Unifying the Interstellar Extinction and Elemental Abundances: I. What Are the Carriers of the UV Extinction Components?

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Abstract: It is well recognized that both the Galactic interstellar extinction curves and the gas-phase abundances of C, O and other metal elements exhibit considerable variations from one sightline to another. By utilizing the wealth of extinction and abundance data obtained by IUE, HST, and FUSE, we explore the dust properties of a large number of sight lines by simultaneously both fitting the observed extinction curve from the near-infrared to the far-ultraviolet and also conforming to the observed abundance constraints. This allows us to gain insight into the physical nature of interstellar grains and how they are related to the physical and chemical conditions of their environments.

Background

- Elements not seen in gas must have been depleted in dust.
- Interstellar abundances of C, O, Mg, Si, Fe (minus those in gas) tell us the dust quantity (and composition).
- Extinction curve tells us the dust size (and composition)

Motivation

1. What would be the likely carriers of the 2175Å bump and far-UV extinction?

➡ Small graphitic grains (Stecher 1965, Draine 1989), PAHs (Joblin et al. 1992, Li & Draine 2001, Steglich et al. 2010)

- Parvathi et al. (2012) and Haris et al. (2016) argued $(C/H)_{dust}$ not correlated with the 2175Å bump.
- Duley (1985) argued silicates or (Mg, Si) oxides are the 2175Å bump carrier.

But we found:

➡ **Lack of correlation between $(Si/H)_{dust}$ and 2175Å bump.**

➡ **$[C/H]_{dust}$ depletion correlates with the 2175Å bump;**

➡ **Graphite/PAH** ➡ 2175Å bump

Models

Depletion Inferred From :

1) Interstellar Extinction Modeling

$$\frac{A_\lambda}{N_H} = 1.086\frac{1}{n_H}\sum_{i}^{2}\int_{a_{min}}^{a_{max}} C_{ext}^{i}(a,\lambda)\frac{dn}{da}da$$

- An exponentially-cutoff power-law size distribution:

$$\frac{dn}{da} \propto a^{-\alpha}e^{-a/a_c} \qquad for\ a_{min} < a < a_{max}$$

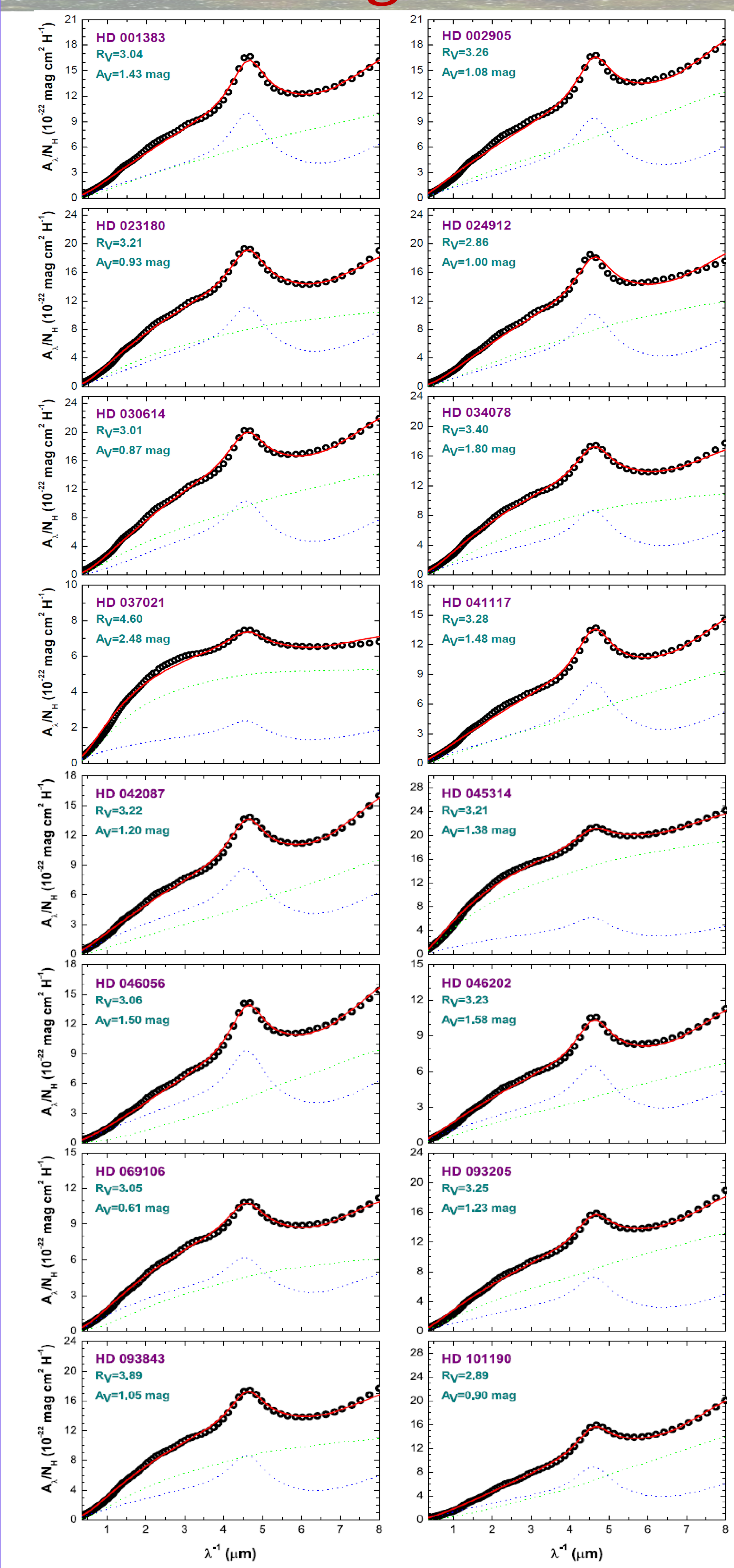
2) Kramers-Kronig Relation

$$\int_0^\infty \frac{A_\lambda}{N_H}d\lambda = 1.086\times 3\pi^2\left\{F_C\frac{V_C}{H}+F_{Sil}\frac{V_{Sil}}{H}\right\}$$

3) $[X/H]_{ISM}$ and $[X/H]_{gas}$, (X= C, Si)

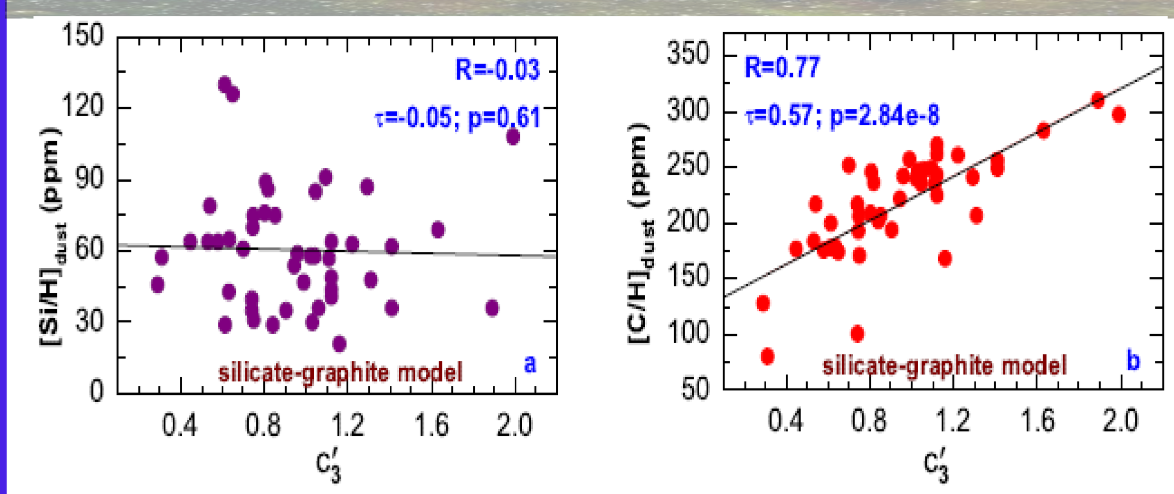
$$[X/H]_{dust} = [X/H]_{ISM} - [X/H]_{gas}$$

Model Fittings



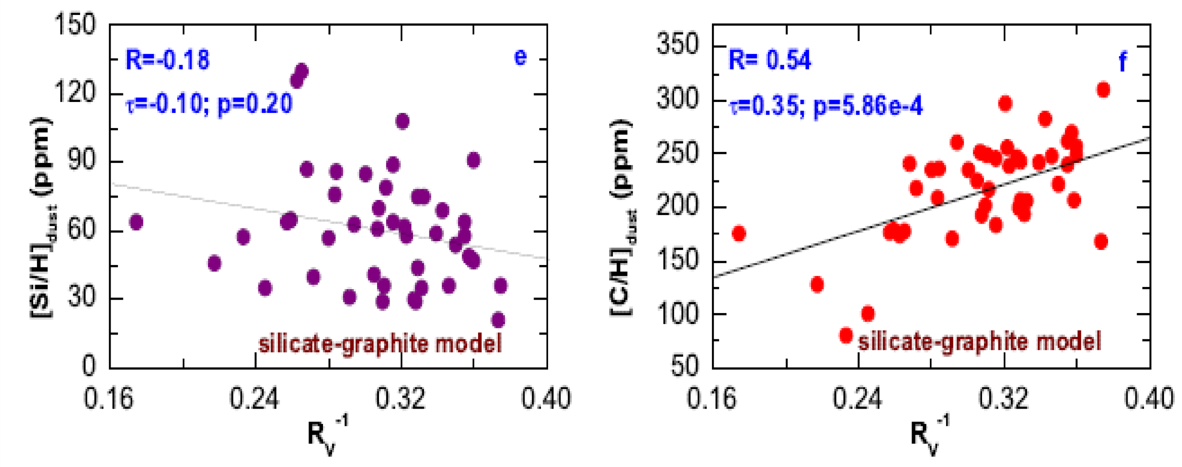
Red line: Model fit with Draine & Lee (1984)
Black Circle: FM & CCM parameterization
Blue line: Extinction due to carbon dust
Green line: Extinction due to silicate dust

Results

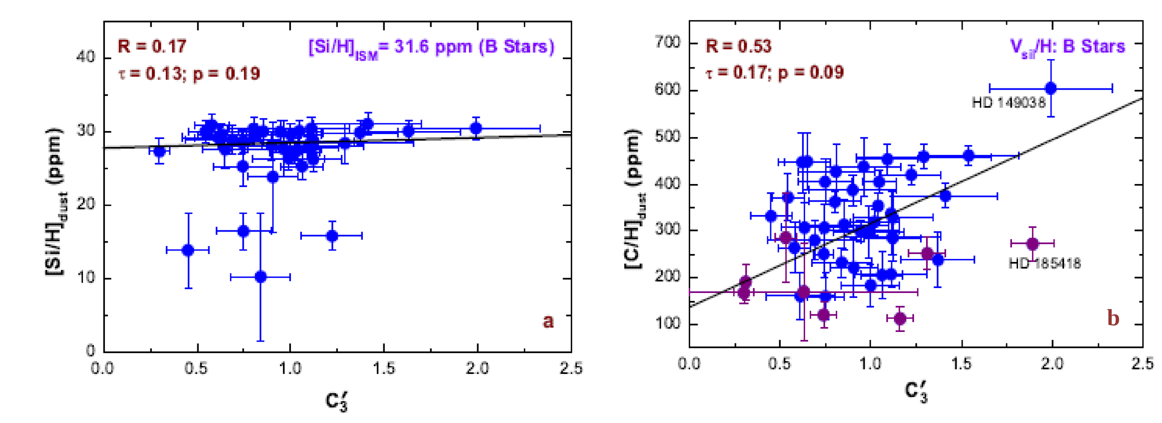


➡ **$(C/H)_{dust}$ correlates with the 2175Å bump;**

➡ **Lack of correlation between $(Si/H)_{dust}$ and the 2175Å bump;**



➡ **Neither $(C/H)_{dust}$ nor $(Si/H)_{dust}$ alone correlates with the far-UV extinction** ➡ both small silicate grains and small carbon grains contribute to the far-UV extinction



The correlation between the 2175Å bump strength (c_3') and $[Si/H]_{dust}$ (a) or $[C/H]_{dust}$ (b) (derived from the Kramers-Kronig relation)

Future Works

- $(C/H)_{gas}$ and $(O/H)_{gas}$ vary from one sight line to another.
- Extinction curve also varies from one sight line to another.
- Information about the dependence of dust properties on local conditions would have been lost for models dealing with the Galactic mean extinction curve.
- Modeling the extinction curves of a large number of sight lines from the near-IR to far-UV, of which R_V ranges from ~2 to ~6 and the gas phase abundances have been observationally determined for the dust-forming elements (C, O, Mg, Si, Fe).
- Exploring the relation between abundances, depletions, extinction, dust properties and the physical and chemical condition of the interstellar environment.

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