IUE Calibration Progress Report

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This report summarizes the highlights of recent calibration work.

I. Wavelength Calibration

- Software Rehosting Status

The conversion of Sigma-9 wavecal software, as used in current IUESIPS production processing, to VAX MIDAS/FORTRAN format and testing of the high-dispersion wavecal processing software has been completed. Occasional discrepancies still exist between the individual dispersion constants for high-dispersion wavecal images, as derived by the VAX code, when compared with their Sigma-9 counterpart. These differences are rendered negligible, however, when the individual dispersion constants are averaged together to produce a set of mean dispersion constants. The line and sample positions, as determined from each set (Sigma-9 and VAX) of mean dispersion constants, differ by no more than one-tenth of a pixel. Both high- and low-dispersion wavecal images are now processed on the VAX computer and the master dispersion constant file is automatically updated. All remaining items that were pending from our previous reports have been successfully converted and the current processing backlog of wavecals has been eliminated. The master dispersion constant file has been analyzed and updated values for the mean dispersion constants and the time and temperature dependent coefficients have been generated.

- New Dispersion Relations for IUESIPS

The mean dispersion constants and correlation coefficients have been updated for current IUESIPS using data taken prior to August 1991. The last update to the dispersion relations, as used in production processing, was April 1988 at GSFC. The estimated error in wavelength assignments for 1991 data as a result of using the outdated coefficients can be summarized as follows. The SWP camera shows shifts of approximately 8.5 km s^{-1} along the spectral orders in high-dispersion and slightly less than one Å in low-dispersion. The errors along the orders in the LWR are around 3.5 km s^{-1} for high-dispersion and almost one and a half Å in low-dispersion. The errors in the LWP data are not noticeable as the time dependent variations are insignificant. Spectral motions perpendicular to the dispersion are of no consequence as they are compensated for during image processing.

II. Flux Calibration for the Final Archive

- **Observations.** Following the recommendation of the Final Archive Definition Committee and the recent Three-Agency agreement of using the white dwarf models as the basis of the Final Archive IUE flux calibration, we report that all the observations of white dwarfs and of the "traditional" flux calibration standard stars have been completed. A total of 199 low-dispersion spectra of 9 white dwarfs and 8 high-dispersion images of the 2 primary white dwarfs have been obtained at Goddard, using approximately 32 hours of US1 time and 100 hours of US2 time for these observations. In addition, 13 low-dispersion and 9 high-dispersion spectra have been obtained by VILSPA of the 2 primary white dwarfs. Lists with all the selected images of white dwarfs and flux calibration standards have been prepared and are awaiting to be re-processed with NEWSIPS in the next few months.

• **White Dwarf Models.** Model fluxes for the primary white dwarfs G191B2B, CD -38 10980, and PG 0549+158 have been delivered to the IUE project by David Finley of the University of California at Berkeley. These models are all assumed to be pure hydrogen, unstratified atmospheres. The model fluxes are each scaled to the flux at the Earth in erg cm^{-2} s^{-1} $Å^{-1}$. The wavelength spacing between each data point in the model fluxes is 0.2 Å near Lyα and about 16 Å in the flat regions of the spectra. The characteristics of the models are listed below:

Star	Temp (K)	log g	Scaling
G191B2B	58,000	7.5	V=11.85 spectrophotometry from Massey et al. (1988).
PG 0549+158	32,000	7.7	V=13.027±0.0033
CD -38 10980	24,000	8.2	V=10.993±0.015

• **Weak "Metallic" Features in White Dwarfs.** Several weak absorption features are present in the IUE spectra of G191B2B (Bruhweiler and Kondo, 1981, 1983) and in several other white dwarf as well. The low-ionization features of CII, NI, OI, MgII, SiII and FeII are thought to be interstellar in origin. Higher-ionization lines of CIV, NV and SiIV have also been detected in G191B2B and in other white dwarfs. Detailed calculations of the radiative levitation on C, N and O showed that they could be supported as trace elements in the hydrogen atmospheres (Vauclair et al. 1979). Several additional metallic lines such as FeV, OIV, OV and possibly FeVI, have been detected in the spectrum of G191B2B (Bruhweiler and Feibelman 1991) which are consistent with their formation in the photospheres of white dwarfs. The abundance of these trace elements are extremely low and are thus unlikely to affect the accuracy of the pure-hydrogen model calculation in the IUE wavelength regions, but are significant for the EUV and soft X-ray.

III. Second Order Light in the LWP Camera.

For some time there have been suspicions of the existence of second order light seen by the long-wavelength spectrograph at wavelengths longward of 3200 Å where the camera sensitivity drops substantially. The most convincing proof of the existence of this additional light in the LWP camera came through the discovery of archival cometary images where the second order Lyα (heavily saturated at 1215 Å) was clearly present at 2430 Å. This effect is particularly evident in series of LWP exposures of comet Bradfield (1979x) and properly identified by the Guest Observers as an instrumental artifact. Unfortunately, the well-exposed cometary observations cannot be used to obtain a proper scaling of this effect since there are serious uncertainties in the accuracy of the centering of the comets in the aperture. Efforts are underway to find a scaling scheme based on heavily saturated point-source exposures in the SWP wavelength range, either in the continuum or emission lines, and its appearance as second order light in the LWP wavelength range. It is evident that objects with stronger UV fluxes at short wavelengths should present the larger incidence of second order light in the LWP camera. In this category, the white dwarf stars, which have been chosen as the flux calibration standards for the IUE Final Archive, are certainly affected by this spectral artifact.

IV. Analysis of the Temperature Dependent Coefficient as a Function of Wavelength

IUE flux values can be corrected for variations in camera sensitivity as a function of THDA (Camera Head Amplifier Temperature) using the temperature dependent coefficients as derived from the sensitivity monitoring analysis. The temperature coefficients assume that the response of the camera to THDA is independent of wavelength. A test of this assumption was performed by deriving temperature coefficients for several wavelength bins and analyzing the results. The plotted data seem to indicate that there is little or no dependence of the temperature coefficients on wavelength for the LWP and LWR cameras, whereas the SWP shows a slight dependence. The calibration group recommends using, at least, a constant correction for the LWP and LWR cameras, while the SWP temperature coefficients could be represented by some sort of fit (linear, polynomial, *etc.*). Assuming a "worst case" scenario, where the camera temperature differs from the reference THDA by five degrees, the LWP fluxes would be in error by approximately one percent, the LWR by almost four and one-half percent, and the SWP by about two and one-half percent. We would like to generate fluxes with an internal accuracy of one to two percent for the IUE Final Archive. The corrections made by the temperature dependent coefficients are of the same order, so their inclusion is worthwhile.

V. FES Photometric Calibration

• **Old Reference Point (-16,-208).** Since this reference point was used from August 1, 1979 to January 22, 1990 at GSFC, and to July 23, 1990 at VILSPA, the data acquired at this location are considered a complete set. Efforts are underway to finalize a new color and photomultiplier dead-time corrections for this calibration. In addition, new sensitivity degradations, represented by third degree polynomials for both underlap and overlap modes, have been derived considering the focus dependence (0.022 $[\frac{\Delta FES\ counts}{focus\ step}]$), which accounts for much of the external scatter in FES data (Pérez et al. 1991).

•**New Reference Point (-144,-176).** The on-going 'FES anomaly' experienced after January 22, 1991, where additional background scattered light was detected in the FES mainly at high beta attitudes, has made useless the previous photometric calibration of this reference point. However, a recent test carried out on September 29, 1991 where overlap UBV standard stars were re-measured and compared with pre-anomaly FES data, confirmed that for stars with $V \geq 7$ a true value of the FES counts can be recovered by subtracting the counts seen by the FES when the object is in the large aperture (SWLA or LWLA). to the counts recorded at the reference point at the time of the acquisition. This can be expressed as,

$$Counts(true) = Counts(R.P. = OUT) - Counts(LGAP = IN), \qquad (1)$$

We note that both kind of counts are recorded in the GSFC scripts. The counts (IN) were similar within the incidental errors, to the counts measured at the four quadrants of the FES, hence, the former are an accurate measurement of the actual background. Additionally, there was no difference between the counts seen by the FES at the reference point or at the location of the large aperture when the star was in the aperture. For brighter stars ($V \leq 4$) the counts (IN) are heavily contaminated by stellar scattered light when the star is in the aperture. In these cases, the counts at the reference point with the star in the aperture represented a better estimate of the true background. Luckily, for these bright stars the background is relatively small that, in general, any correction is unnecessary.

References

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