Interstellar Extinction Law

Extinction curves $\left(\frac{A_\lambda}{A_V} \right)$ ← $\simeq 550\,nm$ Depends on filter, parametrized by:

$$R_V = \text{RATIO OF TOTAL TO SELECTIVE EXTINCTION} \equiv \frac{A_V}{A_B - A_V} = \frac{A_V}{E(B-V)}$$

A_B: $\simeq 440\,nm$

$E(B-V)$: The B-V color excess (also called reddening)

A "color" is the difference in magnitudes between two bands: $B - V$

A color excess measures how much a color changes due to extinction:

$$E(B-V) \equiv A_B - A_V = (B_{obs} - B_{intr}) - (V_{obs} - V_{intr})$$

B_{obs}: observed; B_{intr}: intrinsic w/ NO extinction

$$= (B-V)_{obs} - (B-V)_{intr.}$$

R_V is determined empirically

"Typical" ISM value $R_V \sim 3.1$

But in different environments has been found to range from $R_V \sim 2.1$ up to $R_V \sim 5.7$

Depends on changes in dust size distribution, composition, etc. (i.e. coagulation = grain growth)

IN MILKY WAY: $\left\langle \frac{\text{MASS IN DUST}}{\text{MASS IN GAS}} \right\rangle \sim 0.007 \approx \frac{1}{100}$

this value commonly assumed.

Comparing lines of sight with low A_V and a tracer of how much H gas is along line of sight gives following empirical relationship: [Bohlin et al. 1978 Rachford et al. 2009]

$$\frac{N_H}{E(B-V)} \simeq 5.8 \times 10^{21} \text{ H atoms} \cdot \text{cm}^{-2} \cdot \text{mag}^{-1}$$

NOTE: $N_H = \underbrace{N_{HI}}_{\text{atomic}} + \underbrace{2N_{H_2}}_{\text{molecular}}$ ⇒ IN completely molecular environment $N_H = 2N_{H_2}$

For "Standard" $R_V \sim 3.1$ we find:

$$\boxed{\frac{N_H}{A_V} \simeq 1.9 \times 10^{21} \text{ cm}^{-2} \text{ mag}^{-1}}$$

This gives a simple empirical conversion between how much dust (A_V) and how much gas (N_H)!