aXeTwoZero: The next generation of aXe

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Abstract

The **aXe** spectral extraction software was designed to extract spectra from slitless data such as taken with the Advanced Camera for Surveys (**ACS**) on board of **HST**. Wide Field Camera 3 (**WFC3**), which was installed on **HST** during Service Mission 4 this May, also contains slitless spectroscopic modes on both, the IR and the UVIS arm, and **aXe** is the recommended tool for reducing its slitless data. Rather than adjusting the previous version **aXe-1.71** to **WFC3**,we have chosen to re-factorize the current aXe to build **aXeTwoZero** (**aXeTZ**) ,the next generation of the **aXe** software. We explain the structure and the properties of **aXeTZ**. The reduction of **WFC3** slitless data with **aXeTZ** is demonstrated using early in-orbit calibration data. **aXeTZ** is scheduled to be released as part of the **STSDAS** in November 2009. A brief outlook on further developments is given.

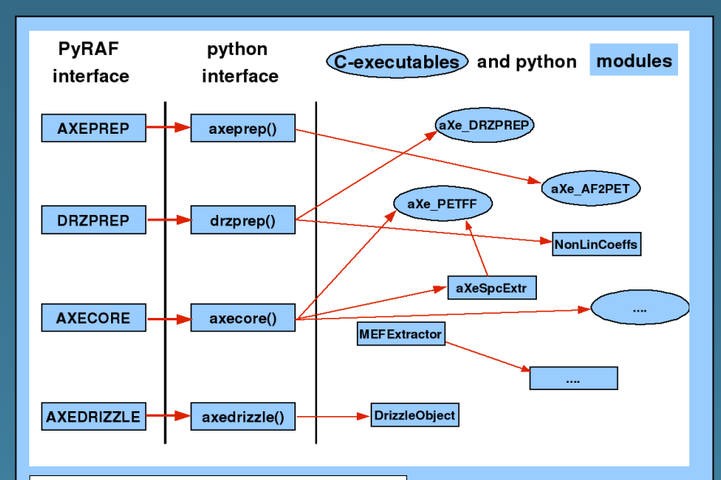

Figure 2: The structure of **aXeTZ**

1. Slitless spectroscopy with aXe

Slitless spectroscopy has some special features and properties which require a dedicated extraction package such as **aXe** [1,2,5]. A slitless data set as shown in **Figure 1** usually consists of a slitless image (lower panel) and a corresponding direct image (upper panel, here **F850LP**) taken at the same position in order to derive the zeropoint of the wavelength calibration. Due to the low spectral resolving power, there are multiple spectral orders of the same object visible in a single image. The absence of slits makes contamination, which is the mutual overlap of spectra, a ubiquitous phenomenon in both the spatial direction and in dispersion direction, even across different spectral orders and at distances of many hundred pixels. The blue circles in **Fig.1** mark two object pairs with overlapping spectra in the slitless image. **Table 1** lists all **HST** slitless spectroscopic modes to which **aXe** has been applied.

Instrument/ Camera	Disperser	Wavelength Range [Å]	Dispersion [Å/pixel]	FOV ["]
WFC3/IR	G102	7800-10700	24.7	123x137
WFC3/IR	G141	10500-17000	47.0	123x137
WFC3/UVIS	G280	2000-4000	13.0	160x160
ACS/WFC	G800L	5500 – 10500	38.5	202x202
ACS/HRC[1]	G800L	5500 – 10500	23.5	29x26
ACS/HRC[1]	PR200L	1600 – 3900	20 [@2500Å]	29x26
ACS/SBC	PR130L	1250 – 1800	7 [@1500Å]	35x31
ACS/SBC	PR110L	1150 – 1800	10 [@1500Å]	35x31
NICMOS/NIC3	G141	11000 – 19000	80	51x51

1: operation discontinued

Table 1: HST slitless spectroscopic modes to which **aXeTZ** is to be applied

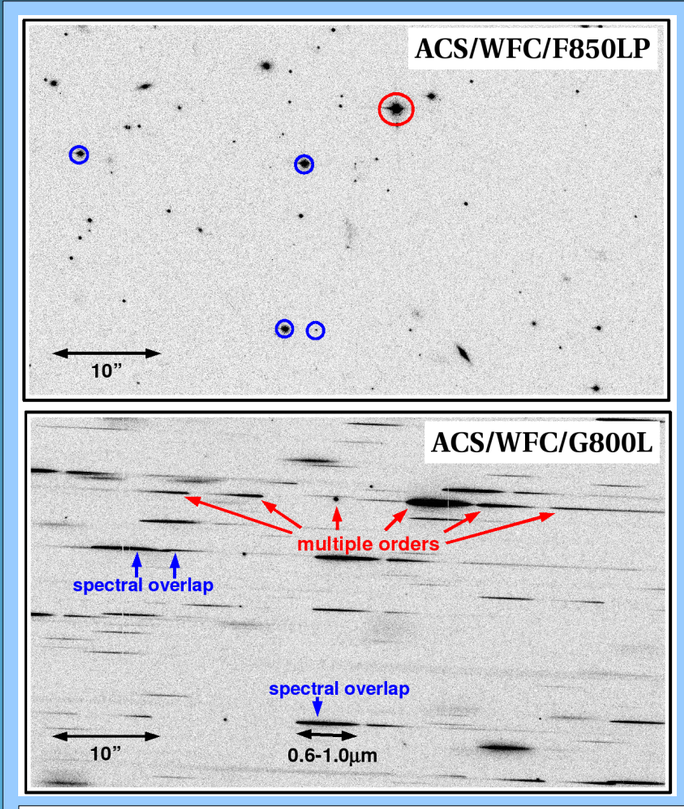

Figure 1: The basic data set of one slitless spectroscopic image (bottom) and the corresponding direct image (top)

2. aXeTZ (aXeTwoZero)

The structure of **aXeTZ** is depicted in Figure 2. As compared to previous versions, **aXeTZ** contains a python interface layer which is capable to fully replace the **PyRAF** layer and would allow an easy transformation of **aXeTZ** into a pure python module. Further features of **aXeTZ** and its development include:

- backward compatibility to previous **aXe** versions. All instrument modes listed in **Table 1** are supported;
- a clear, 'pythonic' software design;
- usage of object oriented techniques and patterns;
- reduced use of external libraries;
- complete 64bit compatibility;

In addition to the usual suite of test programs, stress tests with **aXeTZ** were done using **HLA/ACS** grism data sets [6], which offer the largest challenges in terms of number of objects and data volume. Moreover **aXeTZ** was extensively tested on data from the 'new' **WFC3/IR G102** and **G141** grisms (see Sect. 3) to provide users of these modes with a flawless data reduction software.

3. aXeTZ applied to WFC3 data

The reduction of **WFC3** data with **aXeTZ** is illustrated in **Figure 3**. Slitless data of the Planetary Nebula **Vy2-2** has been taken as part of the Cycle 17 calibration program 11937 (PI: Bushouse) and reduced with a release-ready version of **aXeTZ**. The left panels of **Fig.3** show an example of a **G102** image (top) together with its associated direct image (bottom). The right panels show the combined, aXedrizzled stamp image from the entire dataset (top) and the extracted spectra (bottom) with the identification of all discernible spectral lines. The assessment of the **WFC3/IR** grism properties as determined with **aXeTZ** will be published in a series of Instrument Science Reports (**ISR**) in mid-October [4].

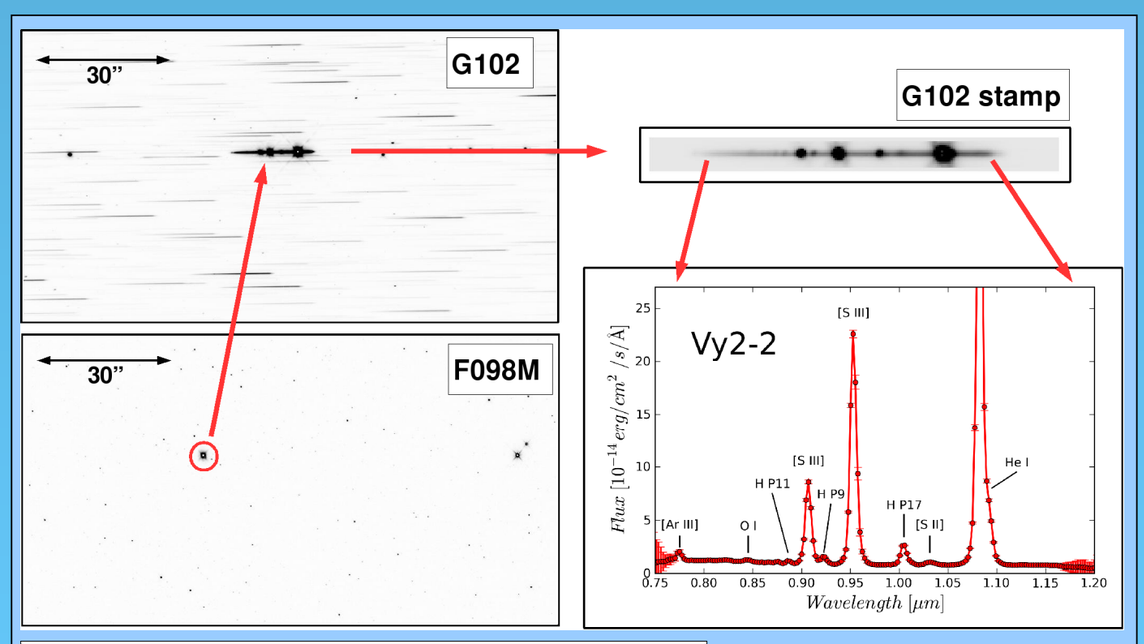

Figure 3: Example of **Vy2-2** observations reduced with **aXeTZ**

4. Release and future developments

aXeTZ is currently in the final testing stages and is going to be released as part of the next **STSDAS** release 3.11 in November 2009. An identical version of **aXe** to be installed as a local **PyRAF** package will be distributed via the **ST-ECF** homepage [5]. On the basis of **aXeTZ**, the future developments of **aXe** will focus on the following areas:

- a new version of aXedrizzle which allows the rejection of deviating pixel values solely based on spectroscopic criteria. This method promises advantages especially for data taken with the **WFC3/IR** detector;
- getting more pythonic by e.g. replacing all the **IRAF/PyRAF** tasks;
- combining the **aXe** software and the **aXeSIM** [6] software package in the python layer and below;
- adjustments that may arise from the exploration of **WFC3** slitless data.

References

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3. Kümmel, M., et al., 2009, **ST-ECF Newsletter** 46, p.6
4. Kuntschner , H., et al., 2009, **WFC3 ISR**, in preparation
5. aXe/aXeSIM webpage: **www.stecf.org/software/slitless_software**
6. Kümmel, M., et al., 2007, **ST-ECF Newsletter** 43, p. 8