OXIDES IN INTERSTELLAR DUST

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Constraints on Potential Oxide Dust Candidates

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What are we really doing

- Motivated by extinction
- Diffuse neutral ISM
  - UV gets through
  - $A_V < 1$ for each component
  - H primarily H I
  - Depletions vary

- How to get constraints
  - Abundance limits
  - What can form in reasonable amounts
  - Does it agree with observations
  - Does it use oxygen

What are we really doing

- Data sets
  - Mostly within 1kpc
  - Mostly toward O & B
  - UV data
  - Incomplete
    - Jenkins (2009)
    - Total abundances
  - Complete
    - HST STIS
    - Echelle spectra (~2.5 km/s resolution)
    - 6 sightlines
    - O, C, Si, Mg, Fe

Composition

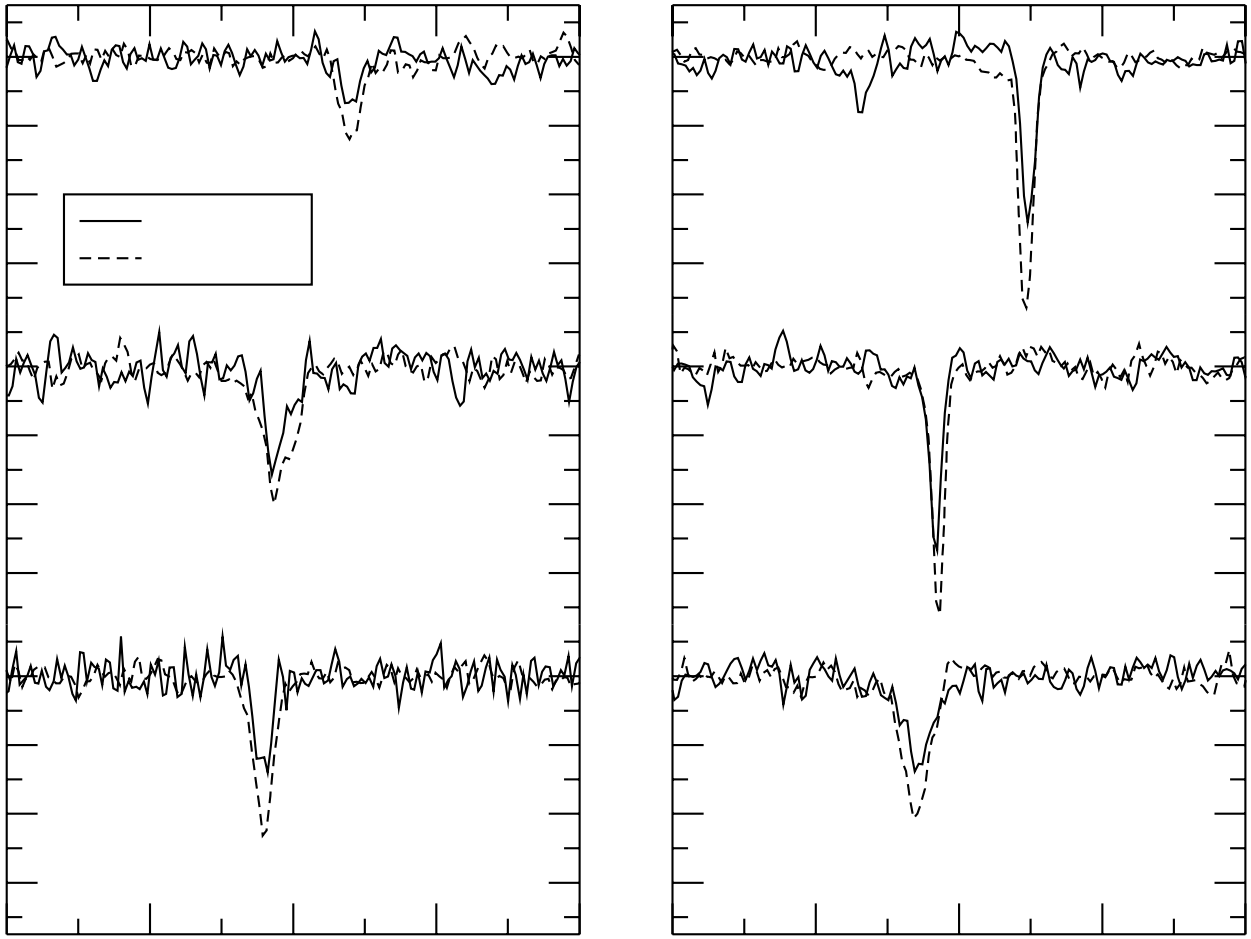
- We can't see dust – So we look at what's missing from gas

Dust = Total ISM – Gas

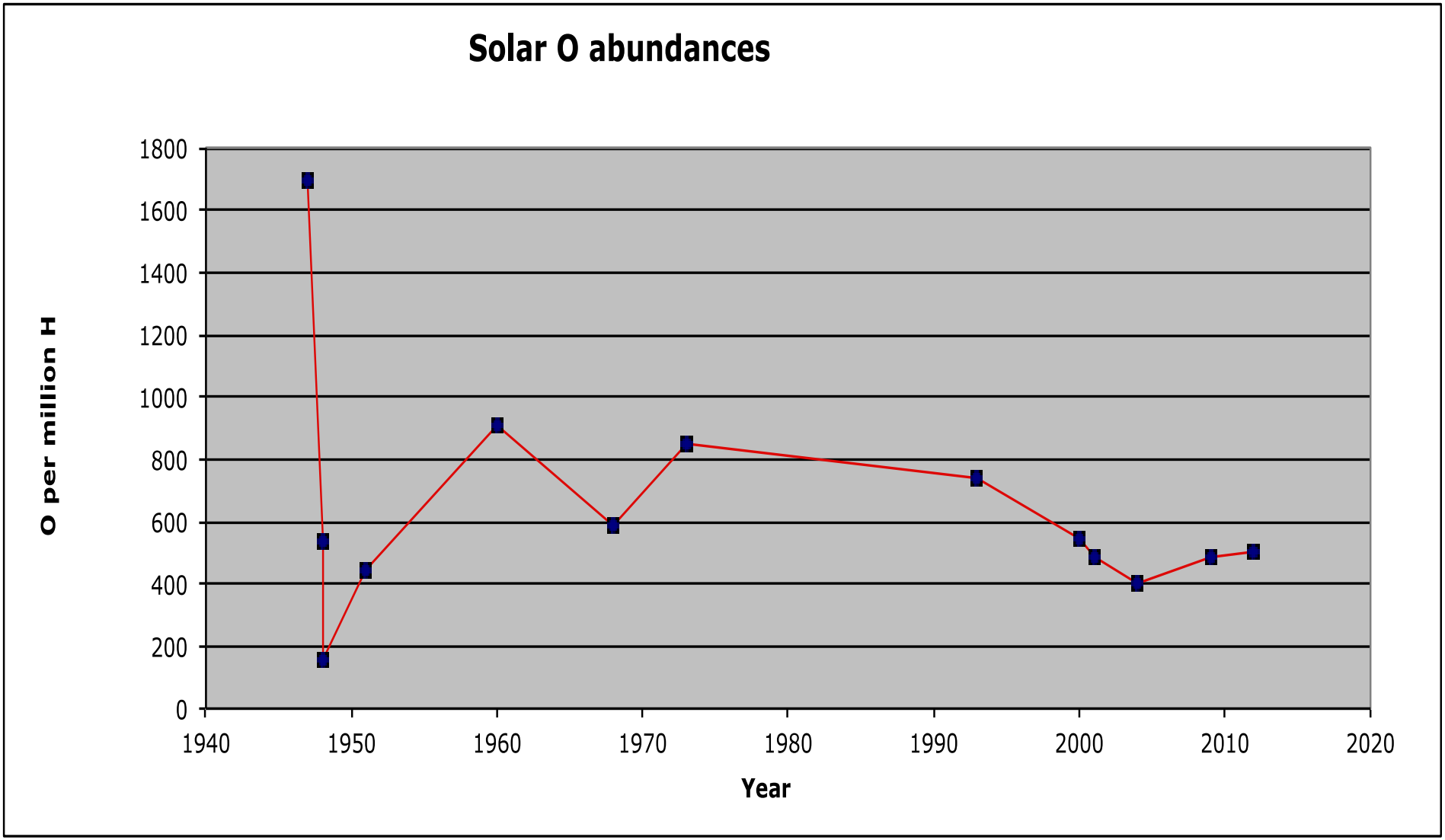
- Measuring the gas is often easy with the right observations!
  - No models
  - Ionization
  - Well mixed
- Total ISM?
  - Solar
  - Young stars
  - Gradients

Composition

OXYGEN AND KRYPTON GAS IN TRANSLUCENT CLOUDS

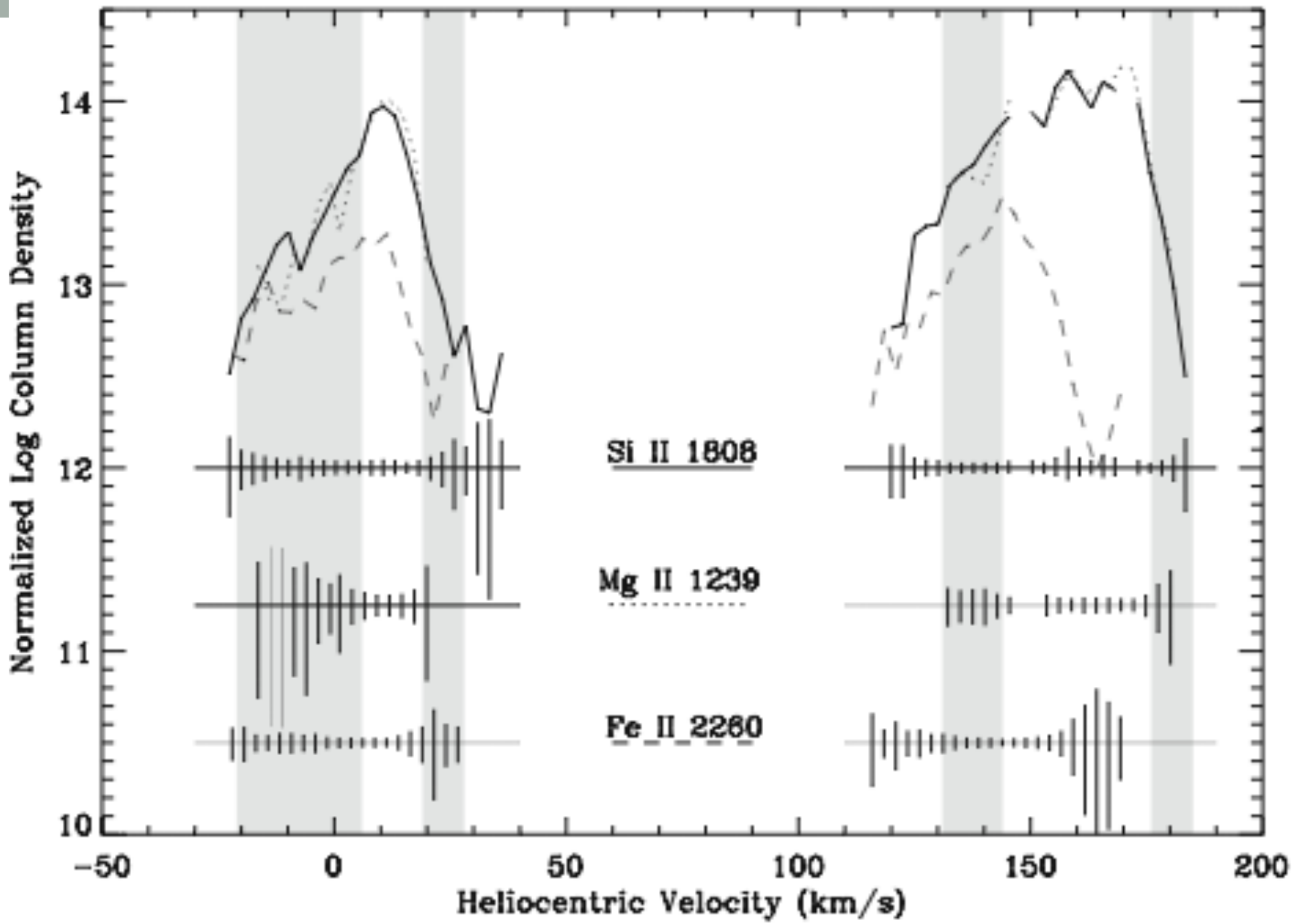


Composition



Where are the elements?

- C, N, O, Mg, Si, Fe, S and Nobles
- Most extinction models still use silicate & carbon grains
- Si is in silicates (Miller et al. 2007)
  - Varies from 35 – 100% in dust
  - This sample is 95%+ in dust
  - Primarily Mg based
    - Circumstellar
    - X-rays
    - Abundances
    - $MgSiO_3$ (Demyk 1999; Mg-based – Dwek et al 1997, Min et al. 2007, Sofia et al. 2006, Pinto et al. 2011)
- Mg in silicates (20% in others?) (Cartledge et al 2006)
- C in PAH, graphite, amorphous carbon grains (Sofia et al. 2004, 2010)


Normalized Log Column Density
14
13
12
11
10
Si II 1808
Mg II 1239
Fe II 2260
−50
0
50
100
150
200
Heliocentric Velocity (km/s)

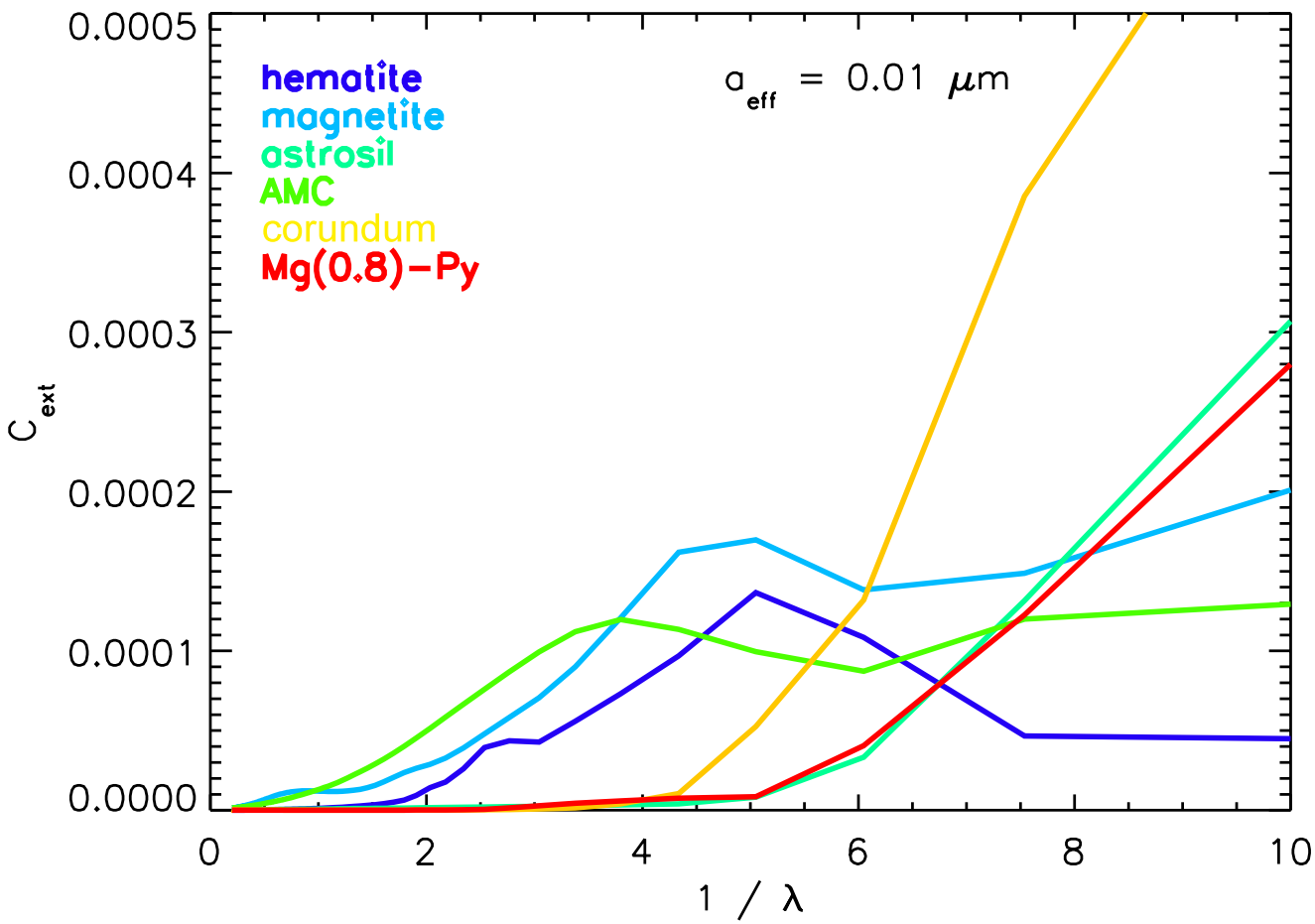
Where are the elements

- S
  - Depletions?
- Fe (Miller et al 2007)
  - Always highly depleted
  - Not in silicates
  - Oxides? (Jones 1990; Rietmeijer 1992)
  - Metal grains?
- N
  - Little to none in dust (Gail and Sedlmayr 1986)
- Nobles
- O (Cartledge et al. 2001)
  - Upto ~115 ppm in silicates
  - A lot somewhere else (300 – 350 ppm in dust)

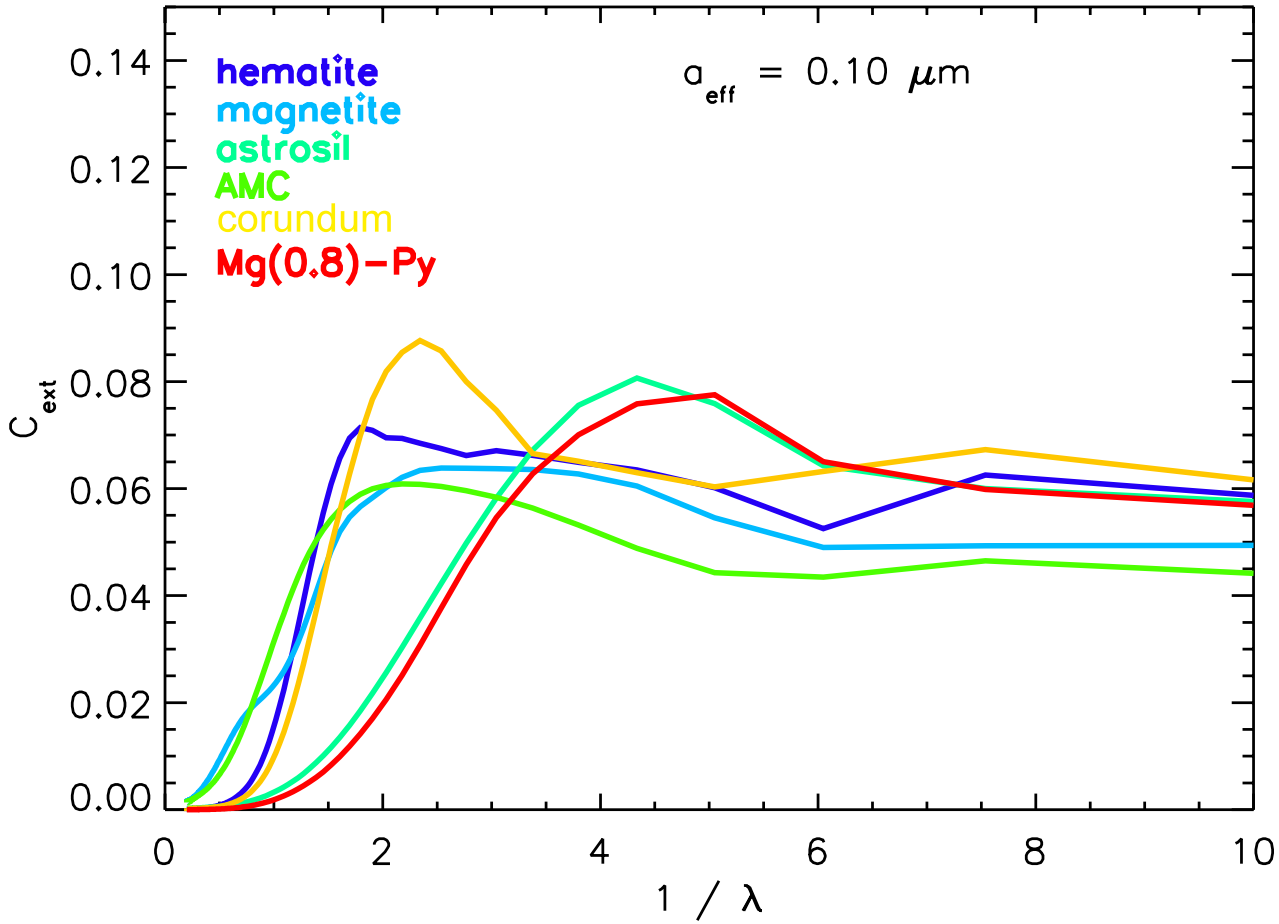
What has been suggested

Katharina, please humor me for a few minutes.

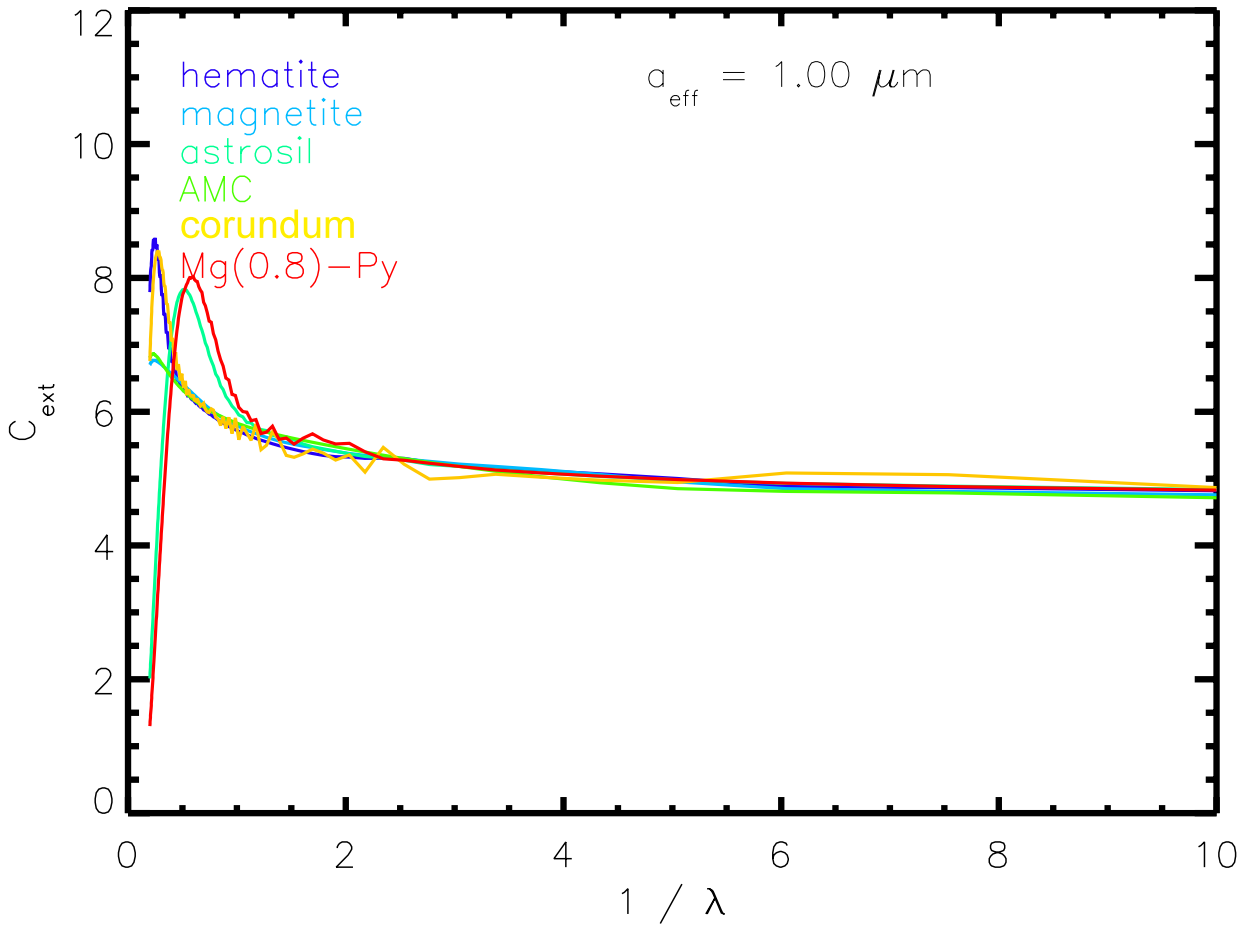
Extinction from small grains



Extinction from medium grains



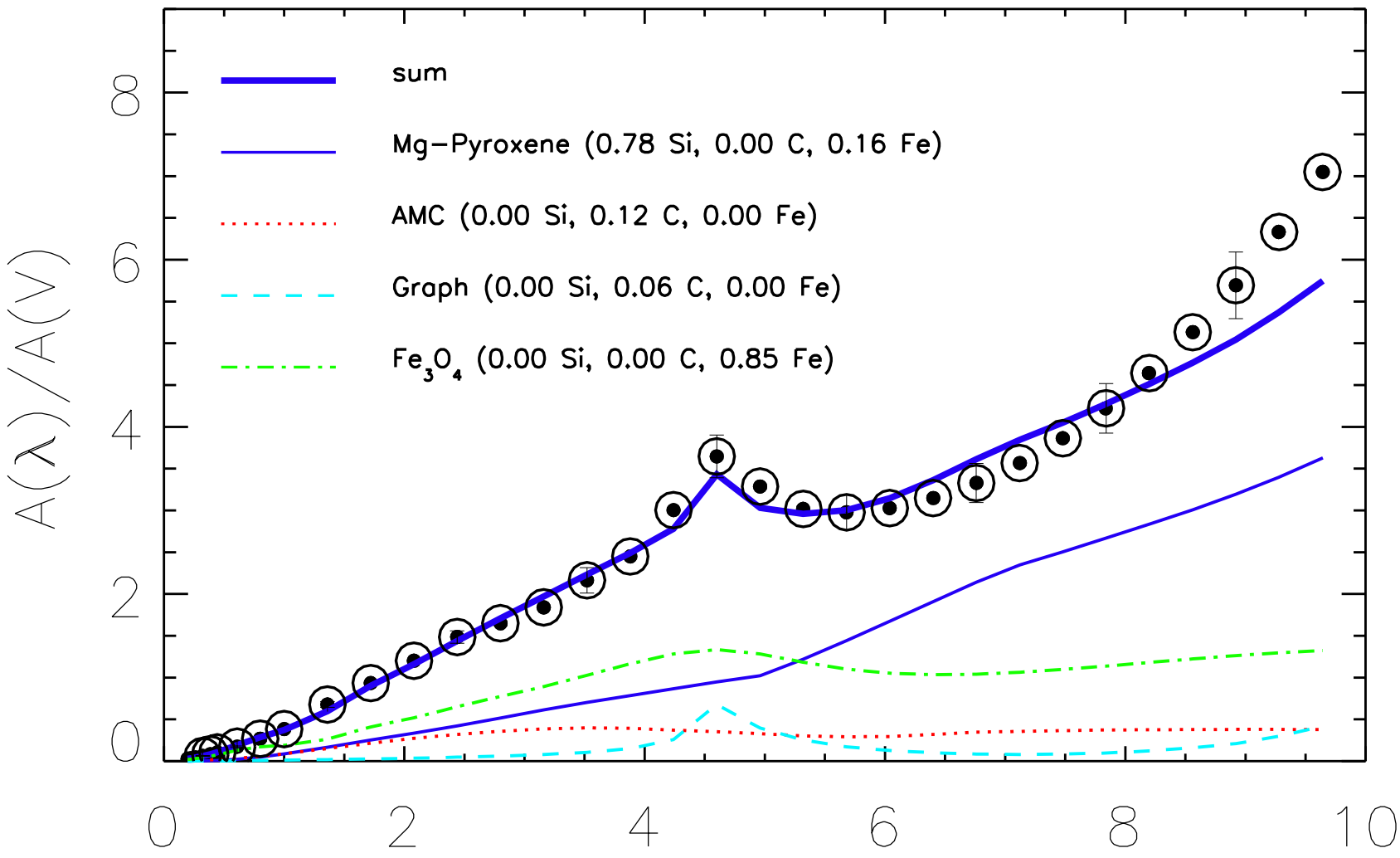
Extinction from large grains



Extinction modeling

- Optical constants are hard to get
- $A_{l3}O_2$
  - Cannot do much because of its low abundance
  - May help fits at short wavelengths
- Iron oxides
  - Provide extinction in the visible usually provided by C

- Models
  - 3 sightlines well fit with silicates, amorphous C and graphite
  - All are well fit when Fe oxides were added
  - Would metallic Fe grains work?


sum
Mg−Pyroxene (0.78 Si, 0.00 C, 0.16 Fe)
AMC (0.00 Si, 0.12 C, 0.00 Fe)
Graph (0.00 Si, 0.06 C, 0.00 Fe)
Fe3O4 (0.00 Si, 0.00 C, 0.85 Fe)
A(λ)/A(V)
0
2
4
6
8
0
2
4
6
8
10

Conclusions

- Iron oxides
  - Help alleviate problems with fitting extinction
  - But can they exist?
  - Does not solve all of our extinction problems
  - Does not solve the problem of here to put O (~50 ppm)
- Al oxides
  - Likely present
  - Hardly take any O (~3 ppm)
- There aren't many places in dust to stuff O
  - I don't know what Ed Jenkins just told you
  - It's not in gaseous molecules
  - Ices?
  - New abundances are not helping the problem
- Estimations of O in dust may not be a good correction