Measured Spectral Properties of the Grism and Prism Spectrometers for the Nancy Grace Roman Space Telescope - Deviations From Model Expectations

Evan Bray,[1,*] Victor J. Chambers,[2] Margaret Dominguez,[2] Guangjun Gao,[2] Qian Gong,[2] John Lehan,[2]

[1] *Peraton, Goddard Space Flight Center, Greenbelt, MD 20771*
[2] *NASA, Goddard Space Flight Center, Greenbelt, MD 20771*

[*] *evan.bray@nasa.gov*

Abstract: The Nancy Grace Roman Space Telescope (RST) slitless spectrometers exhibit characteristics that very closely match the design parameters. This paper reviews the few spectral properties that were found to deviate slightly from model expectations.

1. Introduction

The Grism and Prism imaging spectrometers will provide medium (R=475-900) and low (R=100-180) resolution spectroscopy capabilities for RST. These tools will primarily be used in support of the High Latitude Spectroscopic Survey (HLSS) and High Latitude Time Domain Survey (HLTDS), respectively. These programs make up a significant fraction of the planned telescope observing time and seek to measure the cosmological structure and growth history of the universe by determining photometric redshifts for $>10^7$ galaxies[1] and >10,000 Type 1a supernovae (SN)[2].

To verify their spectral characteristics, the meticulously-designed and constructed Grism/Prism assemblies underwent an extensive characterization campaign on a purpose-built setup called the Ellipse Test Bed. A more complete summary of the tests performed and the capabilities of the setup is given elsewhere[3]. In almost all regards, the performance of the optics match that of their design specifications and any measured deviations are very slight. This brief paper will outline those deviations.

1.1. Bandpass Edges

The custom thin-film bandpass coatings used for both assemblies are sourced from Alluxa, and are produced by depositing hundreds of thin layers of alternating materials on the optic. During each coating run, a number of witness samples are also coated simultaneously so that uniformity and accuracy may be gauged, and many such runs were performed in order to satisfy the stringent uniformity and edge-sharpness requirements of the telescope. In the end, the final short- and long-wavelength edges of the assembly bandpass are shifted slightly from their original design values. A summary of these differences is shown in Table 1.1.

	Design Bandpass (nm)	Measured Bandpass (nm)	
Assembly	**On-axis**	**On-axis**	**Edge Field**
Grism	1000-1930	999.1-1919.3	994.1-1908.0
Prism	750-1800	761.4-1818.9	758.4-1802.1

Table 1.1: A summary of the bandpass edge wavelengths for both assemblies.

1.2. Grism Total Throughput

The driving factor of the Grism total throughput is the efficiency with which its two diffractive surfaces direct light into the desired (1,1) order. In particular, the grating is designed to maximize efficiency at ≈1310 nm. During testing, it was observed that the throughput was lower than what was predicted by the model, as shown in Figure 1. The cause was identified to be diffuse light scattering by the diffractive surfaces, which was not incorporated into the relevant models due to the difficulty of predicting *a priori*.

Despite this discrepancy, the Grism still exceeds all relevant throughput requirements with significant margin. Additional studies on the angle dependence of the diffuse scattering component are being conducted on spare diffraction-etched Grism optics.

1.3. Prism Dispersion

Dispersion scale for both assemblies was characterized with the use of several custom comb filters. When the spectrum produced by these comb filters is passed through the Prism and imaged with an IR camera, a string of well-defined and widely-separated point spread functions (PSFs) is observed. By combining knowledge of each PSF position with its known wavelength, the dispersion can be accurately calculated.

Prism dispersion is measured across the full bandpass and at many field positions. When comparing the measured distance between two known wavelengths, as shown in Figure 1, it is observed that the spectral trace is typically several tenths of a percent shorter than expected. Potential causes for this phenomena are discussed further elsewhere[4].

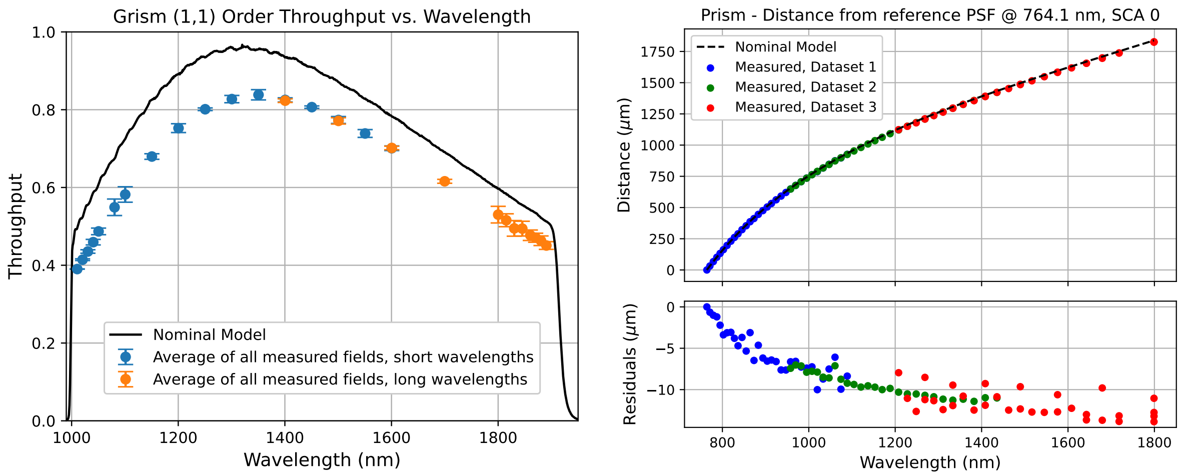

Fig. 1: (Left) A plot of Grism Flight total throughput vs. wavelength. The discrepancy between the measured and modeled values is due to diffuse light scattering off the diffractive surface, which is not incorporated into the model. (Right) A plot of relative distance from a reference wavelength vs. wavelength for the Prism Flight in the on-axis position (SCA 0). The trend in residuals indicate a shorter spectral trace than model predictions.

2. Conclusion

Following a successful spectral characterization campaign, the Grism and Prism assemblies were found to have met or exceeded all of their design goals. For a majority of metrics, the measured features agree with the model predictions exceptionally well. In the cases where discrepancies are observed, as discussed here, the impact to overall telescope performance is small and will not significantly impact the observatory's ability to achieve its primary science goals.

References

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