Planet formation with different gas depleted timescales

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Outline

- Model
- Sketch map
- Results
- Discussions

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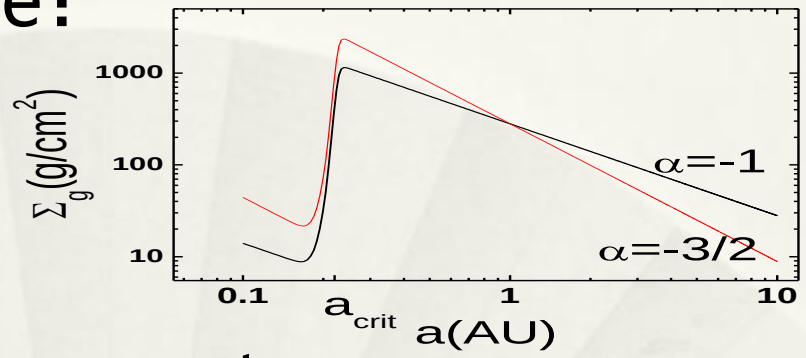
Model:

Surface density profile：

MMSN：$\Sigma \propto r^{-3/2}$



Conservation of mass:

$$\dot{M} = 2\pi R\Sigma \cdot (-v_R)$$

Conservation of angular momentum:

$$\nu\Sigma(-\Omega') = \Sigma(-v_R)\Omega - C/(2\pi R^3) \qquad \Omega' = d\Omega/dR$$

$$R_*\Omega' = 0 \qquad C = \dot{M}(GMR_*)^{1/2}$$

$$\Sigma = \frac{\dot{M}}{3\pi\nu}[1-(R_*/R)^{1/2}] \qquad \text{(Pringle, 1981)}$$

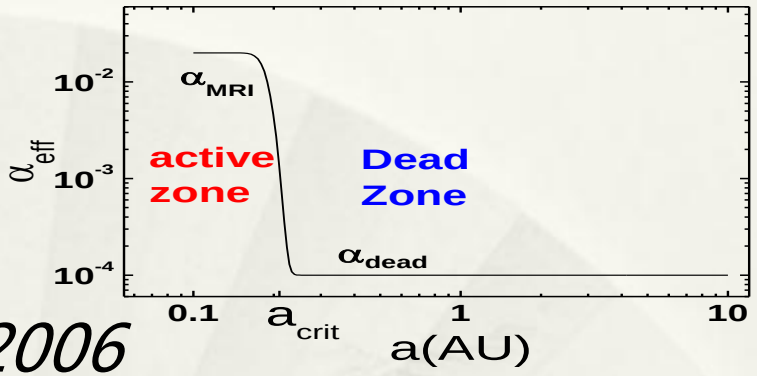
$$\nu = \alpha c_s H,\ c_s \propto H\Omega,\ H \propto r^{5/4}$$

$$\Rightarrow \Sigma \propto r^{-1}$$

$$\Sigma_g = \Sigma_0 \; g \; cm^{-2} \; f_g \left(\frac{\alpha_{eff}}{10^{-4}}\right)\left(\frac{M_*}{M_\Theta}\right)^{-1/2}\left(\frac{a}{1AU}\right)^{-1} e^{-t/\tau_{disk}}$$

Considering MRI: α_{eff}

- Local maximum pressure
- Accumulation of embryos



General migrations:

Type I: *Cresswell & Nelson,2006*

Type II: *Albert et al. 2005*

Tidal damp of gas disk

Cresswell & Nelson,2006

different gas depleted timescales: 0.5-5Myr

Considering N-body interaction.

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Sketch map

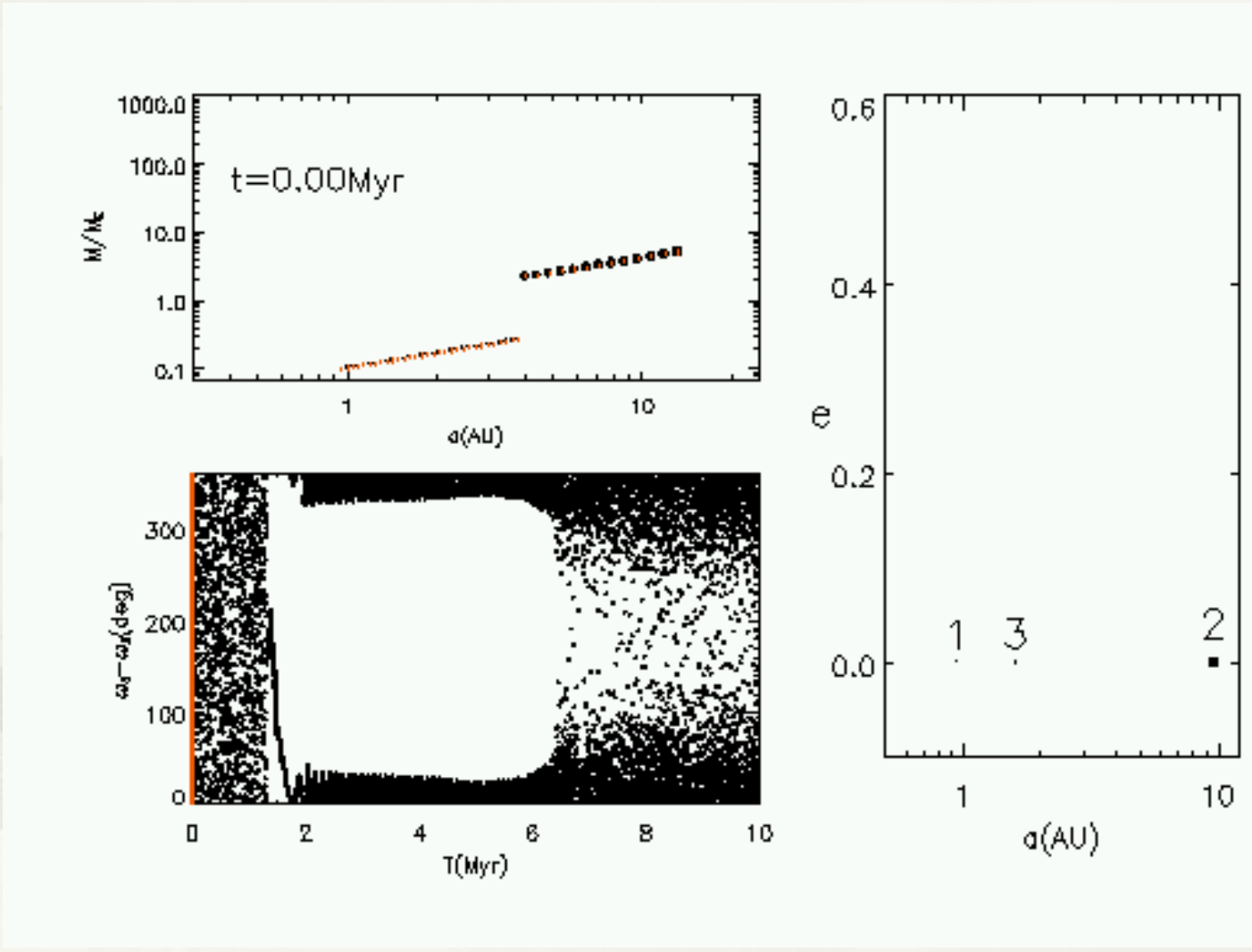
- Collision growth
- Gas accretion (M_{crit})

  long τ_{disk} : sufficient

  small τ_{disk} : Insufficient
- Migration rate

An example of multi-planetary system:

44 embryos, 0.5~12 AU, Mass>0.1M_E


t=0.00Myr
M/M⊕
a(AU)
ω_r−ω_J(deg)
T(Myr)
e
a(AU)
1
2
3

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Formation of planets with different sizes:

Giants

1-10AU

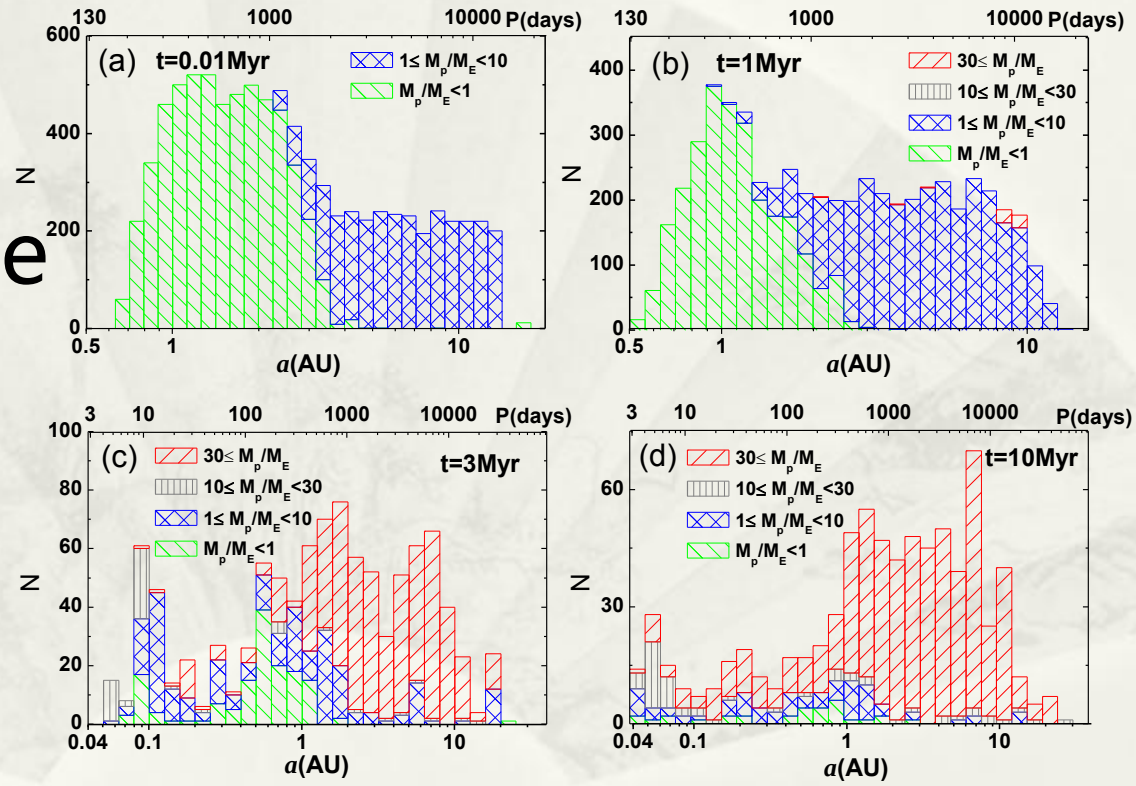
Neptune size

~0.05AU

Super-Earth

Earth size

~1AU



Peaks and deserts

Peaks:

1: inner boundary

2: MRI effect

3: Type II migration

4: insufficient gas accretion

collision growth

5: Asymptotic Mass

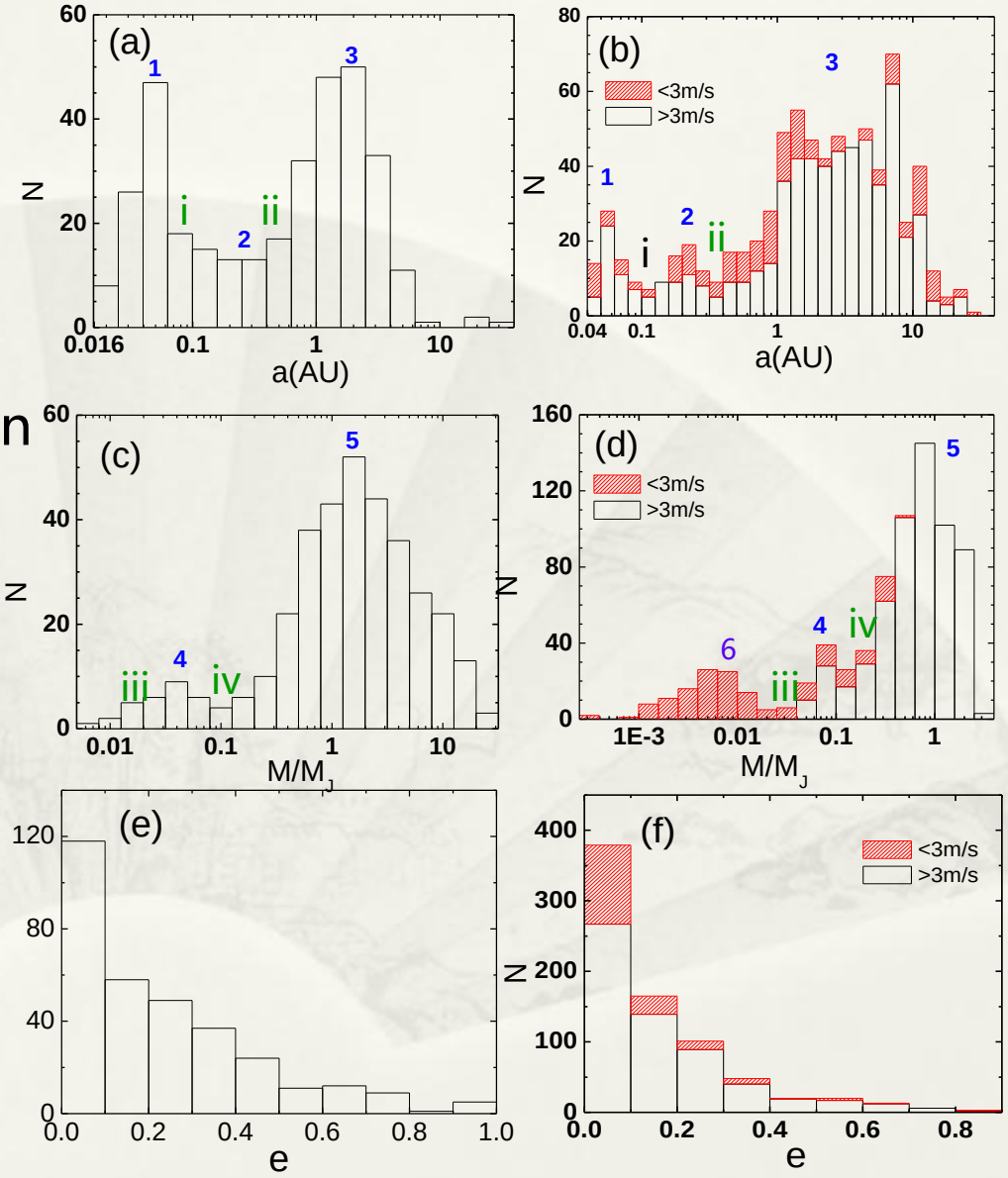
6: Collision growth

Deserts:

i, ii: MRI effect

iii: onset of gas accretion

iv: runaway gas accretion



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Discussion:

- Excluded effects:

  Dynamical friction of small planetesimals

  difficulty: time costing

  Gravitation of gas disk.

  tidal damp of host star

- Comparing with observations:

  influence of $f_g, \dot{M}_{disk}, [Fe/H]$

- Uncertainty of initial conditions:

  a, M of embryos.

The End

Thank You!

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