A cometary interpretation of G2

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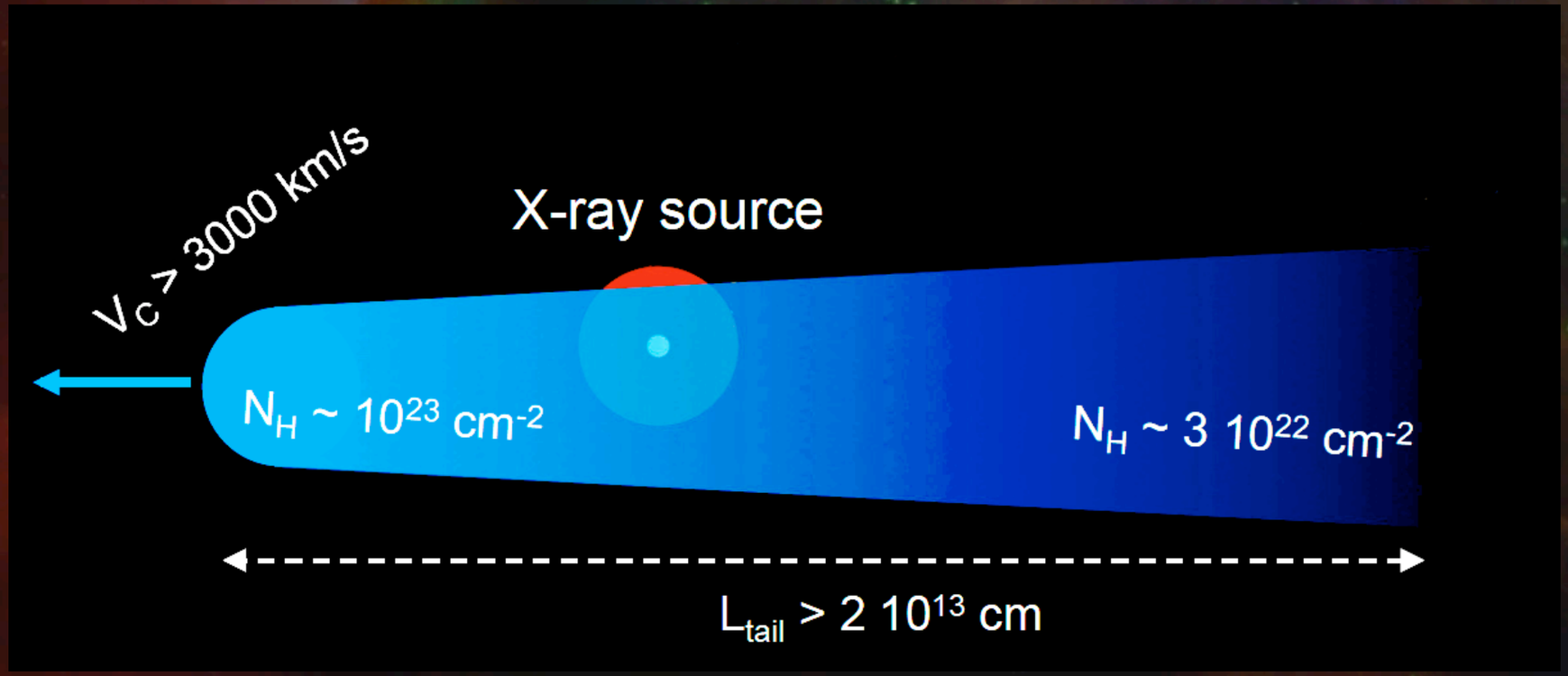
Interpretation of G2 : key points

- Lifetime of G2 ≪ Age of Galaxy → like a comet ∴ follow Oort
  - Reservoir of parent bodies + diffusion into loss-cone
- Planetary-mass gas clouds are abundant
  - In Active Galactic Nuclei

Abundant in Active Galactic Nuclei

- Broad-line clouds "imaged" via X-ray absorption events in NGC1365 (Maiolino et al 2010). Cometary morphology.



- Smoothness of Broad Lines requires large numbers of clouds
- Scale "comet" numbers up / down for Quasars / Sgr A*

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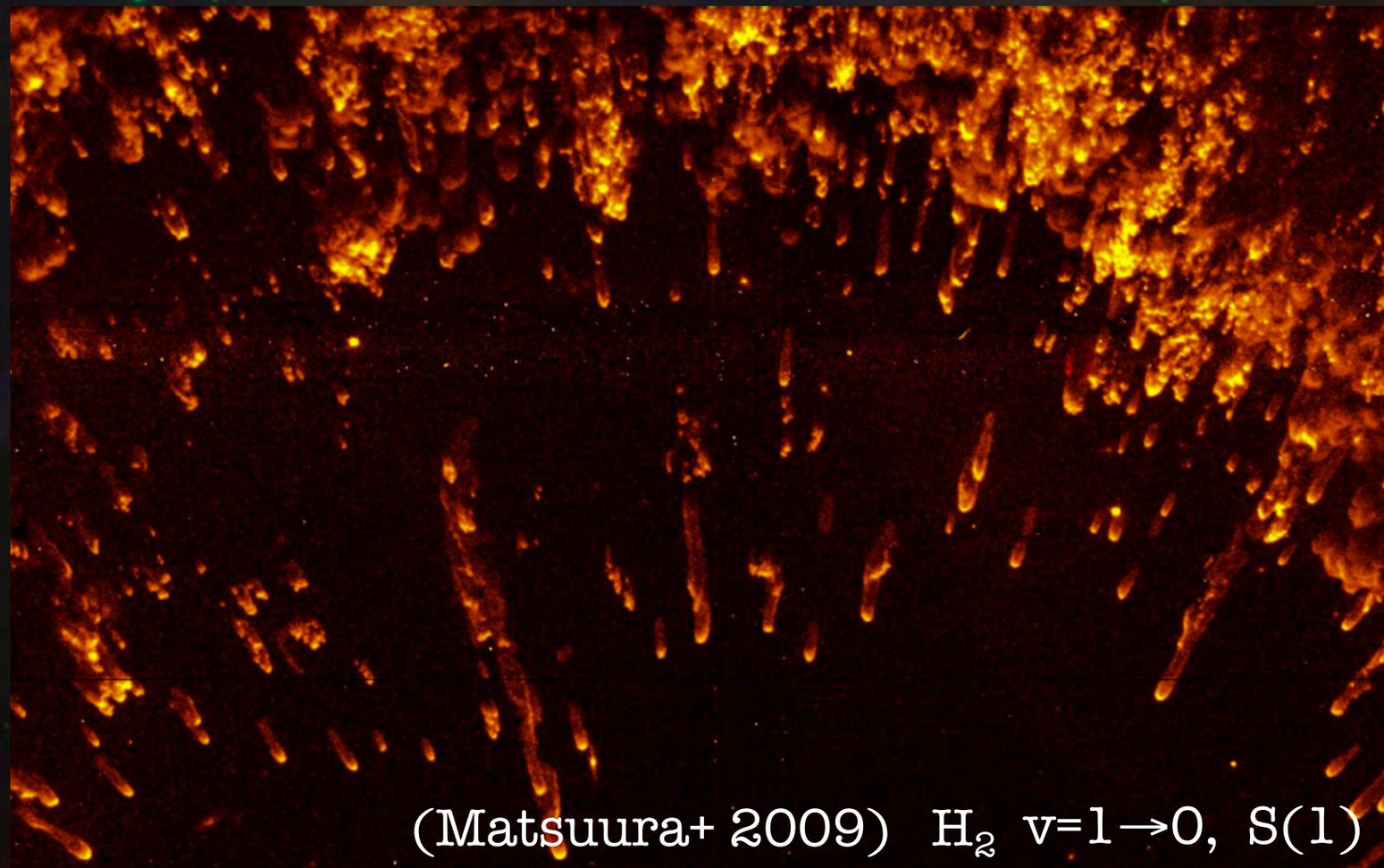
Abundant in Planetary Nebulae

- "Cometary Knots" in Helix Nebula (esp. O'Dell & Handron 1996)
- Interpreted as photoevaporated flows (Lopez-Martin et al 2001) from dense molecular cores (Huggins et al 1992)
- Masses ~ few × 10^{-5} $M_\odot$
  Radii ~ 100 AU
- Matsuura et al (2009) find ~ 4×10^4 knots in H_2



(Matsuura+ 2009) H_2 v=1→0, S(1)

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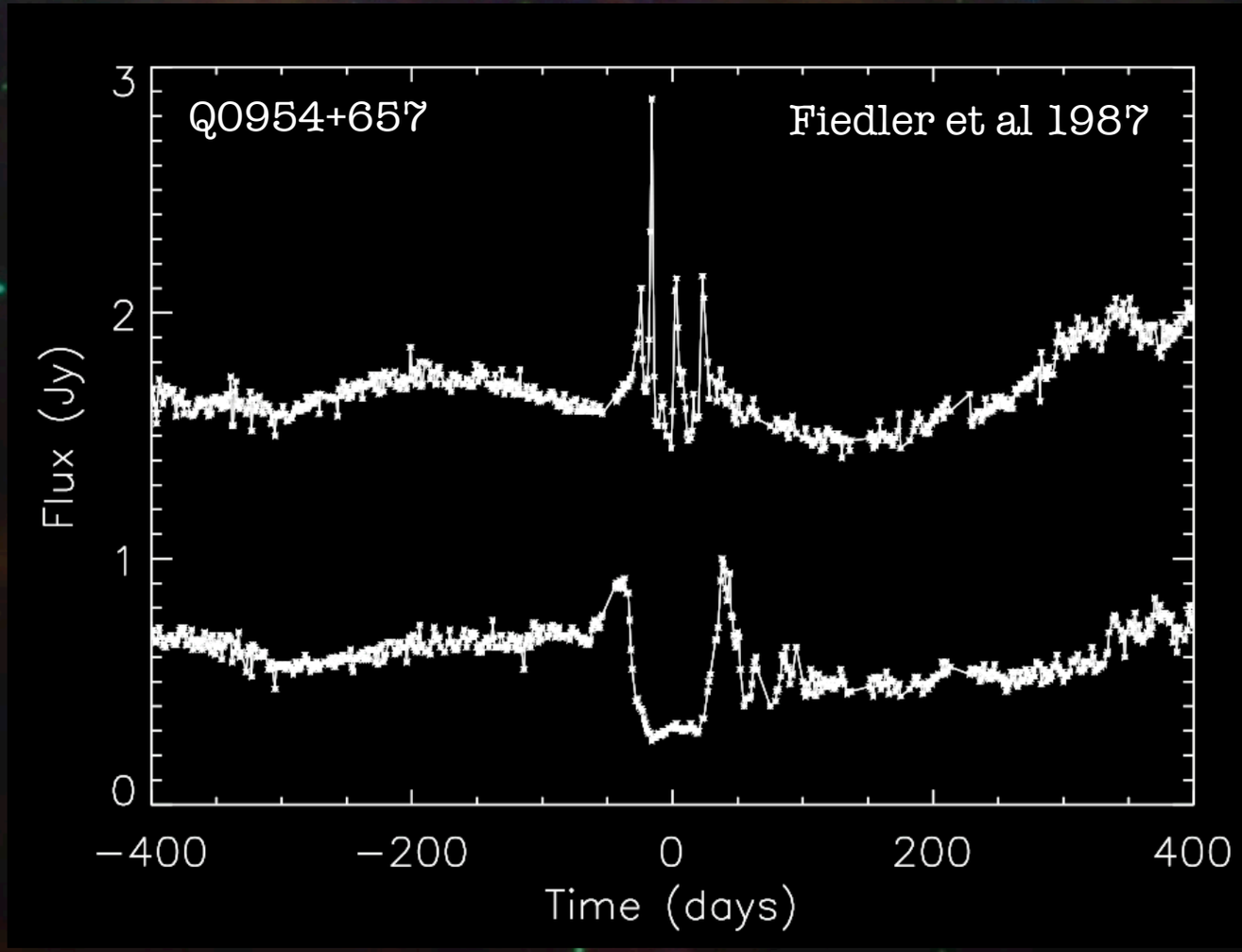
Clouds in ISM revealed by radio-wave lensing events

- "Extreme Scattering Events" (Fiedler et al 1987)
  - Plasma-lensing events (Romani, Blandford & Cordes 1987)
  - High pressure ionised gas
  - Lens radii ~ few × AU
  - Local density ~ few × 10^3 pc^{-3}
- Light-curve analysis (MW 2007):
  - Quasi-spherical lens
    ∴ self-gravitating neutral cloud underlies ionised gas
  - Ram-pressure important
    ∴ supersonic motion
- CSIRO project to find more events ongoing ... (Bannister et al 2014)



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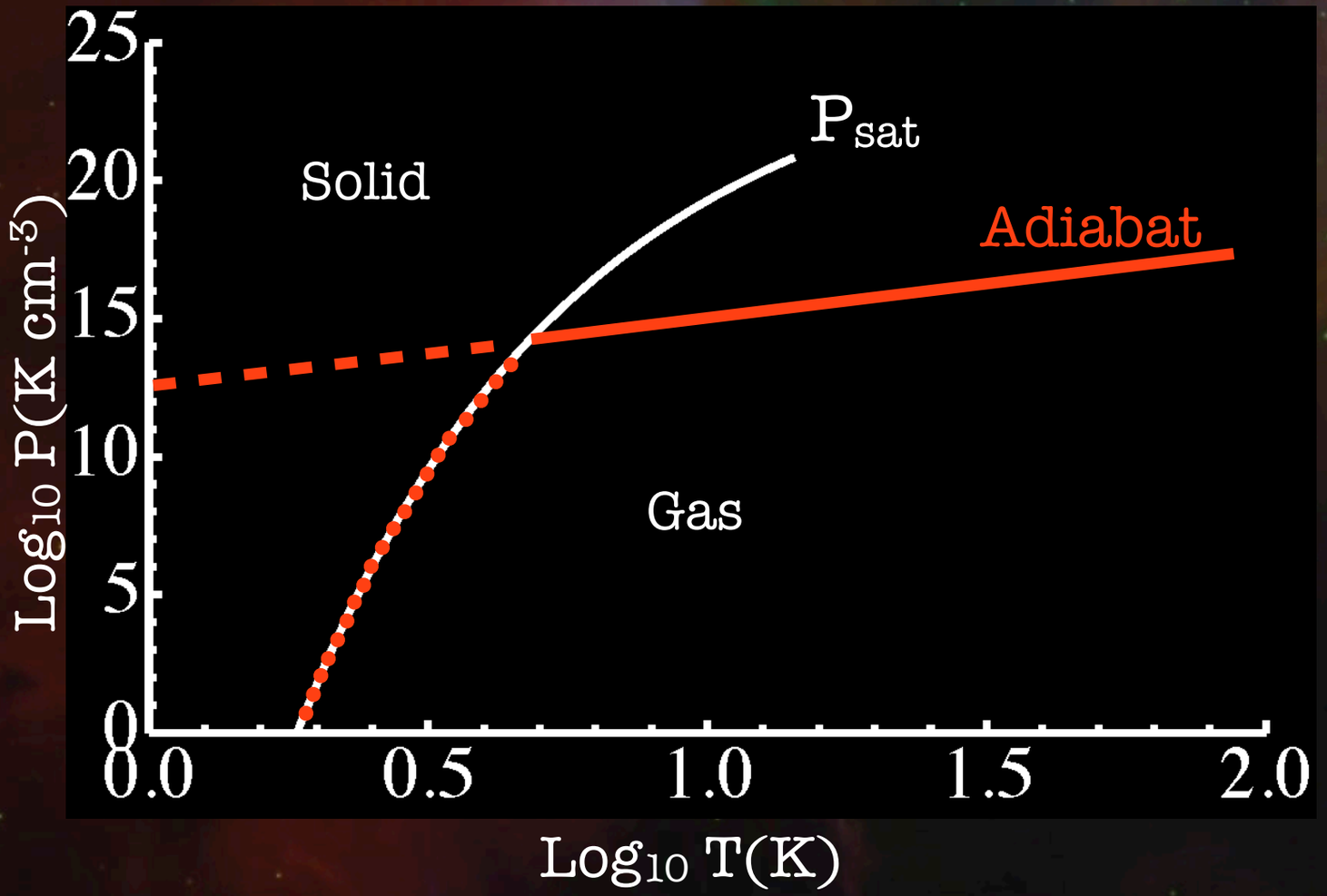
- Models show core+envelope structure due to H_2 snow formation
  - Structures are robust. Masses range from ~ 10^{-7} to ~ 10^{-1} $M_\odot$

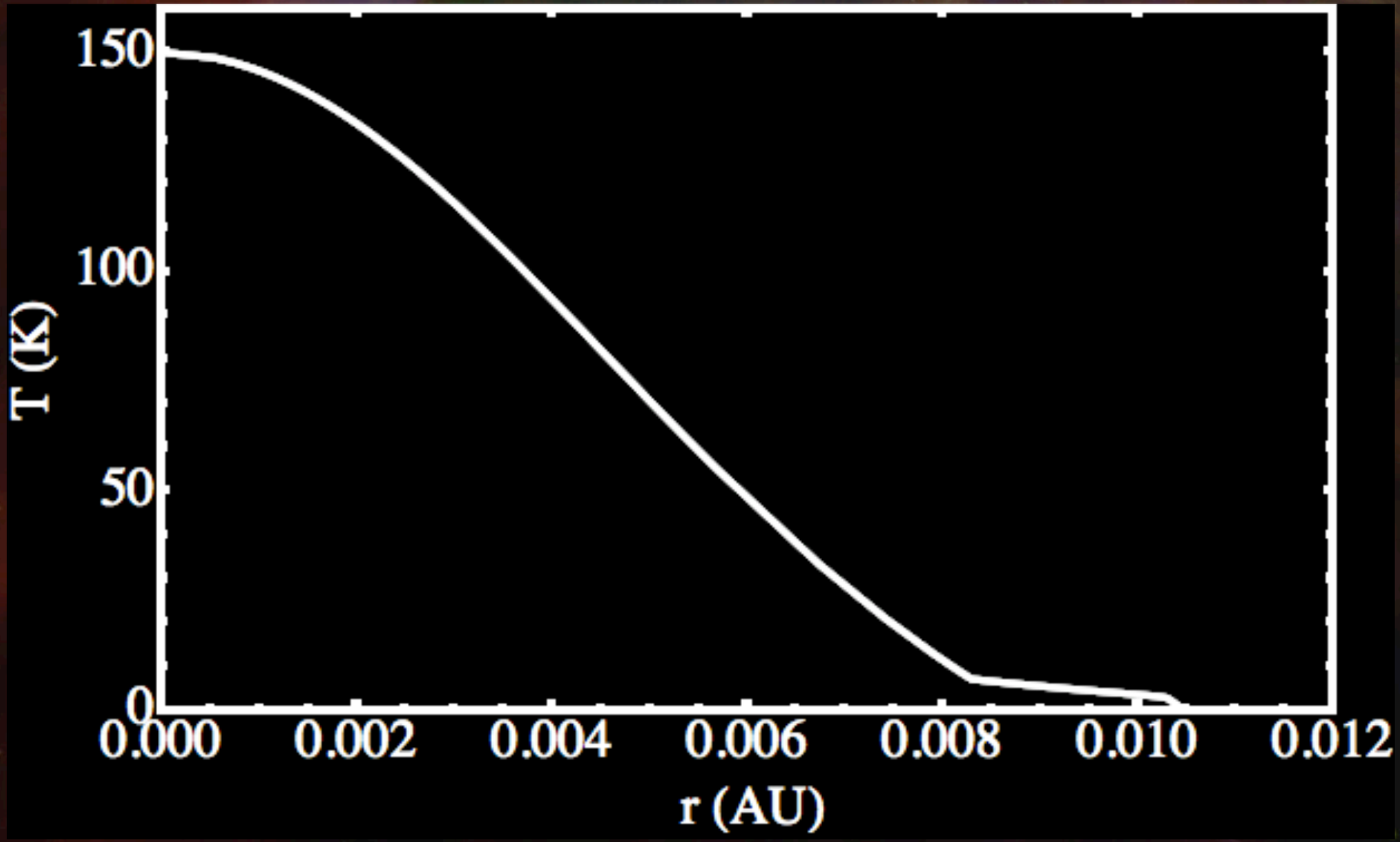
Modelling clouds as self-gravitating equilibria



(MW & M. Wardle 2014)
Solve equations for self-gravitating, hydrostatic fluid in a spherical, equilibrium configuration.

Solid H_2 important for cooling (Pfenniger & Combes 1994), and for the equation-of-state.

Example solution 1: $M = 10^{-5}\ M_\odot$, minimal snowflake content



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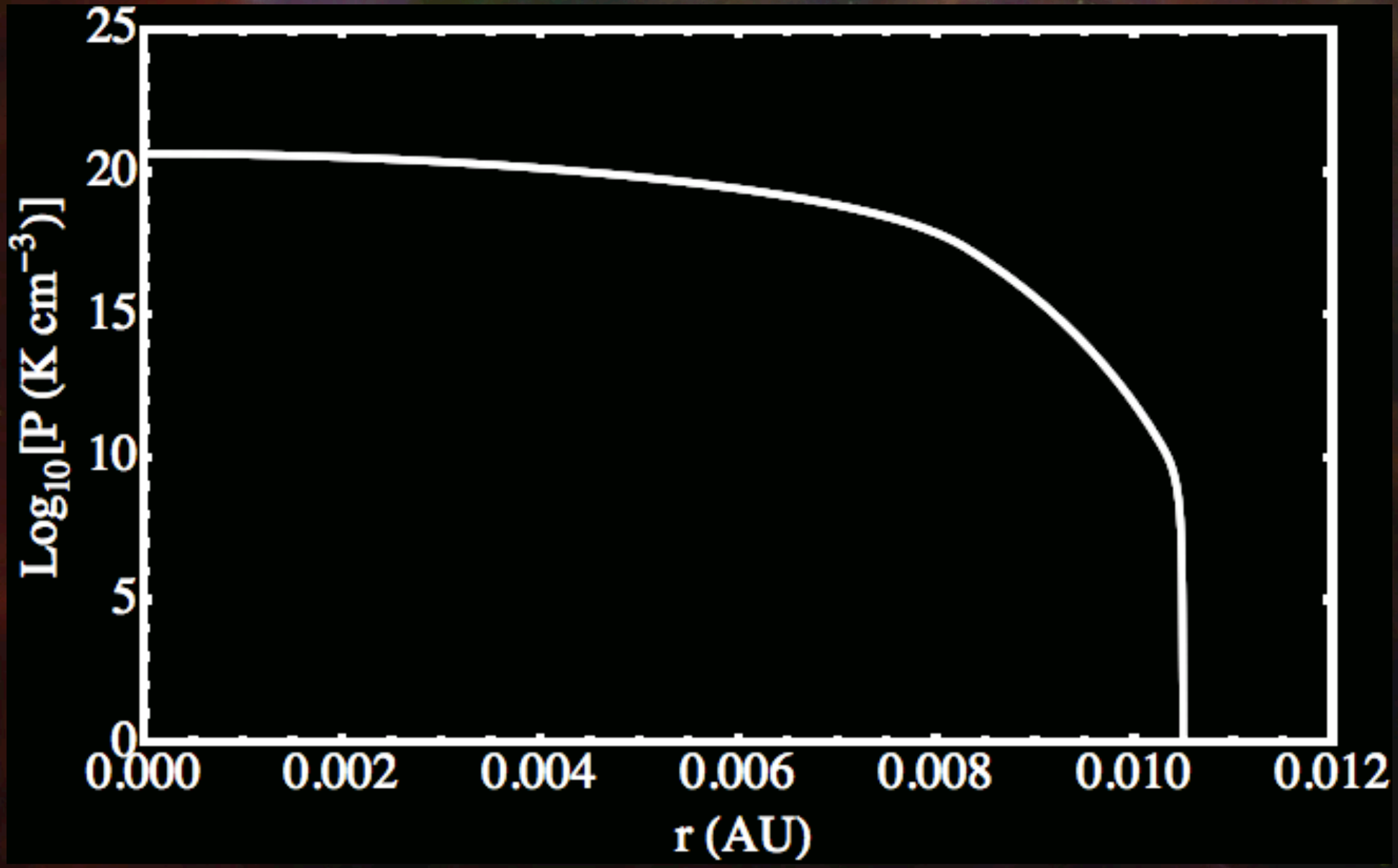
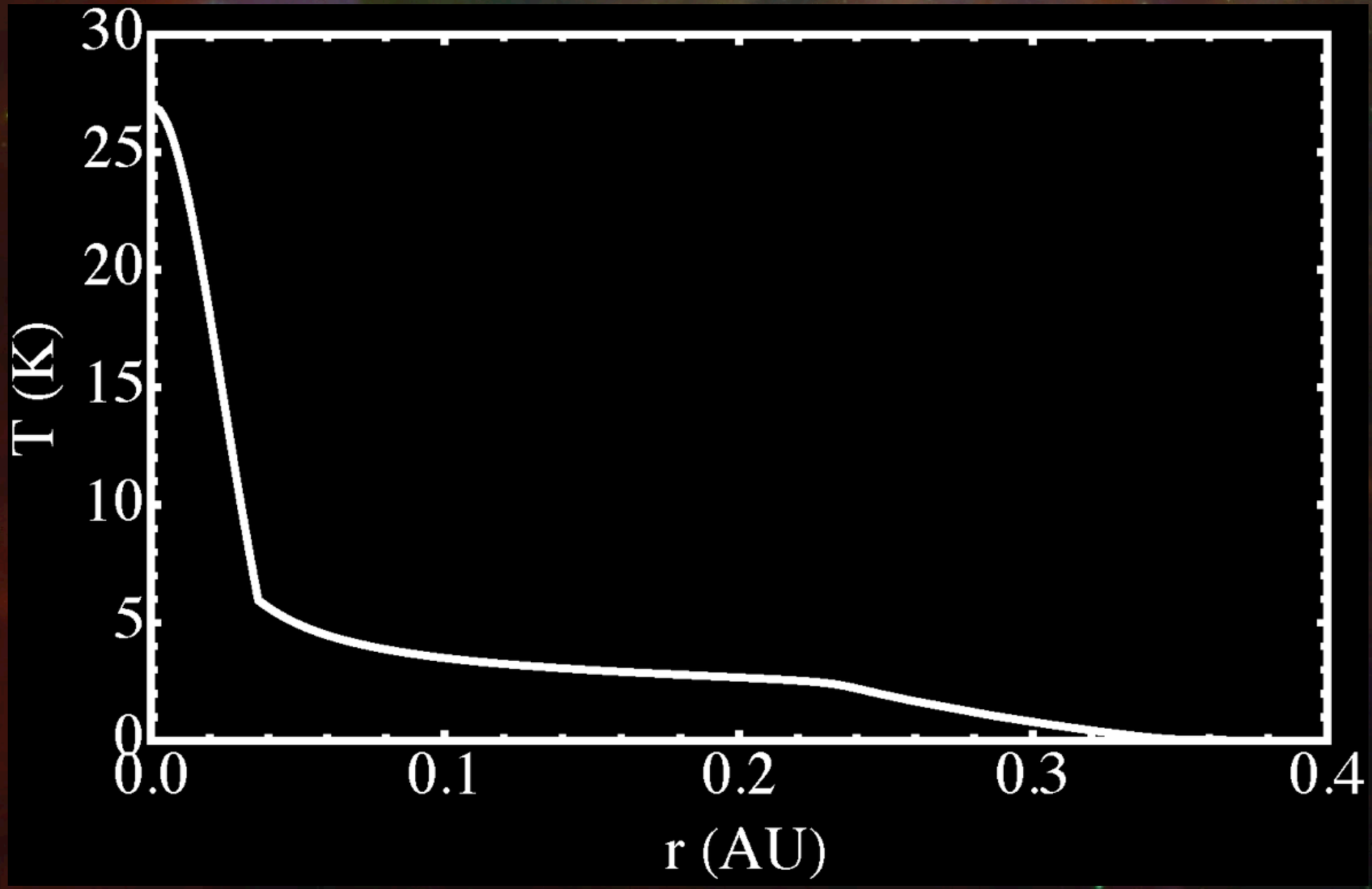


Example solution 2: $M = 10^{-5}\ M_\odot$, minimal snowflake content



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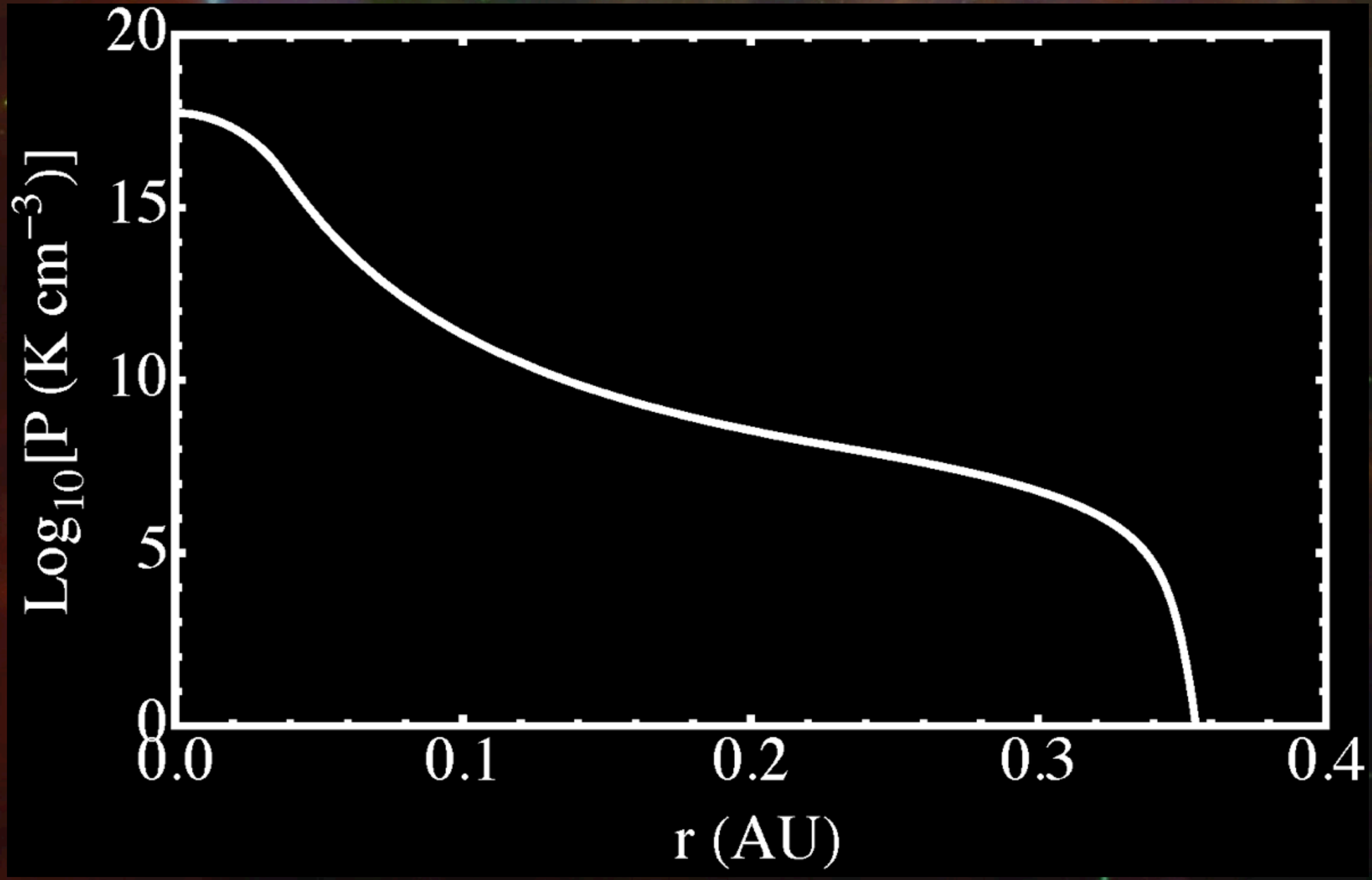
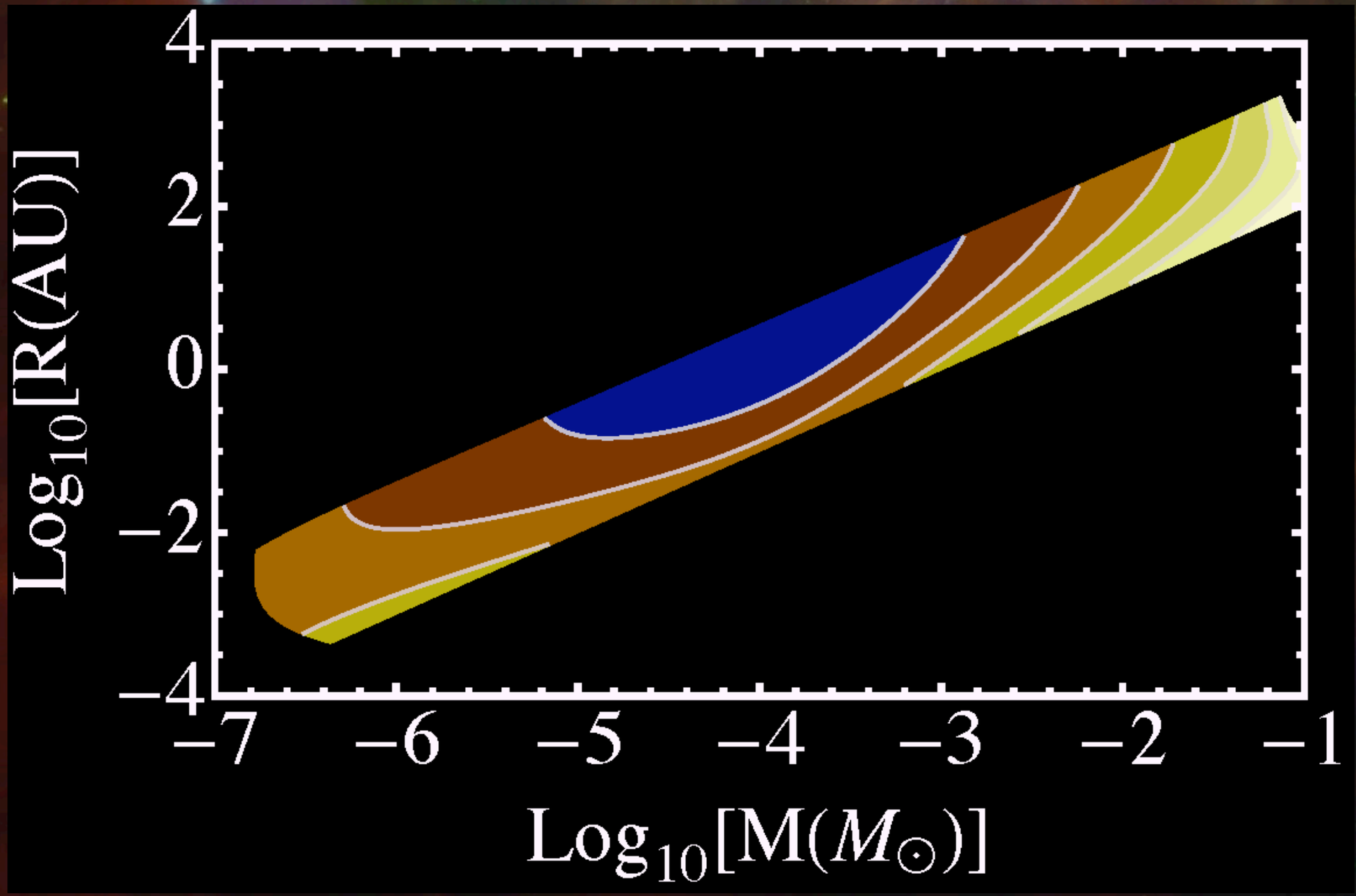


Solutions with minimal H_2 snowflake content



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- Galactic Centre environment modifies characteristics

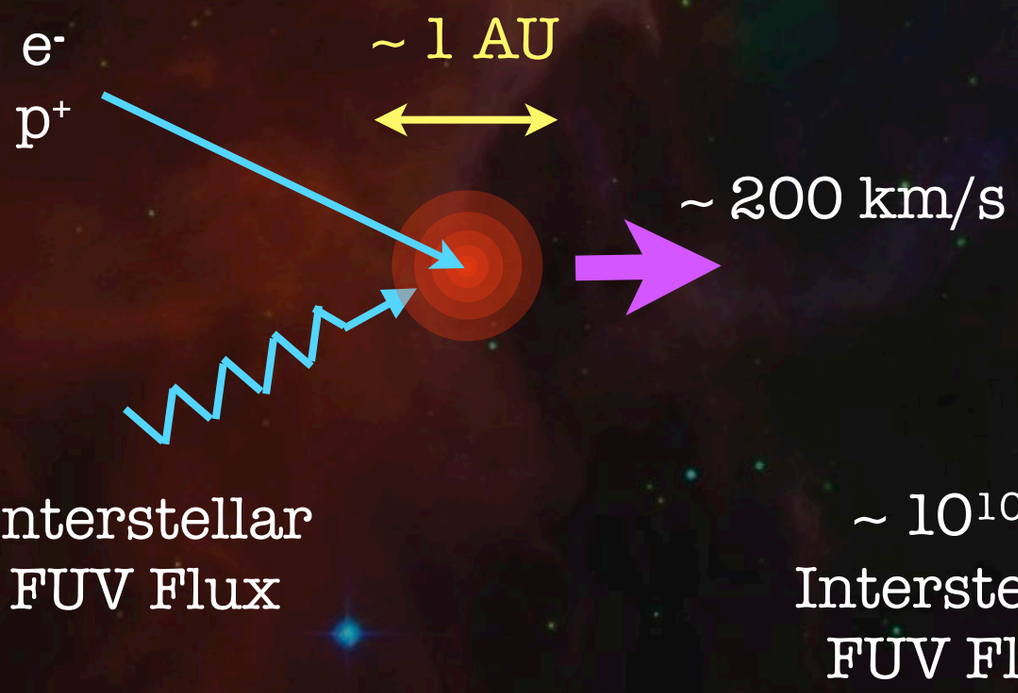
Environmental Influence on Appearance

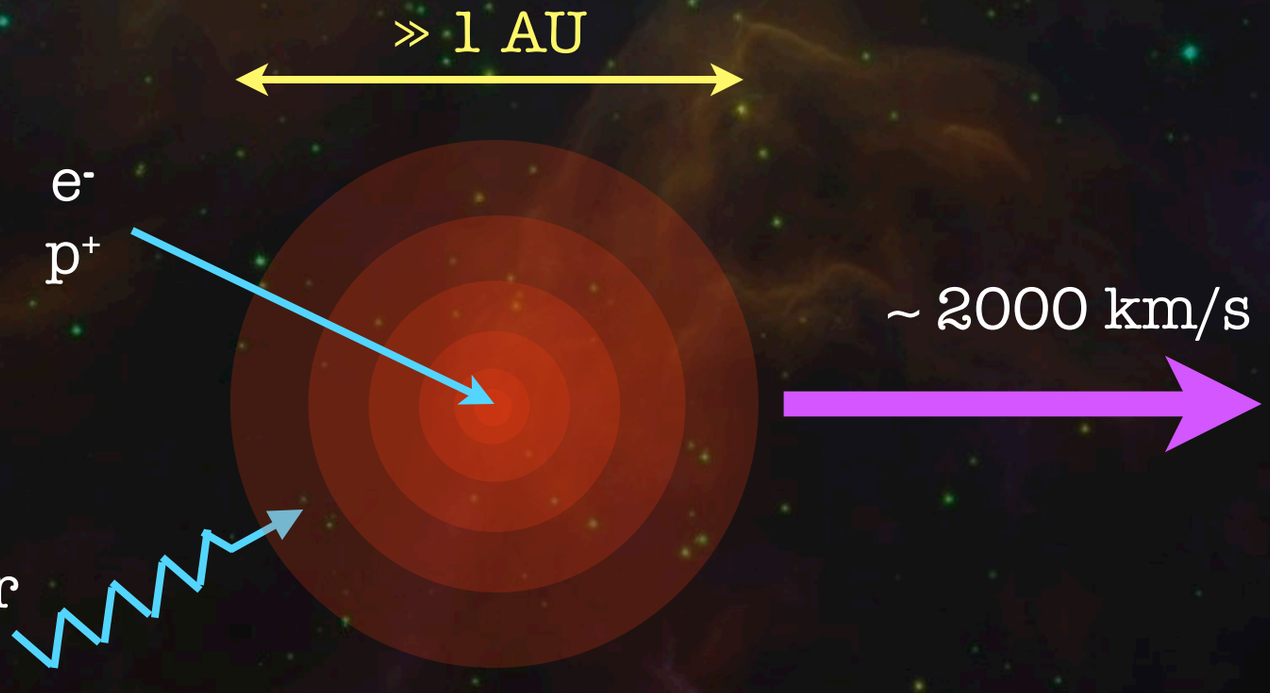
Local ISM

Cosmic-ray heating
Conductive evaporation
Low mass-loss rate
Ram-pressure tail

Galactic Centre

Cosmic-ray heating?
Photoevaporation
High mass-loss rate
Ram-pressure + tidal tail





Summary

- Planetary-mass gas clouds are abundant in AGN, PNe, ISM ...
- Commonality across diverse environments suggests these clouds are a fundamental constituent of the Universe
- Models show robust core+envelope structure with H_2 snow
- Strong FUV field near Sgr A* will inflate clouds and drive winds
- Expect head-tail structure due to ram-pressure and tidal stripping
- G2 naturally interpreted as a "comet"
  - An ordinary gas cloud on an extraordinary orbit