# THE CASE FOR AN EXTRAGALACTIC ORIGIN FOR THE HIGH GALACTIC LATITUDE DIFFUSE ULTRAVIOLET BACKGROUND

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**Abstract.** A simple model is presented which can be used to predict the diffuse background that is to be expected at high galactic latitudes due to the light of galactic plane OB stars scattered from high latitude dust. When combined with a recent and highly reliable determination of the scattering pattern of interstellar grains in the far ultraviolet, this model indicates that such scattering cannot account for the continuous spectrum that is seen at high latitudes by all observers. The spectrum of the extragalactic background is ~ flat longward of 1216 Å and is undetected shortward of that wavelength, suggesting an origin in hydrogen recombination radiation, although the intensity is higher than is expected in common cosmological models (Henry 1991).

There is considerable dust at high galactic latitudes; for example Hauser *et al.* (1984) report, from their study of IRAS cirrus observations, that $A_V = 0.1$ mag at high latitudes. (We use that value, which is probably too high by at least a factor two, in order to be conservative in our conclusions.) Also, there are many bright OB stars in or near the galactic plane (Fig. 1). For our simple model for the scattered light of these stars, we integrate the Henyey-Greenstein (1941) scattering function

$$H(\theta) = \left(1 - g^2\right) / 4\pi \left(1 + g^2 - 2g\cos\theta\right)^{-3/2}$$

over the back-scattering directions, $\pi/2$ to $\pi$, obtaining

$$B = 1/2 - 1/(2g) + \left(1 - g^2\right) \Big/ \left(2g\sqrt{\left(1 + g^2\right)}\right)$$

for B, the fraction of the scattered light that is backscattered. Our model is, then, that at high latitudes we expect a scattered intensity $S = B\ G\ a\ \tau$,where G is the local far-ultraviolet interstellar radiation field (~10,000 photons cm$^{-2}$ s$^{-1}$ sr$^{-1}$ Å$^{-1}$ ("units"), Henry, Anderson, and Fastie 1980), $a$ is the grain albedo (~0.65 at 1500 Å, Witt *et al.* 1992), and $\tau$ is the far-ultraviolet optical thickness of the high-galactic-latitude scattering layer. With $\tau_\lambda = 0.921\ A_\lambda$ and with $E_{1500-V} / E_{B-V} = 5.3$ (Bless and Savage 1972, for $\zeta$ Oph) and $A_V = 3E_{B-V}$, we obtain $\tau = 0.255$ (we emphasize again that this is surely much too high a value).

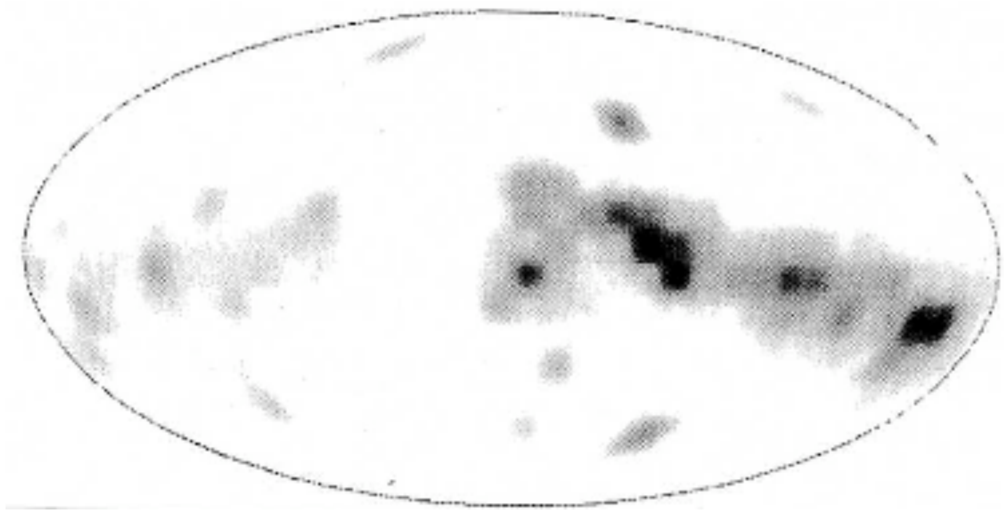

**Figure 1.** *A linear, just saturated, "photograph" of the sky at 1565 Å constructed from the TD-1 observations. This image contains only the light of the stars; that is, of the source function for scattering. The north galactic pole is at the top, and the galactic center is at the center. Just more than 78% of the source function originates between galactic longitudes 180° and 360°.*

For detailed study of scattered light at any particular region of the sky, one unquestionably wants to use a detailed model. However, such models are complex and not generally available. The only competing simple model is that of Jura (1979), which predicts the scattered light as a function of five variables: the source function in the disk (roughly our G), $\tau_0$ (~0.85, Joubert *et al.* 1983) the optical thickness of the galaxy in the ultraviolet, *a*, *g*, and the galactic latitude *b*. Use of Jura's model is illustrated nicely in Joubert *et al.* 1983. We prefer our model: because of its simplicity (no evaluation of an exponential integral is required); because it is valid for all values of *g* (Jura's model fails for large values of g); and because it does *not* give a galactic latitude dependence: the source function of Fig. 1 shows clearly that asymmetry in galactic longitude is very strong (Henry 1977), equalling that in latitude (just more than 78% of the source function originates at | b < 21° |). If more than a crude estimate of the flux expected at high latitudes is desired, use of a detailed model *i*s a necessity.

A crude estimate using our model is, however, very revealing. In Table 1 we present as a function of the Henyey-Greenstein scattering parameter *g,* the predicted high galactic latitude flux, from our model and from that of Jura (for $b = 90°$), using the values that were specified above for the necessary parameters.

The observed level of cosmic background reported at moderate and high latitudes by large numbers of observers is about 300 units (Henry 1991). A glance at Table 1 shows that if the value of *g* in the ultraviolet is, say, 0.6 or greater (keeping in mind the conservative values of our chosen parameters), then the cosmic high-latitude background is not scattered starlight and is presumably extragalactic.

An important new measure of *g* in the ultraviolet has been obtained on the *Astro* mission by Witt *et al.* 1992. Their value is ~0.75, and they emphasize that their result is model-independent. Results similar to those of Witt *et al.* for *a* and *g* were also

**Table 1.**
**Backscattered Light *S* (units) at High Latitudes as a Function of *g***

| g | B | S(present) | S(Jura) |
|---|---|---|---|
| 0.98 | 0.004 | 7 | (-53) |
| 0.90 | 0.023 | 38 | (7) |
| 0.80 | 0.051 | 84 | 81 |
| 0.75 | 0.067 | 110 | 118 |
| 0.70 | 0.084 | 139 | 155 |
| 0.60 | 0.124 | 205 | 229 |
| 0.40 | 0.225 | 372 | 378 |
| 0.30 | 0.286 | 473 | 452 |
| 0.00 | 0.500 | 828 | 675 |
| -0.90 | 0.977 | 1619 | 1342 |

obtained by Henry (1981). We conclude that it appears likely that the high latitude diffuse background is extragalactic in its origin.

## REFERENCES

Bless, R. C., & Savage, B. D. 1972, ApJ, **171**, 293

Hauser, M. G., Gillett, F. C., Low, F. J., Gautier, T. N., Beichman, C. A., Neugebauer, G., Aumann, H. H., Baud, B., Boggess, N., Emerson, J. P., Houck, J. R., Soifer, B. T., & Walker, R. G. 1984, ApJ, **278**, L15

Henry, R. C. 1977, ApJS, **33**, 451

Henry, R. C. 1981, ApJ, **244**, L69

Henry, R. C. 1991, ARA&A, **29**, 89

Henry, R. C. & Anderson, R. C., and Fastie, W.G. 1980, ApJ, **239**, 859

Henyey, L. G., & Greenstein J. L. 1941, ApJ, **93**, 70

Joubert, M., Masnou, J. L., Lequeux, J., Deharveng, J. M., and Cruvellier, P. 1983, A&A, **128**, 114

Jura, M. 1979, ApJ, **227**, 798

Witt, A. N., Petersohn, J. K., Bohlin, R. C., O'Connell, R. W., Roberts, M. S., Smith, A. M., and Stecher, T. P. 1992, ApJ, **395**, L5