The Diffuse Extreme Ultraviolet Background

John Vallerga and Jonathan Slavin

Eureka Scientific Inc., 2452 Delmer St. Suite 100, Oakland, CA 94602-3017, USA

Abstract. Observations of the diffuse EUV background towards 138 different directions using the spectrometers aboard the Extreme Ultraviolet Explorer satellite (EUVE) have been combined into a spectrum from 150Å to 730Å and represent an effective exposure of 18 million seconds. There is no significant evidence for any line flux from any source other than the geocorona. These results are inconsistent with the Wisconsin C and B broad-band surveys assuming the source is a logT = 5.8 – 6.1 hot plasma in ionization equilibrium with solar abundances, confirming the previous result of Jelinsky, Vallerga & Edelstein (1995) (hereafter Paper I) using an observation along the ecliptic with the same instrument. To make these results consistent with the previous broad–band surveys, the plasma responsible for the emission must either be depleted in Fe by a factor of $\sim$ 6, be behind an absorbing slab of neutral H with a column of $2{\times}10^{19}$cm^{-2}, or not be in collisional ionization equilibrium (CIE). One particular non-CIE model (Breitschwerdt & Schmutzler, 1994) that explains the soft x-ray results is also inconsistent with this EUV data.

1 Why Investigate the Diffuse EUV Background?

If the local bubble is filled with a solar abundance hot plasma (log T = 6) in equilibrium, then its dominant cooling mechanism is line emission in the EUV, specifically the Fe line complex near 170–190Å (72–64 eV). If detected, this emission must be reasonably local, as one optical depth at 170Å corresponds to a neutral H column of 10^{19}cm^{-2}. Some non-CIE models of the Local Bubble, such as the adiabatic expansion of very hot ionized plasma (Breitschwerdt & Schmutzler, 1994) can reproduce similar soft x-ray broad band count rates but differ markedly with CIE models in the EUV, since the effective temperature of the electrons is only 40,000K. The EUV flux can therefore strongly constrain CIE and non-CIE models, as well as Fe abundances in the hot gas and local absorption effects.

Though not designed as a diffuse instrument, the spectrometers aboard EUVE have a small but finite area-solid angle product ($A\Omega$=.00005 cm^{-2}sr), especially at the wavelengths of the Fe VIII–X complex near 170Å where the emission from a million degree plasma is the strongest. The spectrometers observe this background in parallel with the point source observations of EUVE Guest Observers, resulting in a combined data set of 18 million seconds of effective exposure during the first two years of the EUVE mission.

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2 Data Reduction, Results and Discussion

Each of the 248 pointings of the EUVE spectrometers were reduced identically. The technique for converting the two dimensional spectral image into a one dimensional count rate spectrum with errors can be found in Paper I. A subsection of the combined spectrum of 18 million seconds exposure can be seen in Fig. 1. We have concentrated our attention on this spectral region for this paper as it is far from the He I and HeII geocoronal lines, is less affected by interstellar absorption than the longer wavelengths, and is most sensitive to a log T $\sim$ 6 plasma, purported to fill the Local Bubble.

The EUVE Medium (140Å– 380Å) and Long (280Å– 730Å) wavelength spectrometers both have a wire grid collimator to spectrally limit the geocoronal background flux, thus providing a triangular spectral signature to any diffuse monochromatic radiation. Intrinsic detector background was removed from this spectrum by determining the background under a filter support structure that shades the detector. An additional non-cosmic background is clearly present in the data which we model as a quadratic function of wavelength. Spectral models of the diffuse background were convolved through the collimator and telescope/detector response functions, added to a quadratic background and compared to the one dimensional count rate spectra.

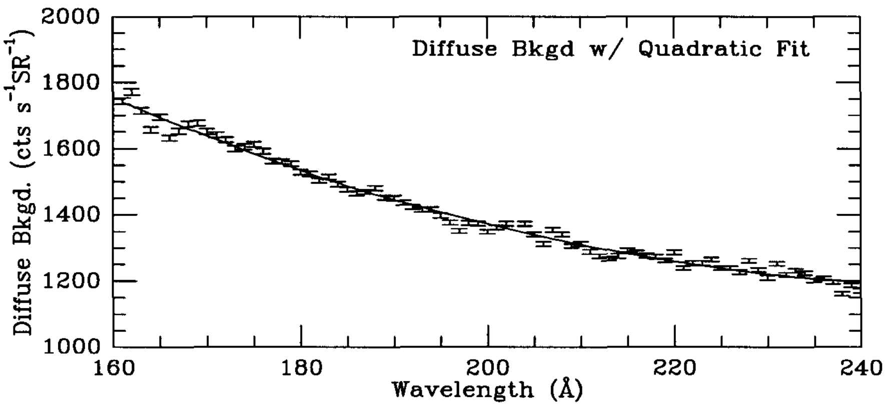

Fig. 1. The 18 million sec. spectrum of the diffuse EUV background between 160–240Å. The sloping continuum has been fit with a quadratic function. A monochromatic emission line would appear as a triangular enhancement with a FWHM of 17Å (bins).

To model the diffuse EUV flux from the Local Bubble, we have used a chi-squared fitting procedure using either a Raymond and Smith (R&S) thermal plasma code parameterized by temperature and emission measure (EM) or a single case of a Breitschwerdt & Schmutzler (B&S) non-CIE model with

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log T = 4.6 (electrons), log n_e = -1.6 and the flux linearly parameterized by distance through the emitting gas where a distance of 100 pc fits the soft x-ray results. In all cases we have assumed a foreground slab of neutral hydrogen with a column of 10^{18}cm^{-2}. We also let the three quadratic background parameters vary in each fit. Fig. 2 shows the predicted EUV spectra of each model folded through the instrumental response, as well as the residual of the measured spectrum after a simple quadratic fit has been subtracted. The model parameters were chosen to fit the average Wisconsin B band flux: an EM of .0036, Log T= 6.0 for the R&S model and 100 pc pathlength for the B&S model. Contrasting with the strong Fe emission lines of the CIE plasma codes, the B&S model is dominated by the HeII recombination continuum emission shortward of the edge at 228Å. Though the instrumental resolution is poor, it is evident that the parameters that fit the x-ray results for both models strongly overpredict the EUV flux. The formal fit to the EUVE data give an EM of .00057 ± .00014 cm^{-6} pc (log T = 6.0) for a R&S model and a pathlength of 21 ± 4.6 pc for the B&S model. Rather than claiming a marginal detection at this level, which requires a detailed understanding and quantification of our systematic errors, we quote a 2σ upper limit of EM =.00085 cm^{-6} pc for the R&S model or a maximum pathlength of 30 pc for this particular B&S model.

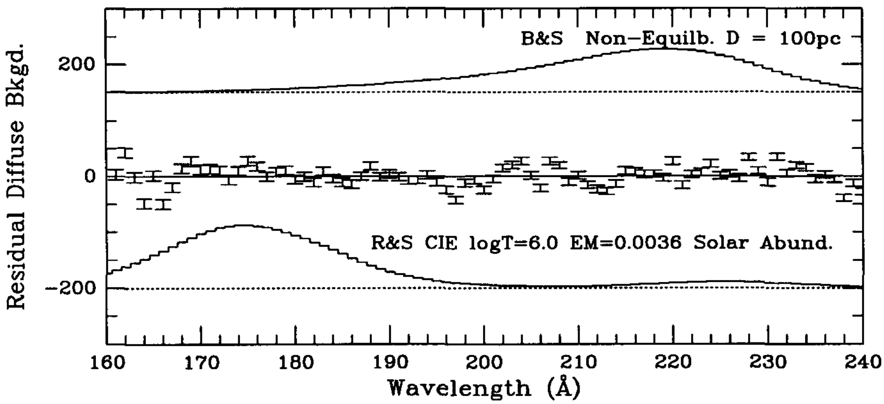

Fig. 2. A residual plot of the data shown in Fig. 1 after subtraction of the quadratic fit. Also shown (offset in Y) are two models with parameters that fit the Wisconsin soft x-ray results, both inconsistent with the residual spectrum.

When the 138 directions on the sky are analyzed separately and fit with a log T = 6.0 R&S model, none of the observations detect an EM greater than a 3 sigma confidence limit. However, there is a hint that the data favor flux from Fe lines rather than HeII recombination. If we separate the 138 directions by their B count rate, those above 75 counts s^{-1} have a weighted

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mean EM of .0011 ± .00032 while those directions with a count rate below 75 counts s^{-1} have a weighted mean of .00036 ± .00016, a significant difference indicating a correlation with the B band. Also, the four observations with the highest positive significance are in directions of a high B band count rate. For the non-CIE model of B&S, there was no correlation of the results with B band count rates.

The thermal plasma models used to explain the soft x-ray rocket and satellite data predict EUV flux assuming low absorbing column, solar abundances and equilibrium conditions and all three could be wrong. We chose to assume a low foreground column based on the knowledge that except in a few directions toward the galactic center, the neutral hydrogen column density measured is consistent with that in the Local Cloud of 1–2 $\times 10^{18}$cm^{-2}. To make the non-detection of EUV flux consistent with the C and B band soft x-rays using slab absorption requires a neutral column a factor of 10 higher, placing the emission beyond the local void, which is also inconsistent with the softer Be band results.

The DXS results (Sanders, this volume) detect diffuse emission in the 40Å–80Å range. However, no equilibrium models with or without elemental depletion fit the data well nor do non-equilibrium models tried to date. Our non-detection supports the view that solar abundance equilibrium models do not work, but also place a strong limit on the amount of Fe in the gas phase of a hot gas in equilibrium. A recent compilation of depletion measurements in neutral clouds towards many stars in the ISM indicate a minimum depletion of Fe of 0.5 dex, interpreted as either a component of dust grains are indestructible in the cloud environment or that the abundance of Fe in the local ISM is not solar (Fitzpatrick, 1996). The lack of Fe in emission implied by our results (0.78 dex to make the EUV derived EM limits consistent with the B band limits) would support either view. But the dust grains in this case are surviving a different environment of high T, low density sputtering.

The B&S models were the first to predict the observed absence of the strong EUV flux at the Fe line complex. Yet the one B&S model we tried overpredicts the longer wavelength HeII recombination continuum flux. We used that particular model to demonstrate the usefulness of the EUV band to differentiate between CIE and non-CIE models and to constrain both. Not much more can be gleaned from the EUVE data set – 18,000,000 seconds is probably the longest astronomical integration in history! What is needed is an instrument with a large solid angle–effective area product combined with spectral resolution to decouple the abundance and emission model effects.

References

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