Understanding the Role of Carbon in Ultraviolet Extinction along Galactic Sight lines

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Introduction

Carbon exists in several phases in the Interstellar Medium (ISM): dust, gaseous atoms/ions and gaseous molecules. C II is the dominant ionization state of carbon in diffuse neutral interstellar clouds. The abundance determinations of carbon in the gas and dust phases of the ISM are fundamental to the understanding of its crucial role in interstellar extinction. As the current number of sight lines with reported carbon abundances as well as measured extinction curves is very few it is not possible to relate the carbon abundances in dust with specific extinction features. In the present study we report the interstellar gas and dust phase abundances of carbon along 21 Galactic sight lines. The gas-phase C II column densities along 6 of the sight lines are taken from Sofia et al. (2011). Their strong-line method is employed to determine the C II column densities along the remaining 15 sight lines.

Transitions of C II Analysed

Transition	Vaccum Wavelength (Å)	Oscillator Strength (log fλ)[a]
^{13}C II	1334.5190	2.234
^{12}C II	1334.5323	2.234
^{13}C II*	1335.6490	1.234
^{12}C II*	1335.6627	1.234
^{13}C II*	1335.6920	2.188
^{12}C II*	1335.7077	2.188

[a]From Morton (2003)

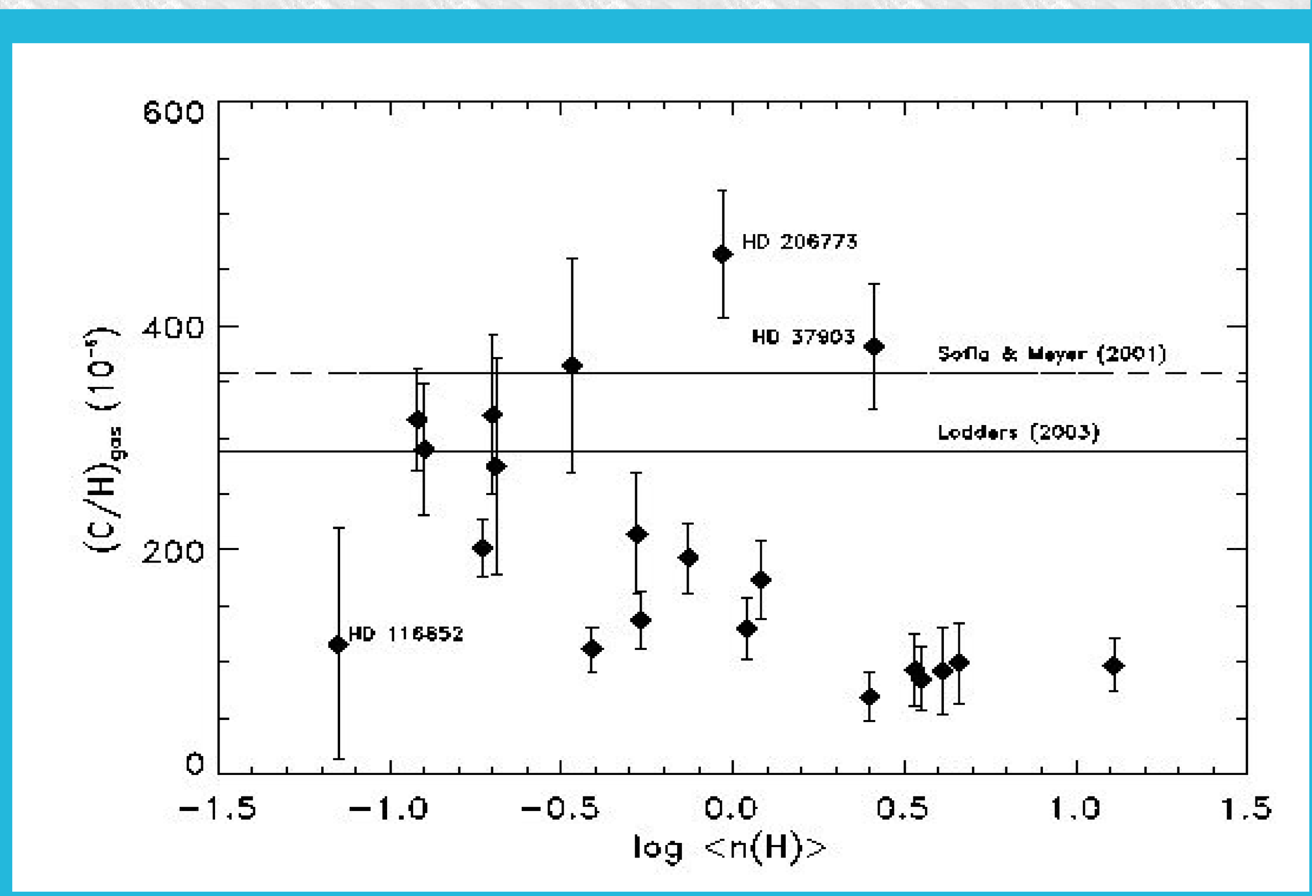

Fig 1 : Gas-phase C/H ratio plotted as a function of the logarithm of average density of hydrogen along the line of sight.

Method

- Normalizing the line flux
  - Used the synthetic spectra of stars in the UVBLUE library
  - Accounted for the differences in radial velocity, stellar rotational velocity, metallicity and sight-line reddening
- Cloud structure information (heliocentric velocities, Doppler broadening parameters and column densities of individual absorbing components along the line of sight)
  - Analyzed the transitions of Mg II at 1239.9253Å and 1240.3947Å
- Column density of C II
  - Simultaneously fitted the six transitions of C II
  - Heliocentric velocities and Doppler broadening parameters obtained from Mg II are used
  - Added more number of clouds at the wings to account for the additional absorption features
  - Assumed the terrestrial value of 92.5 for the ratio ^{12}C/^{13}C
- Dust-phase abundance of carbon
  - Chose the gas-phase abundance of carbon towards HD 206773 as the lower limit of the reference value for the total carbon abundance in the ISM

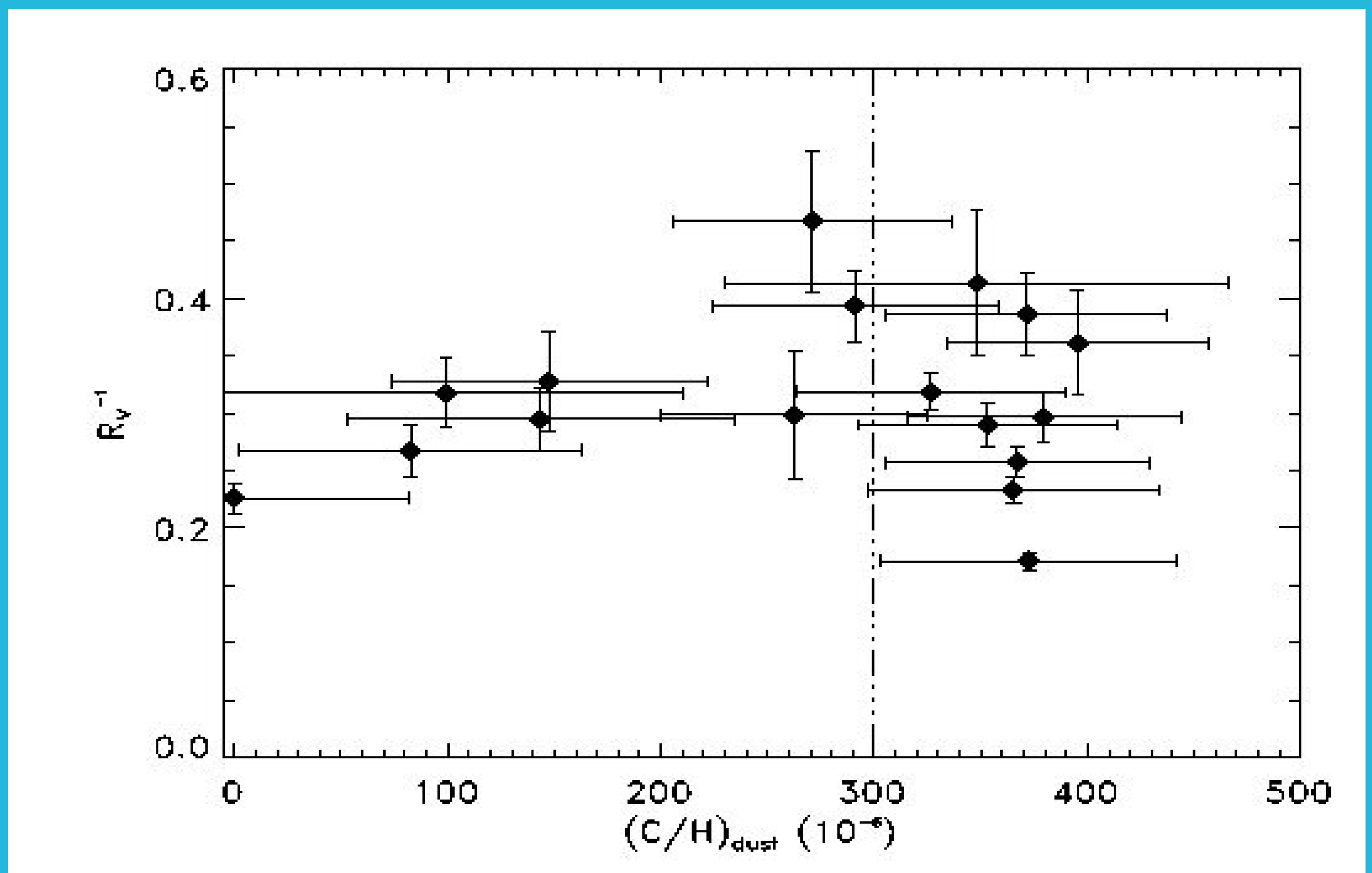

Fig 2 : R_V^{-1} plotted as a function of $(C/H)_{dust}$. The line drawn at 300 ppm is the margin separating two density regimes.

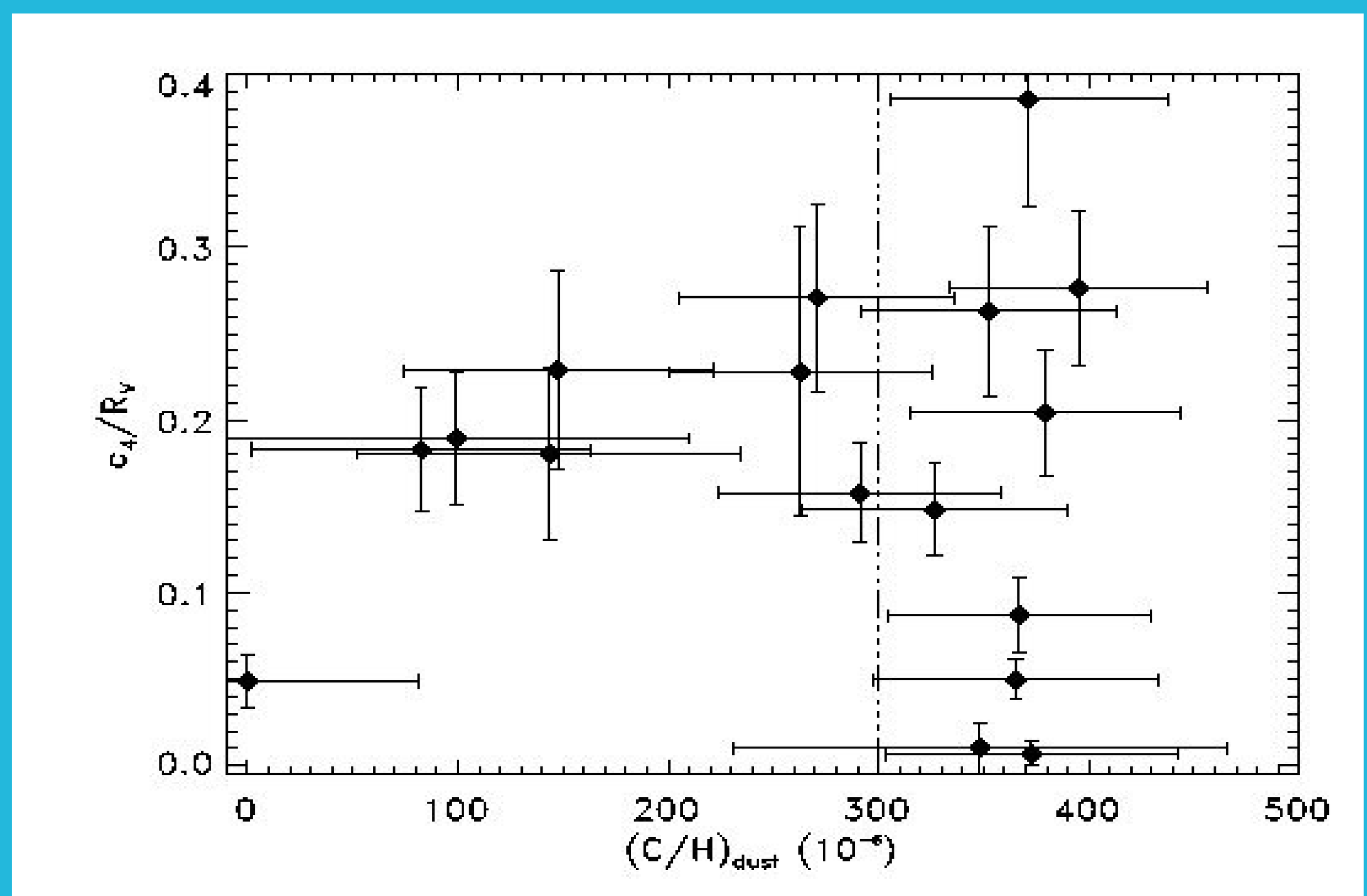

Fig 3 : Variation of c_4/R_V with $(C/H)_{dust}$.

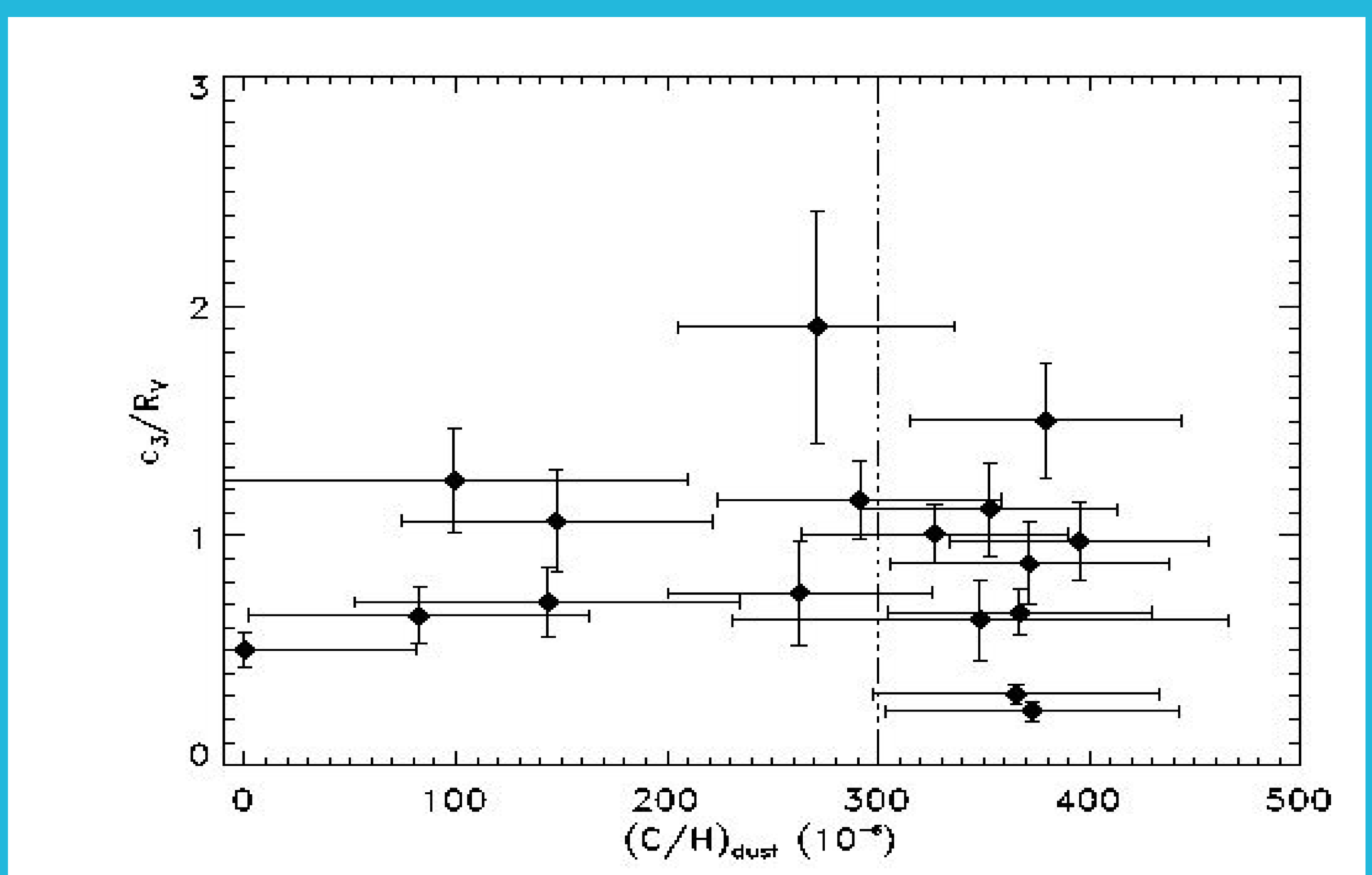

Fig 4 : Variation of c_3/R_V with $(C/H)_{dust}$.

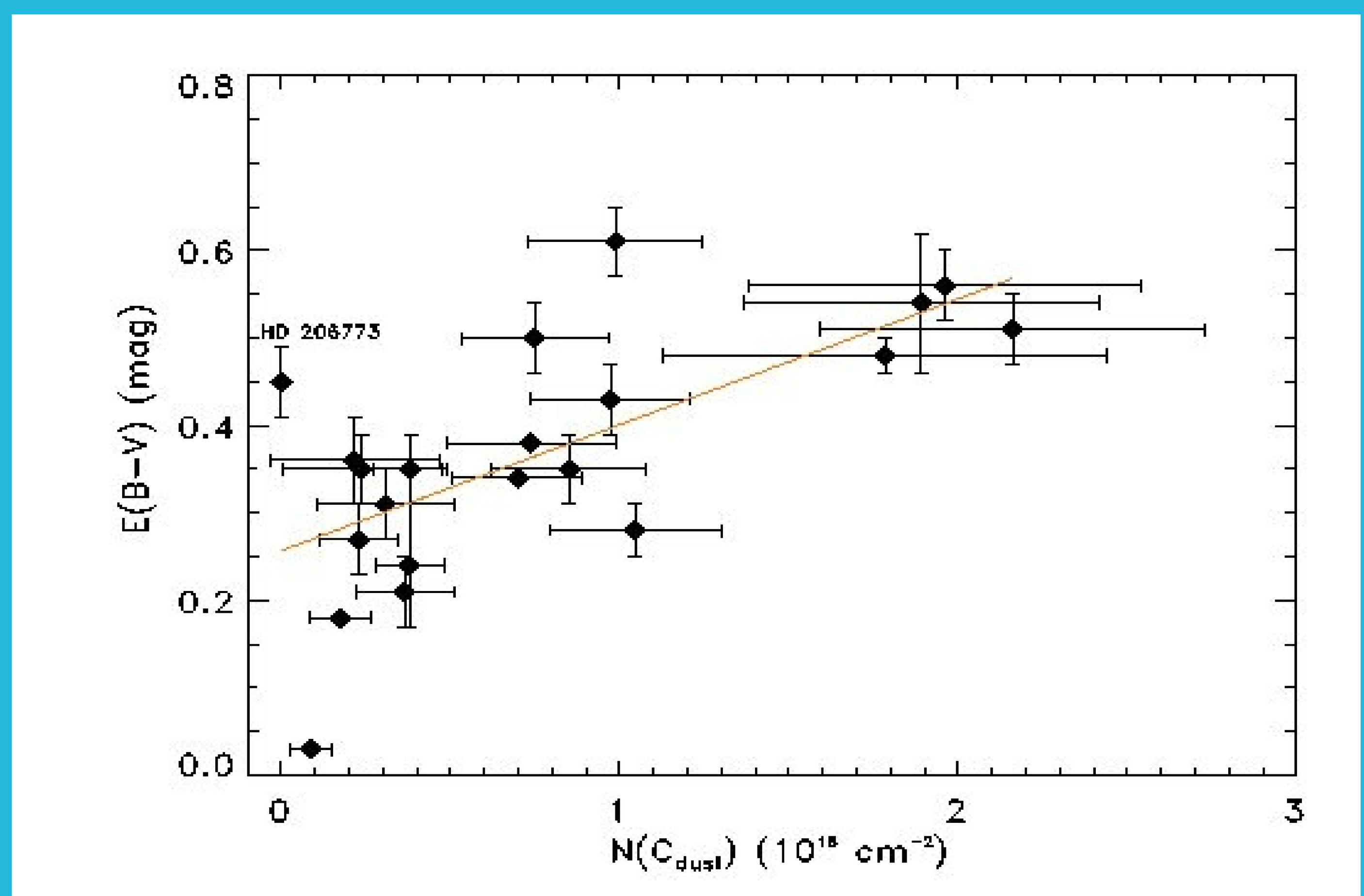

Fig 5 : E(B −V) plotted as a function of $N(C_{dust})$.

Results

- Solar abundances are not a good analogue of interstellar abundances
- Carbon is a dominant constituent of interstellar dust.
- Both big and small grain populations exist in dense environments.
- Perhaps the big grains formed in dense clouds fragment in to smaller grains as they reach the lower density regions along the line of sight.
- The gradual decrease in the FUV extinction parameter in lower density environments could be because of the preferential disruption of smaller grains in to gas as they reach the diffuse ISM.
- Similar correlations are observed for the bump strength and the non-linear FUV extinction parameter with the dust-phase abundance of carbon.
- Perhaps the 2175Å bump feature in the extinction curve is produced by or cohabits with the same small grains which produce the FUV non-linear rise.

References

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