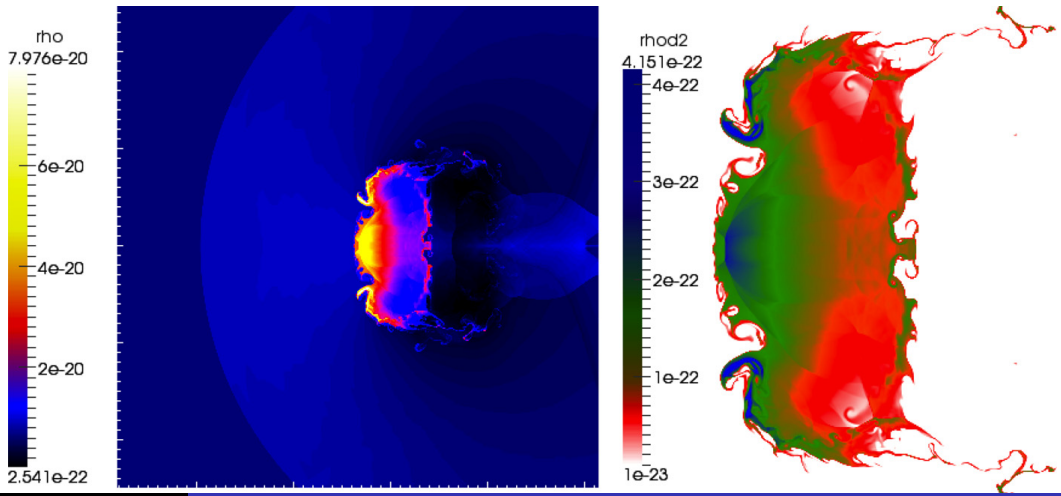
General form

$$\partial_t \mathbf{U} + \nabla \cdot \mathbf{F}(\mathbf{U}) = \mathbf{S}_{phys}(\mathbf{U}, \partial_i \mathbf{U}, \partial_i \partial_j \mathbf{U}, \mathbf{x}, t),$$

$$\begin{aligned} \partial_t \rho + \nabla \cdot (\mathbf{v}\rho) &= 0 \\ \partial_t (\rho \mathbf{v}) + \nabla \cdot (\mathbf{v}\rho\mathbf{v}) + \nabla p &= 0 \end{aligned}$$

$$p = c_{adiab} \rho^{\gamma}$$

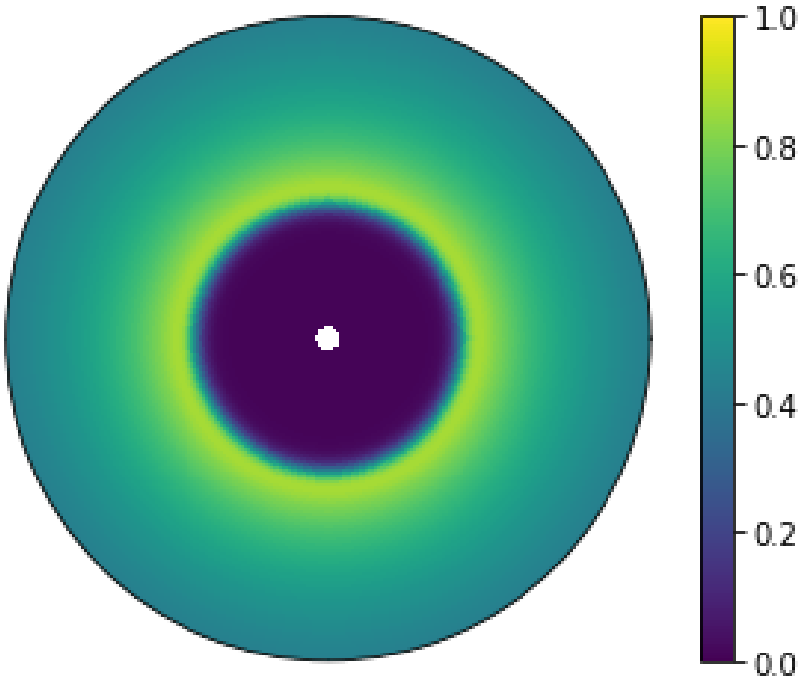




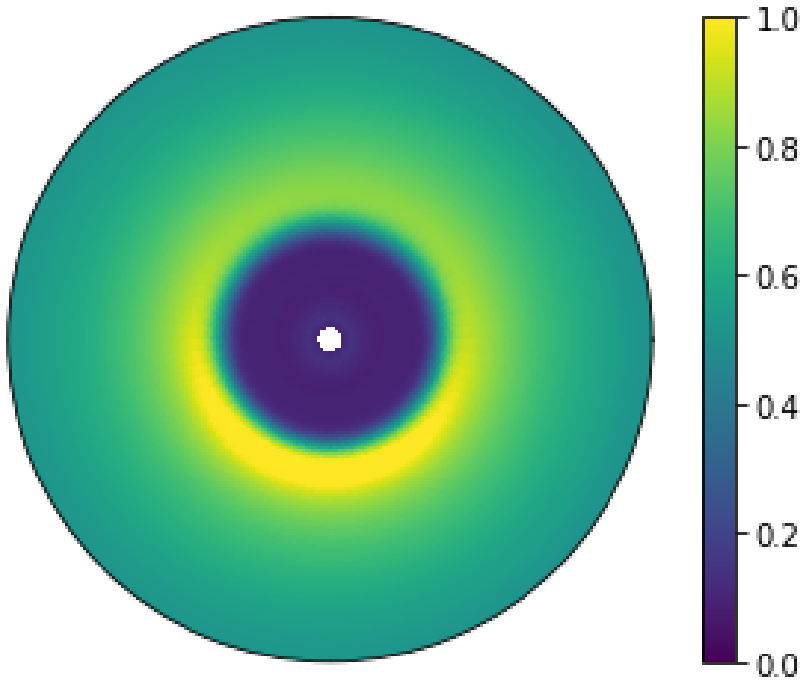
Hydro results (2D)

Gas surface density

Equilibrium model

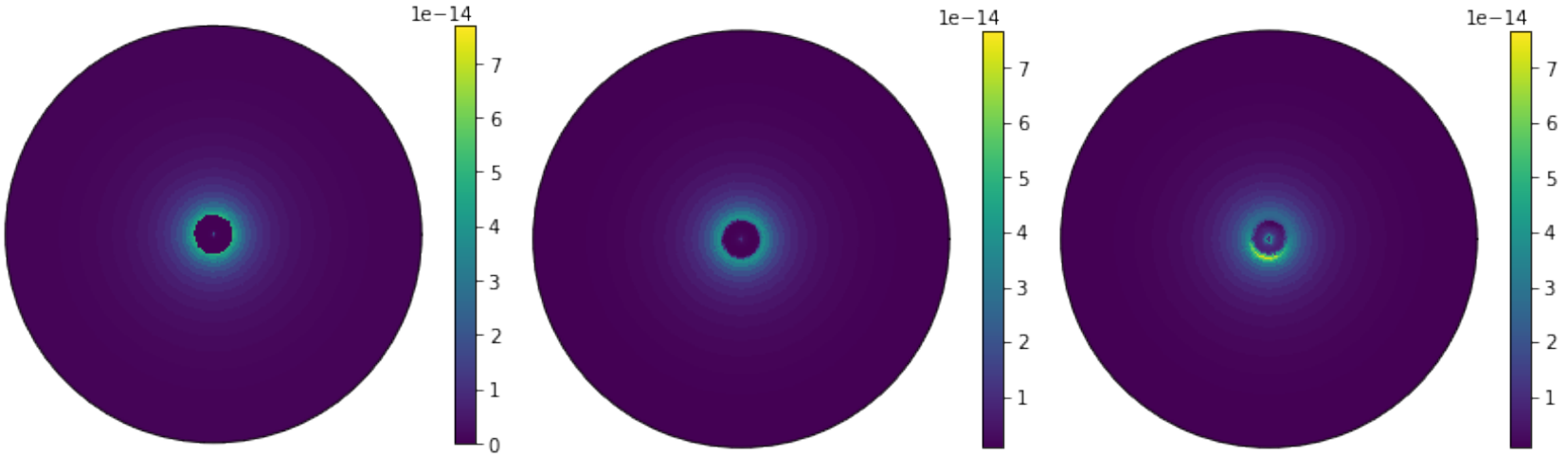


After 100 orbits
(quasi-steady state)



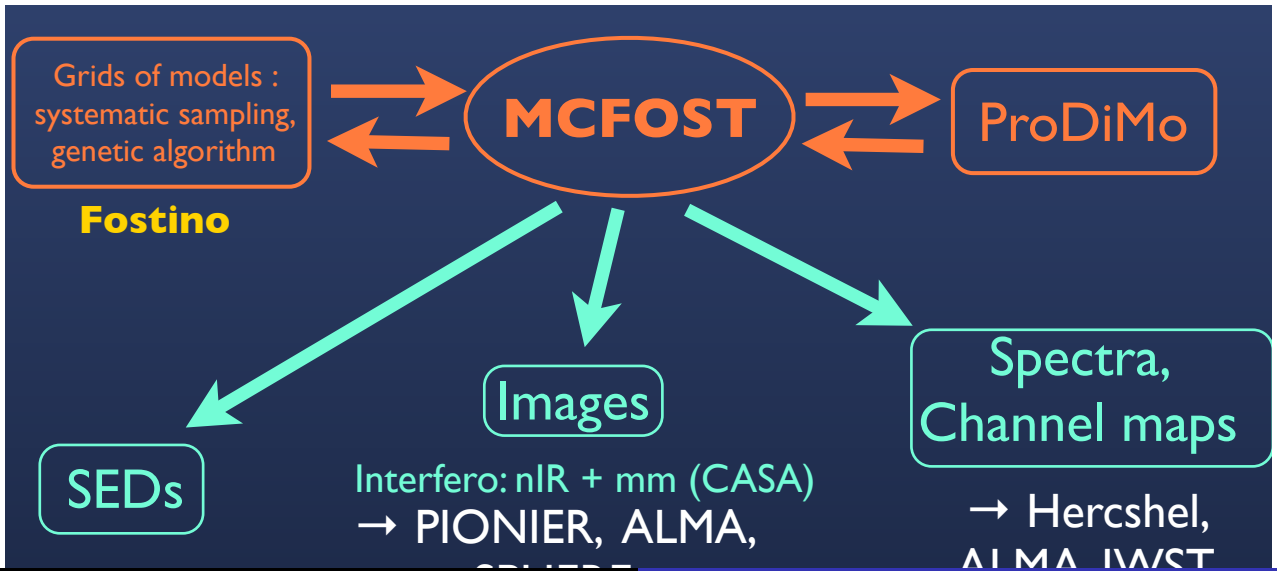
Code interface : Hydro → RT

- interpolation of hydro grid on RT grid
- 2D → 3D
- dust density = gas density
- extent the disk



MCFOST

- Some features
  - 2D/ 3D radiative transfer
  - Monte-Carlo/Ray-tracing
  - Dust + Gas
  - designed for circumstellar environments
  - Input : model or data
  - LTE/N-LTE
- Some outputs
  - Temperature map
  - Optical depth map
  - SED
  - Images
  - Atomic/molecular line maps
  - Stokes parameters



MCFOST - dust

Some dust properties included in the model

- spherical grains (Mie) or distribution of hollow spheres (DHS)
- Mixing rule
- Porosity
- Mass/volume fraction
- Heating method (RE, LTE, N-LTE)
- Size distribution

Optical indices tables given for :

- H2O or CO2 ice
- Silicate
- Graphite
- Porous interstellar grains
- Amorphous MgFeSiO4 olivine
- Ionized or neutral PAHs
- ...