CLEAR APERTURE FRACTIONAL TRANSMISSION FOR POINT SOURCES

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ABSTRACT

The fractional transmission as a function of wavelength for stellar objects is measured for clear apertures by comparing count rates through small apertures to open aperture count rates in STIS first order modes. Because OTA "breathing" causes the throughput of the smallest apertures to vary on short time scales, the best estimate of the aperture throughputs is a theoretical model that is based on PSFs generated by optical modeling software. The photometric repeatability of the slit transmissions improves with increasing aperture size from 12% rms for the 52x0.05 arcsec aperture to 2.7% rms for the 52x0.5 slit to 1.3% rms for the 52x2 slit. Even for the 52x2 slit, the full range of this scatter is seen within one orbit for observations of the same star. The photometric repeatability of shorter echelle slits is probably comparable to the uncertainty in a long slit of similar width.

1. Introduction

The transmission of each STIS slit is required to estimate the stellar flux for point source observations. To date, the pipeline reduction has utilized pre-launch estimates of these aperture throughputs that are based on PSF models produced by G. Hartig using the TIM algorithms of Hasan and Burrows (1995), along with microscope measurements of the aperture sizes. On-orbit measurements of the relative count rates for the same star through small vs. open apertures revealed deficiencies in the models. First, the slope of the measured small aperture transmissions in the far-UV was not as steep as the original predictions. Second, the predicted throughputs were generally too low. Following corrections for these problems, the revised model throughputs agree with the data within the stability of the OTA PSF and are recommended for use in pipeline STIS data reduction. Exceptions

are the three CCD low dispersion modes with Lyot stops, where the transmission of the small apertures with respect to large apertures can be up to 10% higher than our models.

Section 2 describes the observations and compares the measurements to models of the slit transmission. Section 3 describes the original TIM models and the modifications required to match the slope and the value of the measurements in the far-UV. Section 4 quantifies the uncertainty in the adopted transmissions. Section 5 summarizes the results in terms of recommendations and cautions for the observer, while section 6 explains the changes in pipeline fluxes after implementation of the new transmissions.

2. Observations and Transmission Measurements

Table 1 lists the stellar observations that are useful for measuring point source transmissions. Some additional data obtained for this purpose are underexposed and too noisy to extract a reliable signal in the 600 pixel extraction height that includes the wings of the PSF and defines the total signal through each aperture (cf. Bohlin 1998a).

Rootname	Mode	Cenwave	Aperture	Target	Date	Time	Propid	expt(s)
03ZKA8ZPN	G140L		0.1X0.09	BPM16274	26/06/97	11:22:38	7076	150.0
O48X01010	G140L		0.2X0.06	GRW+70D5824	31/10/97	19:12:39	7721	300.0
O48X01020	G140L		0.2X0.09	GRW+70D5824	31/10/97	19:20:42	7721	200.0
O4SP01030	G140L		0.2X0.2	GD71	27/04/98	05:14:19	7932	235.0
O3ZKA4HSM	G140L		25MAMA	BPM16274	20/05/97	08:00:55	7076	50.0
O4DD06020	G140L		25MAMA	GD71	30/11/97	11:05:37	7657	120.0
O4SP01070	G140L		25MAMA	GD71	27/04/98	06:20:07	7932	108.0
O4SP01010	G140L		52X0.05	GD71	27/04/98	04:59:44	7932	315.0
O48X01030	G140L		52X0.05	GRW+70D5824	31/10/97	19:26:43	7721	250.0
O4SP01020	G140L		52X0.1	GD71	27/04/98	05:07:43	7932	235.0
O48X01040	G140L		52X0.1	GRW+70D5824	31/10/97	19:33:37	7721	150.0
O4SP01040	G140L		52X0.2	GD71	27/04/98	05:20:59	7932	180.0
O48X01050	G140L		52X0.2	GRW+70D5824	31/10/97	19:38:51	7721	100.0
O4SP01050	G140L		52X0.5	GD71	27/04/98	05:27:17	7932	135.0
O48X01060	G140L		52X0.5	GRW+70D5824	31/10/97	20:33:15	7721	100.0
O4PG01N1Q	G140L		52X2	GD71	31/03/98	15:58:37	7917	96.0

Table 1: Observations

Rootname	Mode	Cenwave	Aperture	Target	Date	Time	Propid	expt(s)
O4PG01N9Q	G140L		52X2	GD71	31/03/98	16:07:32	7917	108.0
O4PG01NDQ	G140L		52X2	GD71	31/03/98	16:16:39	7917	108.0
O4PG01NHQ	G140L		52X2	GD71	31/03/98	17:06:45	7917	108.0
O4PG01NPQ	G140L		52X2	GD71	31/03/98	17:15:52	7917	108.0
O4SP01060	G140L		52X2	GD71	27/04/98	06:15:01	7932	108.0
O3YX14HSM	G140L		52X2	GRW+70D5824	21/06/97	11:08:56	7064	240.0
O3YX15QEM	G140L		52X2	GRW+70D5824	29/06/97	06:08:42	7064	240.0
O3YX16KLM	G140L		52X2	GRW+70D5824	05/07/97	06:40:03	7064	240.0
O45901010	G140L		52X2	GRW+70D5824	12/08/97	09:18:10	7673	180.0
O45910010	G140L		52X2	GRW+70D5824	16/09/97	21:11:23	7673	180.0
O45911010	G140L		52X2	GRW+70D5824	06/10/97	13:36:39	7673	180.0
O48X01070	G140L		52X2	GRW+70D5824	31/10/97	20:37:57	7721	60.0
O45912010	G140L		52X2	GRW+70D5824	17/11/97	17:23:40	7673	180.0
O45913010	G140L		52X2	GRW+70D5824	19/12/97	23:54:46	7673	180.0
O45914010	G140L		52X2	GRW+70D5824	09/01/98	15:03:40	7673	216.0
O45915010	G140L		52X2	GRW+70D5824	12/02/98	14:55:32	7673	189.0
O45917010	G140L		52X2	GRW+70D5824	12/04/98	17:57:12	7673	204.0
O45940010	G140L		52X2	GRW+70D5824	07/05/98	02:51:18	7673	204.0
O45942010	G140L		52X2	GRW+70D5824	04/07/98	18:54:31	7673	204.0
O3ZKA8ZRN	G230L		0.1X0.09	BPM16274	26/06/97	11:29:41	7076	100.0
O48X01080	G230L		0.2X0.06	GRW+70D5824	31/10/97	20:46:28	7721	350.0
O48X01090	G230L		0.2X0.09	GRW+70D5824	31/10/97	20:55:20	7721	300.0
O3ZKA8ZTN	G230L		25MAMA	BPM16274	26/06/97	11:34:18	7076	50.0
O4DD07020	G230L		25MAMA	GD71	30/11/97	06:15:45	7657	120.0
O4PG01NYQ	G230L		52X0.05	GD71	31/03/98	17:37:45	7917	216.0
O4PG01O2Q	G230L		52X0.05	GD71	31/03/98	17:47:20	7917	216.0
O4PG01O6Q	G230L		52X0.05	GD71	31/03/98	18:42:54	7917	216.0
O4PG01OAQ	G230L		52X0.05	GD71	31/03/98	18:52:29	7917	216.0
O48X010A0	G230L		52X0.05	GRW+70D5824	31/10/97	22:05:07	7721	350.0
O48X010B0	G230L		52X0.1	GRW+70D5824	31/10/97	22:14:01	7721	150.0

Rootname	Mode	Cenwave	Aperture	Target	Date	Time	Propid	expt(s)
O48X010C0	G230L		52X0.2	GRW+70D5824	31/10/97	22:19:15	7721	150.0
O48X010D0	G230L		52X0.5	GRW+70D5824	31/10/97	22:25:03	7721	150.0
O4PG01NTQ	G230L		52X2	GD71	31/03/98	17:27:20	7917	216.0
O3YX11P2M	G230L		52X2	GRW+70D5824	29/05/97	22:52:54	7064	636.0
O3YX12UTM	G230L		52X2	GRW+70D5824	06/06/97	00:10:39	7064	636.0
O3YX13TQM	G230L		52X2	GRW+70D5824	13/06/97	21:11:18	7064	636.0
O3YX16KPM	G230L		52X2	GRW+70D5824	05/07/97	06:53:00	7064	636.0
O45901020	G230L		52X2	GRW+70D5824	12/08/97	10:14:48	7673	184.0
O45910020	G230L		52X2	GRW+70D5824	16/09/97	21:21:49	7673	184.0
O45911020	G230L		52X2	GRW+70D5824	06/10/97	13:47:05	7673	184.0
O48X010E0	G230L		52X2	GRW+70D5824	31/10/97	22:30:15	7721	150.0
O45912020	G230L		52X2	GRW+70D5824	17/11/97	17:34:06	7673	184.0
O45913020	G230L		52X2	GRW+70D5824	20/12/97	00:05:12	7673	184.0
O45914020	G230L		52X2	GRW+70D5824	09/01/98	15:14:20	7673	216.0
O45915020	G230L		52X2	GRW+70D5824	12/02/98	15:05:45	7673	216.0
O45917020	G230L		52X2	GRW+70D5824	12/04/98	18:07:40	7673	204.0
O45940020	G230L		52X2	GRW+70D5824	07/05/98	03:01:46	7673	204.0
O45942020	G230L		52X2	GRW+70D5824	04/07/98	19:04:50	7673	204.0
O4D101010	G230LB		52X2	G191B2B	18/10/97	18:27:14	7805	150.0
O4D102010	G230LB		52X2	G191B2B	22/11/97	19:10:38	7805	150.0
O3TT42010	G230LB		52X2	GD153	21/05/97	10:18:00	7063	600.0
O3TT43010	G230LB		52X2	GD153	28/05/97	06:53:29	7063	600.0
O3TT44010	G230LB		52X2	GD153	04/06/97	11:28:46	7063	600.0
O3TT45010	G230LB		52X2	GD153	10/06/97	22:22:09	7063	600.0
O3TT46010	G230LB		52X2	GD153	18/06/97	04:24:17	7063	600.0
O3TT47010	G230LB		52X2	GD153	25/06/97	04:11:40	7063	600.0
O3TT48010	G230LB		52X2	GD153	01/07/97	12:03:44	7063	600.0
O3TT02020	G230LB		6X6	G191B2B	09/03/97	20:39:28	7063	144.0
O3TT03020	G230LB		6X6	G191B2B	16/03/97	04:15:26	7063	144.0
O3TT04020	G230LB		6X6	G191B2B	21/03/97	01:54:58	7063	144.0

Rootname	Mode	Cenwave	Aperture	Target	Date	Time	Propid	expt(s)
O3TT20020	G230LB		6X6	GD153	28/03/97	20:24:33	7063	600.0
O3TT21020	G230LB		6X6	GD153	04/04/97	12:06:16	7063	600.0
O3TT23020	G230LB		6X6	GD153	17/04/97	13:07:10	7063	600.0
O4SP03030	G430L		0.2X0.2	GRW+70D5824	21/05/98	13:21:16	7932	260.0
O4SP03070	G430L		50CCD	GRW+70D5824	21/05/98	13:43:33	7932	144.0
O40801090	G430L		52X0.05	FEIGE110	13/06/97	18:29:51	7100	192.0
O4SP03010	G430L		52X0.05	GRW+70D5824	21/05/98	13:06:59	7932	350.0
O40801070	G430L		52X0.1	FEIGE110	13/06/97	17:14:25	7100	120.0
O4SP03020	G430L		52X0.1	GRW+70D5824	21/05/98	13:14:49	7932	260.0
O40801050	G430L		52X0.2	FEIGE110	13/06/97	16:52:24	7100	72.0
O4SP03040	G430L		52X0.2	GRW+70D5824	21/05/98	13:27:47	7932	221.0
O40801030	G430L		52X0.5	FEIGE110	13/06/97	15:46:04	7100	72.0
O4SP03050	G430L		52X0.5	GRW+70D5824	21/05/98	13:34:02	7932	180.0
O40801010	G430L		52X2	FEIGE110	13/06/97	15:23:47	7100	72.0
O4D101020	G430L		52X2	G191B2B	18/10/97	18:35:59	7805	150.0
O4D102020	G430L		52X2	G191B2B	22/11/97	19:19:23	7805	150.0
O3TT42020	G430L		52X2	GD153	21/05/97	10:34:18	7063	252.0
O3TT43020	G430L		52X2	GD153	28/05/97	07:09:44	7063	252.0
O3TT44020	G430L		52X2	GD153	04/06/97	11:45:01	7063	252.0
O3TT45020	G430L		52X2	GD153	10/06/97	22:38:24	7063	252.0
O3TT46020	G430L		52X2	GD153	18/06/97	04:40:32	7063	252.0
O3TT47020	G430L		52X2	GD153	25/06/97	04:27:55	7063	252.0
O3TT48020	G430L		52X2	GD153	01/07/97	12:19:59	7063	252.0
O4SP03060	G430L		52X2	GRW+70D5824	21/05/98	13:39:00	7932	144.0
O3TT02030	G430L		6X6	G191B2B	09/03/97	20:47:56	7063	144.0
O3TT03030	G430L		6X6	G191B2B	16/03/97	04:23:54	7063	144.0
O3TT04030	G430L		6X6	G191B2B	21/03/97	02:03:26	7063	144.0
O3TT20030	G430L		6X6	GD153	28/03/97	20:40:37	7063	252.0
O3TT21030	G430L		6X6	GD153	04/04/97	12:22:20	7063	252.0
O3TT23030	G430L		6X6	GD153	17/04/97	13:23:14	7063	252.0

Rootname	Mode	Cenwave	Aperture	Target	Date	Time	Propid	expt(s)
O4SP030A0	G430M	4451	0.2X0.2	GRW+70D5824	21/05/98	16:21:06	7932	1512.0
O4SP030E0	G430M	4451	50CCD	GRW+70D5824	21/05/98	18:22:45	7932	631.0
O4SP03080	G430M	4451	52X0.05	GRW+70D5824	21/05/98	14:40:01	7932	1800.0
O4SP03090	G430M	4451	52X0.1	GRW+70D5824	21/05/98	15:12:01	7932	1380.0
O4SP030B0	G430M	4451	52X0.2	GRW+70D5824	21/05/98	16:48:29	7932	1188.0
O4SP030C0	G430M	4451	52X0.5	GRW+70D5824	21/05/98	17:54:38	7932	810.0
O4SP030D0	G430M	4451	52X2	GRW+70D5824	21/05/98	18:10:06	7932	630.0
O4SP04030	G750L		0.2X0.2	HD101998	20/04/98	15:47:45	7932	14.4
O4SP04070	G750L		50CCD	HD101998	20/04/98	17:00:04	7932	4.8
O408010A0	G750L		52X0.05	FEIGE110	13/06/97	18:38:22	7100	240.0
O4SP04010	G750L		52X0.05	HD101998	20/04/98	15:36:17	7932	18.8
O40801080	G750L		52X0.1	FEIGE110	13/06/97	17:21:08	7100	168.0
O4SP04020	G750L		52X0.1	HD101998	20/04/98	15:42:15	7932	14.4
O40801060	G750L		52X0.2	FEIGE110	13/06/97	16:58:19	7100	120.0
O4SP04040	G750L		52X0.2	HD101998	20/04/98	15:53:19	7932	12.0
O40801040	G750L		52X0.5	FEIGE110	13/06/97	15:51:59	7100	120.0
O4SP04050	G750L		52X0.5	HD101998	20/04/98	16:49:13	7932	9.2
O40801020	G750L		52X2	FEIGE110	13/06/97	15:31:14	7100	120.0
O4D101030	G750L		52X2	G191B2B	18/10/97	18:44:44	7805	1020.0
O4D102030	G750L		52X2	G191B2B	22/11/97	19:28:08	7805	1020.0
O3TT43040	G750L		52X2	GD153	28/05/97	08:04:35	7063	3240.0
O3TT44040	G750L		52X2	GD153	04/06/97	12:41:08	7063	3240.0
O3TT45040	G750L		52X2	GD153	10/06/97	23:33:17	7063	3240.0
O3TT46040	G750L		52X2	GD153	18/06/97	05:46:23	7063	2282.0
O3TT47040	G750L		52X2	GD153	25/06/97	05:31:49	7063	2282.0
O3TT48040	G750L		52X2	GD153	01/07/97	13:11:51	7063	2282.0
O4SP04060	G750L		52X2	HD101998	20/04/98	16:54:40	7932	6.0
O3TT02040	G750L		6X6	G191B2B	09/03/97	20:59:20	7063	792.0
O3TT03040	G750L		6X6	G191B2B	16/03/97	04:35:18	7063	792.0
O3TT04040	G750L		6X6	G191B2B	21/03/97	02:14:50	7063	792.0

Rootname	Mode	Cenwave	Aperture	Target	Date	Time	Propid	expt(s)
O3TT20040	G750L		6X6	GD153	28/03/97	21:51:30	7063	3240.0
O3TT21040	G750L		6X6	GD153	04/04/97	13:22:51	7063	3240.0
O3TT23040	G750L		6X6	GD153	17/04/97	14:21:17	7063	3240.0
O48X02060	G750M	5734	52X0.05	FEIGE110	26/10/97	07:27:21	7721	68.0
O48X02060	G750M	5734	52X0.05	FEIGE110	26/10/97	07:27:21	7721	68.0
O48X02050	G750M	5734	52X0.1	FEIGE110	26/10/97	07:24:39	7721	42.0
O48X02050	G750M	5734	52X0.1	FEIGE110	26/10/97	07:24:39	7721	42.0
O48X02040	G750M	5734	52X2	FEIGE110	26/10/97	07:21:33	7721	28.0
O4SP040B0	G750M	8561	0.2X0.2	HD101998	20/04/98	18:38:15	7932	120.0
O4SP040F0	G750M	8561	50CCD	HD101998	20/04/98	19:05:12	7932	48.0
O4SP040H0	G750M	8561	50CCD	HD101998	20/04/98	20:13:55	7932	48.0
O4SP04090	G750M	8561	52X0.05	HD101998	20/04/98	17:24:34	7932	136.5
O4SP040A0	G750M	8561	52X0.1	HD101998	20/04/98	18:31:06	7932	115.0
O4SP040C0	G750M	8561	52X0.2	HD101998	20/04/98	18:43:54	7932	90.0
O4SP040D0	G750M	8561	52X0.5	HD101998	20/04/98	18:52:13	7932	60.0
O4SP040E0	G750M	8561	52X2	HD101998	20/04/98	18:59:08	7932	48.0

Table 1: Observations

Figure 1 is the comparison of the wide 52x2 arcsec slit with the open 25Mama, 50CCD, and 6x6 apertures. Only ~1-2% of the PSF is cut off by the 2 arcsec width, so that the small transmission correction from a 52x2 slit to an open aperture is accurate to ~1% and does not significantly increase the uncertainty when a 52x2 observation is used as the comparison aperture for the smaller sizes. The circles are low dispersion observations, while the first order medium dispersion data are plotted as triangles. The diamonds are the models of the transmission, as defined in the Figure caption and described in detail in section 3.

Figures 2-9 are the transmissions of eight small clear apertures, as derived from the ratio of the small aperture count rate to the open 25Mama, 50CCD, 6x6, or to a 52x2 aperture spectrum corrected to an open aperture by the theoretical adopted transmission for the 52x2, i.e. the diamonds in Figure 1. Any additional uncertainty in small aperture transmissions caused by using a corrected 52x2 reference spectrum instead of a larger open aperture is less than 1%.

3. PSF Modeling

The aperture transmissions that are based on the microscope measurements at Ball Aerospace and Technologies Company (Coffelt 1995) along with the TIM PSF models are the tiny diamonds in Figures 1-9. These diamonds deviate consistently from the measurements for the smallest apertures in the slope of the UV transmission, which suggests that the amount of scattering in this original model is too severe, especially for the apertures of Figures 2-4 and 7.

The new STIS aperture plane PSFs are simulated using a suite of routines written in IDL; and the relative aperture throughputs are computed with APTHRUS_NEW.PRO (Hartig, unpublished). This simulation differs from the TIM modeling chiefly in the omission of dust scattering and the adoption of a scaled map of the OTA low spatial frequency errors. Dust scattering has the effect of redistributing a portion of the flux to very large angles outside of the area of the largest STIS aperture used in these analyses and, hence, has no substantial effect on the relative aperture throughput values. The mirror maps (Krist 1994, private comm., as determined by C. Burrows and J. Krist using phase retrieval analysis of WFPC2 images) yield a more accurate PSF for HST images than can be produced with an aberration model parameterized only with low order Zernike polynomials. However, the Krist phase map must be scaled by 0.85 in order to match the measured STIS aperture throughput values in the far-UV, where the predicted transmission is most sensitive to the phase errors. In particular, the value of 0.85 is the minimum change from unity required to keep all the measured far-UV transmissions below the model predictions. No additional aberrations are required to fit the measurements. While this modeling indicates that the STIS corrector system is properly correcting the OTA aberrations, the "better than perfect" reduction of the phase errors by 15% remains unexplained.

The modeled transmissions assume a perfectly focused and perfectly centered stellar image. Because of OTA breathing and shrinkage, actual transmission measurements of small aperture transmission are often less than the predictions of the model; but a measured transmission cannot exceed the properly modeled representation of the ideal case. There are not enough transmission observations of most of the apertures to define an upper envelope, which should approach the predictions of our model. One exception is the 52x0.05 aperture, where the average width of 0.044 arcsec from the microscope measurements predicts a transmission curve that is well above the upper envelope of the ensemble of the 15 independent measurements in Figure 6. At the OTA plate scale of 279 microns/ arcsec, this slit is only 12.3 microns wide, while the slit jaws are ragged on the scale of a few microns. The best fit to the upper envelope of the transmission measurements in Figure 6 is for a width of 0.034 arcsec (9.5 microns) at the reference location for stellar observations in the 52x0.05 slit. The average width could still be the 0.044 arcsec value measured by Coffelt (1995). The widths of the 52x0.5 and the 52x2 slits are confirmed to 0.01 arcsec by direct measurement of the width of the observed geocoronal Ly- α line.

The observations of the transmissions of the 0.2x0.06 and the 0.2x0.09 slits in Figures 3 & 4 are systematically below the model predictions by 5-10%; but whether or not this difference is within the range of expected random deviations must await further data. Based on the updated model and the adopted slit sizes of Table 2, these improved throughputs T(new) are the large diamonds connected by a solid line in Figures 1-9.

Aperture	Measurement	Adopted Change
0.1x0.09	0.107x 0.097	
0.2x0.06	0.190 x 0.052	
0.2x0.09	0.195 x 0.082	
0.2x0.2	0.195 x 0.193	
52x0.05	52 x 0.044	52x0.034
52x0.1	52 x 0.095	
52x0.2	52 x 0.197	
52x0.5	52 x 0.500	
52x2	52 x 2.000	

Table 2. Clear Aperture Height and Width in Arcsec

4. Photometric Uncertainties

In order to visualize and quantify the scatter in the measurements with respect to the recommended transmission T, the data values of Figures 1-9 are divided by the computed T to produce the residuals in Figures 10-18. Each observation is rebinned to 16 points, and the Ly- α region is excluded. The average and rms scatter of the data are written on each plot. Table 3 includes the range of transmission over wavelength of the adopted model, along with the 1σ scatter and worst case minimum and maximum range of the observed transmission with respect to the adopted model. The stellar photometric precision improves with aperture width, reaching 1.3% for the 52x2 aperture in Figure 18 (cf. Walborn & Bohlin (1998), who find photometric repeatability in this large slit of 0.3-0.7% for the individual modes averaged over all 16 points). The expected quality of stellar photometry in the 52x0.5 is only about 2 times worse or 2.7% 1σ as shown in Figure 17. Since only one G140L and one G230L observation exist for the three small slits shown in Figures 10-12, there is no relevant statistic on their photometry capabilities. However, photometric repeatability in these three echelle slits should not be much worse than for the long slit of comparable width. Although these slits would not normally be used when good photometry is required, additional observations could require adjustment of the sizes by 1-2 microns to get the best fit to an upper envelope of transmissions. In Figure 13, the

G140L and medium dispersion observations fit well, while the G430L and G750L data deviate from the model. Figure 14 provides the key to understanding the limitations of small aperture photometry.

Aperture	Transmission	RMS(%)	Min(%)	Max(%)
0.1x0.09	0.36-0.69	-	-	-
0.2x0.06	0.33-0.59	-	-	-
0.2x0.09	0.40-0.69	-	-	-
0.2x0.2	0.52-0.77	5.0	-5	+10
52x0.05	0.28-0.50	11.8	-30	+3
52x0.1	0.48-0.75	8.8	-24	+8
52x.2	0.63-0.86	4.5	-10	+10
52x.5	0.82-0.93	2.7	-6	+6
52x2	0.96-0.99	1.3	-4	+2

 Table 3. Transmission Range and RMS, Minimum, and Maximum of Ratio of Observed vs. Model

The four observations with the largest scatter for the 52x0.05 slit in Figure 14 are with G230L, obtained on two back-to-back orbits on 98Mar31. Figure 19 is a blowup of these four adjacent data sets with the UT and location of the spectrum on the NUV MAMA indicated. Since all four spectra lie at the same place (x=1.1,y=0.2) with respect to the detector center to within ~0.1px, the likely cause of the variation in the count rates must be ascribed to OTA breathing, i.e. to motion of the star with respect to the aperture and/or a change in the PSF shape on the scale of ~0.01 arcsec. Initially, the transmission T relative to the model was a few percent low at 17:37UT, and then improved to about unity 10 minutes later. By 18:42 on the next orbit, T had dropped to ~75% of the adopted average, while again improving by ~10% in the next 10 minutes. The lower two curves in Figure 19 show a shift in shape. The minimum lies at a longer wavelength, as would be expected for a diffraction loss, if the star was close to one slit jaw. Diffraction losses are NOT included in our modeled transmission curves. Thus, the deviation of the data from the model by up to ~15% in Figures 13, 15, and 16 may also be ascribed to the lack of perfect pointing stability.

For example, consider the following horror scenario for a stellar observation in the 52x0.05 slit. The center to edge distance for the adopted 0.034 arcsec width is 17mas, while the radius of the Airy core (0.61 λ /D) of the PSF is 13mas at 2500Å. A pointing error of 2mas plus a breathing movement of 2mas toward a slit edge could put the edge of the

bright core of the PSF at the slit edge. For a peakup target acquisition in the 52x0.05 slit, the centering uncertainty is ~2mas (see chapter 8 of Baum et al. 1998), while one quarter of a STIS pixel (6mas) is the observed pointing shift along the slit from the first to the second orbit, as indicated on Figure 19. Any additional jitter, breathing, or defocus could move the bright core further onto the slit edge, which would cause a large geometric loss of light that is compounded by a wavelength dependent diffraction loss. At 5000Å, the Airy radius is 26 mas, which means that diffraction losses are already starting in the 52x0.05 slit. While our modeling includes the geometric losses when a perfectly centered Airy core is partially occulted by a slit edge, the additional diffractions losses are NOT modeled. Thus, the rapid decline in transmission toward 10000A for the G750L measurements is not surprising, if the centering of the star in the aperture was off by a few mas. Perhaps, the G750M-8561 measurement at T~0.85 in Figure 14 represents the case of perfect centering. The Airy disk diameter is 90mas, which is almost three times as wide as the inferred slit width of 34mas, so that the diffraction loss would be the observed 15% deficiency with respect to the model.

Another pecularity is the tendency for many G430L and G750L measurements of small apertures in Figures 5-9 (and 13-17) to exceed the model transmissions by up to 10%. In the optical path after the entrance slit for the three CCD low dispersion modes are Lyot stops that apodize the far wings of the PSF and should cut the throughput for the large reference apertures more than for the small apertures, where the wings of the PSF are truncated by the aperture itself. Confirmation of this idea should be provided by planned transmission measurements with G230LB, where the Airy core of the PSF is smaller and where the measurements are less susceptible to pointing errors that cause a lot of the G430L and G750L data points to dip below the predictions of our model. An update to the G230LB, G430L, and G750L transmissions for small apertures will be made, as required by the new measurements. In the meanwhile, beware of possible excesses of up to 10% in pipeline fluxes for these three modes for slits of 0.2 arcsec and smaller.

5. Recommendations for Stellar Observations in Narrow Slits

In assessing the trade between better spectral purity for small slits vs. higher throughput and better photometric precision for larger slits, the following suggestions should be kept in mind.

a) Choose a slit that is wide enough for your requirements on photometric precision.

b) Avoid the 52x0.05 slit with G750 modes, since the PSF Airy core is much larger than the slit size, which causes light losses that may exceed a factor of 5 in comparison with a 52x2 slit. Furthermore, the instrumental resolution of 2 pixels is a nominal match to a 0.1 arcsec slit width for the CCD modes.

c) Longer wavelengths require wider slits. For example, a rapid loss of light longward of ~5000Å is possible, even for a 52x0.1 slit. For example, Figure 15 shows a 10% loss for a medium dispersion observation at 4000Å and a 25% loss at 8500Å.

d) Since a stellar target may not be perfectly centered, realize that the pipeline fluxes are lower limits, except for observation in the three CCD modes with Lyot stops, where the transmission may be up to 10% above the model transmissions.

6. Changes to Pipeline Fluxes

The new aperture transmission for the 52x2 slit will not affect the absolute fluxes of stars in that aperture, because the first order flux calibrations are derived for the 52x2 aperture (eg. Bohlin, Collins, & Gonnella 1998). Stellar fluxes for smaller apertures will change inversely with the relative change in transmission of the small aperture in comparison with the change from the original to the new 52x2 transmission. For example, at 8800Å for the 52x0.05 slit, the original pre-launch transmission estimate of 0.357 is the tiny diamond at 8800Å in Figure 6, while the new guess is the large bold diamond at 0.306. The change in the estimate for the 52x2 at 8800Å in Figure 1 is 0.990/0.912. Thus, the 52x0.05 fluxes will increase by (.990/.912)/(.306/.357) = 1.27 following the update of the aperture throughput reference files.

Analogously, the echelle calibration for observations in the 0.2x0.2 slit will not change after the aperture throughput files are updated, since Bohlin (1998b) derived the echelle sensitivities for the 0.2x0.2 aperture.

7. References

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8. Figures

Figure 1: Transmission of the 52x2 arcsec aperture. Filled circles are G140L or G430L data, while open circles are G230L or G750L. The triangles are the medium dispersion first order measurements. The bold, large diamonds that are connected by a solid line are the final best estimates of the transmissions, which are based on our modified TIM PSF models. The light, small diamonds are the original TIM models that are described in section 3. The data agree with the bold diamond model within ~1% rms.



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Figure 2: As in Figure 1 for the 0.1X0.09 aperture.



Figure 3: As in Figure 1 for the 0.2X0.06 aperture.



Figure 4: As in Figure 1 for the 0.2X0.09 aperture.



Figure 5: As in Figure 1 for the 0.2X0.2 aperture.



Figure 6: As in Figure 1 for the 52X0.05 aperture.



Figure 7: As in Figure 1 for the 52X0.1 aperture.



Figure 8: As in Figure 1 for the 52X0.2 aperture.



Figure 9: As in Figure 1 for the 52X0.5 aperture.



Figure 10: Measured transmission for the 0.1X0.09 aperture relative to the calculated transmission. Symbols are as described in Figure 1.



Figure 11: Relative transmissions measured for the 0.2X0.06 aperture, as in Figure 10.



Figure 12: Relative transmissions measured for the 0.2X0.09 aperture, as in Figure 10.



Figure 13: Relative transmissions measured for the 0.2X0.2 aperture, as in Figure 10.



Figure 14: Relative transmissions measured for the 52X0.05 aperture, as in Figure 10.



Figure 15: Relative transmissions measured for the 52X0.1 aperture, as in Figure 10.



Figure 16: Relative transmissions measured for the 52X0.2 aperture, as in Figure 10



Figure 17: Relative transmissions measured for the 52X0.5 aperture, as in Figure 10.



Figure 18: Relative transmissions measured for the 52X2 aperture, as in Figure 10.



Figure 19: Blowup of a section of Figure 14. The UT and pixel location on the NUV MAMA are indicated for each observation. The dispersion is in x, while y is along the slit.