Preliminary Comparison of the *HST* and White Dwarf Absolute Flux Scales [1]

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Summary

As part of an ongoing effort to develop a set of standard stars with accurate absolute spectrophotometry from 1050 to 10000Å, the FOS flux spectrum for G191B2B (WD0501+527) is divided by a model spectrum for the case of a pure hydrogen atmosphere to derive the difference between the current *HST* flux scale and the flux scale defined by the physics of model atmosphere calculations. Figure 1 and the Appendix specify the conversion function.

Discussion

G191B2B is one of four standard stars that are used to establish and routinely monitor FOS sensitivity . Figure 1 shows the ratio of the observed fluxes to the model for a) the FOS blue side, b) the FOS red side, and c) the composite reference spectrum of the *IUE* +Oke that resides in the STScI Calibration Data Base System (CDBS). These FOS spectra are from the high dispersion modes, which have a resolving power of ~1200. See Bohlin and Lindler (1992) for details of the pedigree of the CDBS reference spectra. The pure hydrogen model is for 60,000 K, log g = 7.5 and is normalized to m=1 1.79 mag at 5490Å, where m=0 corresponds to 3.61E-9 in F-lambda units (Finley , personal communication). The dots in the top three panels of Figure 1 a-c are the actual ratios of the observations/model in 10Å bins, while the heavy solid lines are spline fits to the ratios using 40 spline nodes. The bottom panel d) compares the adopted fit for the FOS blue side (heavy solid line) with the FOS red (dots) and the CDBS (dashed line).

The FOS spectra have been flux calibrated according to the prescription of Lindler and Bohlin (in prep), which will supersede the current pipeline procedure that is documented in Neill, Bohlin, and Hartig (1992). The main improvements in the new calibration procedure account for the changing sensitivity of FOS with time and for the OT A focus changes due to desorption (Lindler and Bohlin 1993). The agreement in Figure 1d to ~2 percent typically between the FOS blue and red side high dispersion fluxes in their overlap region longward of 1600Å is indicative of the internal consistency of the new flux calibration procedure. If the 4 coadded FOS blue side observations happened to be all low by a 2-3 sigma statistical scatter in the repeatability of FOS spectrophotometry , the systematic difference of ~4 percent between the FOS blue correction and the CDBS (i.e. *IUE*) correction in the 2000-

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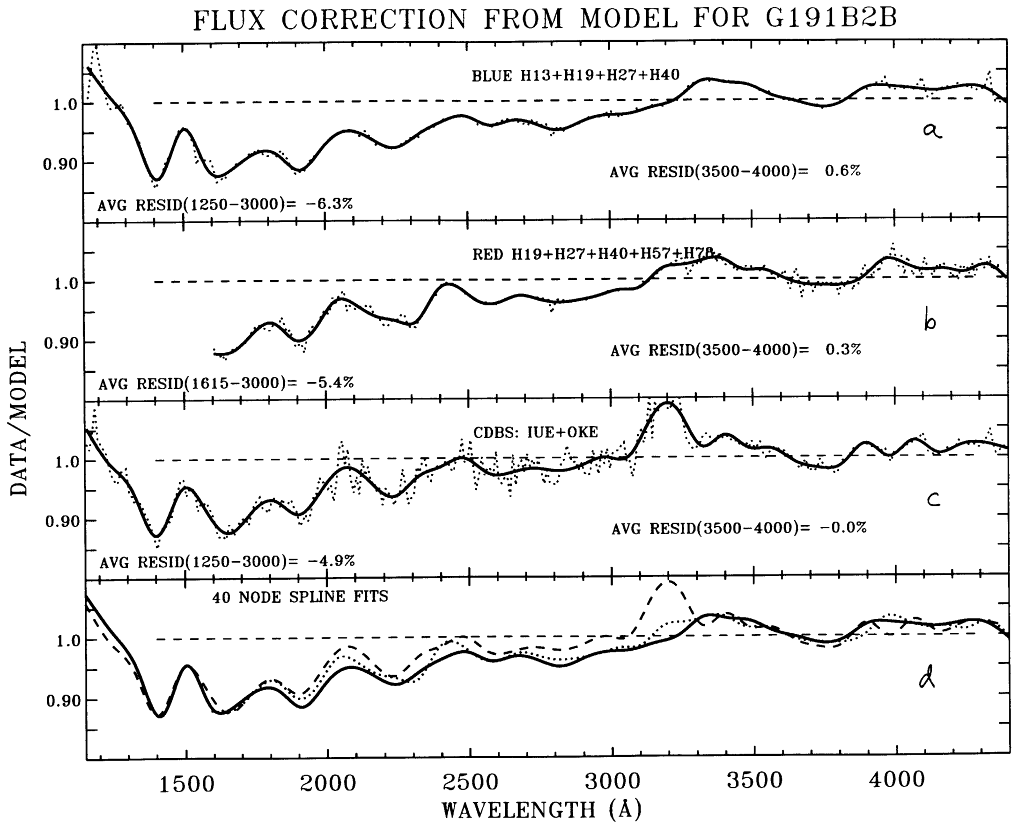

Figure 1: Montage shows the ratio of the observed fluxes to the model for a) the FOS blue side, b) the FOS red side, c) a composite *IUE* and Oke spectrum, and d) a comparison of the adopted fits.

3000Å region could be explained. Alternatively, our *IUE* reference spectrum of G191B2B (Bohlin et al. 1990) might be high by up to ~4 percent, since that flux level is defined by the sum of only 6 *IUE* long wavelength (LW) spectra. More study is need to resolve this small inconsistency.

The +10 percent bump in the CDBS correction at 3200Å is caused by a mismatch between the *IUE* and the Oke (1990) spectra. Since this region of the reference spectrum is ignored in the fitting process used to derive FOS calibrations, the residuals of the FOS fluxes with respect to the model are much less. However, the deviation of the FOS from the model at 3200-3500Å is probably due to the uncertainties of the Oke reference data. Longward of 3500Å, the residuals illustrate the current uncertainty level of ~3 percent in the data/model.

The preliminary conversion from the current *HST* flux scale to the WD flux scale is accomplished by dividing the current FOS fluxes by the function represented by the heavy solid line in the bottom panel of Figure 1. The Appendix is an IDL conversion procedure, which contains the table of the 40 spline nodes that define this conversion function.

Future Work

Without the complications of an intervening atmosphere, more accurate relative spectrophotometry should be possible with FOS than has been previously achieved over the wavelength range 1150-8500Å. Therefore, the goal of the analysis of the calibration data is to understand all uncertainties above the 1 percent level. Eventually, the adjustment of the *IUE-HST* absolute flux scale should probably be converted to the white dwarf flux standard. However, more FOS observations of white dwarfs with the purest hydrogen atmospheres are needed to derive the white dwarf based FOS calibration to greater precision. Additional work on the inclusion of metals in the model atmosphere calculations for G191B2B is needed, since Sion et al. (1992) have shown that absorption in metal lines is important at the ~2 percent level in some wavelength regions.

References

Bohlin, R. C., Harris, A. W., Holm, A., and Gry, C. 1990, Ap. J. Suppl., 73, 413.
Bohlin, R. C., & Lindler, D. J. 1992, Instrument Science Report CAL/SCS-001.
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Neill, J. D., Bohlin, R. C., & Hartig, G. 1992, FOS Instrument Science Report CAL/FOS-077.
Oke, J. B. 1990, Astron. J., 99, 1621.
Sion, E., Bohlin, R., Tweedy, R., and Vauclair, G. 1992, Ap. J. Lett., 391, L29.

Appendix

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FUNCTION FLXCOR,WAVE,FLX
;+
;
; PURPOSE:
;CORRECT UV FLUXES TO THE WD SCALE IN THE 1150-4400A RANGE. THESE
;PRELIMINARY CORRECTIONS ARE BASED ON FOS HI-DISP BLUE OBS AND
;FINLEY
;MODEL FOR G191B2B ONLY.  rcb
;
;calling sequence:
;CORRECTED_FLUX=FLXCOR(WAVE,FLX)
;
; input: WAVE-WAVELENGTH ARRAY OF FLUX VECTOR TO BE CORRECTED
; FLX-CORRESPONDING FLUX VECTOR TO BE CORRECTED
; output-THE FLX SPECTRUM CONVERTED TO THE WD STANDARD
; SPECTROPHOTOMETRY SCALE.
;
; HISTORY:
;93DEC8-RCB
;93DEC14-UPDATE SPLINE NODES
;-
; TABLE OF x spline nodes for g191b2b blue fos hi-disp
WFIT=[
$
1168.0,1250.8,1333.6,1416.5,1499.3,1582.1,1664.9,1747.7,1830.6,1913.4,$
1996.2,2079.0,2161.8,2244.7,2327.5,2410.3,2493.1,2575.9,2658.8,2741.6,$
2824.4,2907.2,2990.1,3072.9,3155.7,3238.5,3321.3,3404.2,3487.0,3569.8,$
3652.6,3735.4,3818.3,3901.1,3983.9,4066.7,4149.5,4232.4,4315.2,4398.0]

; TABLE OF y spline nodes for g191b2b blue fos hi-disp
CFIT=[
$
1.0616,1.0074,0.9473,0.8713,0.9547,0.8905,0.8843,0.9117,0.9121,0.8852,$
0.9250,0.9507,0.9369,0.9219,0.9443,0.9653,0.9745,0.9596,0.9675,0.9607,$
0.9507,0.9654,0.9754,0.9782,0.9893,1.0024,1.0322,1.0299,1.0255,1.0081,$
0.9979,0.9882,0.9954,1.0198,1.0222,1.0186,1.0157,1.0215,1.0200,1.    ]

GOOD=WHERE((WAVE GE 1150) AND (WAVE LE 4400))
CORRFLUX=FLX
CORRFLUX(GOOD)=FLX/CSPLINE(WFIT,CFIT,WAVE(GOOD))

RETURN,CORRFLUX
END
```

```
FUNCTION CSPLINE,XX,YY,TT
;+
;
;*NAME:CSPLINE
;
;*PURPOSE:
; function to evaluate a cubic spline at specified data points
;
;*CALLING SEQUENCE:
;result=cspline(x,y,t)
;
;*PARAMETERS:
; INPUTS:
;     x - vector of spline node positions
;     y - vector of node values
;     t - x-positions to evaluate the spline at
;
; OUTPUT:
;the values for positions t are returned as the function value
;
;METHOD:
;NUMERICAL RECIPES - natural cubic spline is used.
;
;HISTORY:
;version 1  D. Lindler May, 1989
;       Mar 16 1991      JKF/ACC    - forced doubleword to avoid
;                                     integer overflow errors.
;version 2  D. Lindler  Dec, 1991- moved to IDL V2.
;version 3 JKF/ACC      28-jan-1992 - handle not found case of WHERE
;-
;-------------------------------------------------------------------;
 x= double(xx)
 y= double(yy)
 t= double(tt)

 n=n_elements(x)
 y2=dblarr(n)     ;vector of 2nd derivatives at nodes in xtab
 u=dblarr(n)
;
; decomposition loop of tridiagonal algorithm
;
 for i=1,n-2 do begin
            sig=(x(i)-x(i-1))/(x(i+1)-x(i-1))
            p=sig*y2(i-1)+2.
            y2(i)=(sig-1.0)/p
            u(i)=(6.0*((y(i+1)-y(i))/(x(i+1)-x(i))-(y(i)-y(i-1))/$
                  (x(i)-x(i-1)))/(x(i+1)-x(i-1))-sig*u(i-1))/p
 end
;
; backsubstitution
;
 for i=n-2,0,-1 do y2(i)=y2(i)*y2(i+1)+u(i)
;
; find locations of t in xtab using bisection
```

```
;
 m=n_elements(t)
 klo=lonarr(m)
 khi=replicate(n-1,m)
 bisect:
      not_done=((khi-klo) gt 1)
      if max(not_done) gt 0 then begin
            k=(khi+klo)/2
            higher=x(k) gt t
            sub=where(not_done and higher, sub_found)
            if sub_found gt 0 then khi(sub)=k(sub)
            sub=where(not_done and (not higher), sub_found)
            if sub_found gt 0 then klo(sub)=k(sub)
            goto,bisect
      endif
;
; x(klo) and x(khi) now bracket t
;
 xhi=x(khi)
 xlo=x(klo)
 h=xhi-xlo
 a=(xhi-t)/h
 b=(t-xlo)/h
return,a*y(klo)+b*y(khi)+((a^3-a)*y2(klo)+(b^3-b)*y2(khi))*(h^2)/6.0
 end
```