Magnetic Fields in Giant Planet Formation

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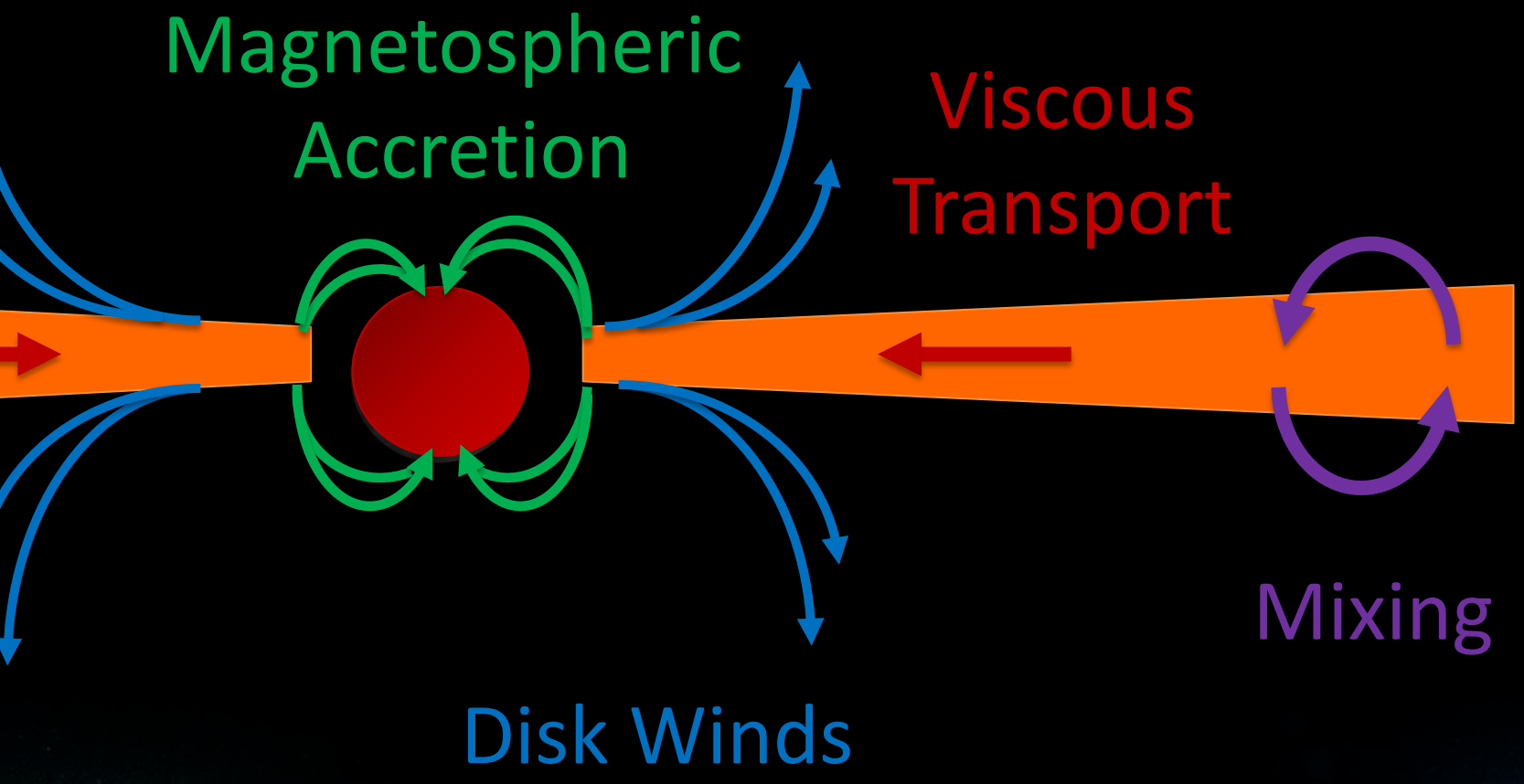
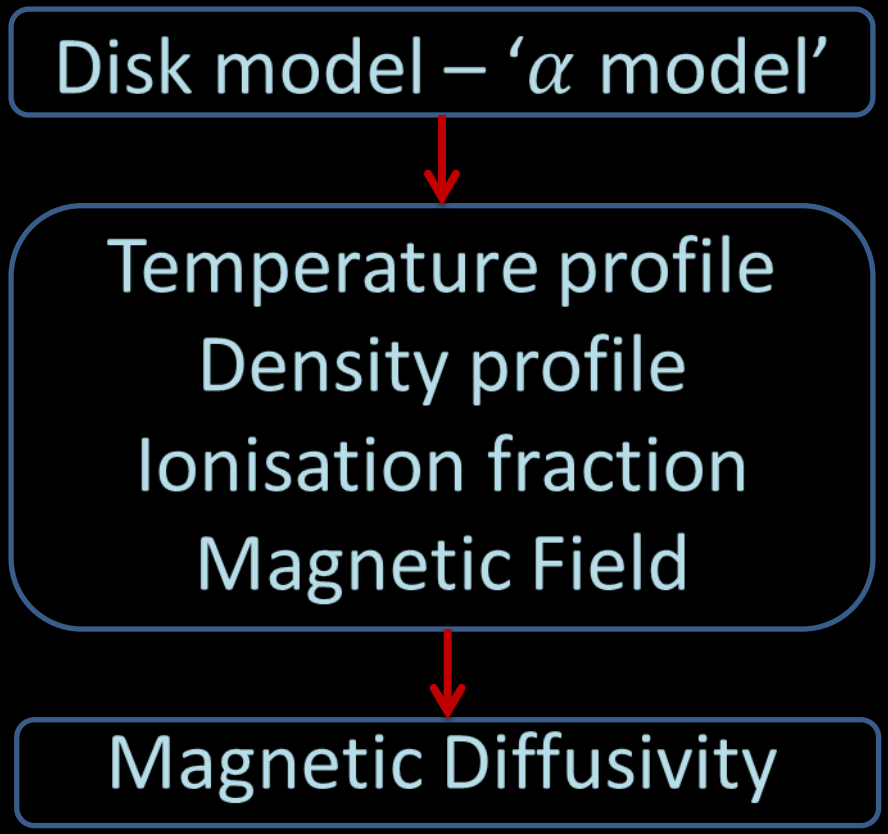
Impact of Magnetic Fields



Question:

Do circumplanetary disks couple to magnetic fields?

Outline


Disk model – ‘α model’
Temperature profile
Density profile
Ionisation fraction
Magnetic Field
Magnetic Diffusivity

Disk model

- Standard α disk (Shakura & Sunyaev, 1973)
- Viscosity
  - determines temperature and density
  - parameterised by 'α'
- Model Parameters:

$M = M_J$ $\dot{M} = 10^{-6}\ M_J$/year $\alpha = 2 \times 10^{-4}$

Calculating disk profiles

- Self consistently solve for disk profiles analytically

Radiative Transfer equation

$$\sigma {T_{mid}}^4 \propto \tau \sigma {T_{eff}}^4$$

- Optical depth, τ

  Previous studies a priori specified a constant value for the opacity (E.g., Canup & Ward 2002)

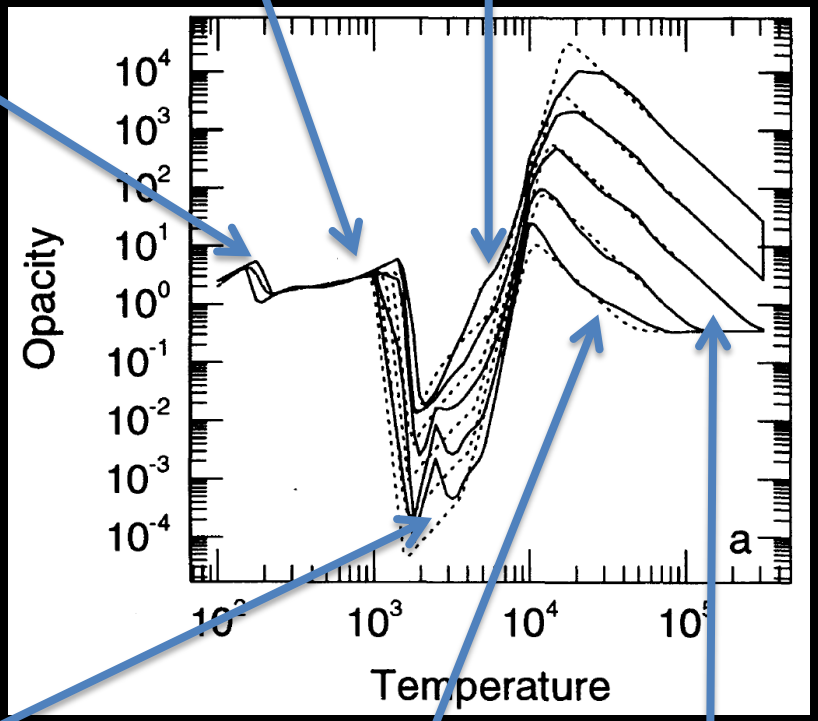
Opacity Law

Ice Grains

Metal Grains

H-Scattering

We solve for the opacity using the Bell & Lin 1994 opacity law



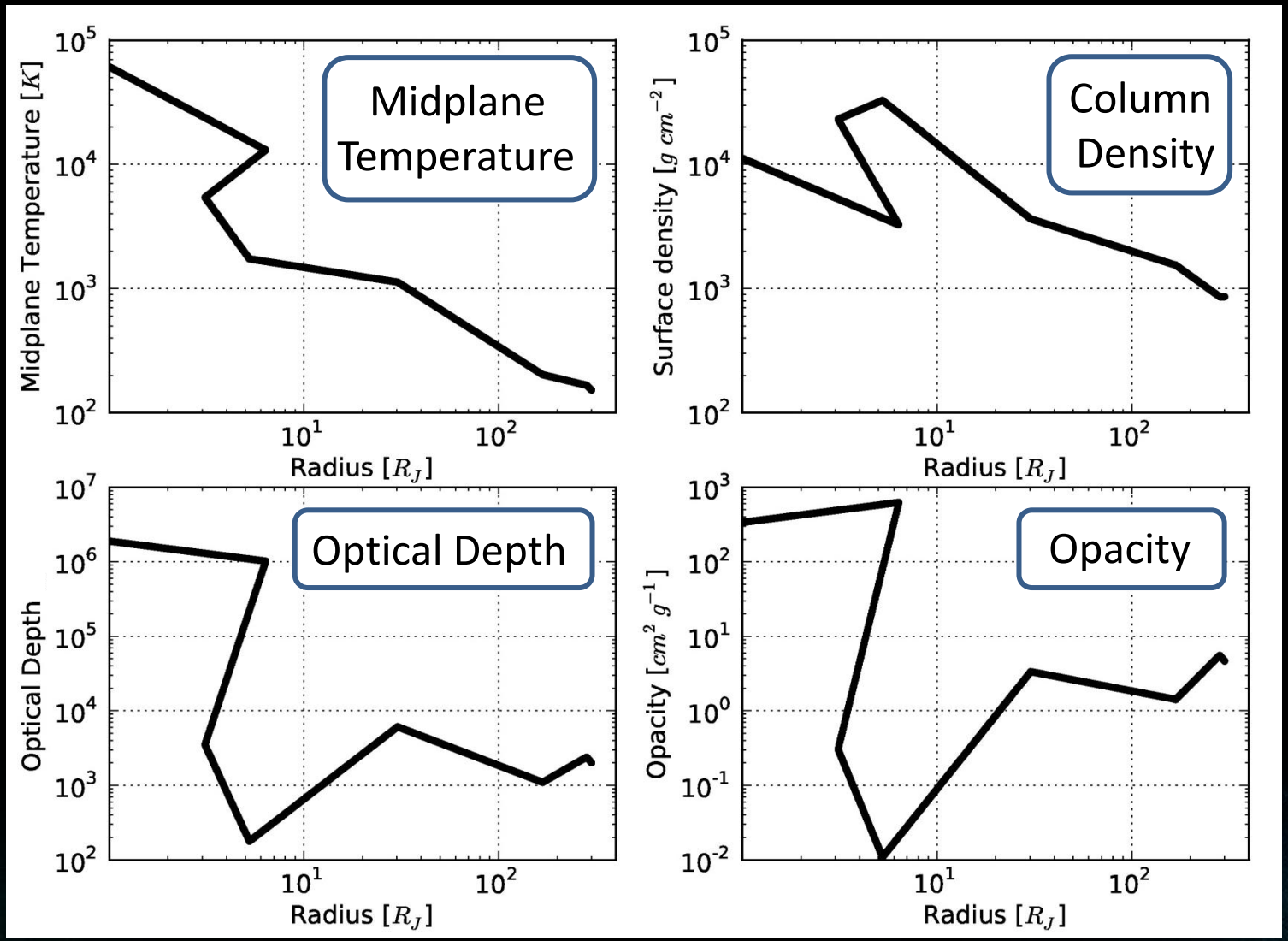
Bell & Lin 1994

Molecules

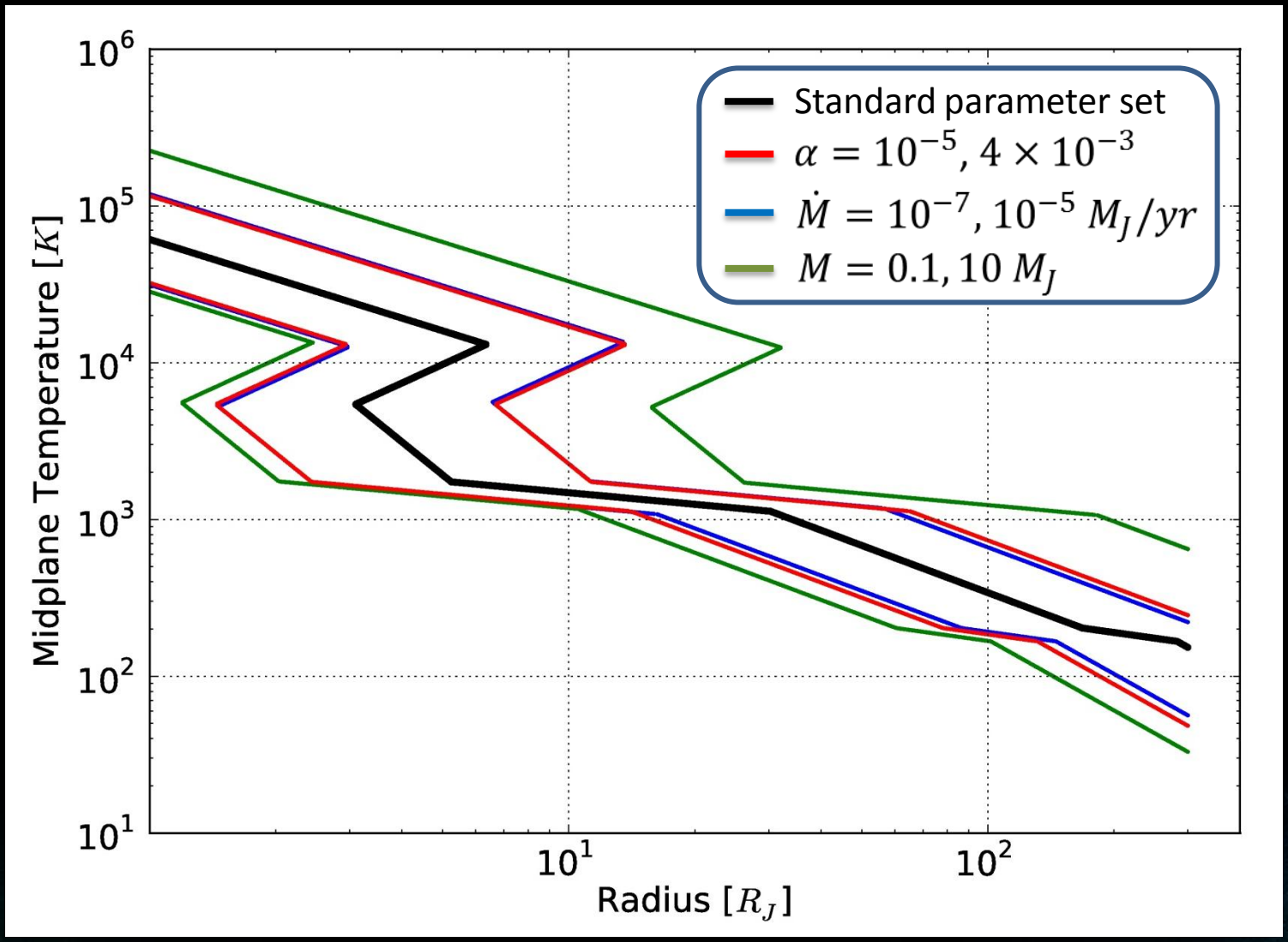
Bound-free & free-free

Electron Scattering

Disk Profiles



Temperature Profile



Ionisation Fraction

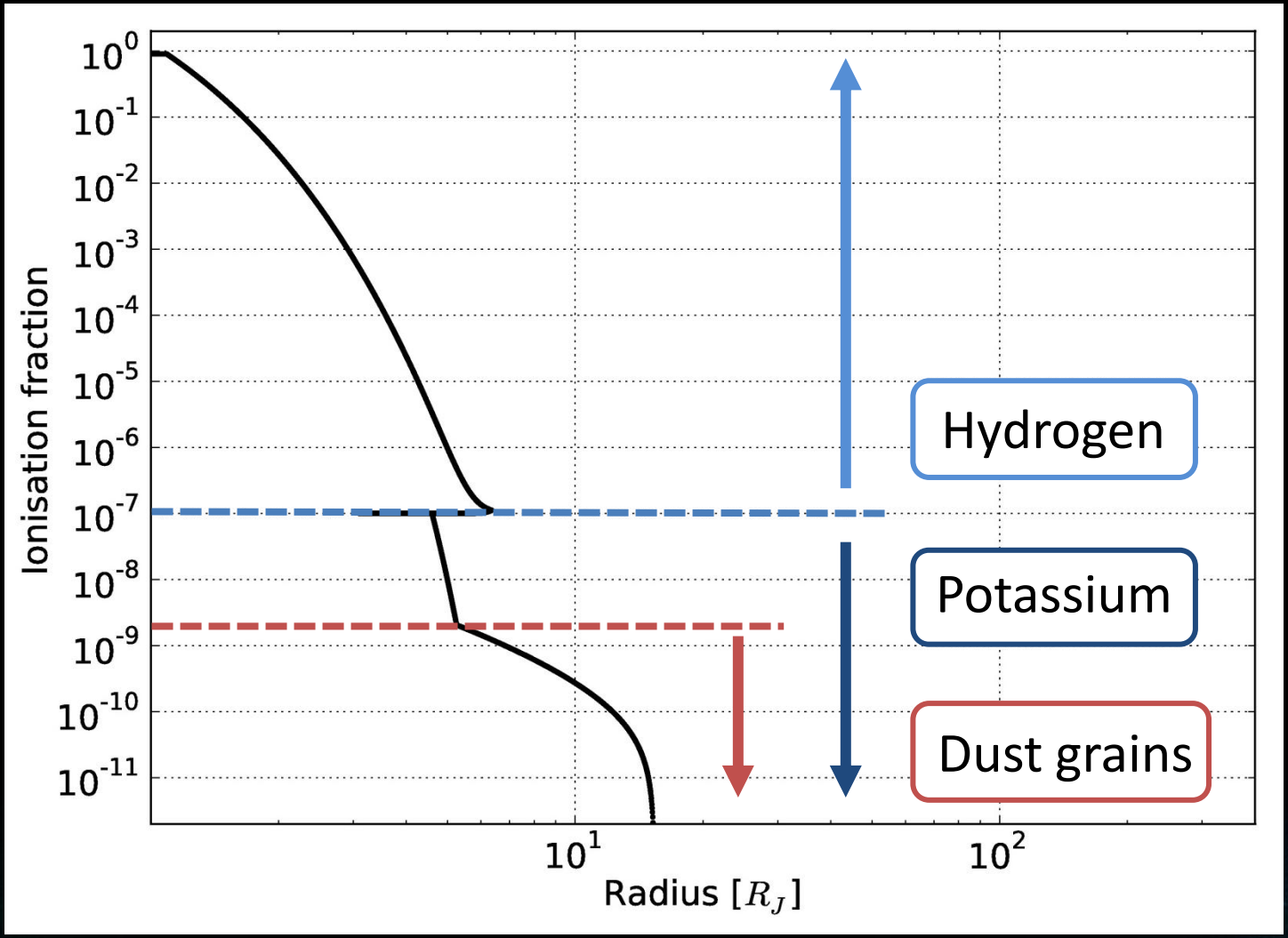
SOURCE : Thermal ionisation

Potassium (Cooler regions)

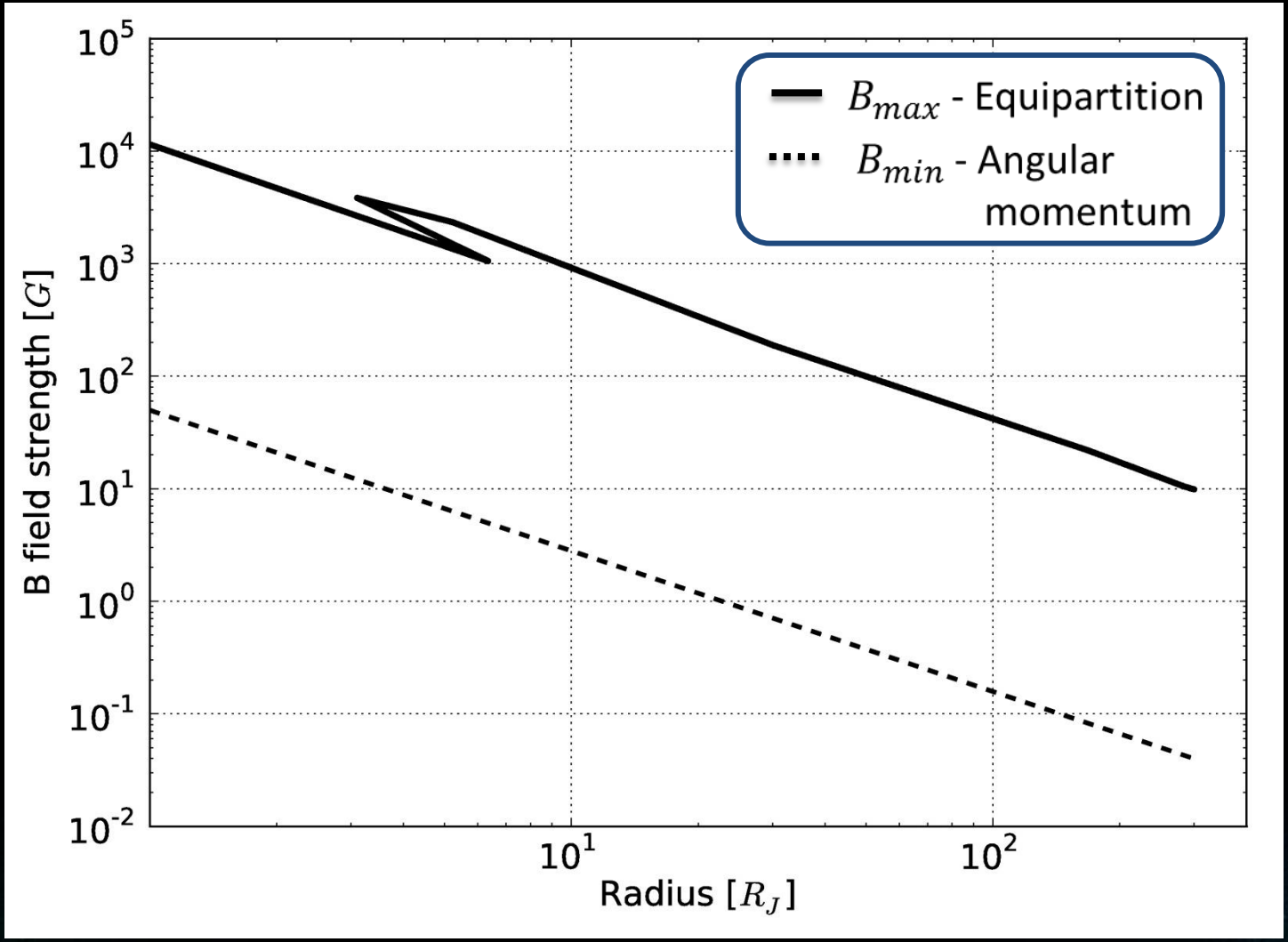
Hydrogen (Hotter regions)

SINK : Dust grains

Ionisation Model



Magnetic Field



Magnetic Diffusivity

HIGH DIFFUSIVITY

Field lines slip through gas

→ POORLY COUPLED

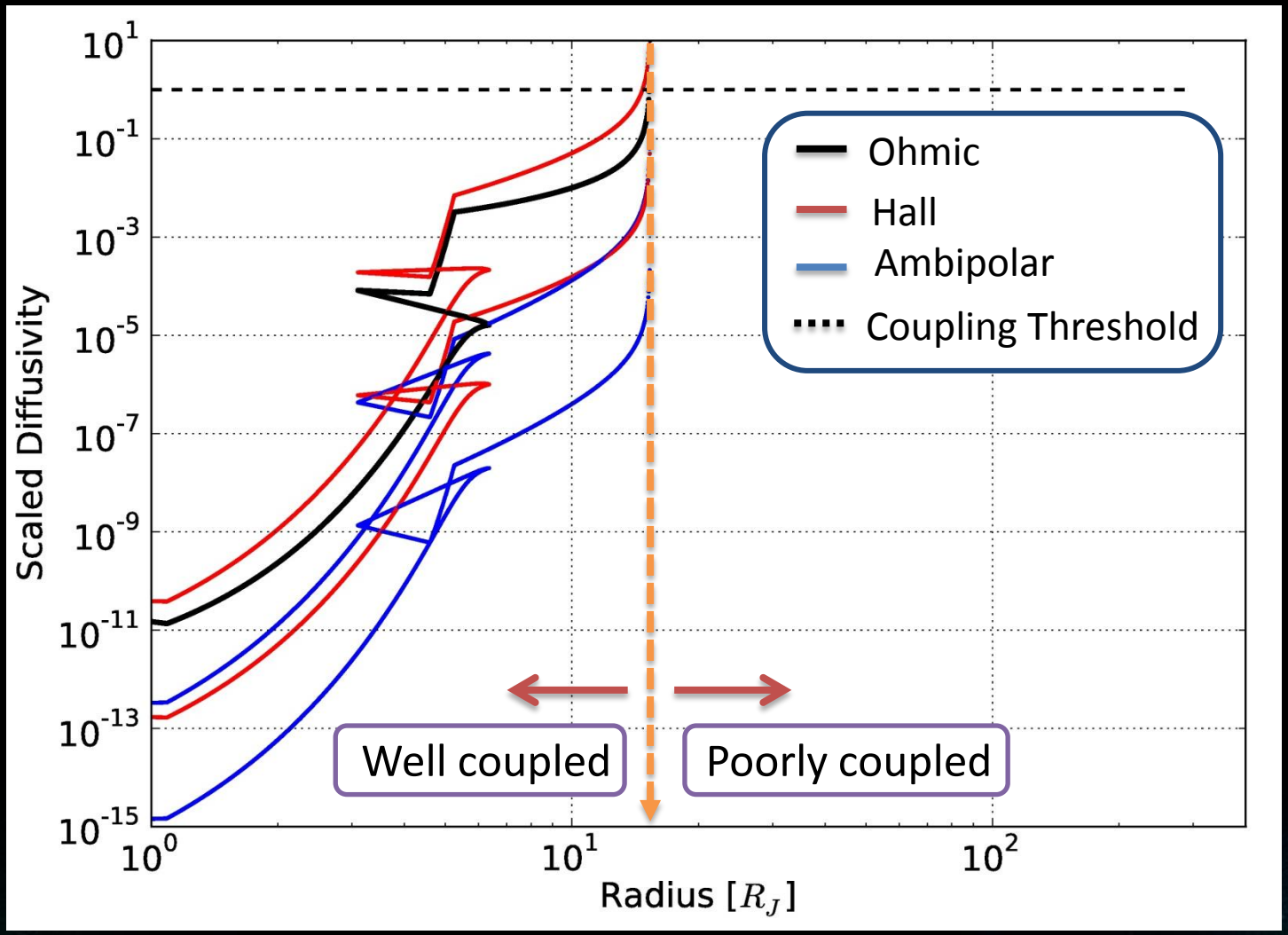
LOW DIFFUSIVITY

Field lines and gas locked together

→ WELL COUPLED

Diffusivity Types: Ohmic, Ambipolar and Hall

Magnetic Diffusivity



Conclusions

- The disk couples to the magnetic field out to 15 Jupiter radii

- A large fraction of the disk midplane remains uncoupled

- It is not clear how accretion proceeds