Chapter 6

Conclusion and future outlook

'Man is dispensable. Telescopes are not.'

— Richard Preston, *First Light.*

This thesis presents a comprehensive account of the integration, calibration, and performance testing of the Solar Ultraviolet Imaging Telescope (*SUIT*), the first instrument to provide spatially resolved, full-disk solar observations in the 200–400 nm near-ultraviolet (NUV) wavelength range. The work presented here encompasses a wide range of activities, including optical alignment, mechanical integration, rigorous optical testing of science filters, photometric calibration, and validation of the spectral response of the payload. Each phase was meticulously executed to ensure that *SUIT* meets its stringent scientific and operational requirements in the space environment aboard Aditya-L1.

We performed the optical characterization and environmental qualification tests of all the *SUIT* science filters, including the spatial and angular transmission variations, along with out-of-band leakage. The filters show uniform spatial transmission with minimal central wavelength fluctuation. The maximum relative fluctuation in central wavelength is 2.09×10^{-2} nm for a bandpass with FWHM of 0.13 nm for the NB08 filter. Tilt-induced bandpass shifts were optimized for each filter to reduce ghost reflections. The out-of-band to in-band ratio was within design expectations, with a few filters exhibiting higher values due to filter manufacturing limitations at wavelengths below 250 nm. For two filter combinations it is in the $> 1\%$ domain, and that for three filters is in the $> 0.1\%$ domain, with the rest being in the order of 0.01%. Overall, the results confirm that *SUIT* filters meet the required mission requirements.

Precision alignment of multiple optical components—including mirrors, field corrector lens, and filters was achieved to ensure optimal image quality. The RMS wavefront error of *SUIT* is 34 nm, corresponding to $\lambda/8.8$ at 300 nm, signifying good optical alignment. The integration process also involved cable routing, and ensuring all components are torqued to specification, while maintaining stringent contamination control. *SUIT* was successfully mounted on the Aditya-L1 satellite and co-aligned with the satellite coordinate system. The final alignment results confirmed that all optical and mechanical specifications were met, establishing a robust and stable configuration for in-orbit operation.

The end-to-end photometric calibration and spectral validation tests of *SUIT* are performed after complete payload assembly. For this purpose, we loaded the payload in an ultra-clean high-vacuum chamber to simulate space-like conditions. The flight spare *SUIT* optics is used as a collimator. The wavelength of the test beam is controlled with a monochromator, and the intensity is measured with a NIST-traceable photodiode. *SUIT* optical response is simulated with sun-as-a-star spectra and the individual optical characteristics of each sub-unit. The transmission characteristics agree with forward modeled performance of *SUIT* within 10% for NB04, NB05 and NB06 filters, within 20% for NB02 and NB08 filters, and within 30% for NB03 and BB03 filters. The tests are not performed for NB01, BB01, and BB02 filters as the bandpasses are below 250 nm. Spectral validation also shows strong agreement with the designed bandpasses. The results affirm the accuracy of the calibration pipeline and the robustness of SUIT's optical design for solar UV observations.

Finally, we discuss the pre- and post-flight tests of *SUIT*, evaluating the image quality and performing calibration for generating science-ready data. The 80% encircled energy radius of the PSF is 24.8 μm, $\approx$ 2 pixels. The MTF test reveals a contrast of 10% at 2.5″spatial scales. The plate scale is measured to be 0.698″/pixel. The read noise is measured to be 8 e^-, which is below the required limit of 10 e^- *SUIT* has a clear field of view up to a radius of 0.39°from the center of the frame as designed. The mean dark signal is measured to be 1.82 $e^{-}px^{-1}s^{-1}$, which is exceptionally better than the upper limit of 10 $e^{-}px^{-1}s^{-1}$. Multiple pointings of the telescope are used to generate the large-scale flat-field. On-board LEDs are used to measure pixel-to-pixel variations in response. The total photometric error after image calibration is 0.56%, which is much better than the desired limit of 1%. All key optical parameters were found to comply with the design goals, with the exception of the spatial resolution, which limits effective photometry to coarser scales than expected.

Given the on-board optical performance as alluded earlier, *SUIT* will help us achieve the projected science goals of studying prominences, flares, the coupling and dynamics of the solar atmosphere, and help us better understand Sun-climate interactions due to NUV irradiance. The methods, techniques, and technology developed in the pursuit of building and commissioning *SUIT* will help develop future ground and space-based missions.

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