Extinction by H_2 particulates

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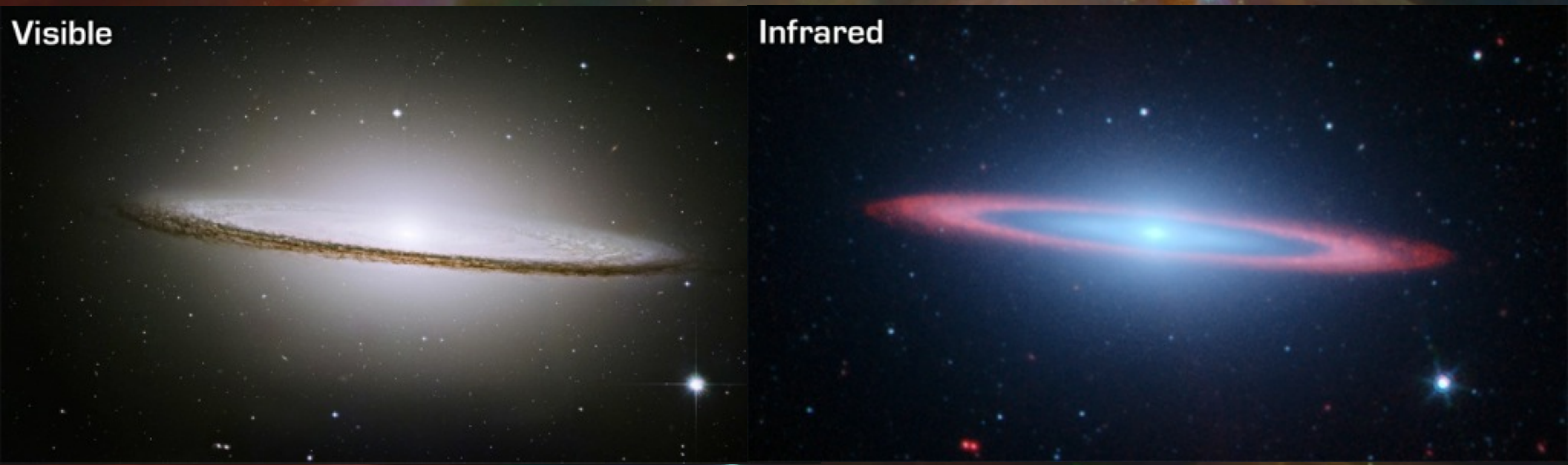
(Manly Astrophysics)

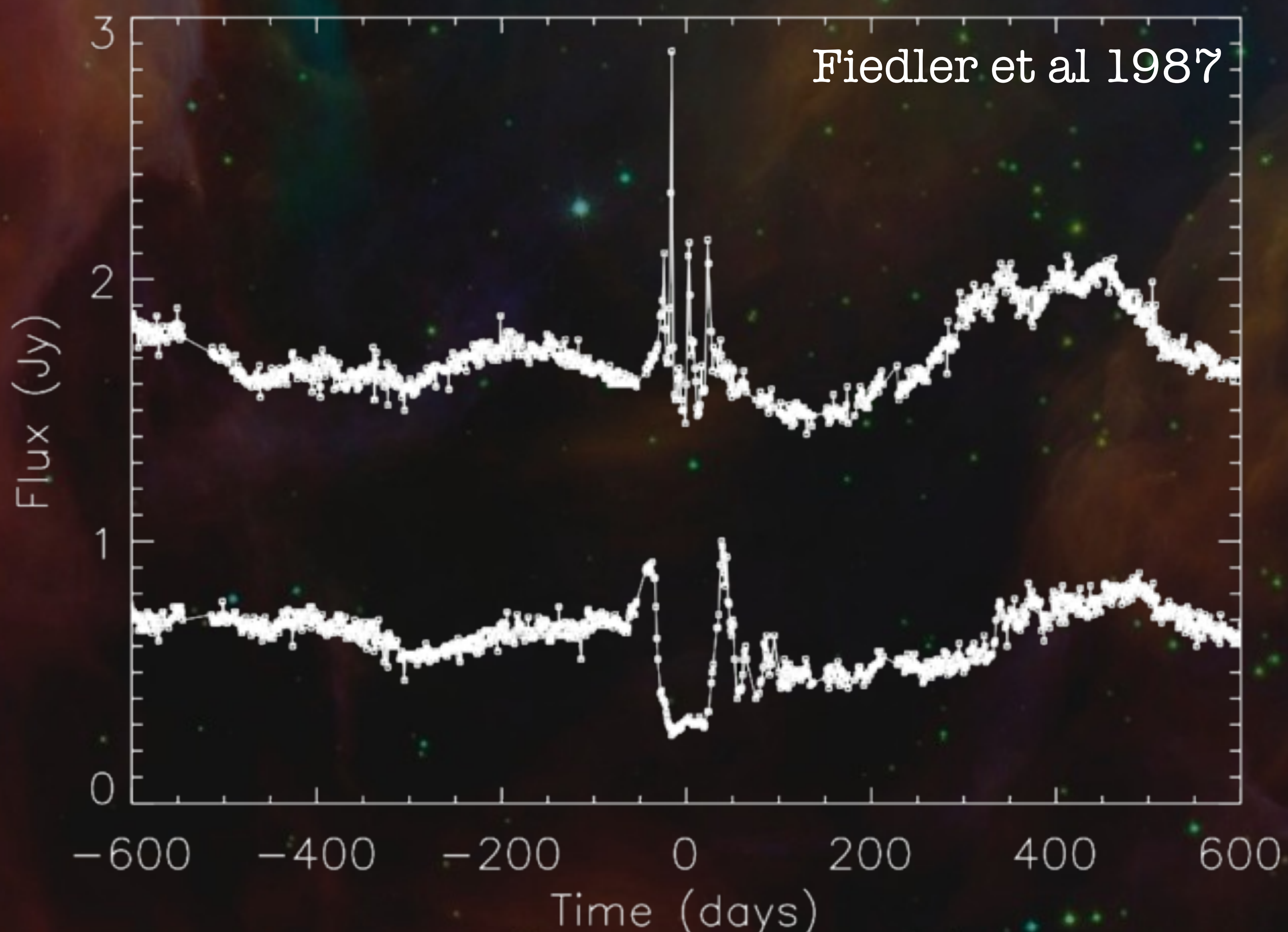
Interstellar Dust



- Extinction, emission etc. due to small particles
- Observed extinction $\rightarrow$ volume fraction $\sim 10^{-26}$
  $\therefore$ must be abundant material (Purcell 1969)
- Conventional composition: silicates + graphite
  - But no unambiguous spectral features
- Unconventional composition: solid H_2

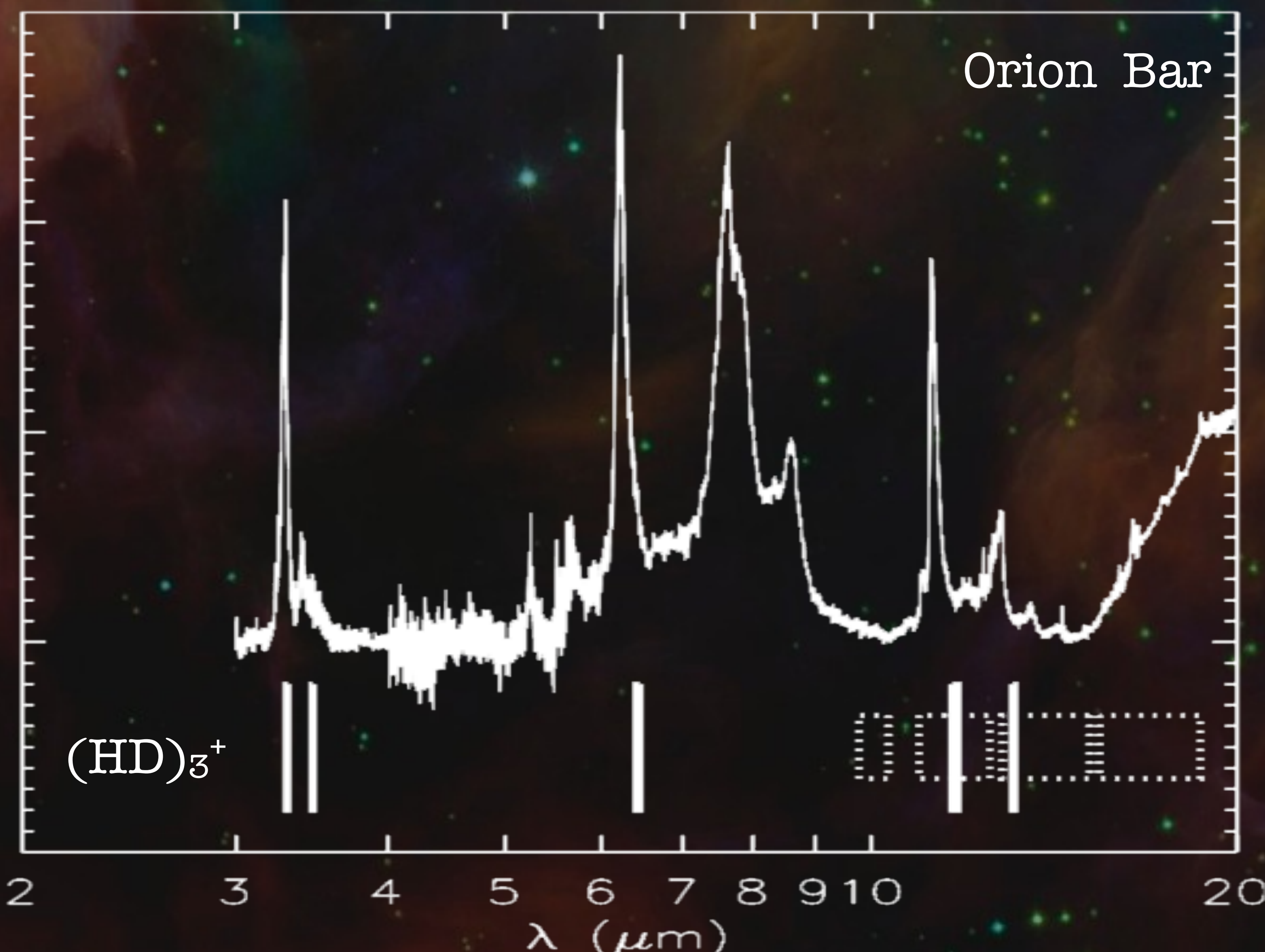
Why consider hydrogen dust? : Part 1

- Need H_2 dust for stability of tiny molecular clouds (MW[2] 1999)
- Need tiny molecular clouds to explain Extreme Scattering Events (MW 2007; MW[2] 1998)



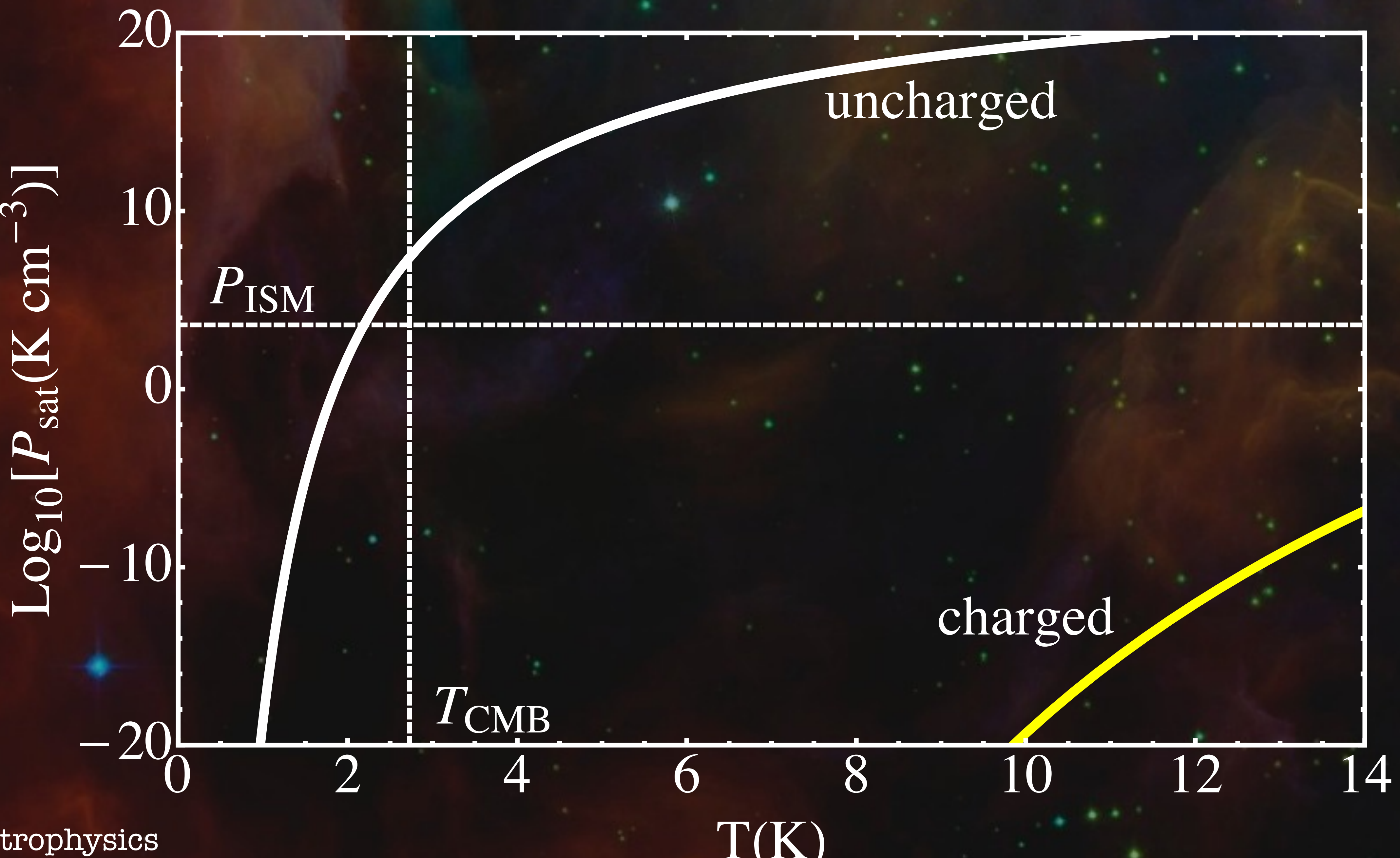
Why consider hydrogen dust? : Part 2

- Ionisation chemistry different for condensed H_2
  - "New" molecules: H_6^+ and $(HD)_3^+$
    (Miyazaki, Kumada, Kumagai, Kurosaki, Takayanagi)
  - Vibrations coincide with strong ISM bands
    (Lin, Gilbert & MW 2011)



Why consider hydrogen dust? : Part 3

- Pure H_2 dust dismissed circa 1970 : too volatile
- But dust acquires surface charges
  - Charged H_2 grains much more robust (MW2013)



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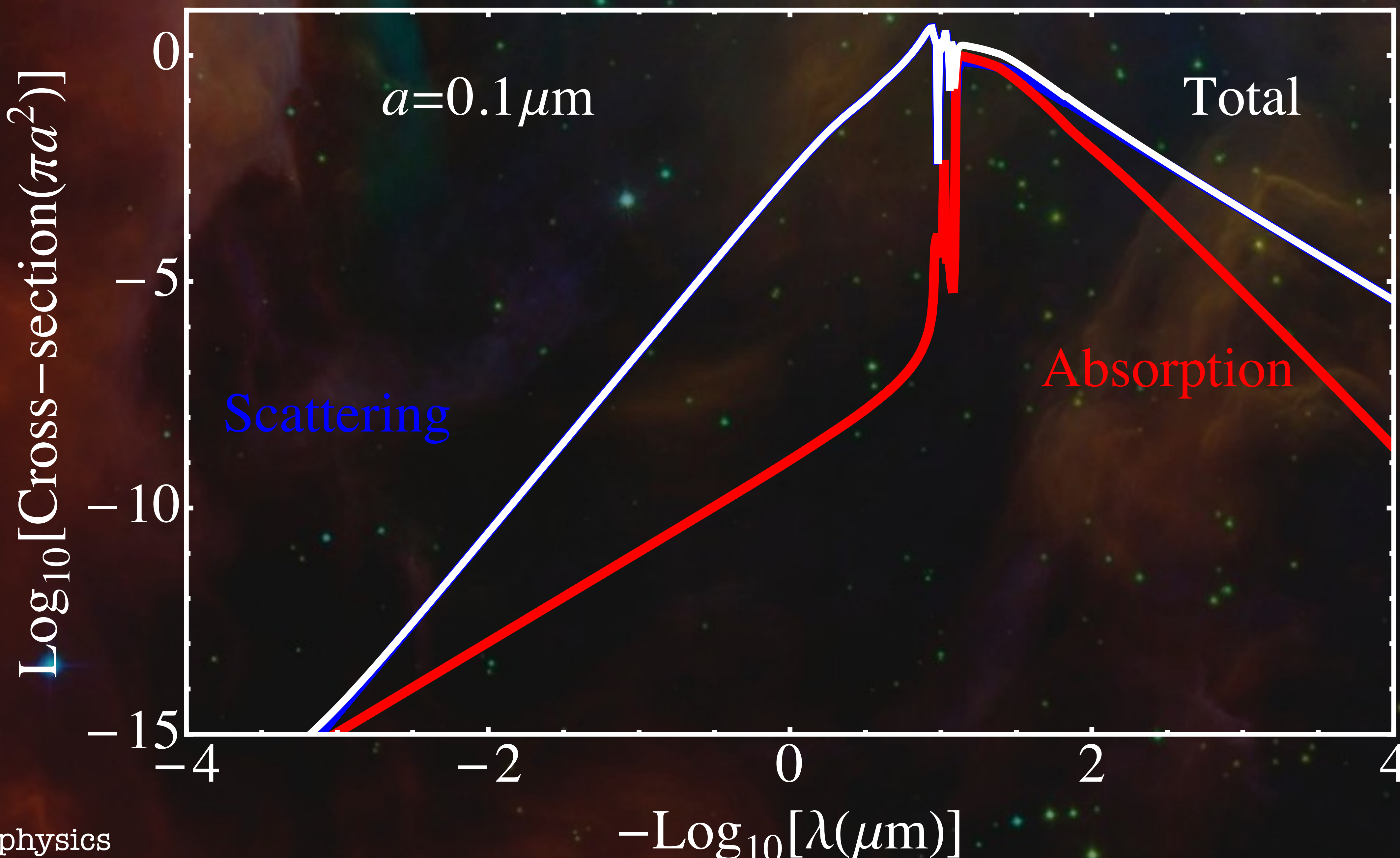
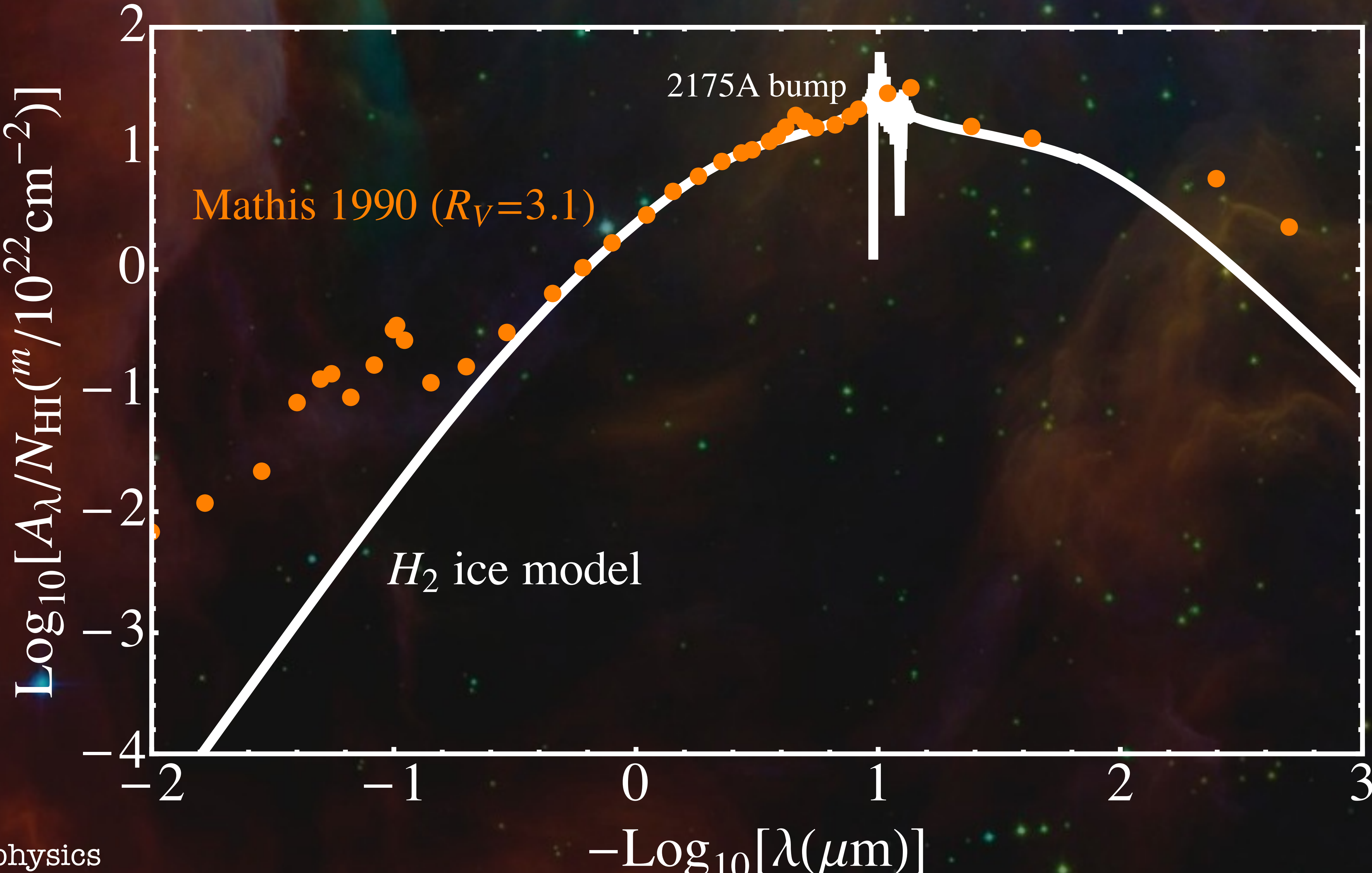
Extinction: pure H_2 grains

- H_2 ice: Lyman/Werner + Bound-Free in UV
- Clear and very transparent IR to Optical
  - Very large grains needed in IR



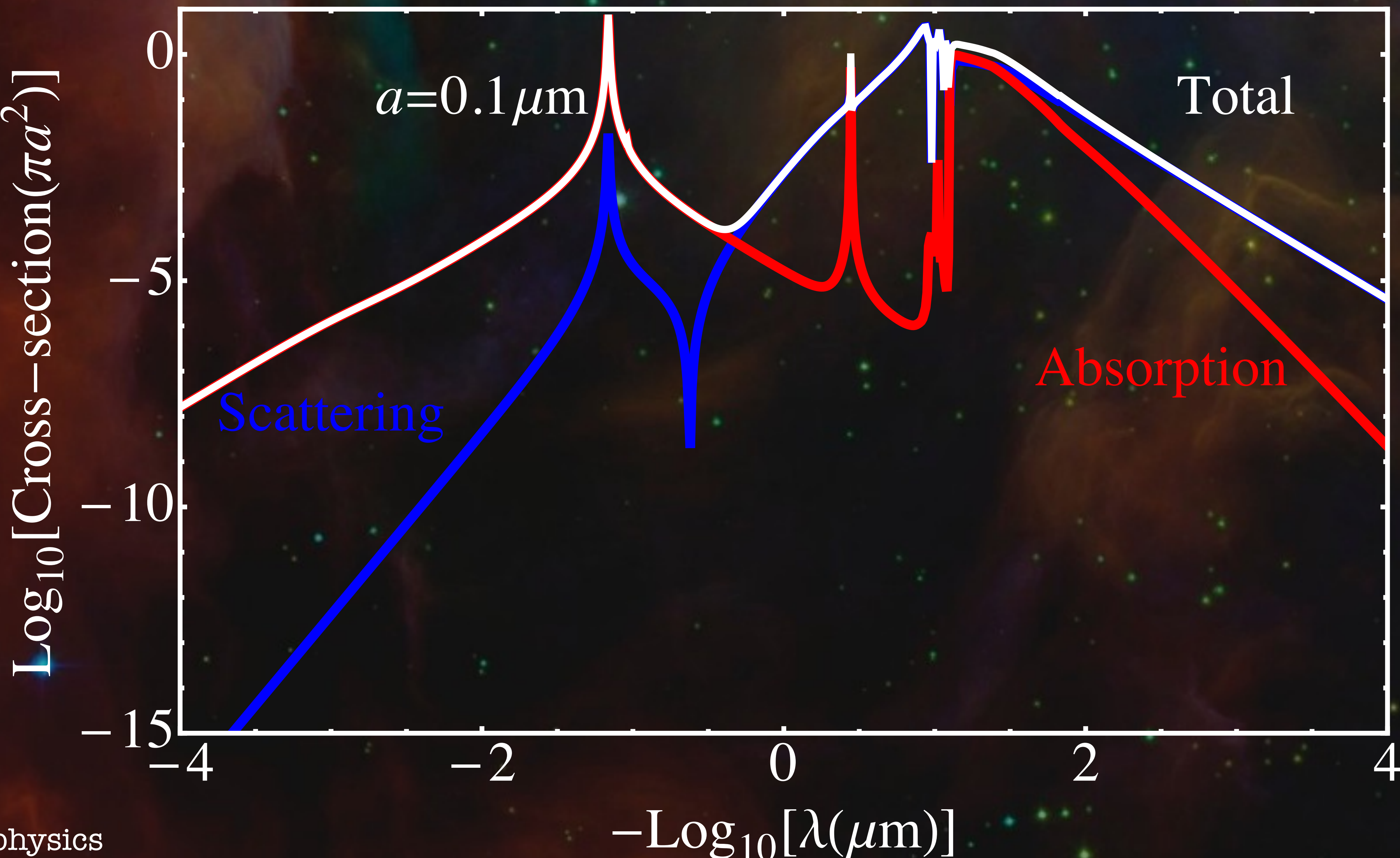
Extinction: pure H_2 grains

- Reasonable fit in UV/O (with broken power law)
- Need H_2 ice/HI = 0.0014 (by mass)
- Severe discrepancy in IR – even with large grains



Extinction: effects of electron shell

- UV/Optical essentially unchanged
- Huge boost in IR absorption
- Resonance in NIR — very constraining



Summary

- Ice confers thermal stability to tiny H_2 clouds
- $(HD)_3^+$ emission lines coincide with ISM bands
- Electrons do not penetrate solid, form coating
- Charged grains survive in ISM on their own
- Bulk H_2 can reasonably fit UV/O extinction
- Surface electrons boost extinction in IR
  - perhaps too much so?
- IR resonance would be very constraining
- More work is ongoing