WSO-UV Spectrographs' Simulations

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1. Introduction

The World Space Observatory - Ultraviolet (WSO-UV) is an international space telescope to observe in the ultraviolet range. The WSO-UV spacecraft is equipped with the WUVS (WSO UltraViolet Spectrographs) instruments, two high resolution ($R \sim 55,000$) spectrographs, VUVES and UVES. VUVES is a far UV echelle spectrograph designed to carry out high resolution spectroscopy of point sources in the range 1020-1800 Å. UVES is the near UV echelle spectrograph, working in the range 1740-3100 Å. The performance of these instruments can be evaluated through simulations of the expected observation.

2. Noise model

A previous preliminary version of the simulator developed for the PLATO Mission has now been adapted to the WUVS characteristics. It relies on a modular architecture, to make it adaptable to other missions as well. The WUVS Simulator generates synthesized images by simulating the acquisition process of a space-based detector instrument as realistically as possible. Each image is numerically modelled, based on a number of input parameters, which define the set-up of the CCD and its electronics, the properties of the optical instrument, the pixel response non-uniformity (PRNU) and all related noise sources. The process of image generation can be classified according to this sequential order:

- Observed source spectrum.
- Imaging FoV:
  - The CCD sub-pixel matrix;
  - High-energy particle hits;
- CCD Sensitivity variations: PRNU;
- Noise effects:
  - Read out smearing;
  - Sky background;
  - Photon noise;
  - Electronic noise sources.

Input Parameter	*Value*	*Input Parameter*	*Value*
CCD Size	$4096 \times 3112\ px$	Collecting area	$113.09\ cm^2$
Sub-Field size	$4096 \times 3112\ px$	Digital saturation	$16384\ ADU$
Pixel resolution	1/4	Full well pixel capacity	$1243000\ \mathrm{e}^-$
Transmision efficiency	0.638466	Gain	$6\ \mathrm{e}^-/ADU$
Quantum efficiency	85 %	Electronic offset	$100\ ADU$
Number of exposures	2500	Readout noise	$3\ \mathrm{e}^-$
Exposure time	$22\ s$	Flatfield pixel-to-pixel noise	1.6 %
Charge transfer time	$3\ s$	Mean Charge Transfer Efficiency	0.999999
Pixel scale	$0.101\ arcsec/px$	Pixel size	$12\ \mu m$

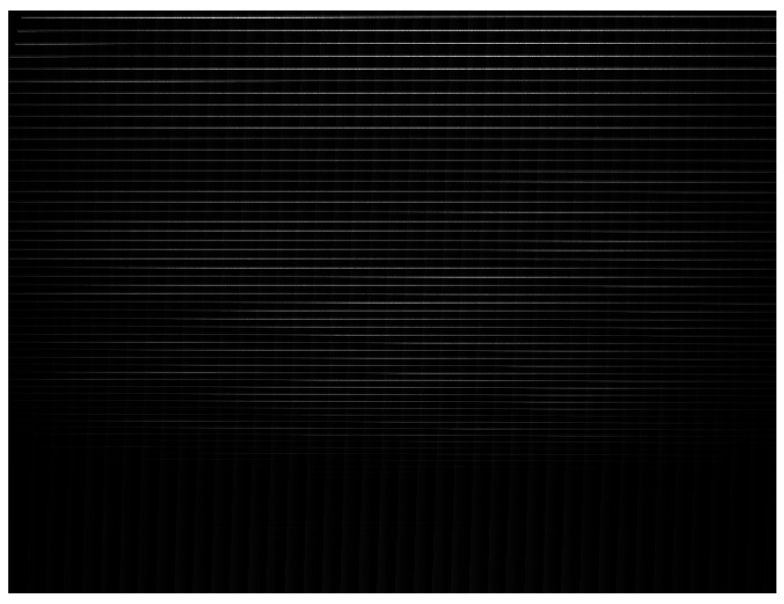
Table: Values of the input parameters applied to the WUVS simulations.

3. Results

We get, as outcome of the simulation, 2500 almost identical FITS files. Figure 1 shows one of these simulated images. Analysing the FITS files we can identify some of the noise effects, for example the electronic offset count at the black background in images1 set to 100 counts. Figure 2 shows the comparison between the spectrum input image and one of the simulated images. It can be seen the echelle spectrum pattern in the difference image due to the electronic noise sources, proportional to the signal in the original input image. It can also be easily identify the electronic offset (100) in the white background and the photonic noise in that background that would be flat if not for that photonic noise.

The photonic noise is easier to be seen at figure 3, where it is shown the difference between two simulated images (concretely image 1 and image 2500, but there is no difference between two pairs of images except for the photonic white noise).

This image is not showing any of the saturation effects since the input image is far from saturation, but interesting analysis in this regard can be performed using different types of input images in order to exploit the functionality of the simulator. This is also applicable to the high energy particle hits or the sky background, both effects were not included in this simulation since the input parameters would be arbitrary somehow and would had affected the simulation outcome. Concrete simulations would be necessary to analyse how these effects would affect the observations.



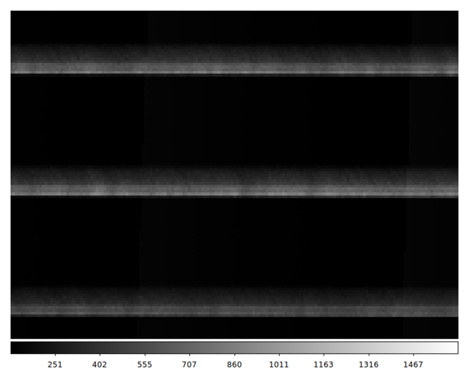
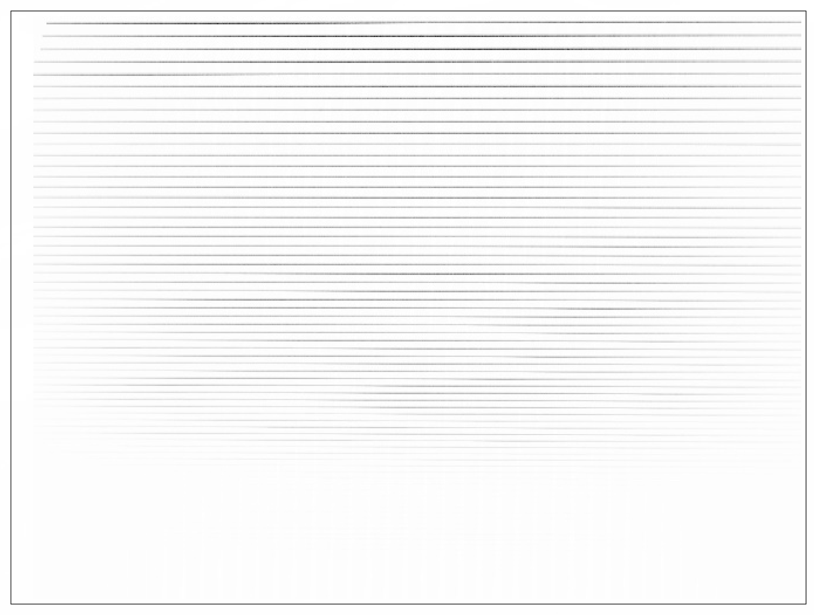


Figure 1: (Left) Simulated image of VUVES. (Above) Zoom of the VUVES image on the left.



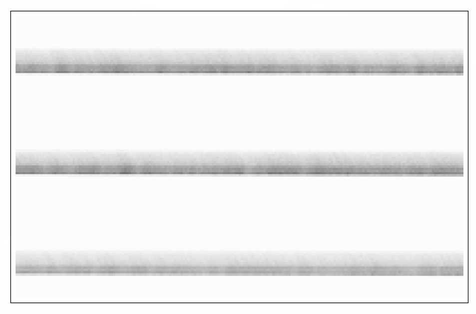
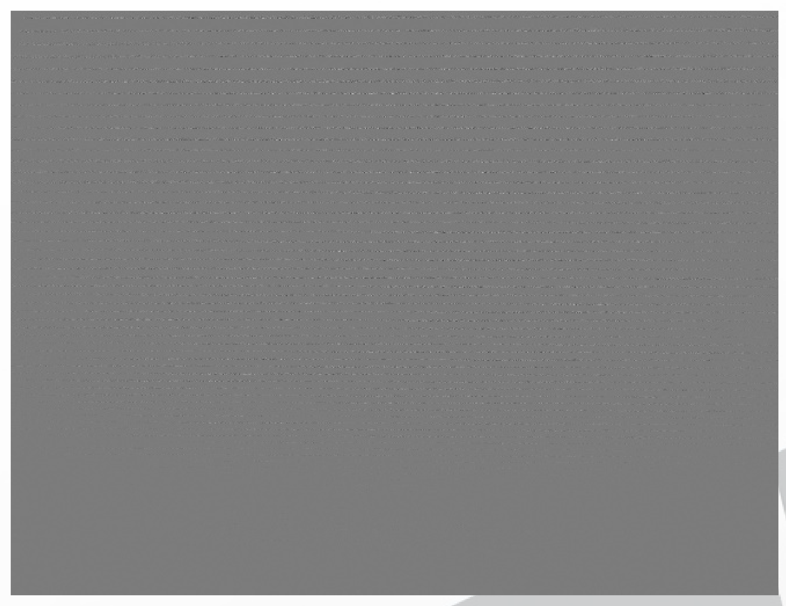


Figure 2: (Left) Difference image between VUVES simulated image and input image. (Above) Zoom of the image on the left.



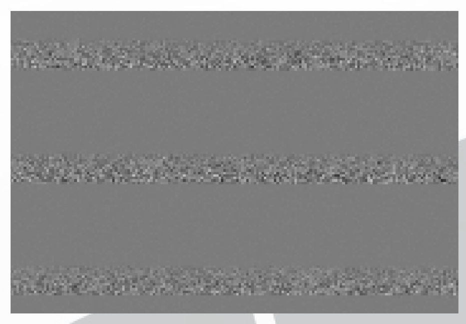


Figure 3: (Left) Difference image between two simulated images. (Above) Zoom of the image on the left.

4. Conclusions & Future Prospects

WUVS instruments are high-precision spectrographs whose expected performance must be evaluated carefully from an appropriate overall instrument model. Since it is not feasible to build and test a prototype of a space-based instrument, numerical simulations performed by an end-to-end simulator are used to model the noise level expected to be present in the observations. The performance of the instrument can be evaluated in terms of noise source response, data quality, and fine-tuning of the instrument design for different types of configurations and observing strategies. In this way, a complete validation of the expected instrumental behaviour of the mission can be derived.

There are many improves to be done to this simulator in order to ease its usability and performance. Source to echelle spectra transformation, satellite jitter and graphical user interface and code parallelization among others.

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