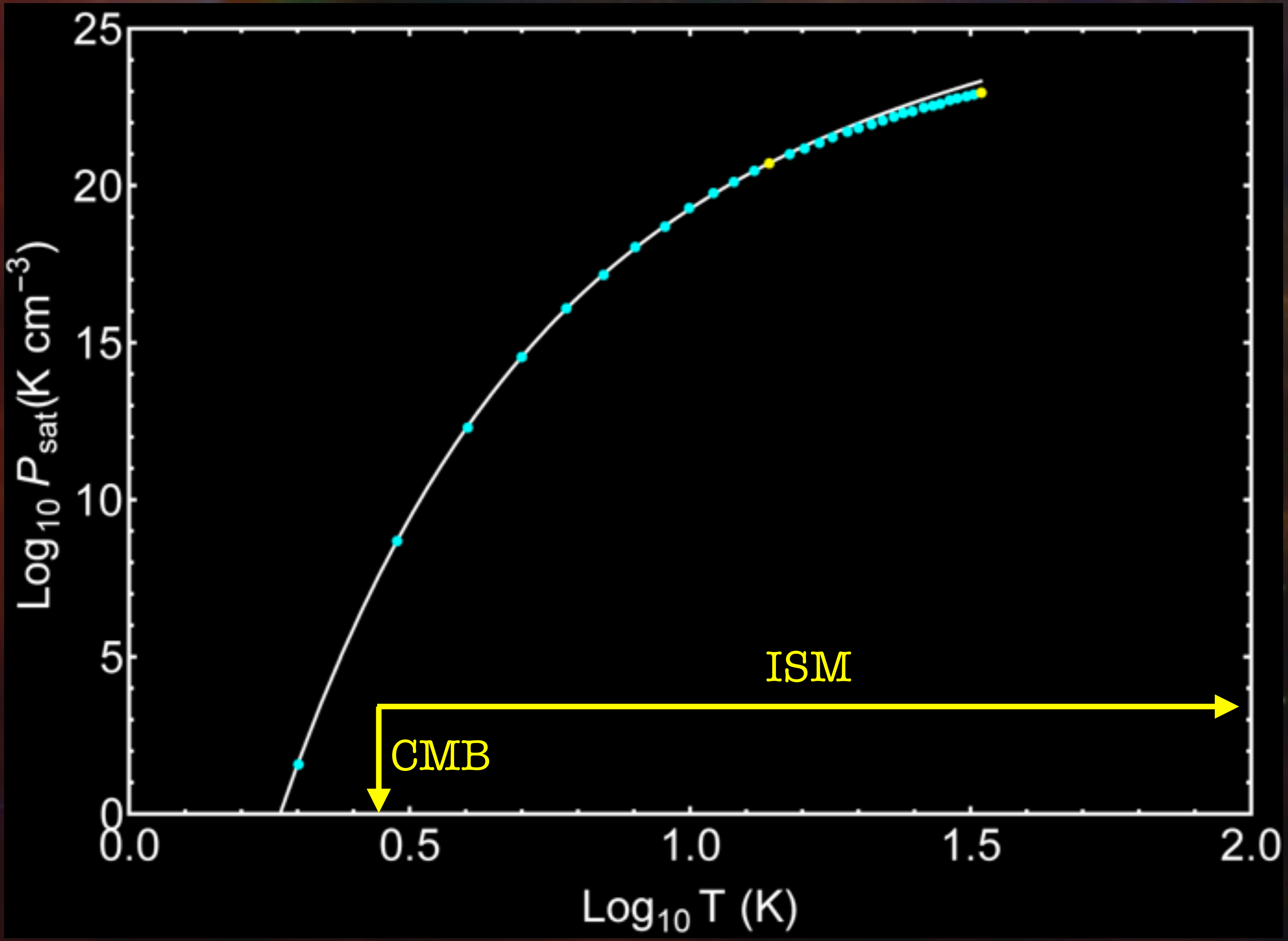
Astrophysical aspects of solid H_2

Mark Walker

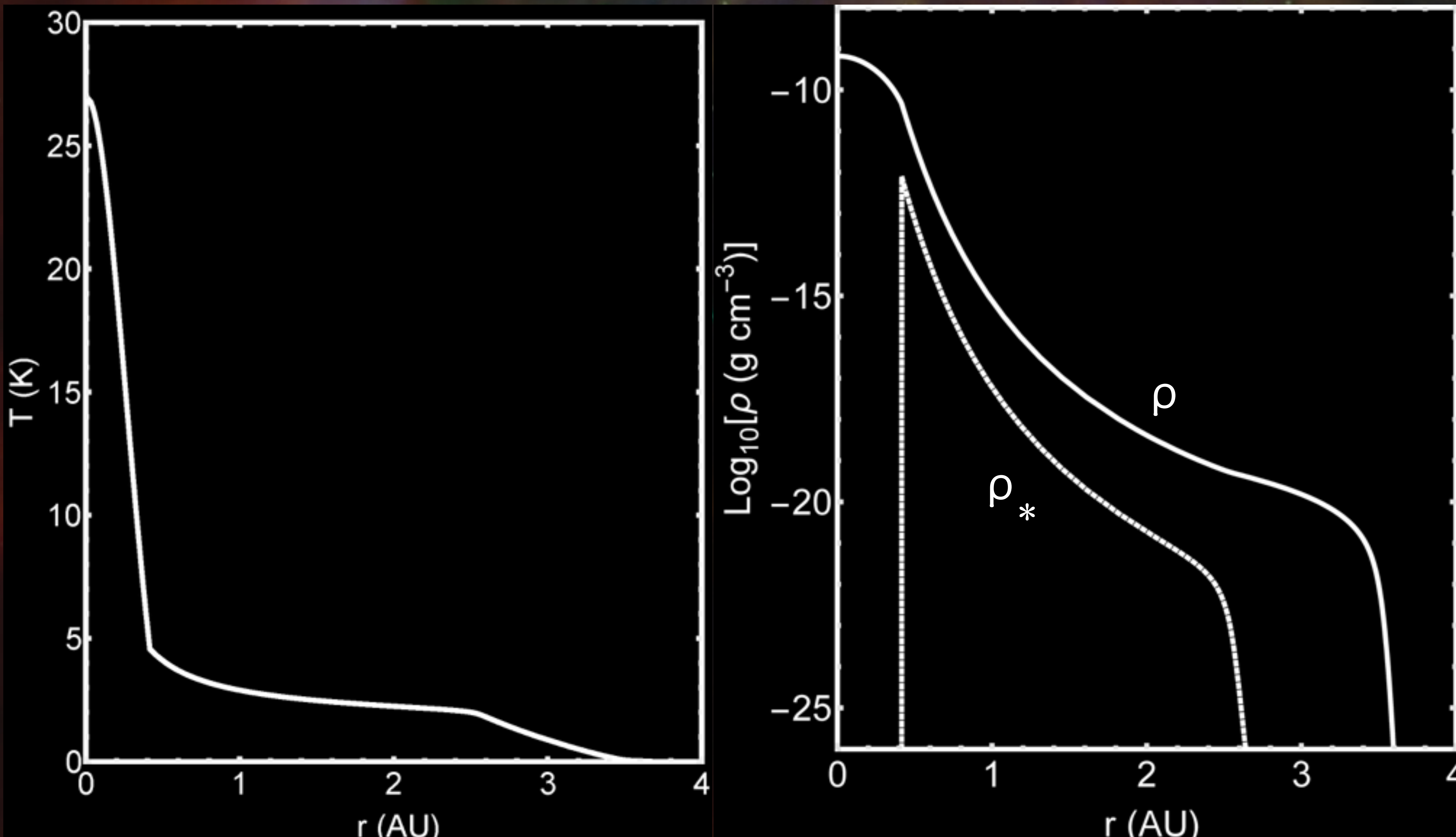
H_2 snow requires cold, dense gas

- $P = P_{sat} \gg P_{ism}$: self-gravitating (Pfenniger & Combes 1994)



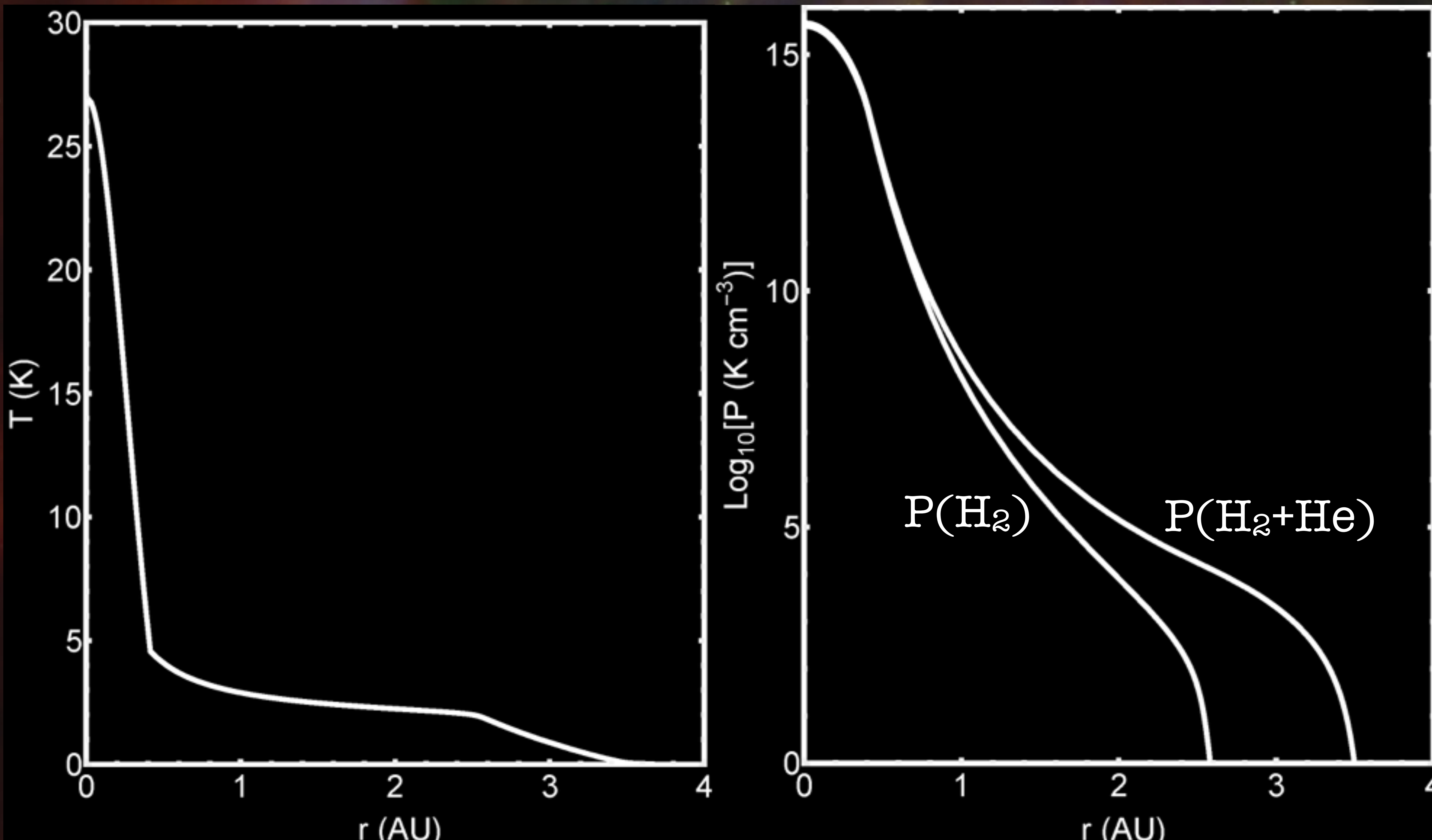
High density, robust structures

Example with $M \simeq 10^{-4} M_\odot$



High density, robust structures

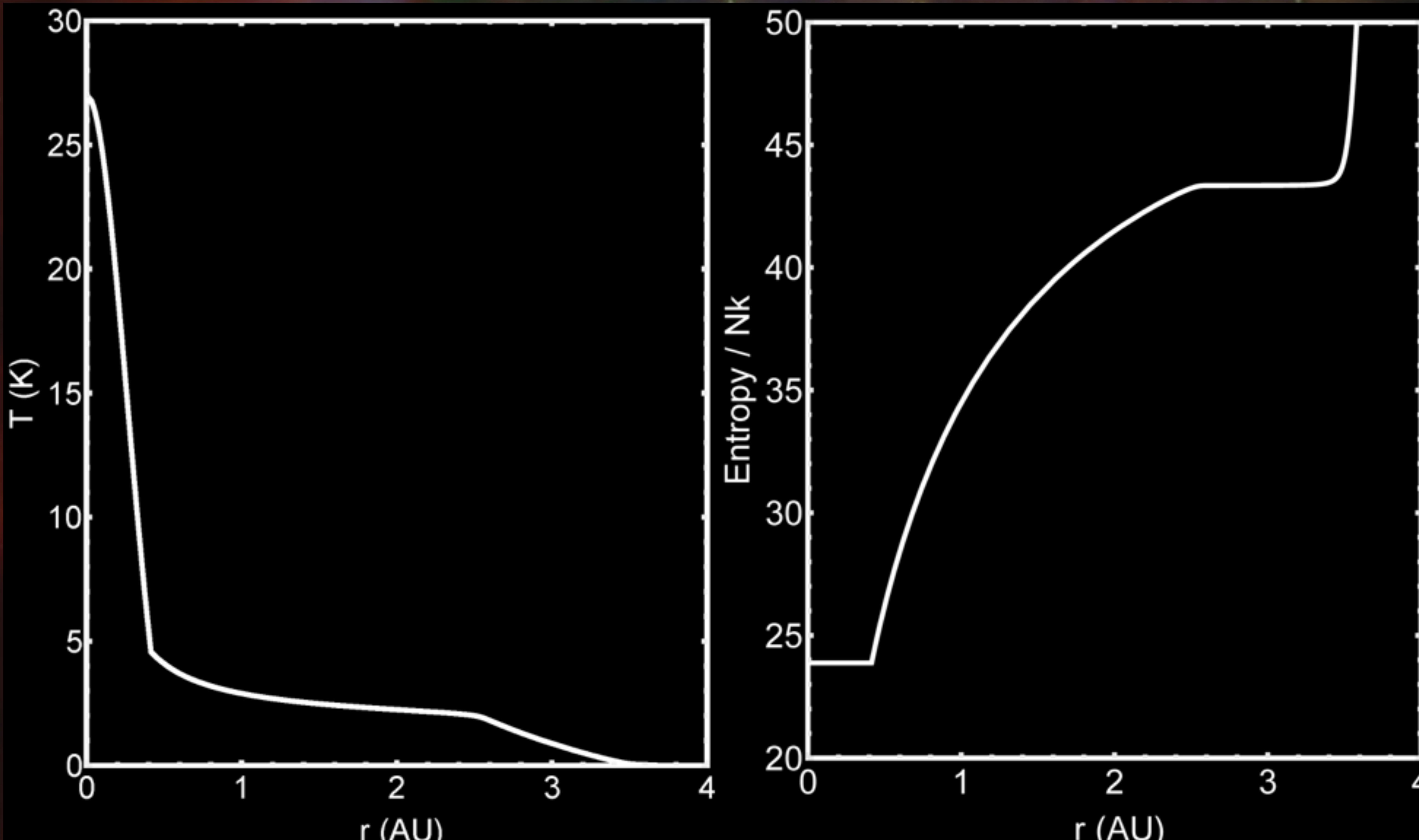
Example with $M \simeq 10^{-4} M_{\odot}$



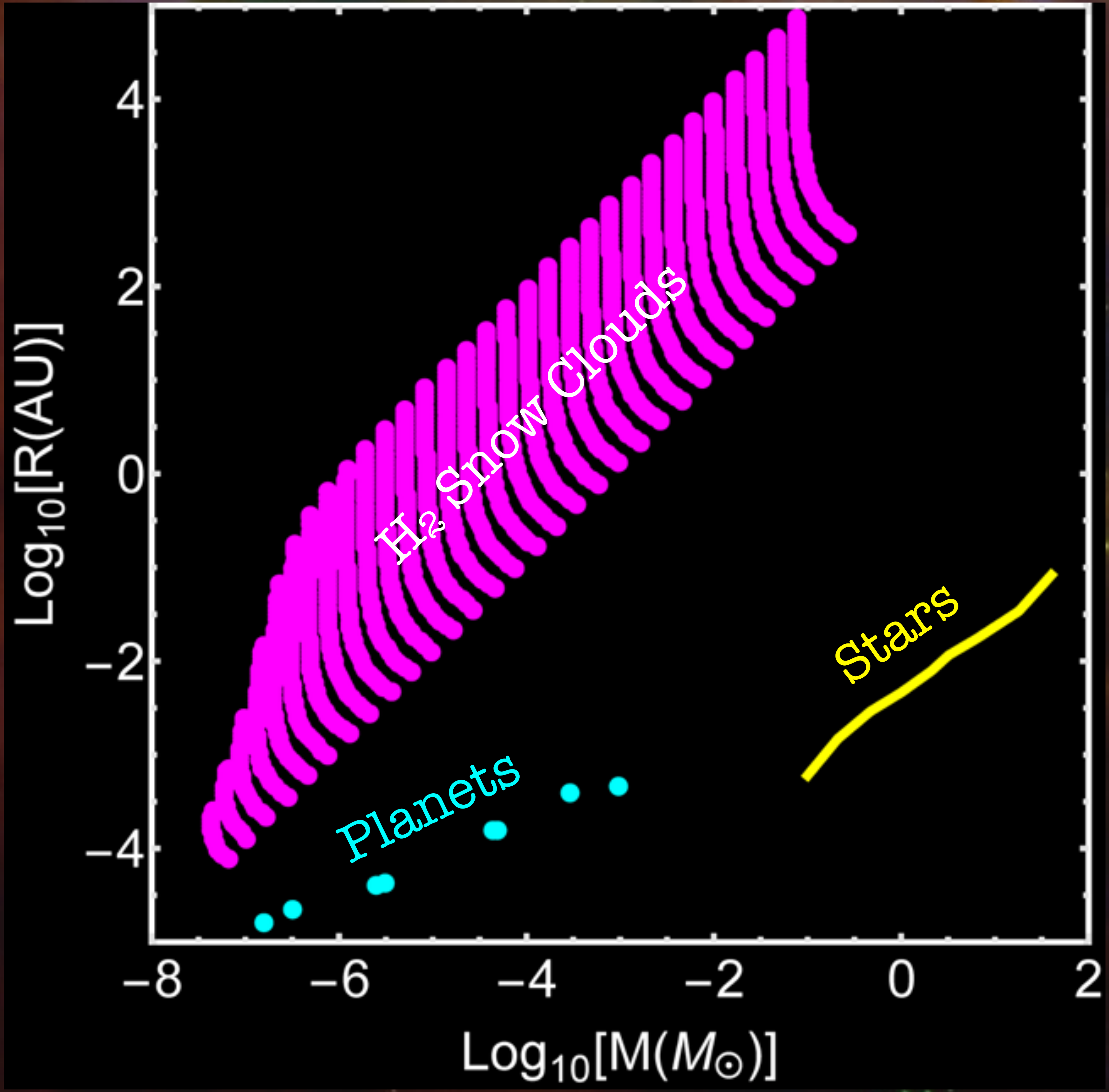
Manly Astrophysics

Convection of heat up ∇T

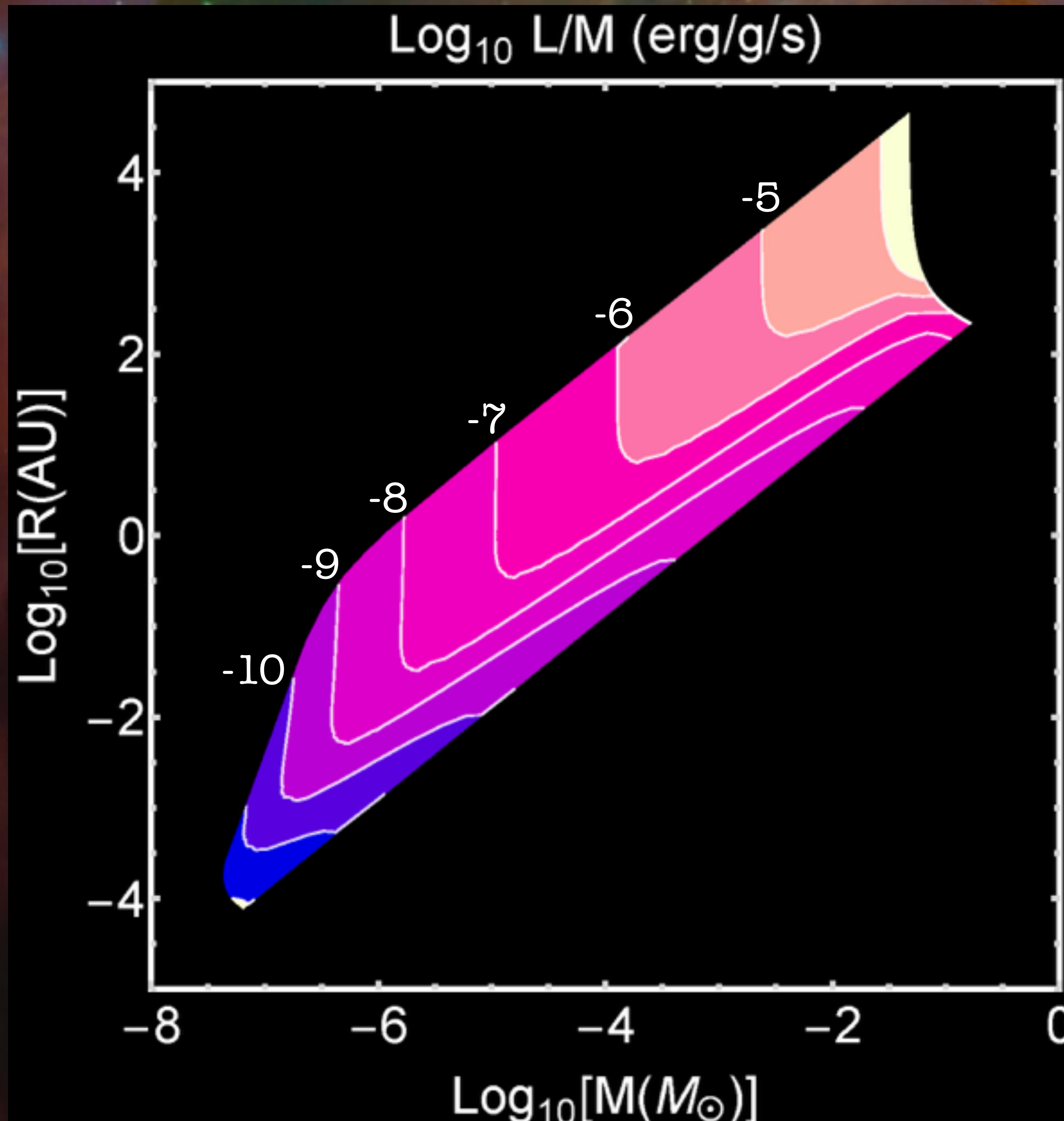
Example with $M \simeq 10^{-4} M_{\odot}$



Low masses, but large radii

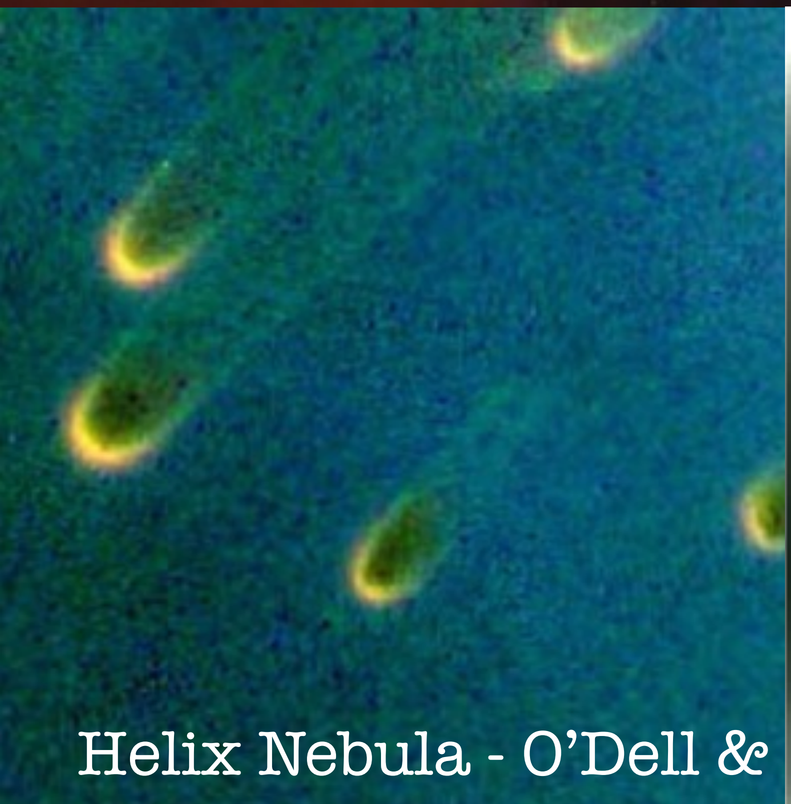


Snow clouds are very dark

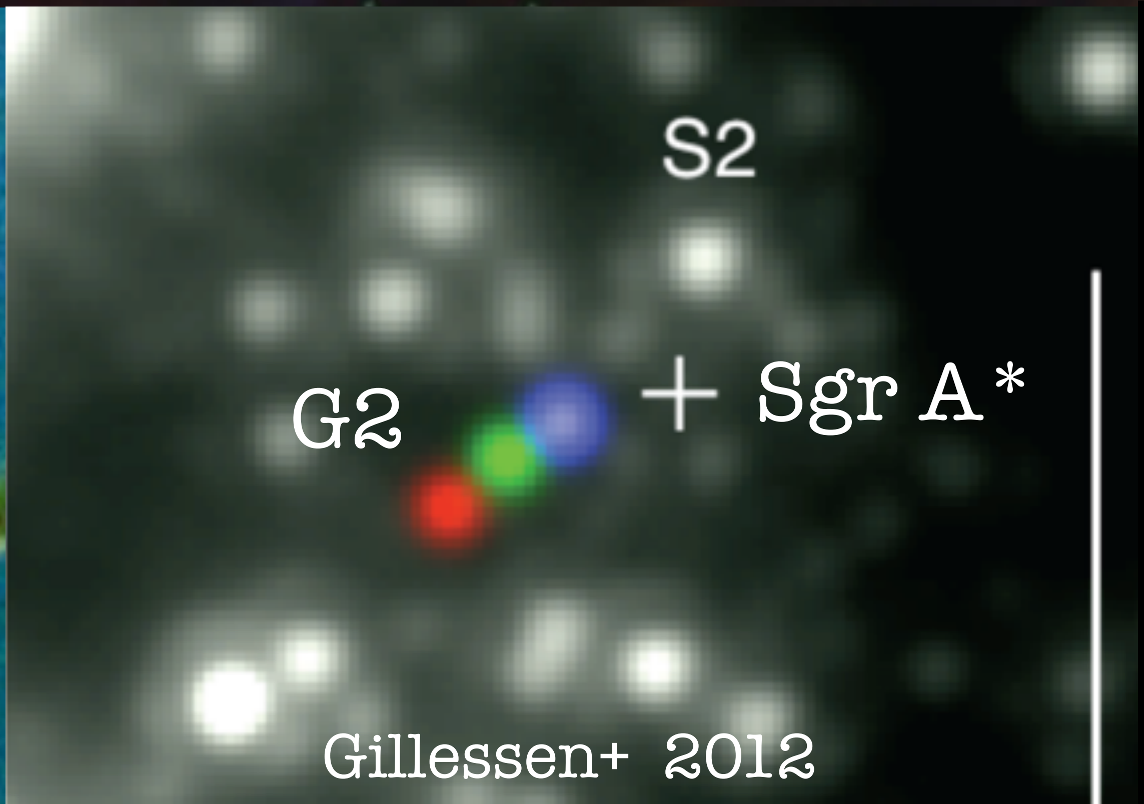


Harsh radiation environments produce snow

- Strong heating → secular expansion → H_2 condensation
- Impulsive heating : unbinding of cloud on dynamical time
  - In the vicinity of novae and supernovae
- Continuous heating : snowflake laden wind
  - In Planetary Nebulae
  - In galactic nuclei
  - In close orbit around a massive star



Helix Nebula - O'Dell &

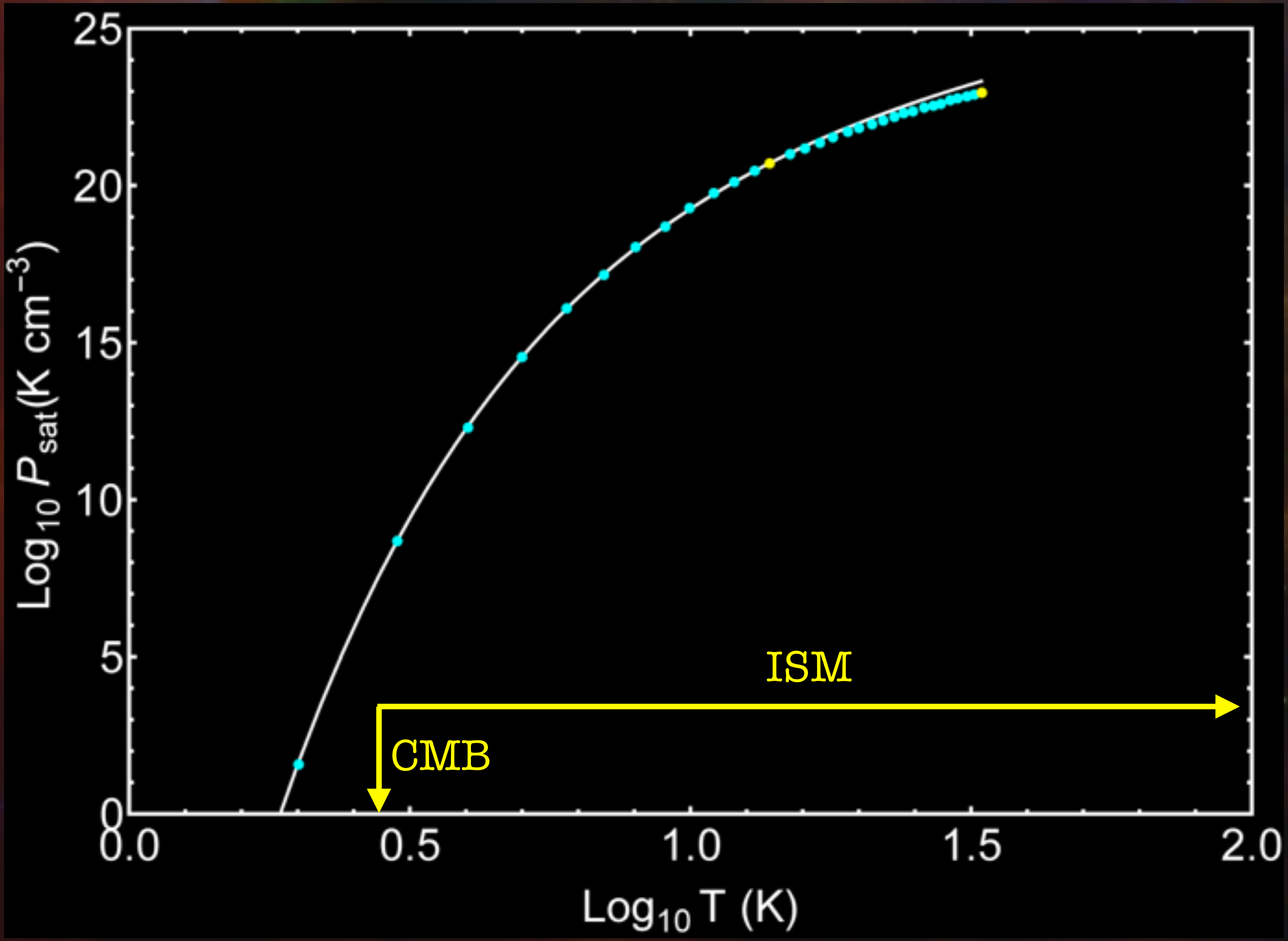


Gillessen+ 2012

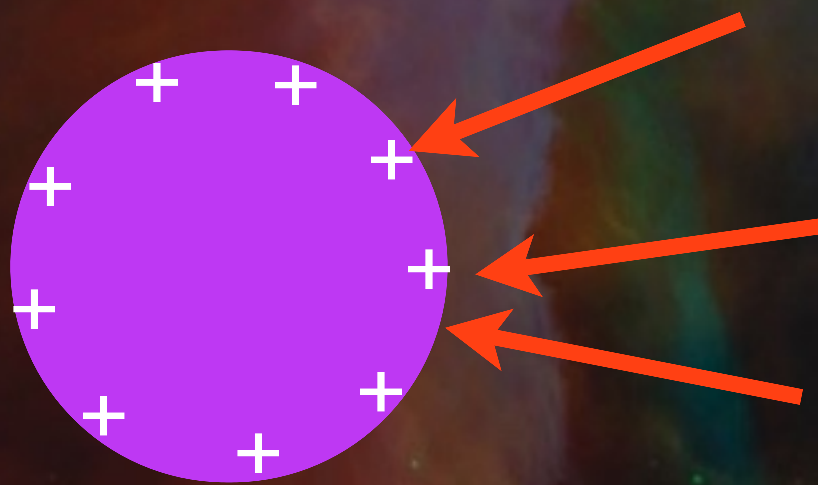
WR104 - Tuthill+ 1999

H_2 snow requires cold, dense gas

- $P_{sat} \gg P_{ism} \rightarrow$ rapid sublimation



Charging of dust grains



γ : Photoelectric

e^-

p^+ Collisional

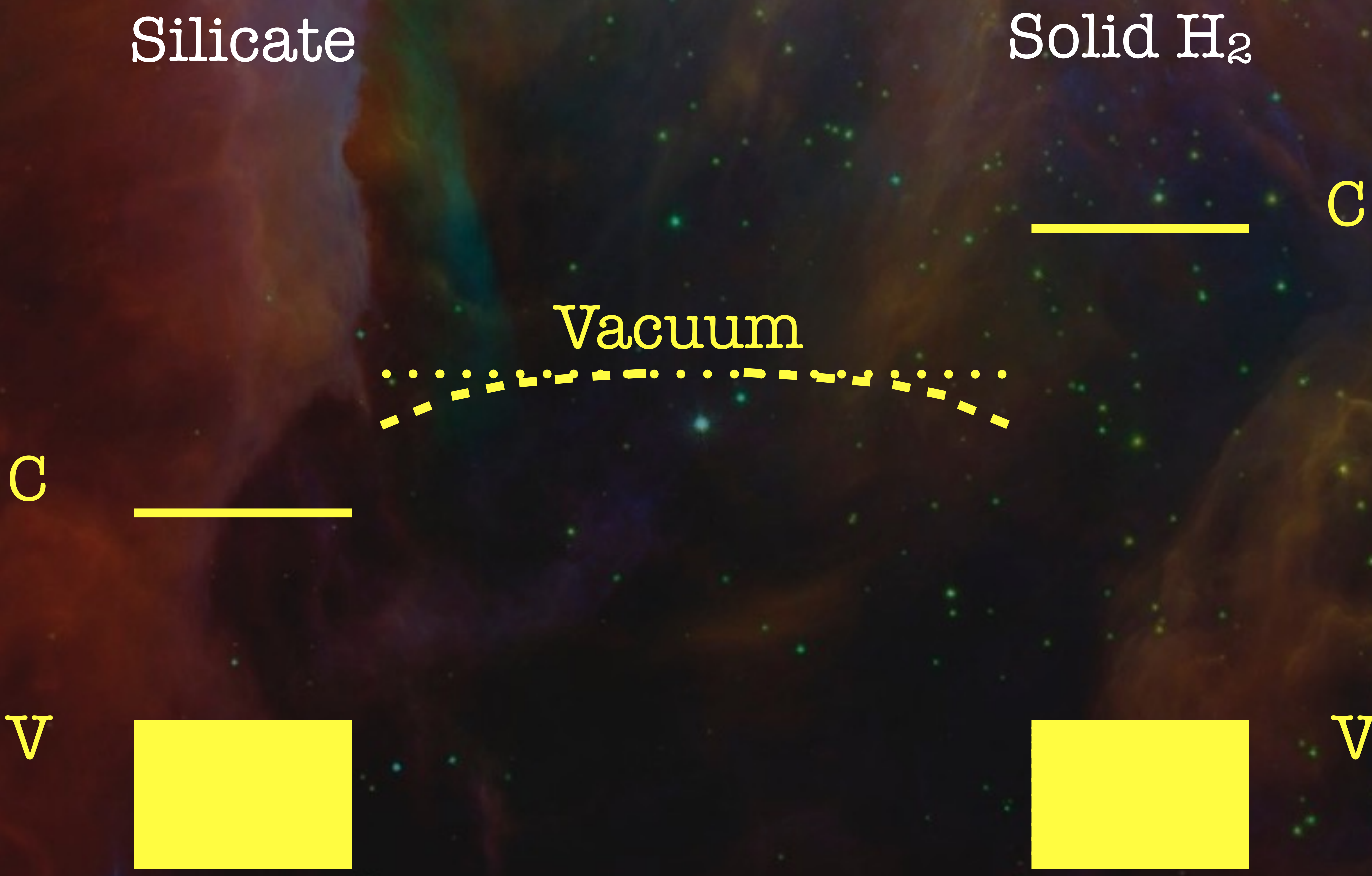
$\Phi \sim$ few V

$L \sim$ few $\times$ 0.1 μm $\quad\therefore\quad$ $E \sim 10^7$ V m^{-1}

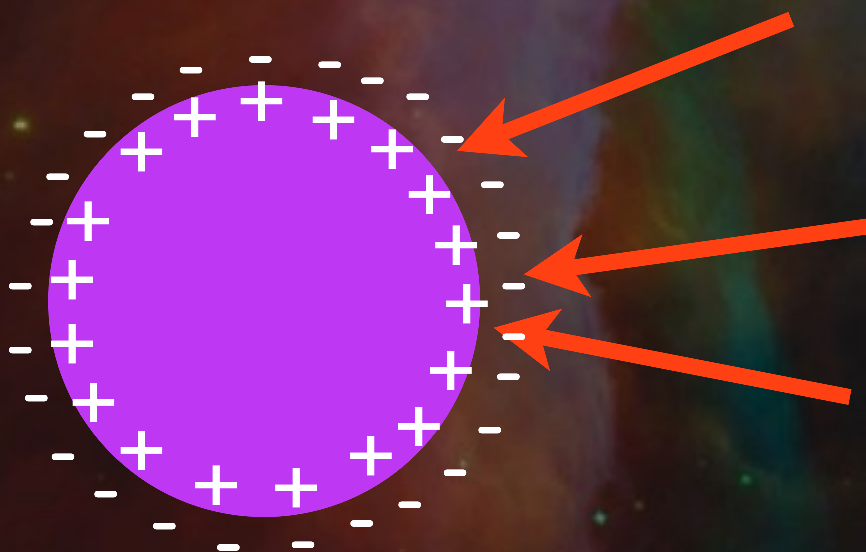
$U_{pol} = \alpha E^2 / 2 \sim 1$ mK

Small correction to sublimation energy (91 K) ?

Electronic band structure



Charging of H_2 grains



γ : Photoelectric

e^-

p^+ Collisional

$\Phi \sim$ few V

$L \sim$ few Å $\quad \therefore \quad E \sim 10^{10}$ V m^{-1}

$U_{pol} = \alpha E^2 / 2 \sim 1000$ K

Ionisation products

Gas phase: $H_2^+ + H_2 \rightarrow H_3^+ + H$

Solid phase: $H_2^+ + 2\,H_2 \rightarrow H_6^+$

ESR : Miyazaki, Kumada, Kumagai

Theory : Kurosaki & Takayanagi

No lab spectroscopy yet

Ab initio theory : Lin+ 2011