Improved Cosmic Ray Rejection for Slitless Spectroscopic Data

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Abstract
Data from space based instruments such as the Advanced Camera for Surveys (ACS) and the Wide Field Camera 3 (WFC3) on the Hubble Space Telescope (HST) suffer from a high rate of cosmic ray hits. In WFC3 IR data, cosmic ray hits are detected and rejected during the "up-the-ramp" fitting of the individual detector reads. For direct imaging, the MultiDrizzle software can detect deviant pixel values such as from cosmos when combining differenced data. We have implemented a similar technique in the aXe software package to be able to detect and flag deviant pixels in slitless spectroscopy data. We introduce the method and demonstrate its application to WFC3/IR and ACS/WFC slitless data. Details on the number of previously undetected cosmos are given and examples of improved extracted spectra shown.

Figure 1: The ERS grism field (green) in GOODS I

Figure 2: Comparison of extractions with the basic and the new aXedrizzle using the 2D grism stamp images (lower panels) and the final 1D spectra (upper panels). Differences and their significance are marked. Blue and red mean lower and higher values in the basic extraction, respectively.

Figure 3: Histograms of all differences in the G102 (left) and G141(right) data. The insets zoom on sig>2.0.

Figure 4: Histograms of all differences in the ACS/WFC G800L data set (left) and the zooms on sig>2.0 (right).

Results
Figure 2 compares the basic and extended aXedrizzle extraction for three objects (IDS11, ID50, ID410) in the ERS G102 and G141 data. The upper panels show basic aXedrizzle spectra (black dots plus error bars) and the new aXedrizzle spectra (yellow dots). The lower panels show the corresponding deep 2D grism stamp images from which the spectra were extracted. Differences and their significance are marked with ellipses, with red and blue colours indicating enhancements and depressions in the data reduced with basic aXedrizzle, respectively. It is evident that blue depressions in the basic aXedrizzle reduction originate from individual, unstable pixels. The red enhancements show the typical signatures of cosmic ray depressions in the data reduced with basic aXedrizzle. For spectral bins with specl>2.0, we compute the significance, defined as:

\[ \text{sig} = \frac{|\text{spec}_{\text{red}}|}{\text{error}} \]

where \( \text{spec}_{\text{red}} \) is the difference spectrum.

Figure 4 shows the histograms of the significance of all differences in the G102 and G141 datasets in the left and right panels, respectively. Differences where the spectrum from the basic extraction is enhanced are marked red, the ones with depressions in the basic aXedrizzle are blue. We now focus on all differences with \( \text{sig}>2.0 \) as having a clear impact (see Fig. 2) when corrected with the new aXedrizzle. There are 102 and 185 differences with \( \text{sig}>2.0 \) for the negative (blue) and positive (red) deviations for G102 and 34 and 154 for G141, respectively. Almost every second spectrum from the G102 in the entire dataset is significantly improved with the new aXedrizzle. The average fraction of rejected pixels is 0.3% in an exposure of 1sec.

A similar analysis based on ACS/WFC G800L data leads to the histogram of differences in Figure 4. Here we compare the pixel rejection from running MultiDrizzle on the slitless images [3] (named “basic” in Fig. 4) with the extended aXedrizzle (using the optimized parameters \( \text{combine}_\text{high}\text{g}, \text{driz_cr_snr}=[3.5, 3.0] \)). In contrast to WFC3/IR, the number of differences with a high significance is rather small. Even on the deep 2D grism stamps it is very difficult to identify an undetected image artifact in one reduction. Identifying cosmic ray hits in ACS grism data with the new aXedrizzle is thus equivalent to the previously recommended method of using MultiDrizzle before the aXe extraction.

References