Laboratory Spectroscopy of Astrophysically Relevant Materials

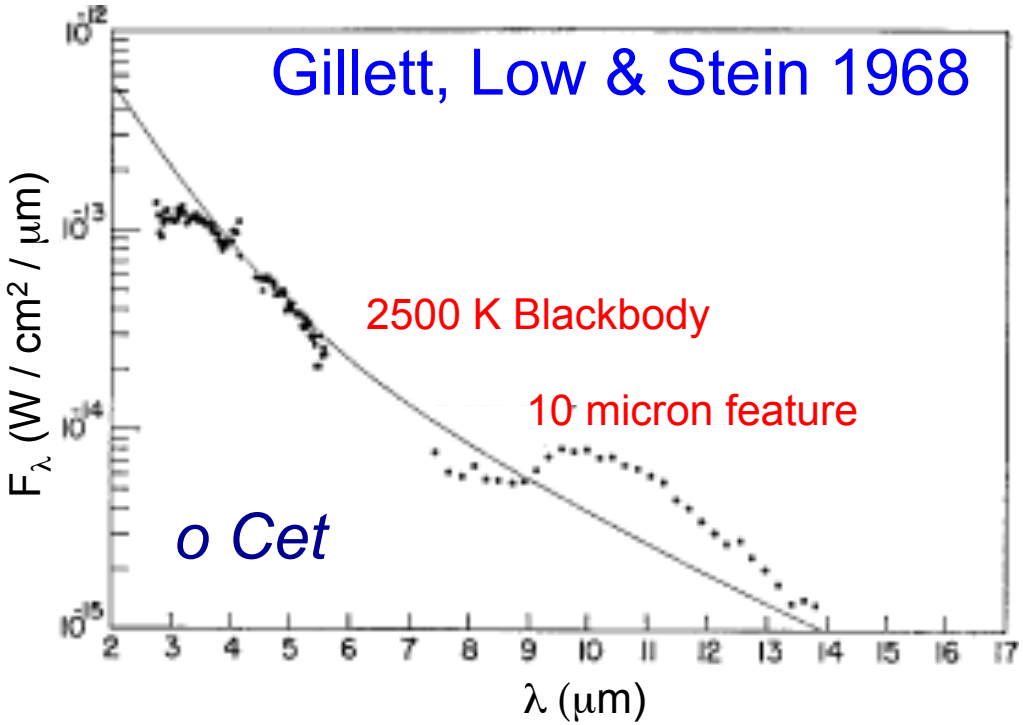
Developing Dust as a Diagnostic

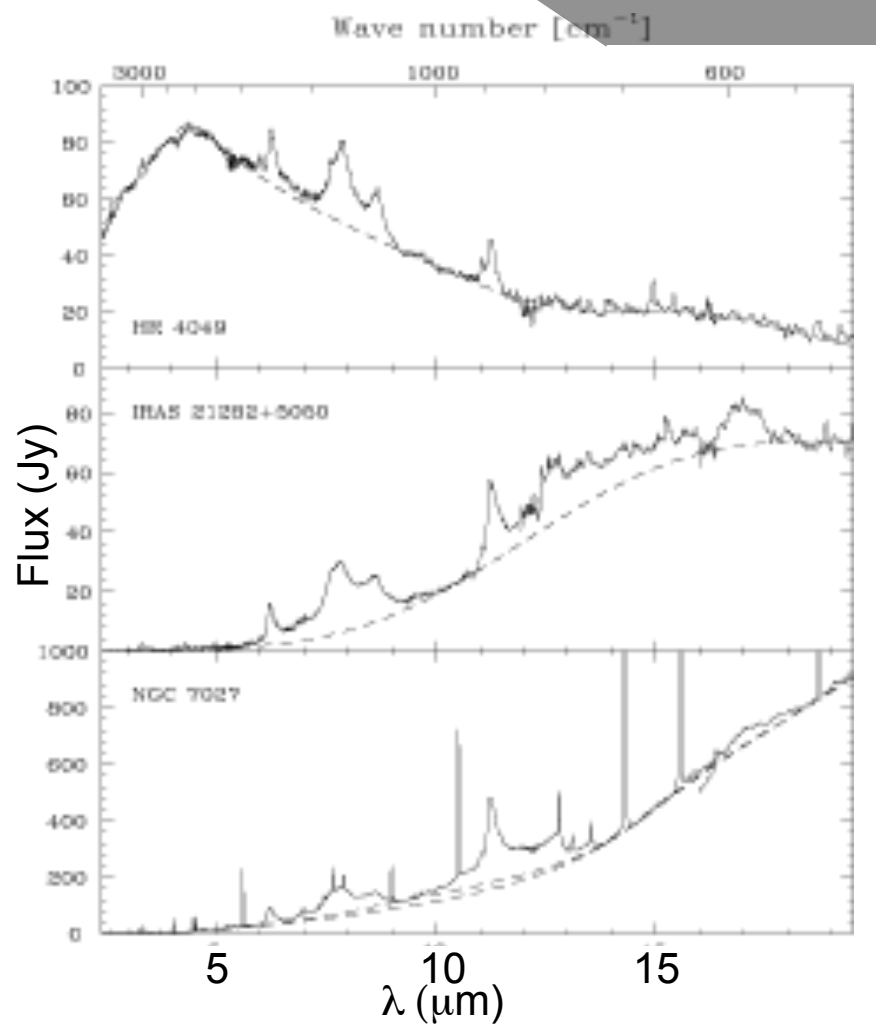
S. Rinehart

NASA's GSFC

OPASI-T poster
by Kinzer (#53)

Context & History





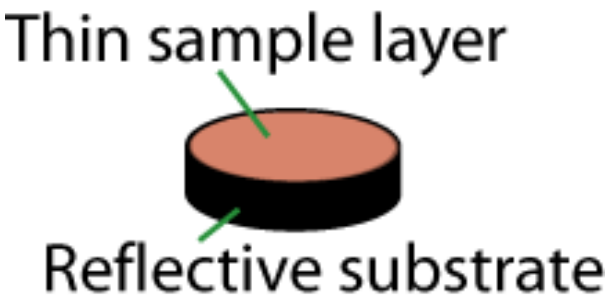
PAH Discovery:
Gillett, Forrest, & Merrill 1973

Beintema et al. 1996

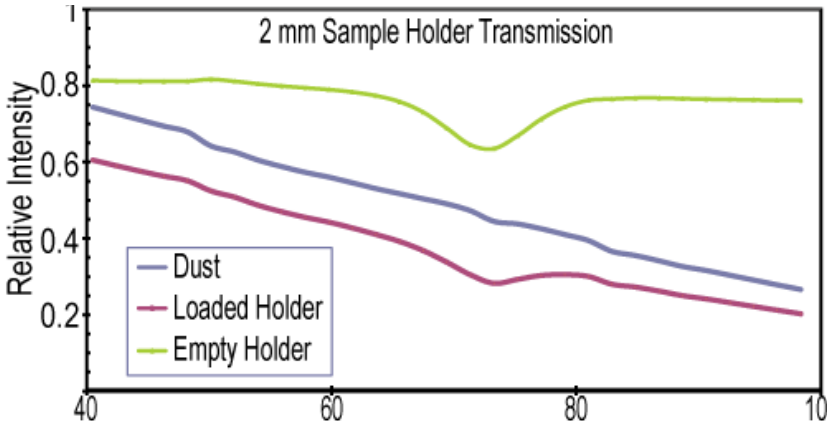
Methods I

In the past, two major methods:

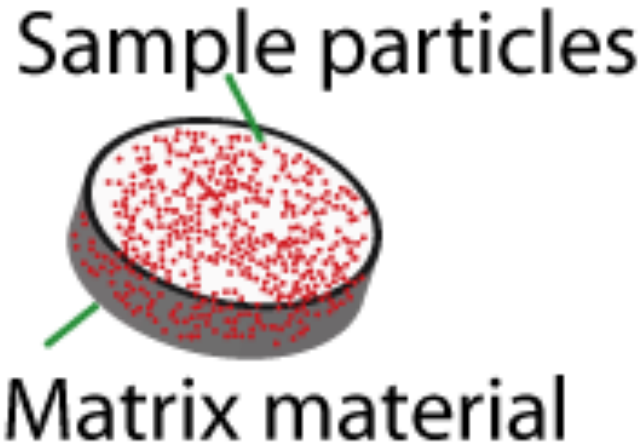
– Bulk



Sample holders



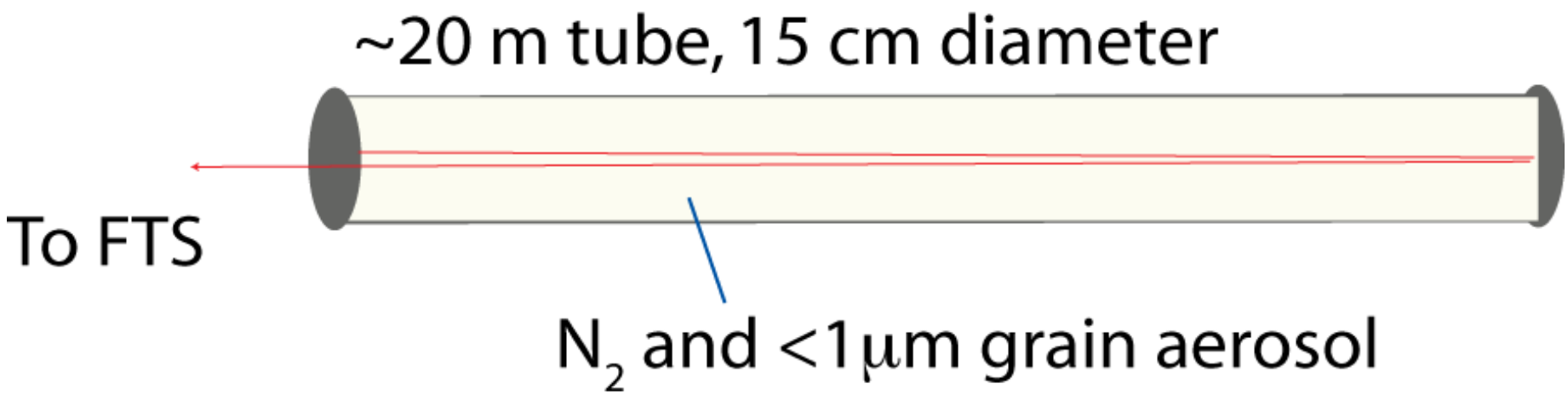
– Matrix



Methods II

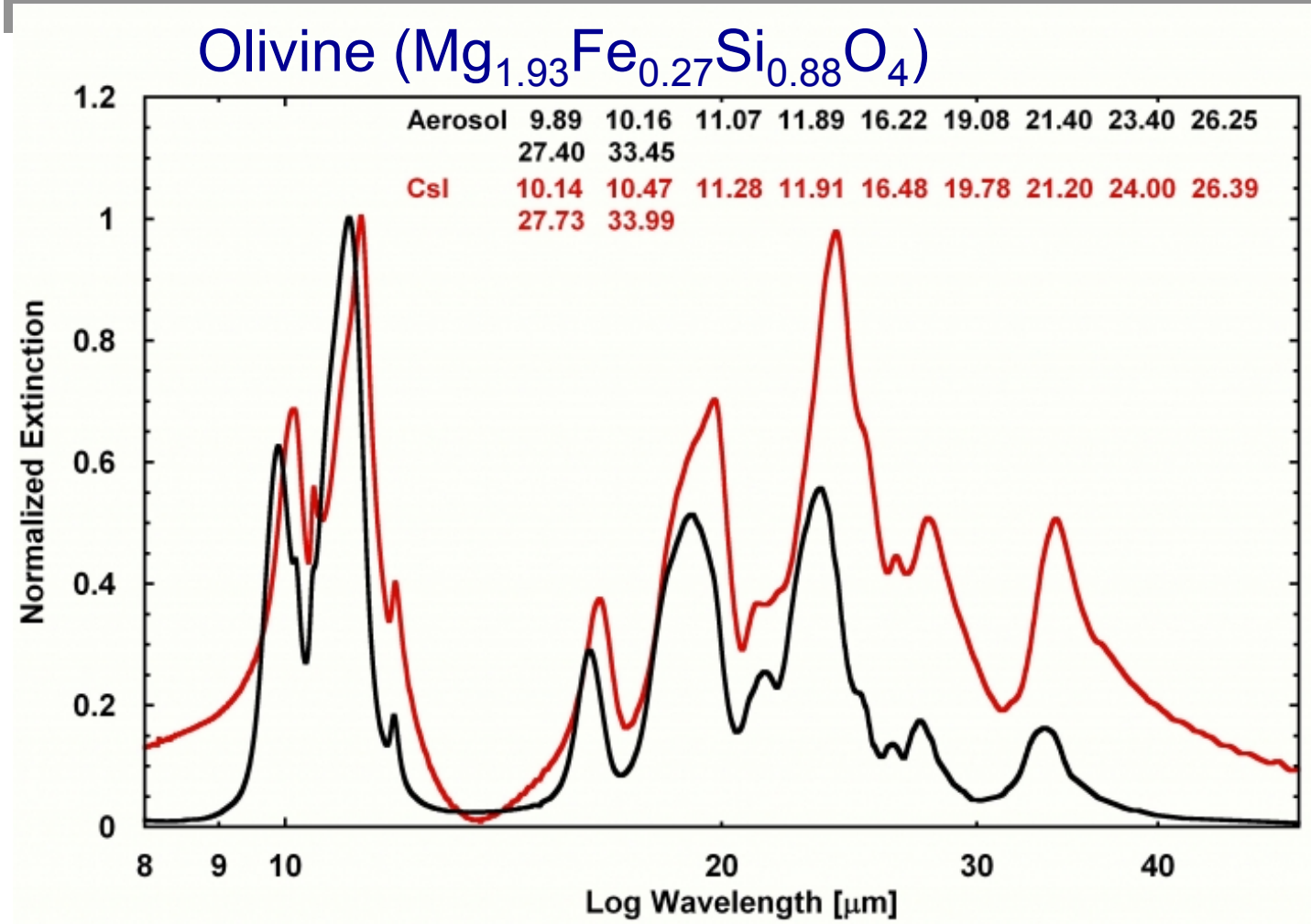
A new method is on the scene:

– Aerosols



Tamanai, et al. 2006

Aerosols



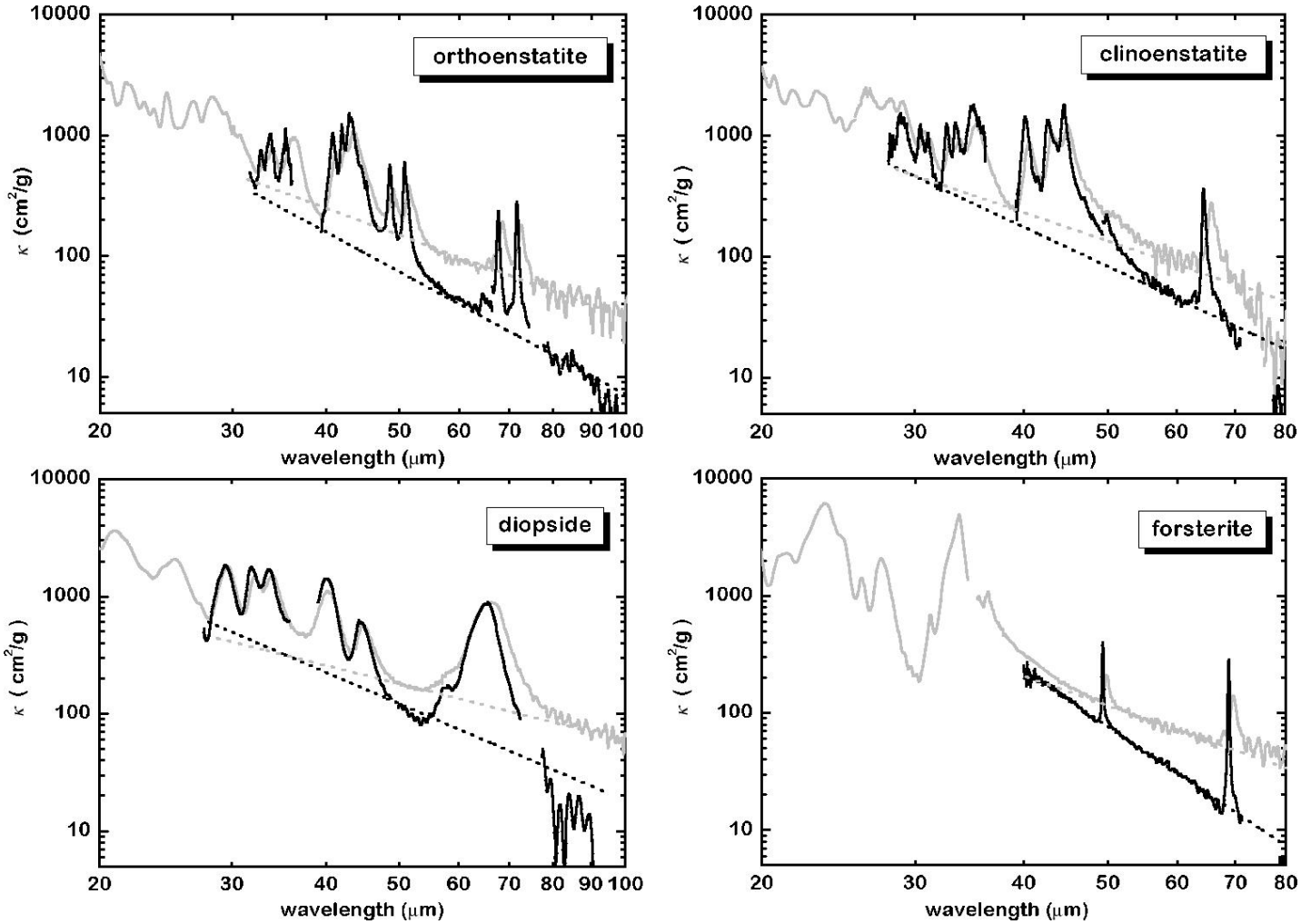
Jena database

http://www.astro.uni-jena.de/Laboratory/OCDB/index.html

Strengths/Weaknesses

Method	Advantages	Disadvantages
Bulk	• Simplicity	• High Optical Depth
Matrix	• Small amounts of material required • Ease of measurement	• Embedding medium • No Post-measurement analysis
Aerosol	• Free of embedding medium • Flexibility in optical depth	• Uncertainty in column depth • Temperature control • Time dependence

Temperature

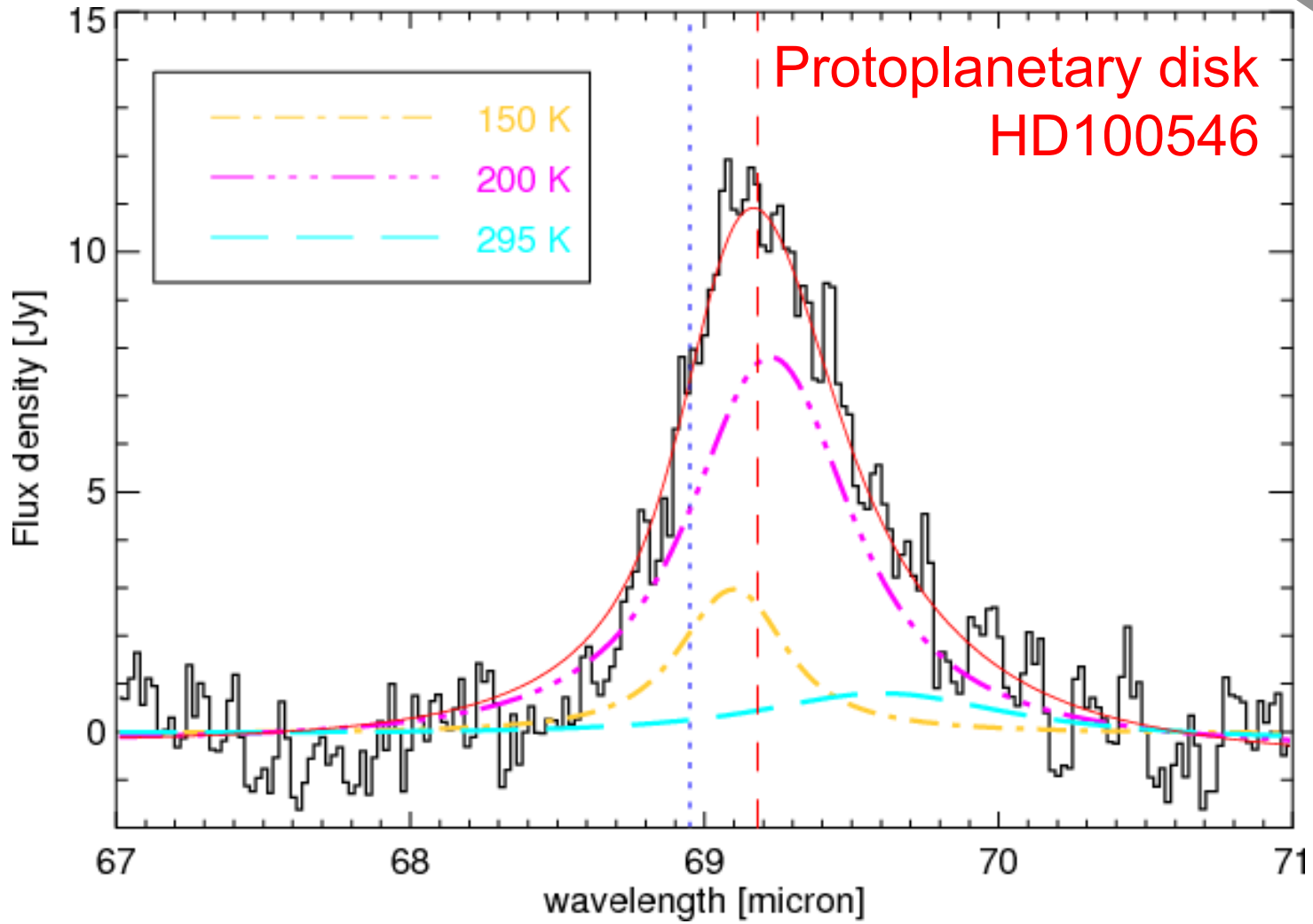


Also, two-state systems: Anomalous opacity behavior at low T (< 10K)

- Bosch 1978
- Agladze, et al. 1996

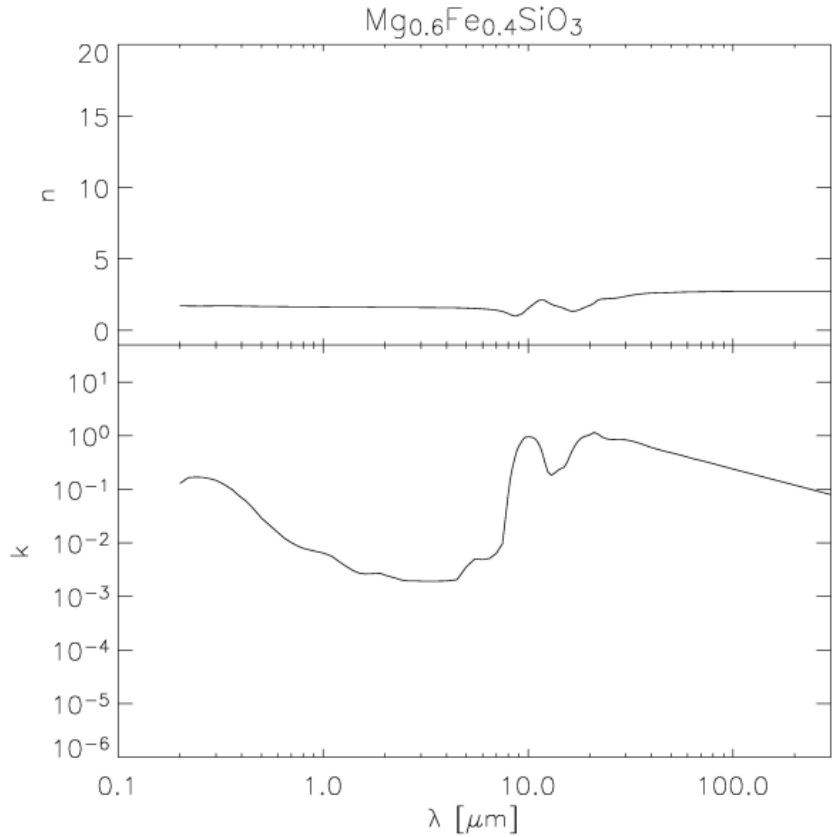
Chihara, et al. 2001

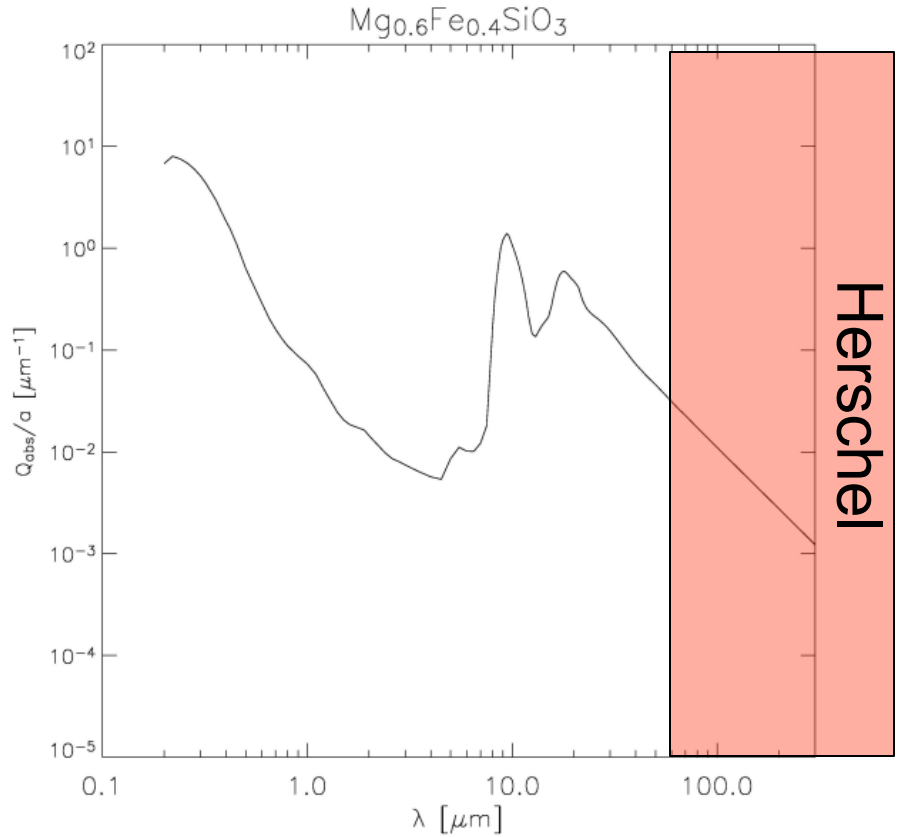
Astronomical Results



Sturm, et al. 2010

Wavelength Coverage

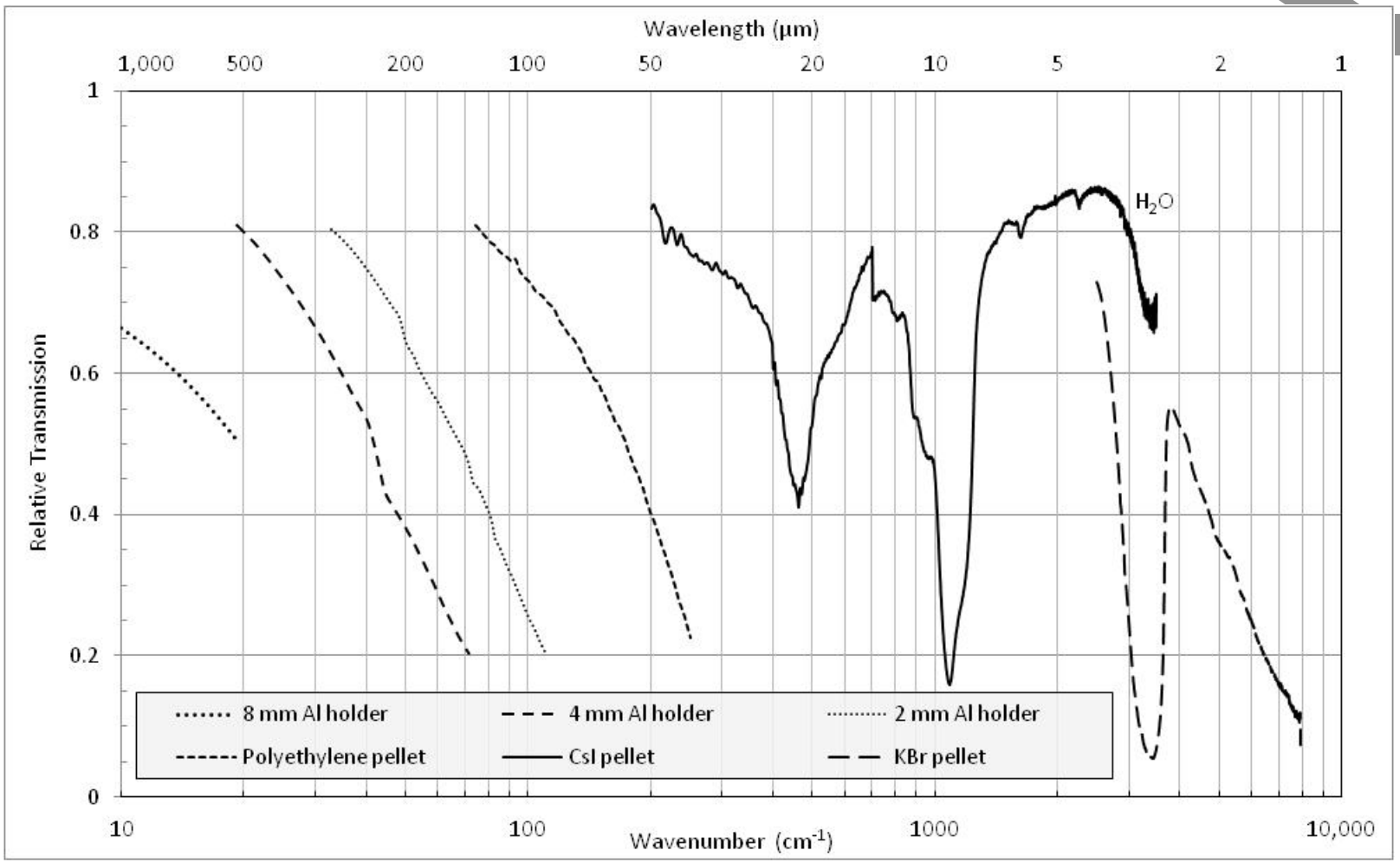




Jena database

http://www.astro.uni-jena.de/Laboratory/OCDB/index.html

Getting Coverage



Kinzer, et al. 2010

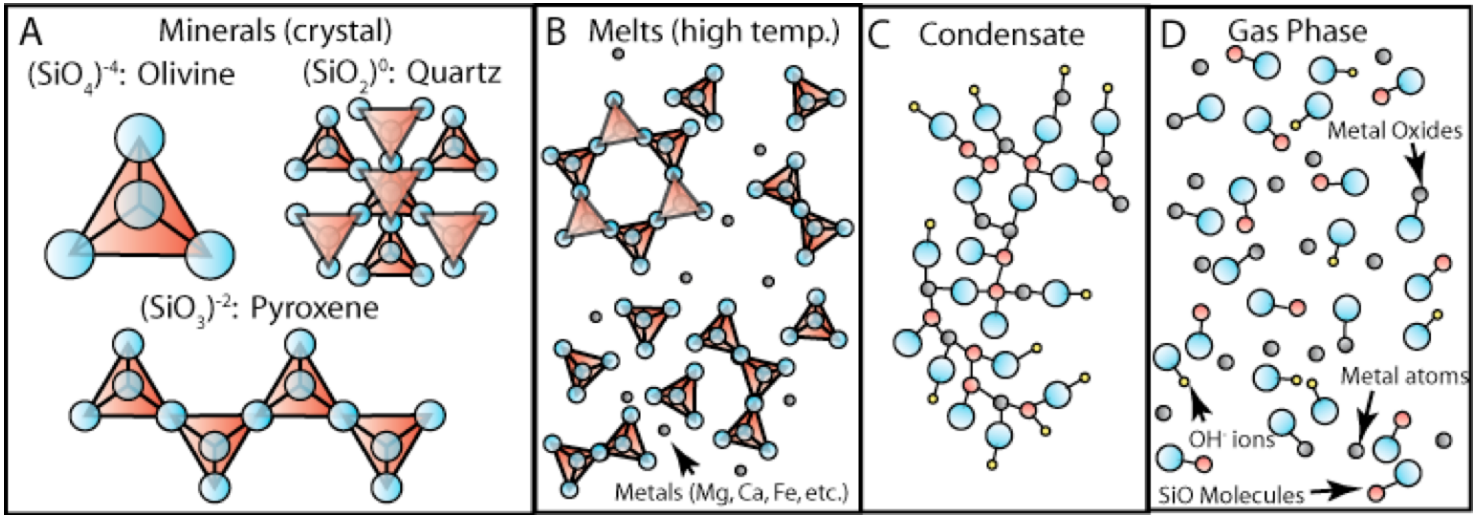
Materials (Silicates)

Silicate Production

- Grinding
- Sol-Gel
- Melts
- Smokes

Issues:

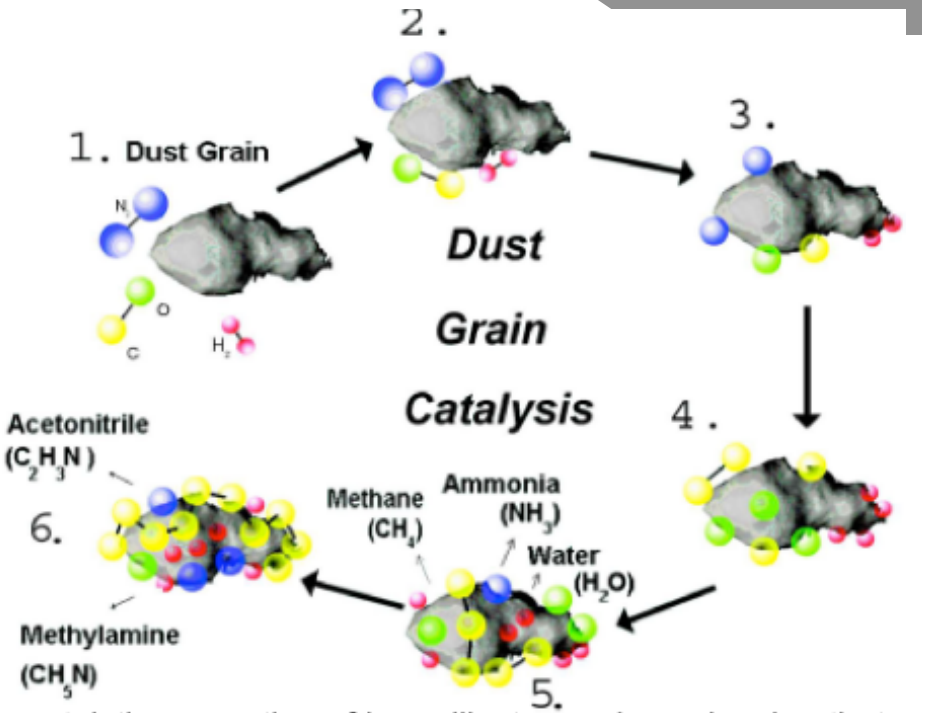
- Annealing (Hallenbeck, et al. 2002)
- Irradiation



Rinehart, et al. 2008

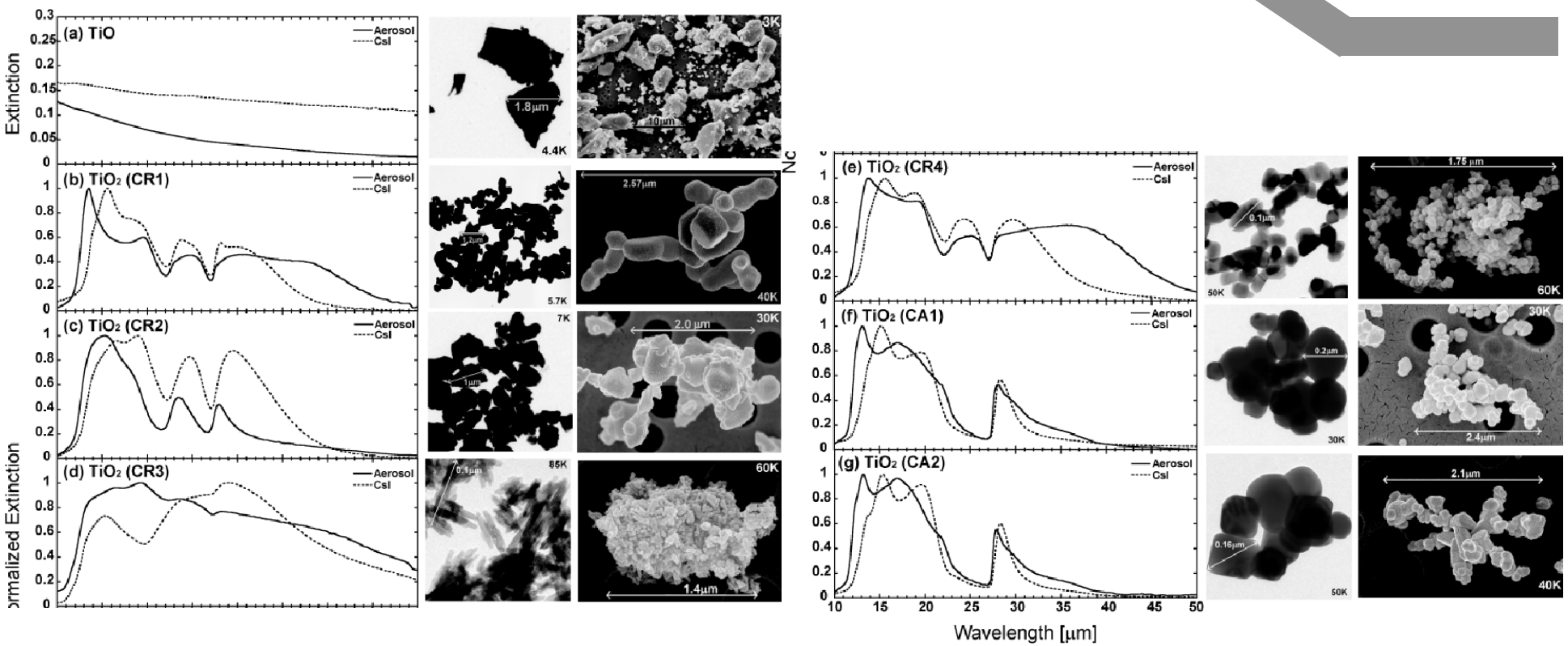
Other

- Titanium (Helling, et al 2001)
- Nitrides (Lodders & Fegley 1992)
- Metal Oxides



- Mixes
  - Dust/ice
  - Silicate grains with carbonaceous mantles
    - Possible site for catalysis (Hill & Nuth, 2003)

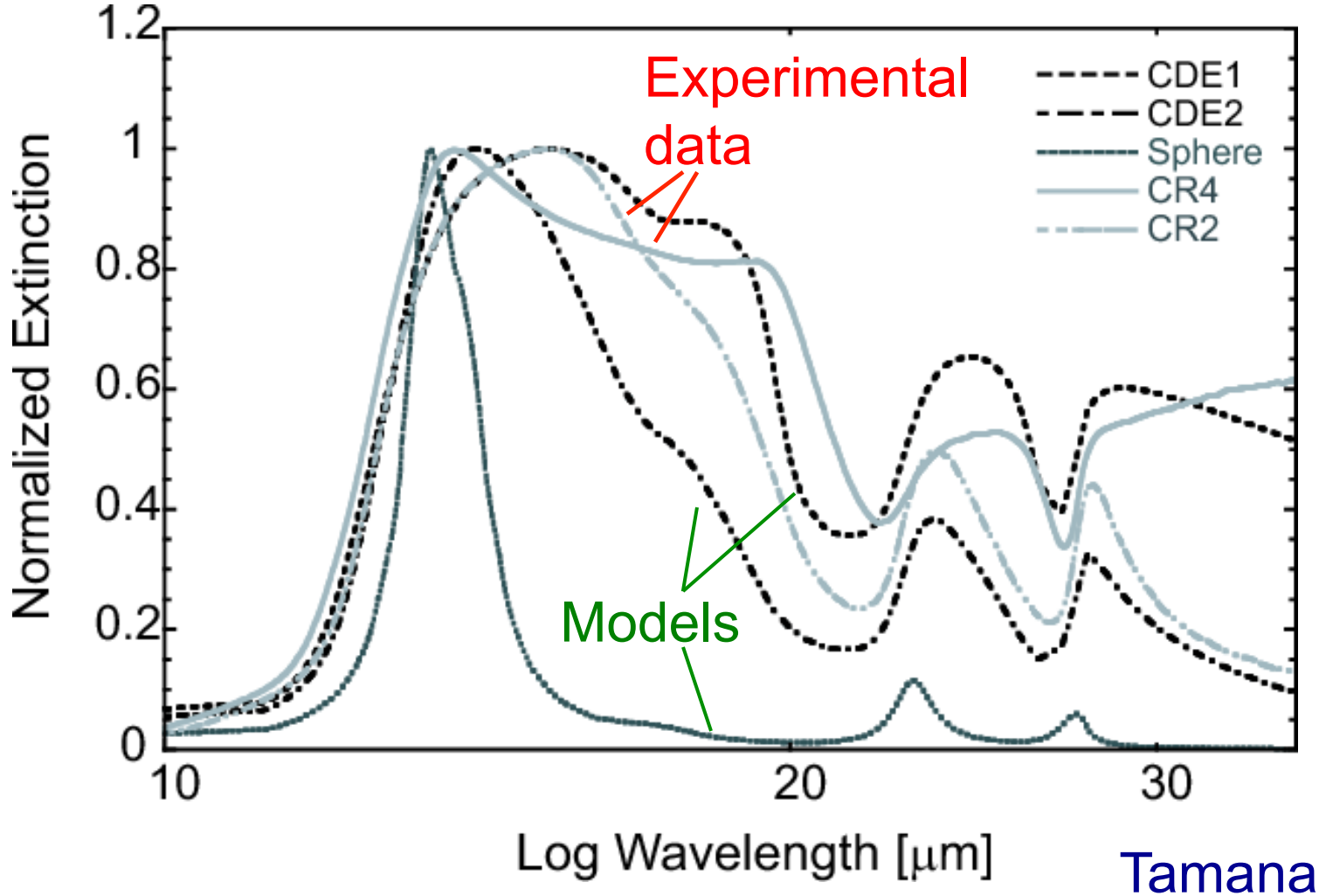
Grain Shape



Six different versions of TiO_2.

Tamanai, et al. 2009

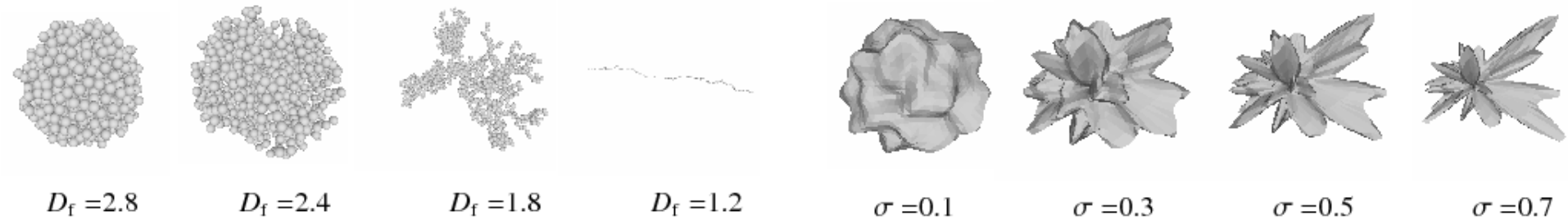
Grain Shape

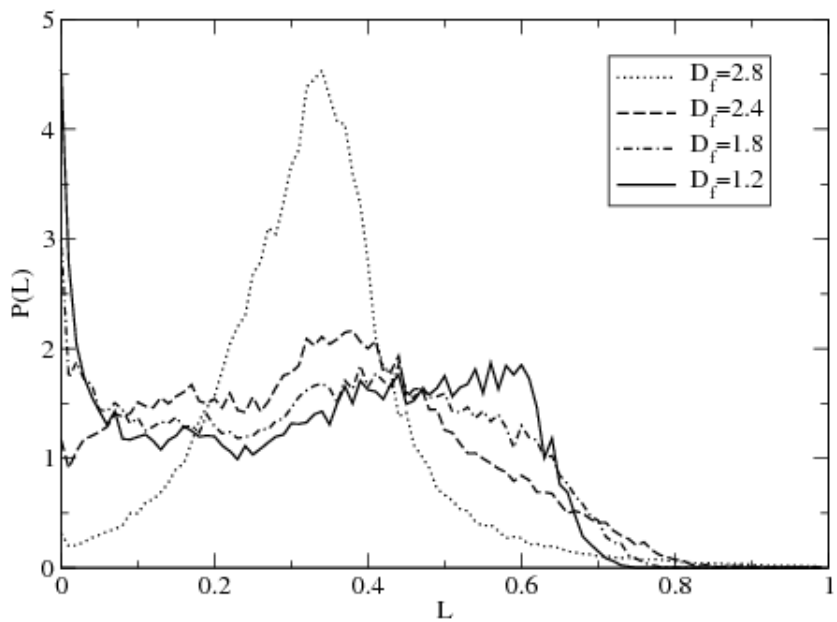


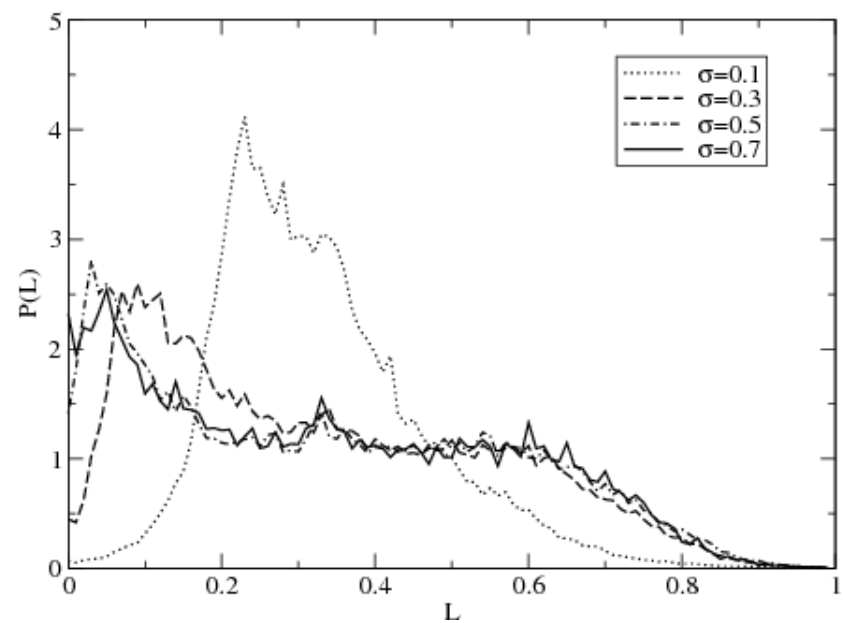
Tamanai, et al. 2009

CDE = Continuous Distribution of Ellipsoids

Models



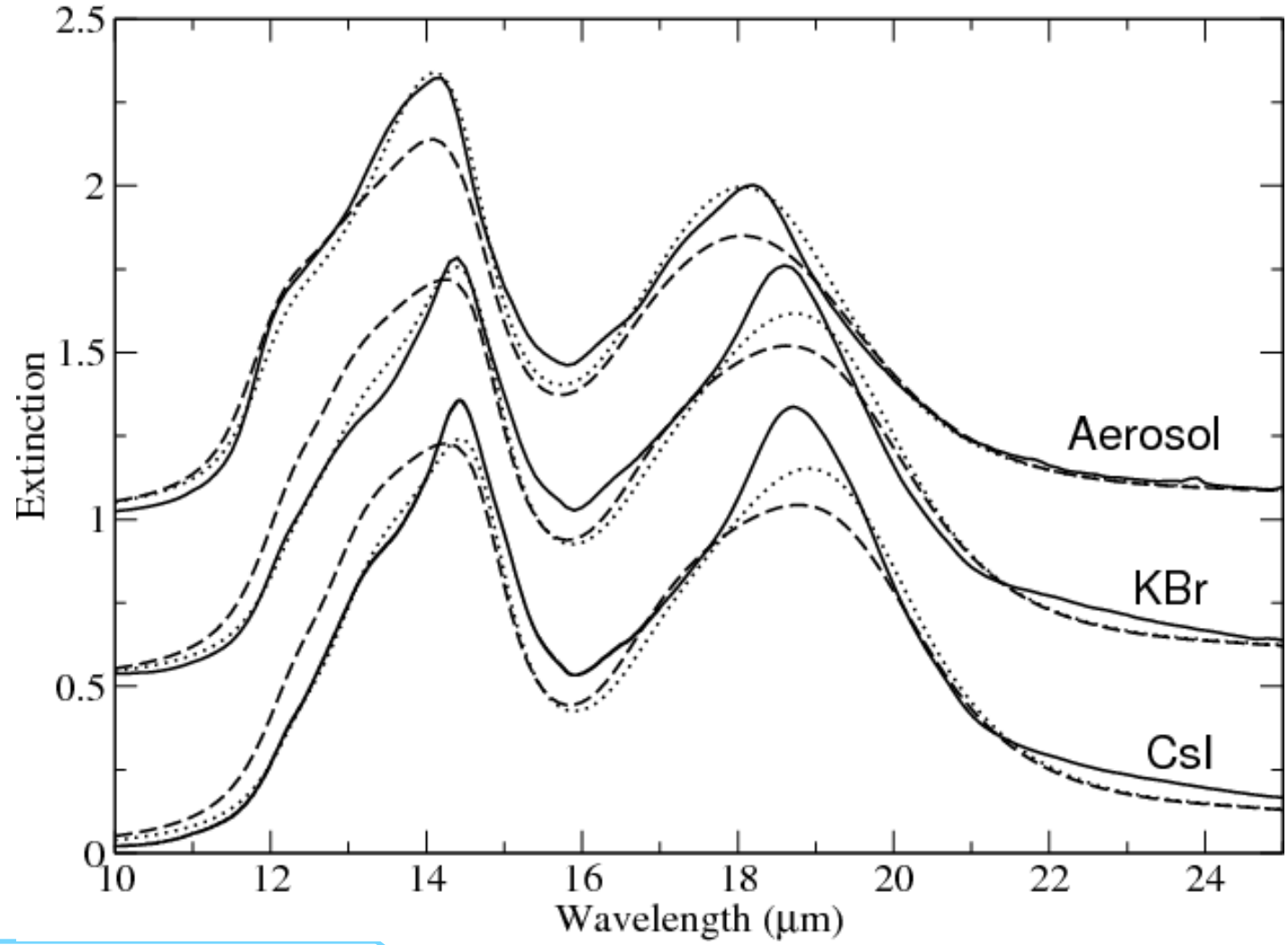




Distribution of Form Factors (DFF)

Mutschke, Min & Tamanai 2009

Models



Spectra of irregular Spinel ($MgAl_2O_4$)

Mutschke, Min & Tamanai 2009

Summary

- Models
  - Be able to reconcile matrix, bulk, and aerosol measurements
  - Be able to differentiate effects of composition, grain shape, temperature
- Lab work
  - Explore shifts with temperature
  - Increase wavelength coverage
  - Continue exploring new materials and material manufacture (smokes!)

Some References

- Reviews
  - Posch, et al. 2006. Rev. Modern Ast. 19, 251.
  - Colangeli, et al. 2003. A&A Rev., 11, 97.
  - Henning & Mutschke 2010. arXiv:1004.5234 (to be published in the Journal of Nanophotonics)

- PAHs
  - Tielens, 2008. Ann Rev. Astronomy & Astrophysics, 46, 289.
  - Bauschlicher, et al. 2010. ApJS, 189, 341.
  - Salama, 2008. *Organic Matter in Space*, Proc. IAU 251, 357.