



Interstellar Extinction: Amorphous Carbon and Nanodiamonds

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Introduction

Prominent features of the interstellar extinction include the 217.5 nm absorption bump and steep far-UV rise. While the UV bump is largely attributed to graphitic dust other forms of Carbon viz. *diamond, amorphous carbon and PAH clusters* can also influence extinction in different ways.

Observations of 3.43 and 3.53 μm lines in Ae/Be Herbig stars [1] suggests the presence of hydrogenated nanodiamonds in the ISM. Nanodiamonds (ND) are the most abundant pre-solar grains in primitive meteorites [2] and could be important component of the interstellar dust. Their formation possibilities include CVD and shock in supernovae but due to highly symmetric lattice their direct detection is difficult.

The carbonaceous grain growth is more likely to result in amorphous structures [3]. But extinction modeling shows good fits for galactic extinction curve by graphite without any need of amorphous carbon (AMC). In order to explain the far-UV extinction and improve the overall match, it is necessary to incorporate other forms of carbon e.g. AMC and ND.

AMC can exist in many different forms in the ISM [4]. To explain the anomalous extinction regions, Rai & Rastogi [5] incorporate ND-inside a popular form of AMC produced from carbon soot - AC1 [6]. In the present work different forms of AMC are considered to see which is most suitable in the ISM. This will enhance understanding of their formation scenario in different regions.

Table 1: Component fractions giving best χ^2 fitting

		Si+Gr	Si+Gr+ ND-AC1	Si+Gr+ ND-ACAR	Si+Gr+ ND-ACH2	Si+Gr+ ND-BE
HD 21483	χ^2	0.09	0.017	0.034	0.034	0.026
	R_V	2.16	2.86	2.70	2.78	2.86
	Gr	0.47	0.28	0.33	0.35	0.33
	Si	0.53	0.14	0.14	0.35	0.45
	ND-A	—	0.41	0.16	0.25	0.14
HD 23512	χ^2	0.522	0.178	0.068	0.269	0.183
	R_V	2.16	2.75	3.37	2.83	3.89
	Gr	0.40	0.20	0.22	0.21	0.25
	Si	0.64	0.00	0.17	0.05	0.28
	ND-A	—	0.77	0.75	0.98	0.55
HD 27778	χ^2	0.102	0.017	0.040	0.034	0.042
	R_V	2.18	2.81	2.85	2.73	2.65
	Gr	0.40	0.33	0.33	0.34	0.43
	Si	0.65	0.17	0.21	0.11	0.24
	ND-A	—	0.43	0.34	0.58	0.28
HD 147889	χ^2	0.149	0.107	0.099	0.117	0.054
	R_V	3.10	3.26	3.60	3.29	3.79
	Gr	0.62	0.55	0.43	0.53	0.47
	Si	0.18	0.00	0.05	0.00	0.12
	ND-A	—	0.23	0.41	0.37	0.34

Conclusions

- Simple MRN-distribution is used. A small percentage of ND improves the extinction curve fitting and the silicate requirement is reduced.
- Nanodiamond-AMC is not unique for every sightline and evolves differently in different environments.
- Extinction along HD 21483 and HD 27778 is best explained with AC1 type of AMC. While HD 23512 and HD 147889 fit best with ACAR and BE respectively.
- Sightlines with steep far-UV rise show preference for ND-AC1 or more sp^3 favored structure and sightlines with large R_V values show preference for ND-BE or more sp^2 favored structure.

Modeling

Mie theory and optical properties of Allend type nanodiamonds [7] are used. Zubko et al. [8] report the optical properties of different AMC and call them ACAR (produced in Ar atmosphere), ACH2 (in H_2 environment) and BE (from Benzene). ND-AMC core-mantle grain model is considered along with silicates and graphite. The three component models using different AMC are fitted to specific stellar extinction curves.

Results

Nanodiamond within amorphous carbon are considered as spherical core-mantle component. Figure 1 shows (a) the plot of real and imaginary parts of refractive indexes of the four AMC considered and (b) the extinction efficiencies for the four ND-AMC components.

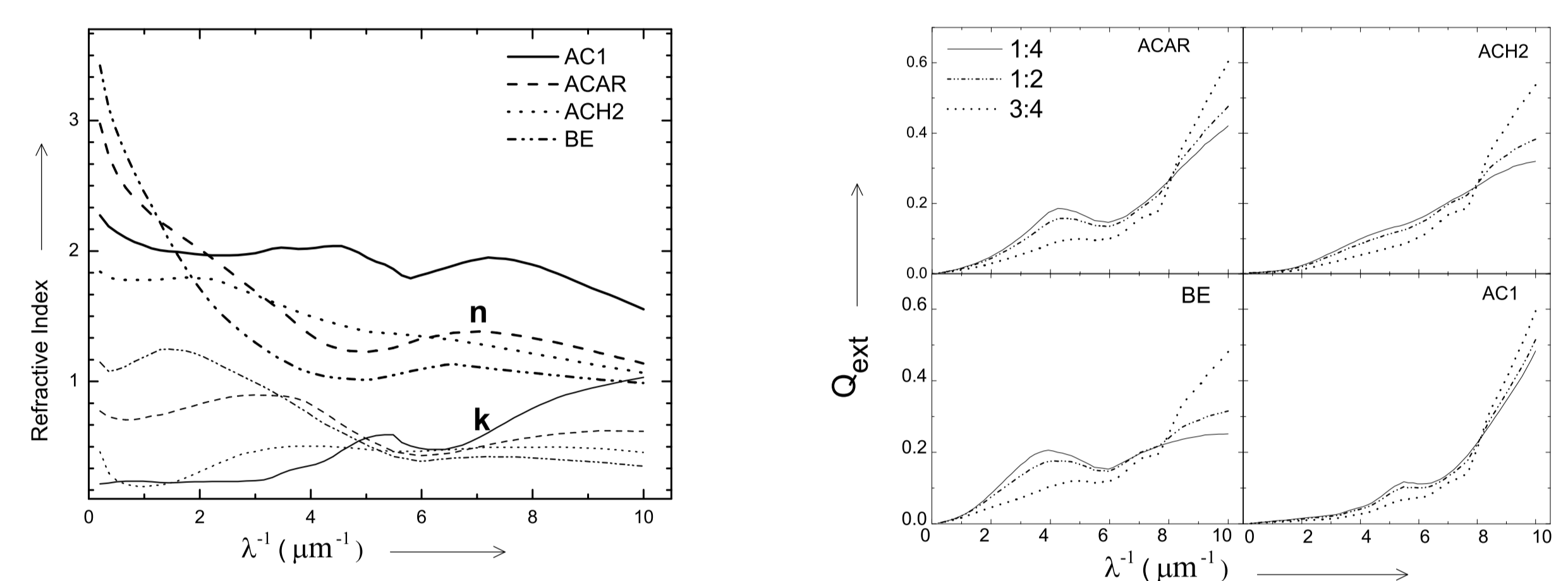


Figure 1: (a) Refractive Indexes for four AMCs (b) Extinction efficiency of different ND-AMC

The radius of ND core and of AMC mantle are supposed to be in the ratio 1:4, 1:2 and 3:4. Results shown in Figure 1 are for particle size 4 nm. ND-ACAR and ND-BE have nearly same normalized extinction curve. In ND-ACAR a peak/plateau is present in the visible region. ND-ACAR has steeper far-UV rise than BE. ACH2 has featureless rise with saturation property in far-UV. AC1 has monotonous rise in extinction in the studied region and also is largest.

The radius varies from 0.001 to 0.120 or 0.150 μm for the outer radius in two different cases. The initial ratio of core-mantle in range [0.001,0.120] μm is 1 to 2 and 3 to 4 for range [0.001,0.150] μm . The cut-off size of the ND is supposed to be 0.010 μm for both size range. Thus ND percentage diminishes slowly in grain with increasing size. The far-UV rise is more pronounced in the normalized curve of ND core inside AMC.

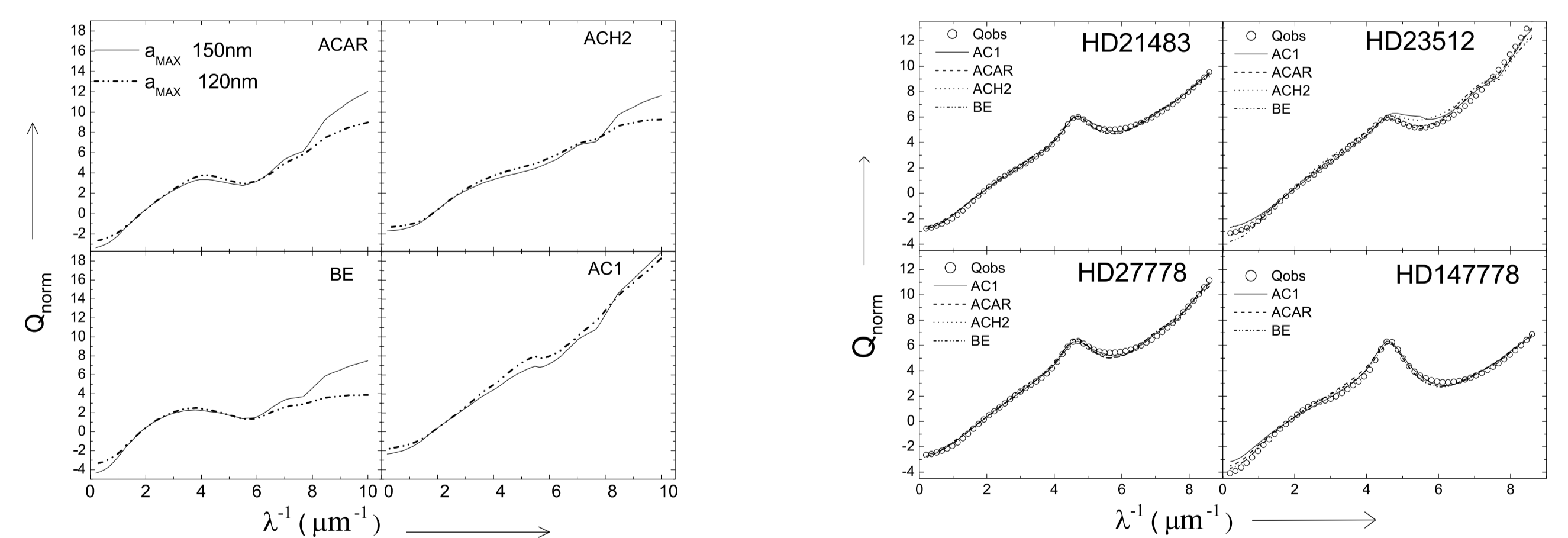


Figure 2: (a) Normalized extinction for two size range (b) Modeling ND-AMC for four sightlines

The modeling of four stars using the four different AMC mantles on ND core are shown for the best χ^2 values in Figure 2(b). Table 1 gives the corresponding χ^2 values along with the fraction of the three components used. The R_V is also tabulated.

References

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