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External Signal Degredation Con't

I. Outside the atmosphere

(a) Solar System

Earth's Magnetosphere - Radiation Belts, SAA

Geocorona

Solar Wind

Interplanetary Dust / scintillation

(b) The Galaxy

Galactic Magnetic Field

Cosmic Ray Trapping

Polarization by Aligned Dust

HI and H_2 absorption

HI effectively blocks far UV, ~100-912 Å

Dust Extinction

Interstellar Lines

(c) Galactic Extinction

In the galactic plane, it corresponds to approximately A_V = 1.9 magnitude per kiloparsec. (1.6 magnitude from discrete interstellar clouds, 0.3 madnitude from diffuse dust) To the galactic center, the visual extinction is greater than 30 magnitudes — we cannot see the galactic center optically.

Roughly speaking, galactic extinction to extragalactic sources is treated by assuming that the galaxy is plane parallel and that solar system is near the center of the plane. Then the treatment is like that for the earth's atmosphere, with extinction following a cosecant law in galactic latitude, b^{II},

$$A_B \approx 0.2\ csc(b^{II})$$

This is the simple form often applied by De Vaucouleurs. A different form, with essentially a clear opening towards the galactic poles (possibly caused by a nearby supernova explosion bowing out the interstellar medium in the solar system neighborhood) is used by Sandage and others

$$A_B = 0.0 \qquad for\ b^{II} \geq 50^\circ$$

$$A_B \;=\; 0.132(cscb - 1) \qquad for\ b^{II} \;\leq\; 40^\circ$$

and smoothly joined between. $A_V = 0.75\ A_B$, and $A_R = 0.72\ A_V$.

Both of these are only crude approximations, and both are certainly wrong in detail. Better estimates have been derived using maps of the neutral hydrogen (HI) density and applying the calibration of extinction to HI column density

$$1\ A_V\ per\ 2 \times 10^{21}\ atoms\ cm^{-2}$$

This has been done extensively based on an HI map of the galaxy from Burstein and Heiles (1982) and also based on the IRAS 100μ and COBE DIRBE (Diffuse Infrared Background Experiment) data (Shlegel, Finkbeiner & Davis 1998). Alternatively

$$E_{B-V}\ = 1\ per\ 7 \times 10^{21}\ atoms\ cm^{-2}$$

. An even better calibration could be used by parameterizing the extinction in terms of the column densities of HI plus CO or H_2 to account for the contribution of molecular clouds. Note that the SFD maps and software are available at http://www.berkeley.edu/davis/dust.

The quantity E_{B-V} is the *color excess*, defined as

$$E_{B-V} \;=\; A_B \;-\; A_V$$

It is often the case that extinction is measured by comparing the expected *color* for an object (star or galaxy) of a known spectral type with its actual observed color — hence color excess. The ratio of the total amount of extinction to the color excess, also known as the ratio of *total-to-selective absorption*, is

$$\frac{A_V}{E_{B-V}} \;\approx\; 3.3$$

and its variation as a function of position or line-of-sight is a measure of the variation of interstellar dust properties (and has also been a question of some controversy over the years).

Table 1 UV Extinction Law

λ (Å)	A_λ (in magnitudes)	
5530	1.0	
3330	1.7	
2500	2.3	
2200	2.9	2200Å bump
2000	2.8	
1670	2.7	
1250	3.3	
1000	4.2	

This is adapted from Van de Hulst's Curve #14, which is calculated from the laboratory properties of possible interstellar dust gains, and which is an excellent match to the observed interstellar reddening law.

One of the most recent and now most used results on interstellar reddening is from Cardelli, Clayton and Mathis (1989) who parameterize the reddening law as a function of wavelength and also as a function of the total to selective extinction, R. They empirically derive

$$< A(\lambda)/A(V) > \; = \; a(x) \; + \; b(x)/R_V$$

where x is the wavenumber in units of μ^{-1}, and a(x) and b(x) are given by polynomial fits for appropriate wavelength ranges:

For the **IR,** $0.3\mu^{-1} \leq x \leq 1.1mu^{-1}$, ($\lambda$ between 0.9 and 3.3 μ):

$$a(x) \; = \; 0.574x^{1.61}$$

$$b(x) \; = \; -0.527x^{1.61}$$

For the **optical,** $1.1\mu^{-1} \leq x \leq 3.3mu^{-1}$, ($\lambda$ between 3000 Å and 9000 Å):

$$a(x) \; = \; 1.0 + 0.17699y - 0.50447y^2 - 0.02427y^3 + 0.72085y^4 +$$

$$0.01979y^5 - 0.77530y^6 + 0.32999y^7$$

$$b(x) \; = \; 1.41338y + 2.28305y^2 + 1.07233y^3 - 5.38434y^4 -$$

$$0.62251y^5 + 5.30260y^6 - 2.09002y^7$$

where $y \; = \; (x - 1.82)$

For the **UV**, $3.3\mu^{-1} \leq x \leq 8mu^{-1}$, ($\lambda$ between 1200 Å and 3000 Å):

$$a(x) \; = \; 1.752 - 0.316x - 0.104/[x - 4.67)^2 + 0.341] + F_a(x)$$

$$b(x) \; = \; -3.090 + 1.825x + 1.206/[(x - 4.62)^2 + 0.263] + F_b(x)$$

where, to take into account the 2200Å bump, we add

$$F_a(x) \; = \; F_b(x) \; = \; 0 \qquad \text{for } x < 5.9$$

$$F_a(x) \; = \; -0.04473(x - 5.9)^2 - 0.009799(x - 5.9)^3 \qquad \text{for } 8 \leq x \leq 5.9$$

$$F_b(x) \; = \; 0.2130(x - 5.9)^2 + 0.1207(x - 5.9)^3 \qquad \text{for } 8 \leq x \leq 5.9$$

For the **far-UV**, $8\mu^{-1} \leq x \leq 10mu^{-1}$, ($\lambda$ between 1000 Å and 1200 Å):

$$a(x) \; = \; -1.073 - 0.628(x - 8) + 0.137(x - 8)^2 - 0.070(x - 8)^3$$

$$b(x) \;=\; 13.670 + 4.275(x-8) - 0.420(x-8)^2 + 0.374(x-8)^3$$

In addition to HI absorption, other abundant species with strong transitions produce interstellar absorption lines. The strongest of these in the optical are the H+K lines of CaII at 3933 and 3968 Å, and the D lines of NaI at 5890 Å. In the ultraviolet, there are enormous numbers of interstellar lines due to low ionization states of O, Si, C, etc.

(d) Inter Galactic Medium

QSO Cutoff at z $\sim$ 5 ??????

Gunn-Peterson effect

(e) Other Hazards of Low Earth Orbit

LDEF Results

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