Spectroscopic Point Spread Functions for Centered and Offset Targets

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As seen in Figure 1, course sampling by pixels and charge diffusion on the detector can obscure the source of the difference between the spectroscopic PSFs. Figure 2 shows that the source of the difference in the modelling is an expansion of the PSF by the Lyot stop, rather than an increase in the flux in the first Airy ring relative to the flux in the Airy disk. A single annulus of flux as a function of distance from the center was computed for the X and Y quadrants of the model imaging PSF. The resulting flux profiles for the models with and without the Lyot stop are shown in the upper panel of the figure. In the lower panel, the model with the Lyot stop has been expanded credibility by 10%, and the total flux has been conserved. The profiles for the expanded model are seen to be a good match to the profiles for the model with the Lyot stop.

The S20X1 and S20X2 slits were frequently used in perpendicular-to-slit stepping patterns for the purpose of mapping the spatial distribution and kinematics of extended sources. To assess the accuracy of the Tiny Tim modelling used in the analysis of such data, observations of HD74371 with grating G750L were obtained in STIS calibration program 98-10. The S20X slit was stepped in a perpendicular-to-slit pattern of five 0.1 arcsec steps along the slit, near the readout end of the CCD to reduce CTI losses. For each slit position, a spectrum was obtained along the 3.5-A. pixel height. Since there is no constraint on the y positioning of the spectrum within a pixel, the fractional pixel drops in the trace are visible and can be used to produce a finely sampled monochromatic image of the slits. A band of many columns can be used to sample the slit profile.

For gratings with a spectral range that drops by several nm as it crosses the detector, a single spectral image is sufficient to produce a finely sampled PSF. The fractional pixel drops in the trace from one column on the slit to the next in X or Y can be treated as a series of small shifts. The observed PSF is produced by normalizing out the stellar spectrum and centering the flux profile in each column on the trace. For the STIS-I, a band of many columns can be used to sample the PSF because it does not measurably change across the short span of wavelengths. A spectral image of the star BBD+70013 taken with the S22X2 aperture was used to produce the G750M PSF at 6000 Angstroms.

Two techniques can be used to produce finely sampled observational spectroscopic PSFs: depend- ence.

1. For gratings with a spectral range that drops more rapidly than the detector, a single spectral image is sufficient to produce a finely sampled PSF. The fractional pixel drops in the trace from one column on the slit to the next in X or Y can be treated as a series of small shifts. The observed PSF is produced by normalizing out the stellar spectrum and centering the flux profile in each column on the trace. For the STIS-I, a band of many columns can be used to sample the PSF because it does not measurably change across the short span of wavelengths. A spectral image of the star BBD+70013 taken with the S22X2 aperture was used to produce the G750M PSF at 6000 Angstroms.

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A comparison of the observed S22X0.1 6600 Angstrom PSF for the G750L without Lyot stop (G750L) and S20X1 (Lyot stop is on) shows in Figure 2. The profiles expected from Tiny Tim modelling are also shown. For each slit position, a spectrum was obtained along the 3.5-A. pixel height. Since there is no constraint on the y positioning of the spectrum within a pixel, the fractional pixel drops in the trace are visible and can be used to produce a finely sampled monochromatic image of the slits. A band of many columns can be used to sample the slit profile.

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Figure 1: Spectroscopic PSF at 6000 Angstroms for the S22X1.4 slit before blocking the subpixels into pixels (top panel), after the blocking (bottom panel), and after applying charge diffusion (bottom panel).

Figure 2: Modelled 6600 Angstrom PSF (top panel), data derived PSF for S22X0.1 and G750L (left), G750M (right). The PSF at S22X0.1 aperture is well measured (solid line), and the PSF at G750L (squares) for the 52X0.1 aperture (left) and the 52X0.1E1 aperture (right) centered on the 52X0.1 aperture. The trefoil structure in the first Airy ring is caused by the three support pads on the HTS primary mirror.

Figure 3: Upper panel: Profiles of annular averages of the X and Y quadrants of the model imaging PSF. The profiles expected from Tiny Tim modelling are also shown. Lower panel. Same as upper panel except that the unstopped PSF has been expanded by 10% with kernels (with the observed fluxes for the Lyot-stopped PSF (solid lines) and unstopped PSF (dashed lines). The fluxes are somewhat lower than predicted in the brighter segment of the Airy ring. They are greater than predicted in the faintest wings of the PSF, due to the halo of scattered light not included in the Tiny Tim modelling.

Figure 4: Modelled 6600 Angstrom PSF (top), spectral image of the 52X0.1 slit (middle), modelled and observed PSFs (bottom). The PSF at 52X0.1 aperture is well measured (solid line), and the PSF at G750L (squares) for the 52X0.1 and G750L (right). The PSF at S20X1 (Lyot stop is on) shows in Figure 2. The profiles expected from Tiny Tim modelling are also shown. For each slit position, a spectrum was obtained along the 3.5-A. pixel height. Since there is no constraint on the y positioning of the spectrum within a pixel, the fractional pixel drops in the trace are visible and can be used to produce a finely sampled monochromatic image of the slits. A band of many columns can be used to sample the slit profile.

CONCLUSIONS

I have compared Tiny Tim model predictions and G750L flux profiles at 6600 Angstroms for a star centered in a slit (S20X1, S20X1E1, S20X2, or S20X2E1) and moved out of the slit by one or two slit widths. The model under-predicts the flux in the centered slit at distances greater than 0.2 arcsec from the slit center, which is consistent with the combined effects of broadening of flux in a spectral image, undersampling by pixels, and charge diffusion on the CCD. The flux profiles for the Lyot-stopped PSF (squares) centered on the 52X0.1 slit. Tiny Tim modelling reproduces the observed spectroscopic PSF well for both gratings. A confirmed treatment of the effect of the Lyot stop means that the models predict the effect of the Lyot stop in a consistent way.

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REFERENCES


Figure 5: Observed flux along the central slit and the PSF model prediction for the S20X1 slit. The left column of plots shows the S20X1 observations (centered on the air-cooled CCD) compared to a flux-matched PSF model, with and without the Lyot stop (Lyot stop is the model with Lyot stop). The resulting fluxes for the models with and without the Lyot stop are shown in the upper panel of the figure. In the lower panel, the model with the Lyot stop has been expanded credibility by 10%, and the total flux has been conserved. The profiles for the expanded model are seen to be a good match to the profiles for the model with the Lyot stop.

Figure 6: Observed flux along the central slit and the PSF model prediction for the S20X1 slit. The left column of plots shows the S20X1 observations (centered on the air-cooled CCD) compared to a flux-matched PSF model, with and without the Lyot stop (Lyot stop is the model with Lyot stop). The resulting fluxes for the models with and without the Lyot stop are shown in the upper panel of the figure. In the lower panel, the model with the Lyot stop has been expanded credibility by 10%, and the total flux has been conserved. The profiles for the expanded model are seen to be a good match to the profiles for the model with the Lyot stop.

Figure 7: Observed spectroscopic PSF for the 52X0.1E1 aperture (left) and modelled PSF (squares) for the 52X0.1E1 aperture (right).