SPECTRA OF THE FAR-ULTRAVIOLET BACKGROUND SHORTWARD OF 1200 Å FROM VOYAGER 2

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ABSTRACT. Deep spectra of the far-ultraviolet sky background have been obtained by the Voyager 2 Ultraviolet Spectrometer (UVS) in the 500 to 1200 Å wavelength range. New diffuse galactic background results—particularly in the 900 to 1100 Å region—are presented, which extend the North Galactic Pole results of Holberg (1986) over a range of lower galactic latitudes. Twenty-four lines of sight are analyzed for the presence of residual diffuse continua. Typical upper limits of several hundred photons cm^{-2} s^{-1} $Å^{-1}$ sr^{-1} are obtained for most lines of sight; however, a faint residual continuum is detected at several low-latitude locations. In Ophiuchus, a diffuse stellarlike continuum is attributed to scattering from interstellar dust.

1. INTRODUCTION

In contrast to the wavelength region longward of 1200 Å, where a considerable number of observations of the sky background have been conducted, relatively little is currently known concerning the spectral region in the vicinity of the Lyman limit at 912 Å. Existing observations in this region consist, for the most part, of upper limits over broad photometric bands (Henry, 1973; Opal and Weller, 1984; and Bixler, Bowyer, and Grewing, 1984). The primary exceptions to this situation are the early Voyager UVS results of Sandel, Shemansky, and Broadfoot (1979), which detected the presence of diffuse continuum emission along several lines of sight. The most restrictive upper limits in this region remain those derived from Voyager 2 observations (Holberg 1986) obtained near the North Galactic Pole. In these observations, strict limits were placed on the presence of sky background radiation in the 500 to 1200 Å region corresponding to 100–200 photons cm^{-2} s^{-1} $Å^{-1}$ sr^{-1} for continuum emission and 6000 photons cm^{-2} s^{-1} $Å^{-1}$ sr^{-1} for line emission. (Hereafter, the units photons cm^{-2} s^{-1} $Å^{-1}$ sr^{-1} are referred to as "CU," continuum units.) These limits were obtained from long-integration spectra of regions of the sky free of stellar sources within the $0.1° \times 0.87°$ UVS field of view (FOV). The technique employed by Holberg (1986) to achieve these results decomposes the observed background spectrum into its instrumental and interplanetary emission line components. The resulting residual spectrum, often null, is then used to place limits on the diffuse sky background.

Presented here are new results obtained from an extensive sample of long-duration Voyager 2 observations obtained over a range of galactic latitudes. A second set of data considered here consists of a slow drift of the UVS FOV back and forth across a limited region of the constellation Ophiuchus. Throughout this observation, the presence of a faint diffuse continuum was noted. The intensity and spectral nature of this continuum is discussed here.

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2. OBSERVATIONS

The observations presented here consist of Voyager 2 long-duration spectra. For the most part, these were intended as observations of various astronomical targets. For various reasons, including intrinsic faintness below 1200 Å or suitably long observations of adjacent sky background, no discrete sources were detected and these observations have been analyzed in terms of their sky background content. Voyager 2 observations of 24 locations, which met the criteria of being free from stellar sources and having integration times in excess of 100,000 s, were analyzed. These locations covered a range of galactic latitudes down to $|b| = 12°$. All but two showed no evidence of diffuse background shortward of 1200 Å. For these locations, *upper limits* of 100 to 900 CU were determined. For the two remaining locations, a diffuse continuum was present. One of these locations (l = 175.8°, b = −15.2°) exhibited a brightness of 1900 CU in the 900 to 1200 Å band. This location corresponds to region A discussed by Sandel, Shemansky, and Broadfoot (1979). The second is discussed in detail below.

In addition to the results of individual sky background spectra at various locations discussed above, there also exists an extended ~100-day observation in which the UVS FOV drifted back and forth across a ~3° arc in Ophiuchus near l, b = 3°, +17°. This observation occurred during a period when the spacecraft scan platform remained inactive following its seizure at the time of the Saturn encounter in 1981. The UVS was left pointed in an arbitrary direction and the heliocentric motion of the spacecraft (with its high-gain antenna fixed on the Earth) caused the UVS FOV to move slowly across the sky. During this period, approximately 10 to 12 hours of data were obtained each day by the UVS. These data were summed into a single average spectrum for each day and dark counts and instrumental scattering were removed in the manner described in Holberg (1986). Contributions from the interplanetary H I Lyman α, β, γ emission lines were removed, leaving a faint, diffuse stellarlike continuum in the region 912 to 1200 Å. In Figure 1, the intensity of this continuum is plotted as a function of the day of the year 1982. In addition to the diffuse continuum, at least one discrete source, the V = 7, B8 star HD151884, was also detected. Its presence is indicated in Figure 1 by two peaks centered on days 36 and 86 due to the FOV crossing this star twice; no other discrete sources were evident. A residual diffuse continuum at a level of ~2000 CU is evident

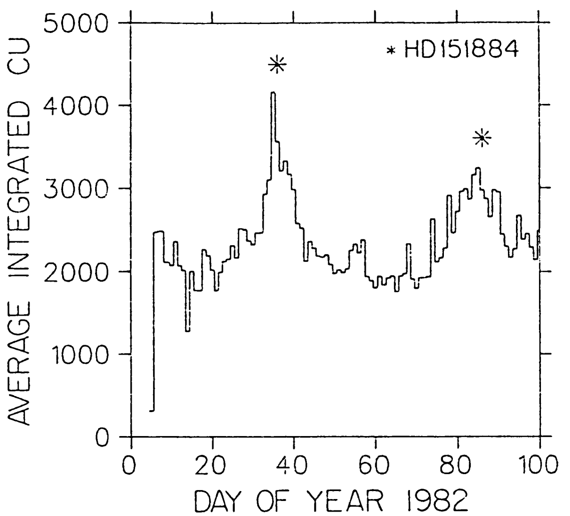

Figure 1. A time series of observed daily averages of the diffuse continuum flux in the 912 to 1100 Å band during the Ophiuchus drift. The peaks centered at 36 and 86 days (*) are due to HD 151884 (B8, V=7), which was crossed twice. A uniform diffuse continuum at a level of ~2000 CU is present over the entire 3° region covered by the drift. At higher latitudes, *upper limits* in the same band are typically a factor of ten or more *lower* than the signal observed here.

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throughout the entire drift. In contrast, upper limits on diffuse continuum levels of at least an order of magnitude lower are characteristic of most UVS backgrounds. The spectrum of the diffuse Ophiuchus background is shown in Figure 2. No emission is present shortward of the Lyman limit at 912 Å. There are two important aspects of this spectrum. The first is its stellarlike appearance. To illustrate this, a scaled Voyager 2 spectrum of the O8 star 68 Cyg has been overplotted on the background spectrum in Figure 2. The match is quite good, indicating that the background arises, ultimately, from stellar sources of early spectral type. A second aspect of the background spectrum is its intensity. The Voyager 2 68 Cyg [V = 5.00, E(B-V) = 0.30] spectrum has been scaled downward by a factor of 0.00406 (Δ mag = 5.95) to match the intensity of the background so that it is equivalent to a single O8 star at V = 10.95. Such a hypothetical star would normally be unobservable with Voyager due to excessive reddening. Attributing the background to direct starlight from a number of unresolved stars within the UVS FOV only worsens the reddening problem. The most likely explanation involves the detection of scattered FUV radiation by interstellar dust from early O/B stars. This mechanism is similar to reflection nebulae seen at longer wavelengths. To the author's knowledge, these observations represent the first reported detection of scattering by interstellar dust at these wavelengths. Further analysis of these and additional lines of sight are currently underway and will be reported elsewhere.

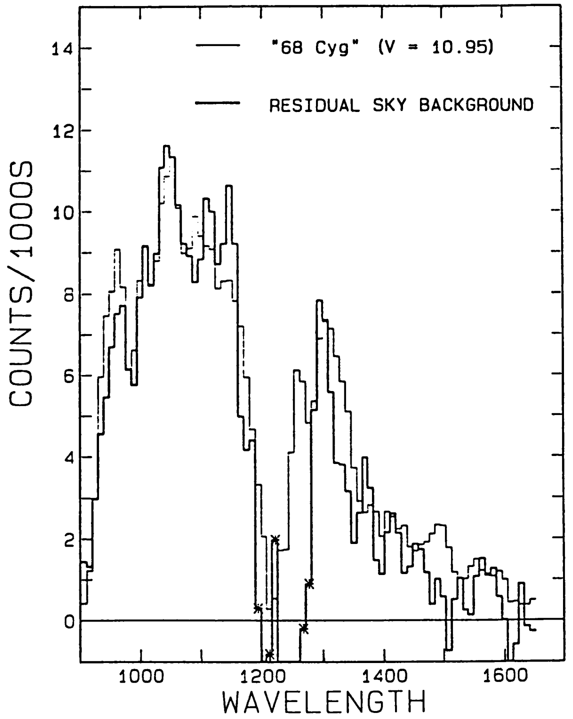

Figure 2. A comparison of the observed spectrum of the diffuse background present during the Ophiuchus drift with a Voyager 2 spectrum of 68 Cyg [O8, V = 5.00, E(B-V) = 0.32] uniformly attenuated by 5.95 magnitudes. The residual background spectrum is closely matched by that of a moderately reddened O star, but at an intensity equivalent to a single such star at 11th mag.

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