Solid H_2 : Interstellar Dust

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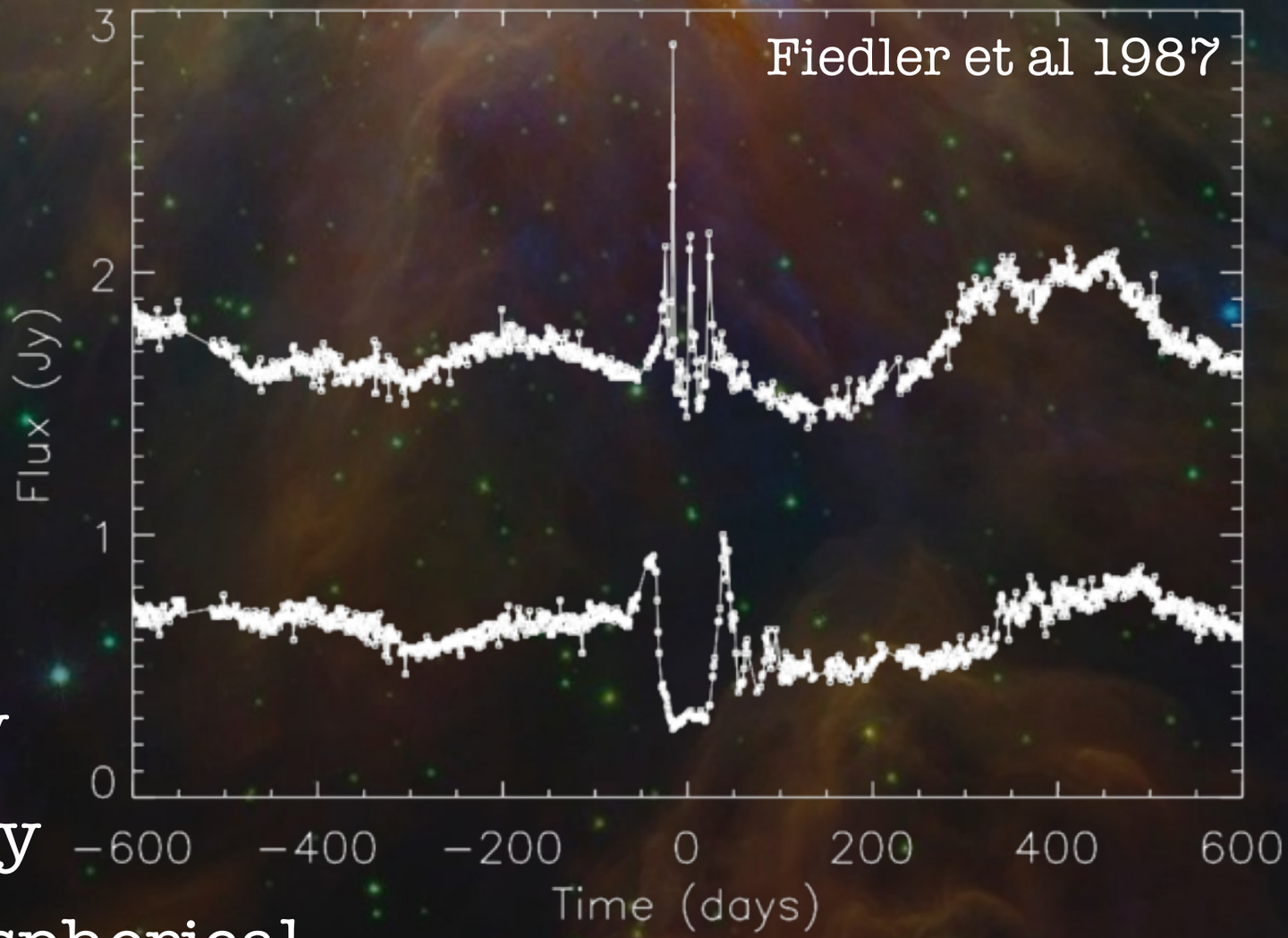
(Manly Astrophysics)

Extreme Scattering Events

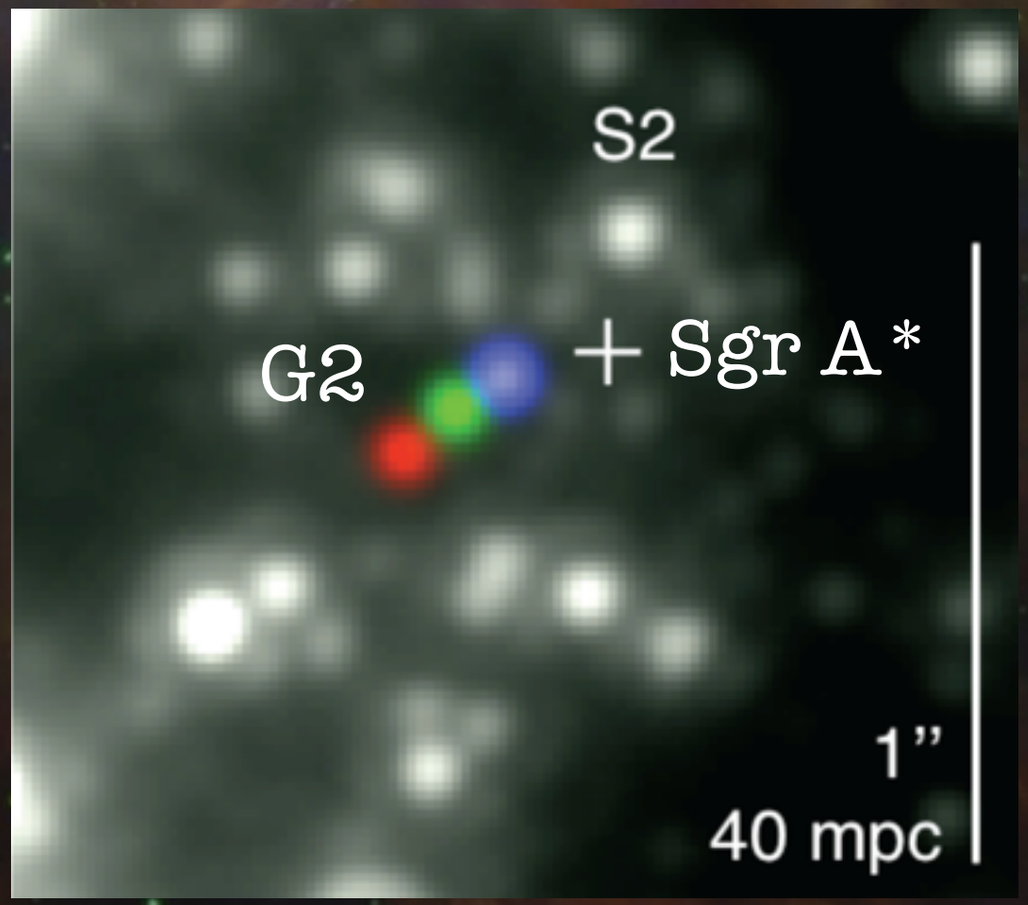
- Radio-wave lensing
- Ionised gas clouds
- Size ~ 1 AU
- Pressure ~ 10^3 P_{ism}
- numbers ~ 10^4 pc^{-3}



- Light-curve symmetry
- Implies lens symmetry
- Axisymmetric lens ∴ spherical
- ∴ underlying self-gravitating neutral cloud
- Planetary mass

Are tiny gas clouds a fiction?

Not in the Helix Nebula
(O'Dell & Handron 1996)



Not in the Galactic Centre
(Gillessen et al 2012)

Clouds must be cooled by H_2 snow

$\therefore$ H_2 snowflakes injected into ISM

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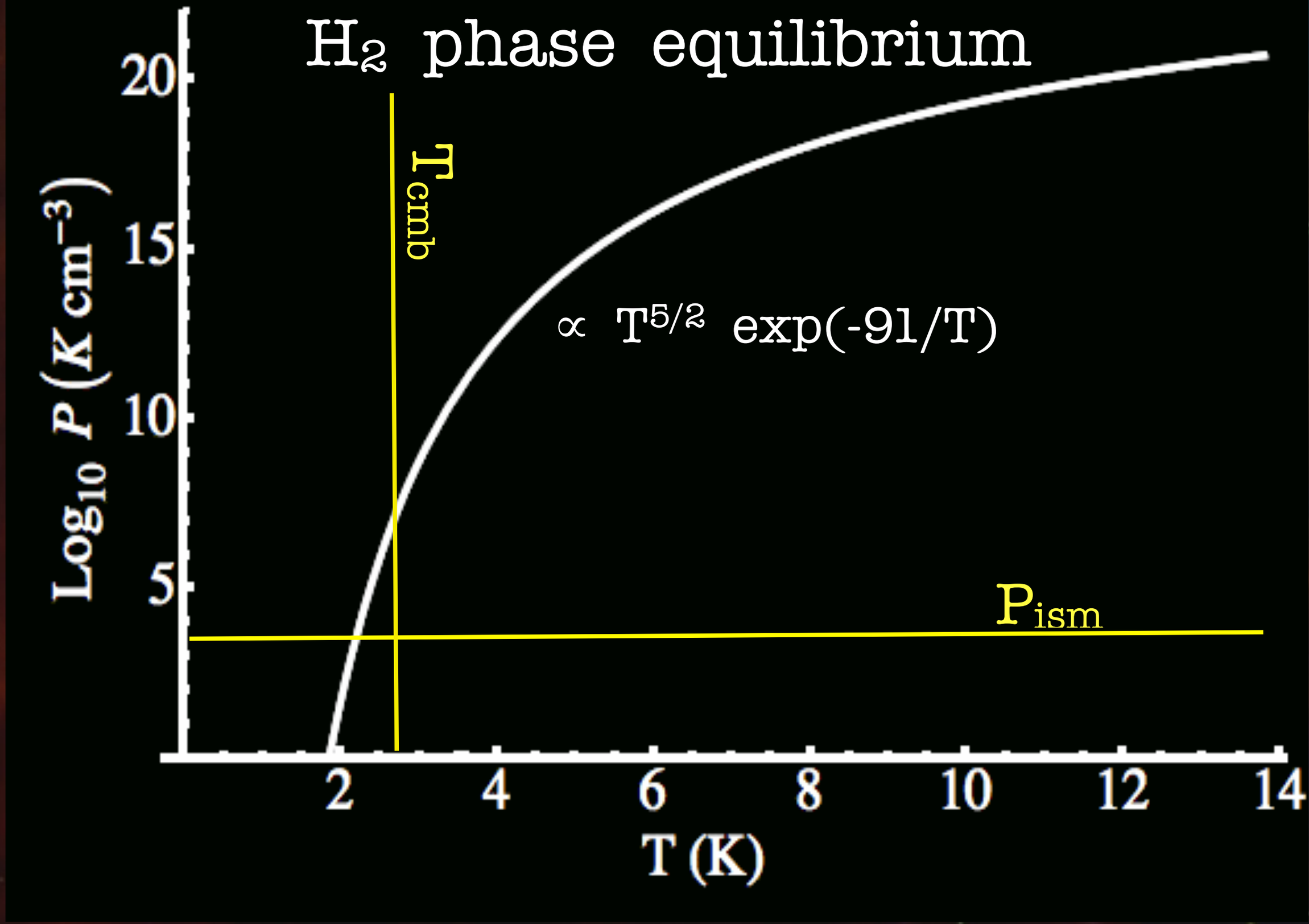
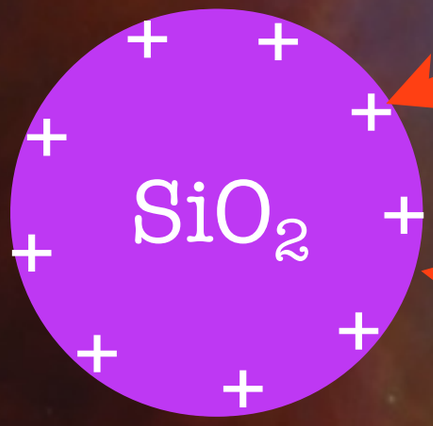
H_2 phase equilibrium



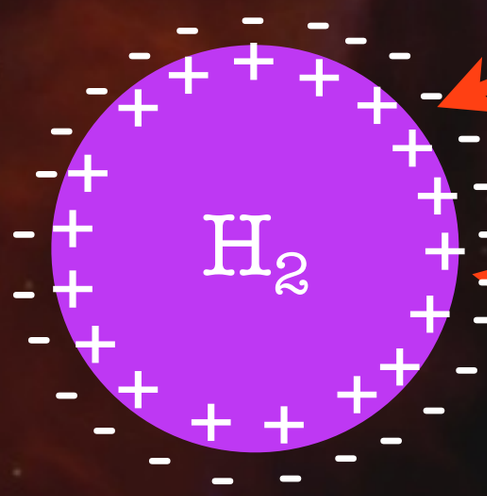
Charging of dust grains



γ : Photoelectric

e^-

p^+ Collisional



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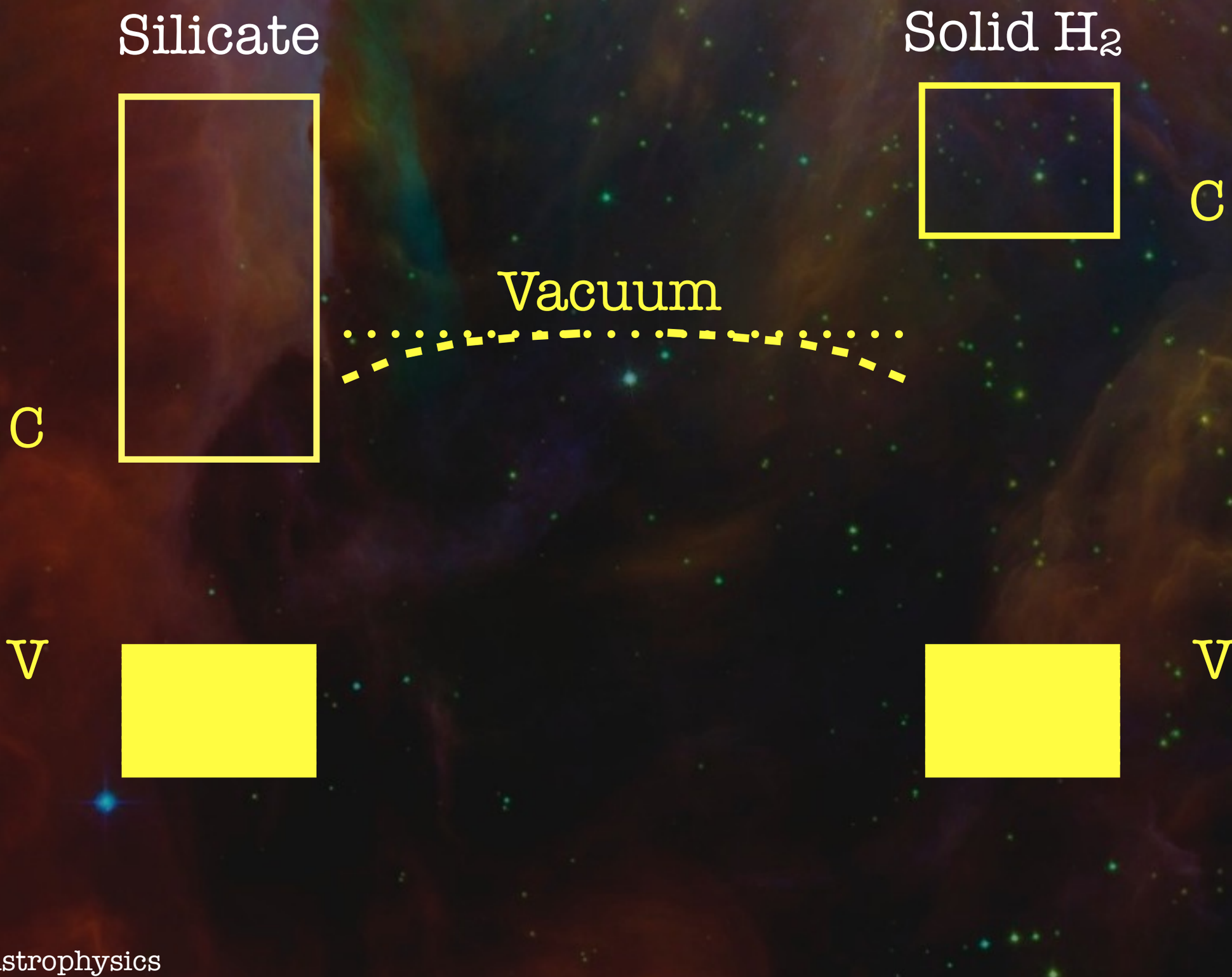
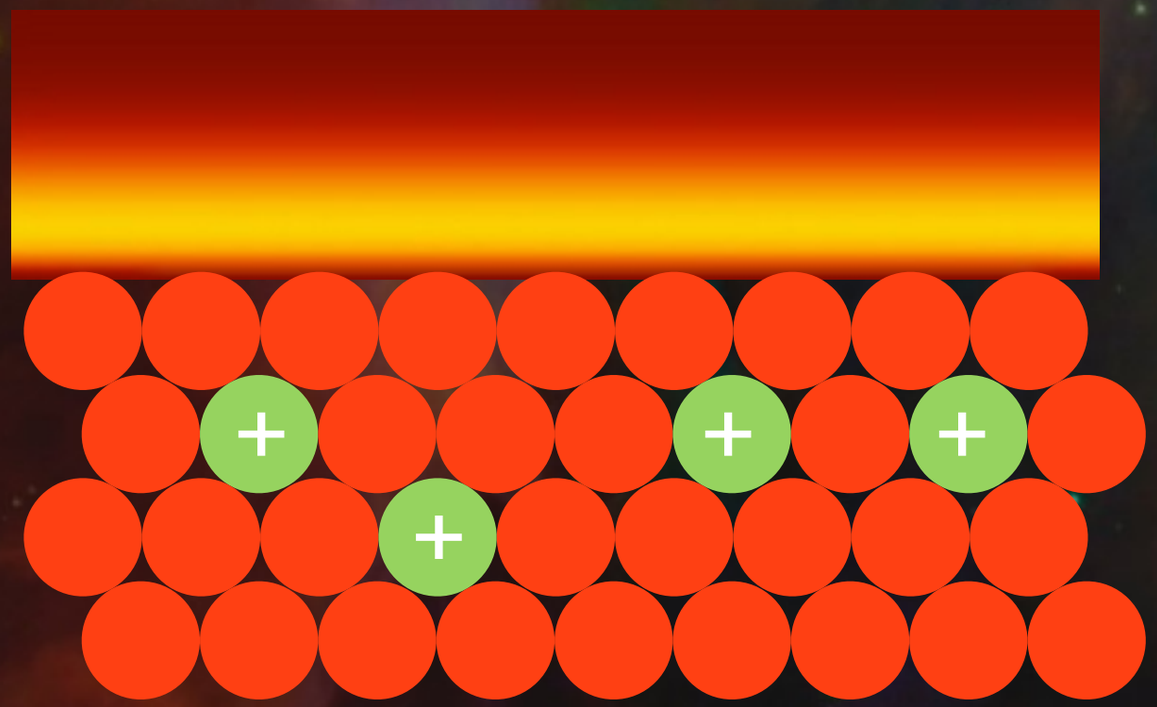
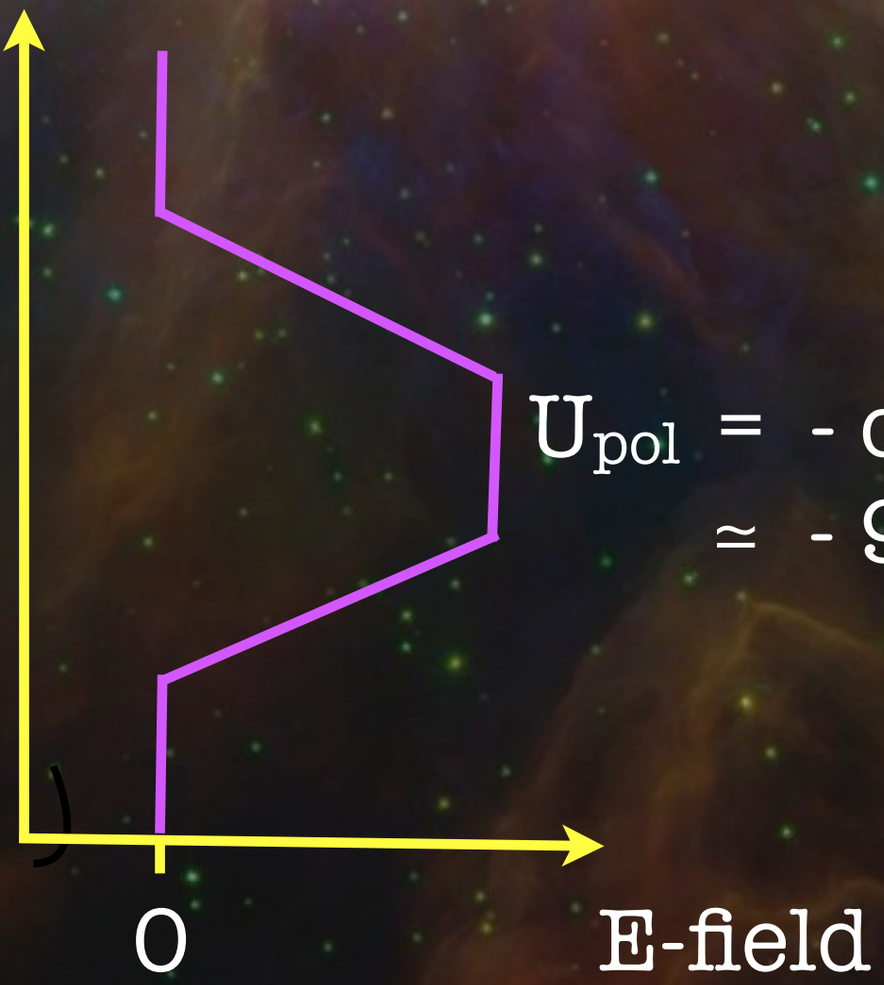
Electronic band structure



Surface layers of H_2 crystal





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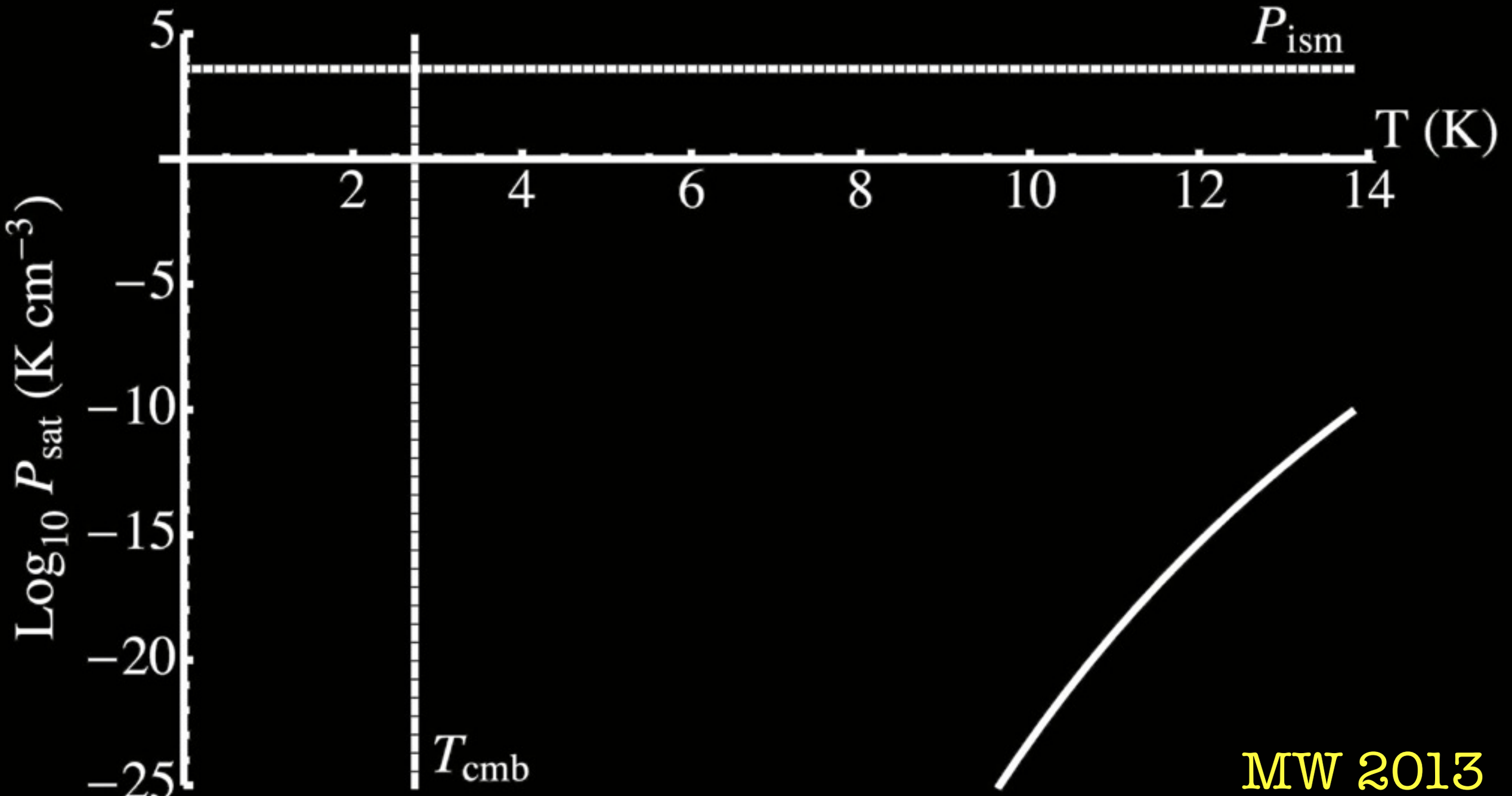
Charged-grain H_2 phase equilibrium



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H_2 ionisation chemistry

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 : Symons, Woolley, Kurosaki & Takayanagi

"New" molecule
No lab spectroscopy yet

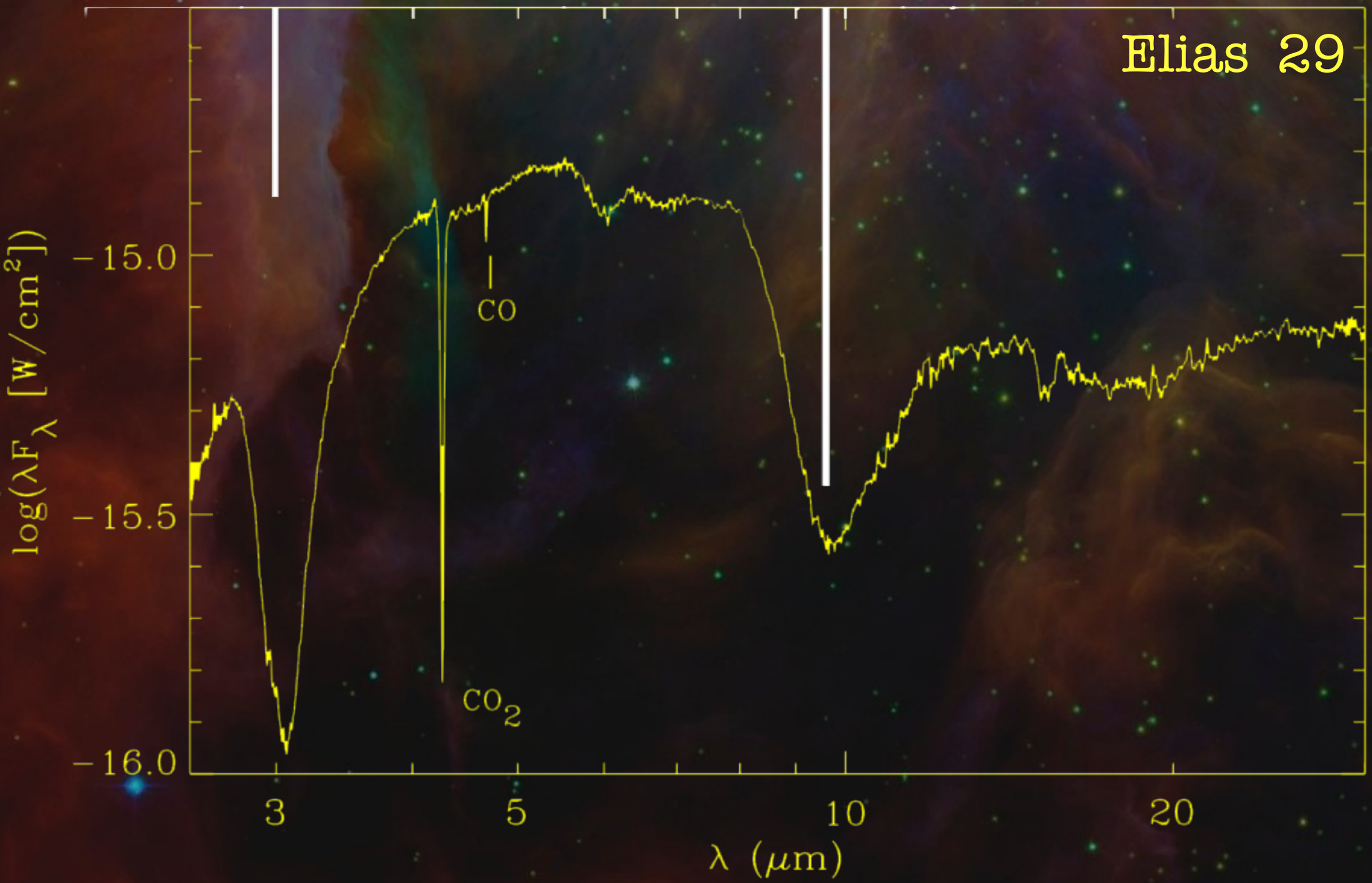
Ab initio model
H_6^+ and $(HD)_3^+$ isotopomers
Characterised 5 vibrational modes
(Lin, Gilbert & MW 2011)

Dust features in absorption

H_6^+

Boogert et al 2000

Elias 29



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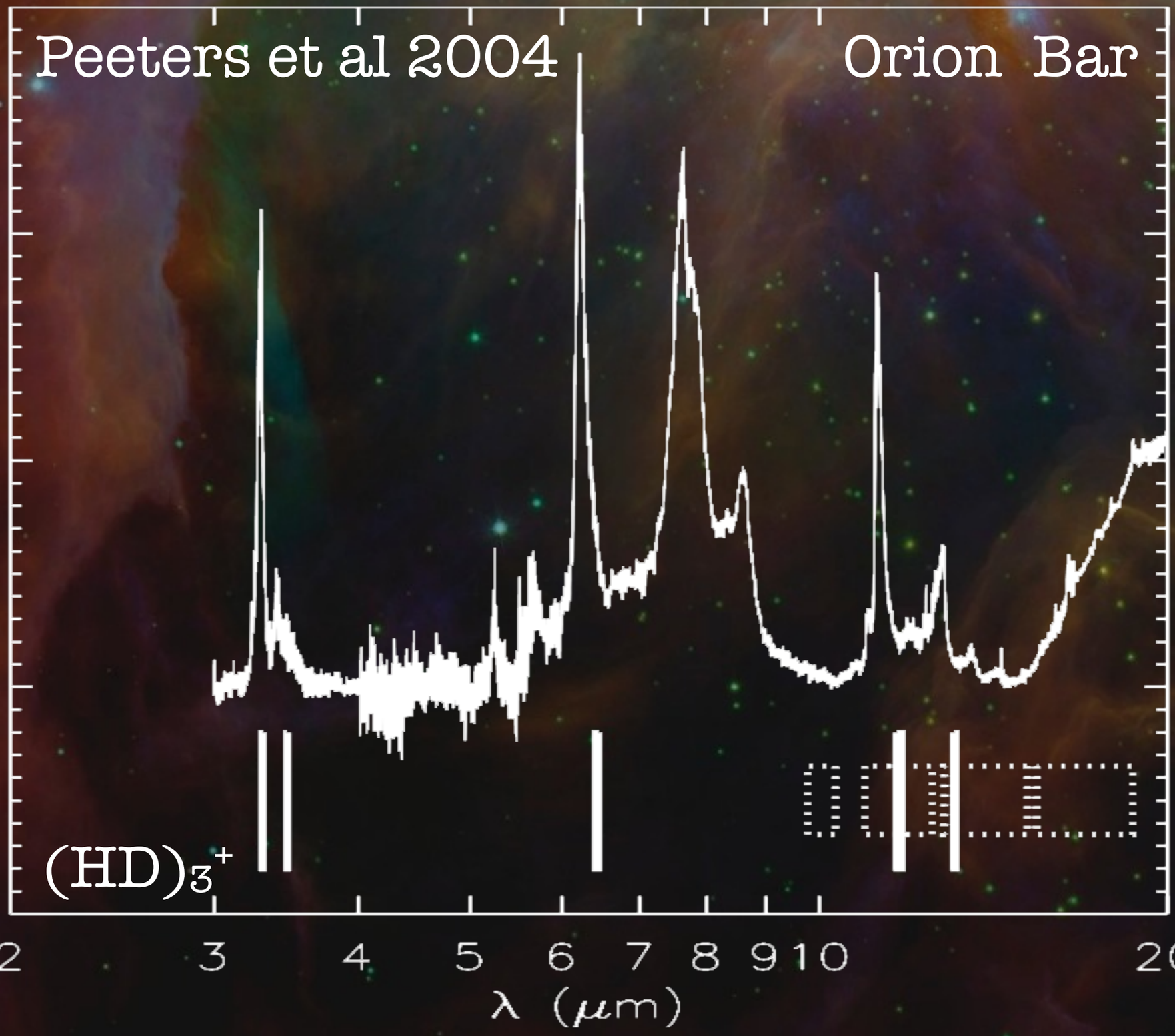
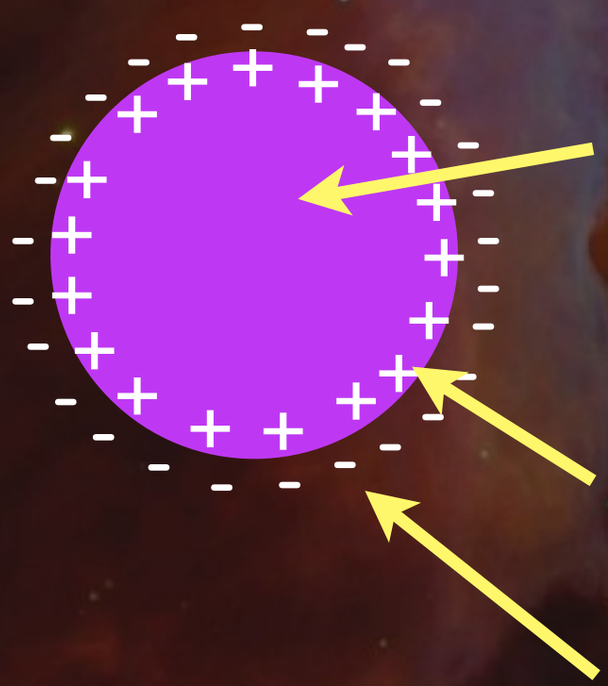
Dust features in emission



Electromagnetic properties of H_2 grains



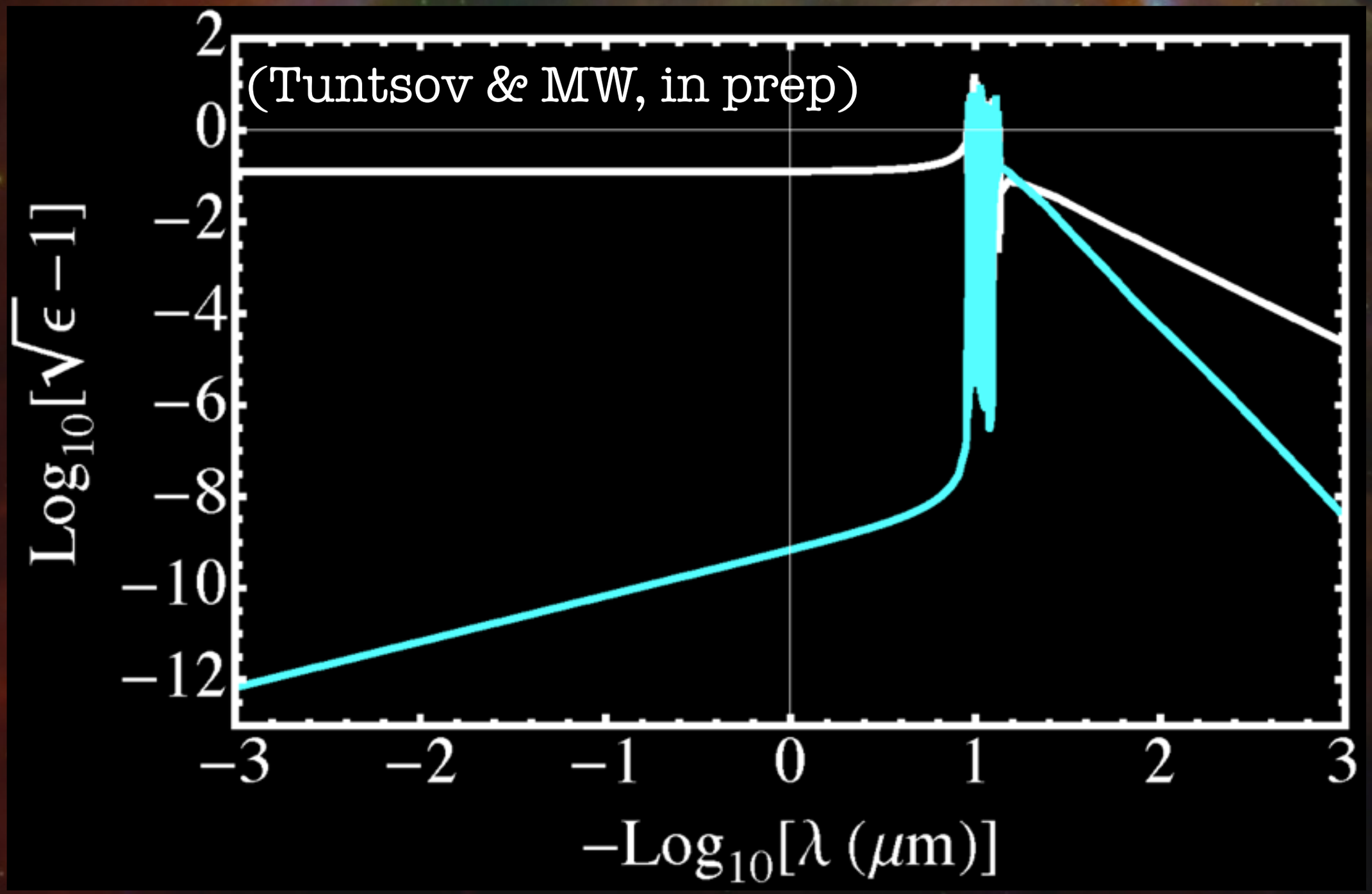
Contributions from:

1. Solid H_2 (modelled)
   - FUV resonances (Lyman, Werner etc)
   - Bound-Free transitions

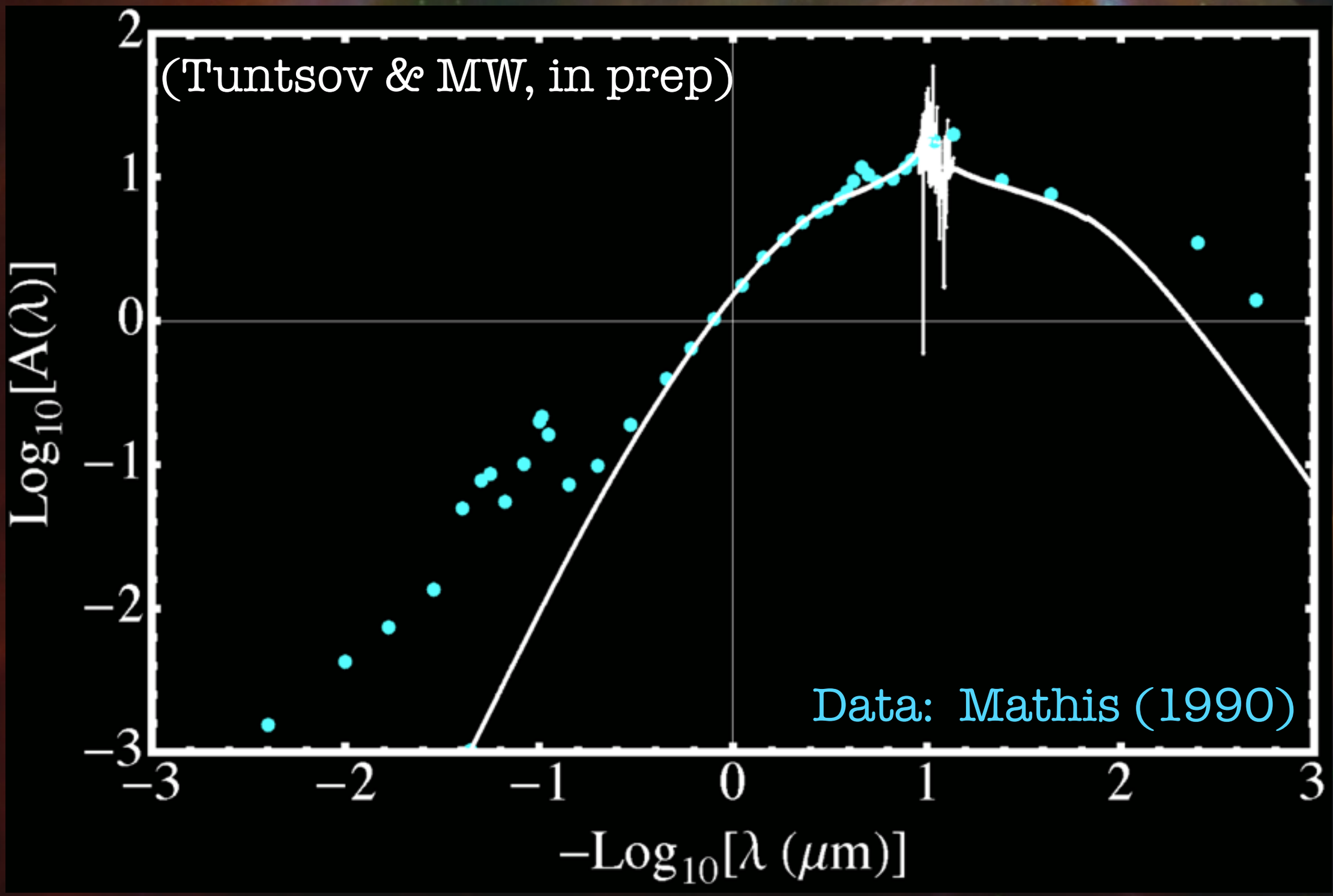
2. Sub-surface ions - e.g. $(HD)_3^+$

3. Vacuum electrons (modelling in progress)
   - Confer metallic character
   - FIR resonance from in-plane d.o.f.
   - High-freq. inter-band absorption

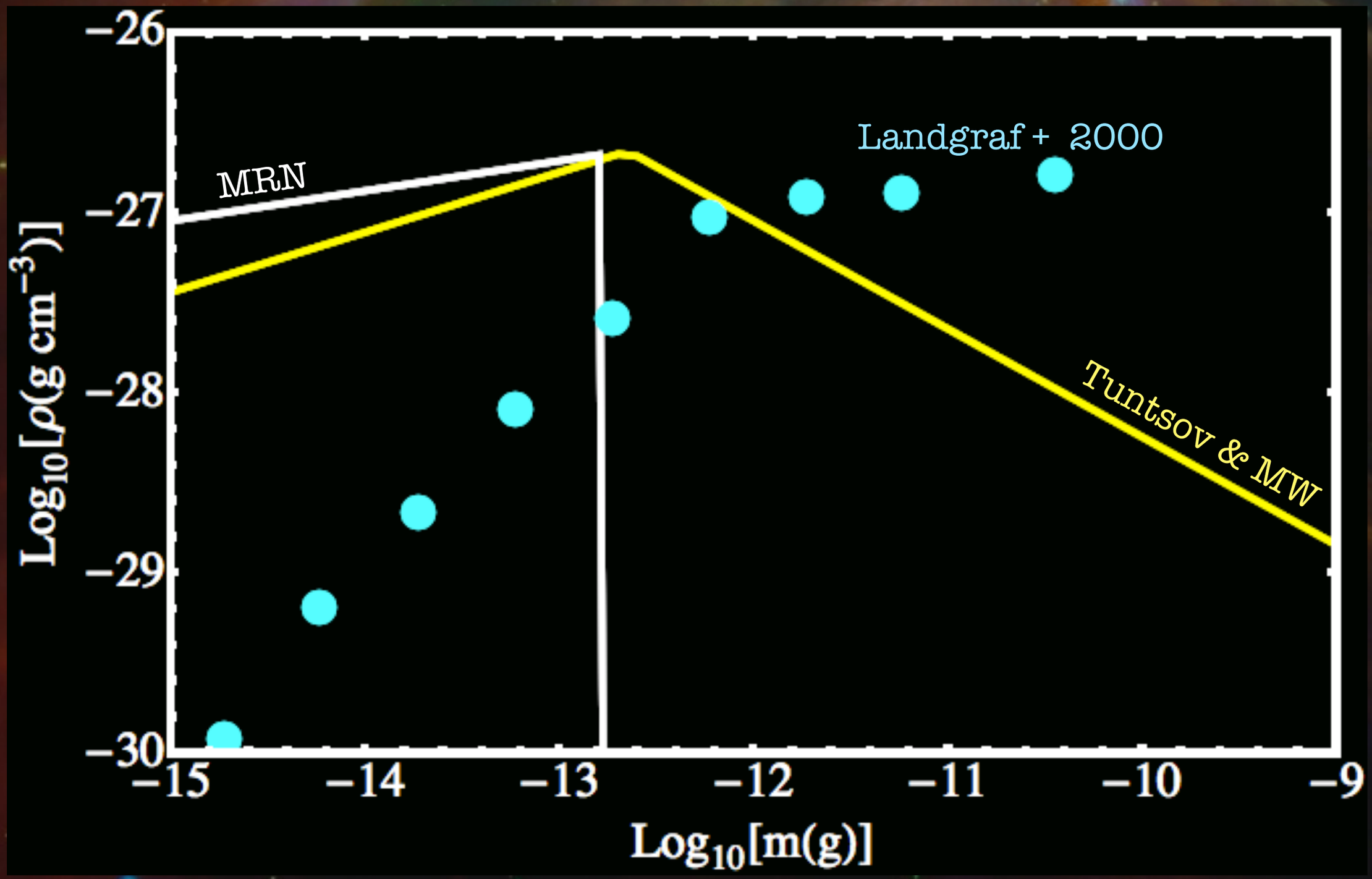
Solid H_2 refractive index



First attempt at extinction curve model



Dust-grain mass spectra



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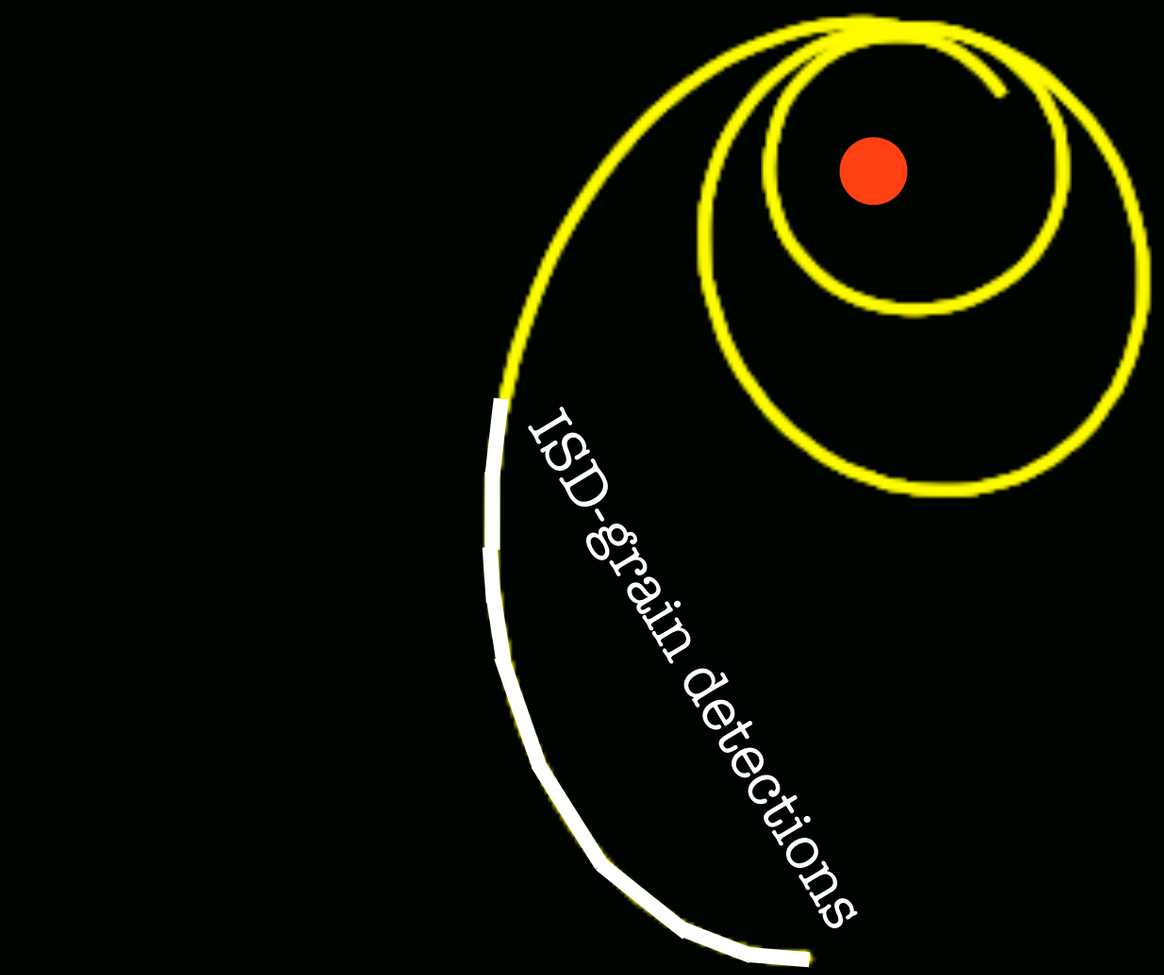
Galileo's Orbit



Local Interstellar Wind

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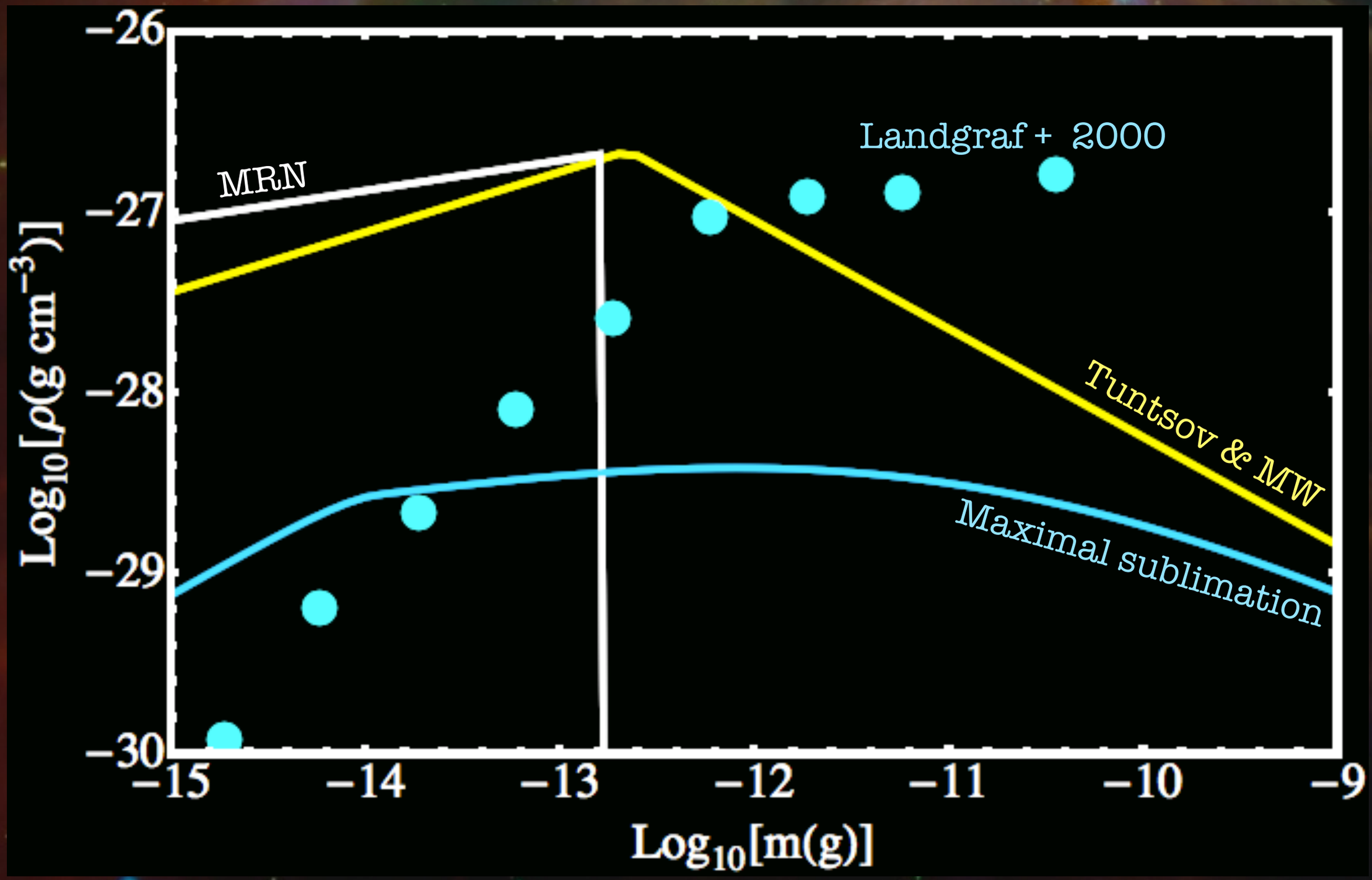
Dust-grain mass spectra



Summary

- Fiedler events point to a large, Galactic population of tiny molecular gas clouds
- Cooling via solid H_2 confers thermal stability
- Hydrogen snowflakes injected into ISM
  - Collisions & SNe effective at high-z
- Sublimation inhibited by charged surface
  - Solid H_2 can survive in the diffuse ISM
- Striking coincidences between ISM bands and vibrational modes of H_6^+ & $(HD)_3^+$
- Potential to reconcile observed extinction curve with in-situ detections of ISD-grains
- No abundance problems