

## **Spectral Extraction from ACS and VLT Multi-object Spectroscopic Data**

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**Abstract.** We have developed a new extraction software package called aXe that was specifically designed to handle the ACS spectrophotometric data. Using a pair of direct/grism or direct/prism images, aXe can extract tilted spectra, estimate and subtract the local background, wavelength calibrate, flat-field, and flux calibrate them.

Due to the increasing number of instruments on modern telescopes capable of performing spectrophotometric observations similar to those of ACS, aXe was designed to also be used with non-ACS data.

### **1. Introduction**

New large format slitless spectroscopic instruments have become available to the astronomical community. These produce images containing large numbers of spectra and can be very time consuming to analyze. One of these is the Advanced Camera for Surveys (ACS), which has recently been installed on HST. The ACS provides for both grism and prism slitless spectroscopy and these modes can result in data sets containing hundreds of spectra on the large format detectors. A method of easily extracting the information from these data and quickly producing spectra of individual objects is highly desirable.

aXe is being applied to real science data from ACS and proving a powerful facility for studying faint point sources, particularly in the red in observations containing hundreds of individual objects.

### **2. What is aXe?**

The aXe software was designed to extract spectra in a consistent manner from all the slitless spectroscopy modes provided by the Advanced Camera for Surveys (ACS) that was installed on the Hubble Space Telescope in February 2002. What we refer to as aXe is in fact a set of libraries containing C-level functions to perform the extraction process, and a set of stand-alone aXe tasks that can be used successively to produce extracted spectra. The extraction process is a set of well isolated steps that can be individually applied and tweaked by the user (Figure 1). These tasks communicate through a set of user-readable configuration files and produce output that may be directly modified. The core of the software package is written using ANSI C and is highly portable from one platform to another.

The advantage of using separate tasks to perform the extraction process is that it allows one the option of implementing each task in several ways without affecting the entire extraction process. For example, a different Background Estimator could be devised once more knowledge is gained about the instruments, or a different flux calibration of the extracted 1D spectra, and so on. An example of a possible extraction process is shown in Figure 1.

The extraction process is designed to start from a pair of pipeline calibrated direct and sliless images. The grism image should not be flat-fielded since flat-fielding is a wavelength dependent operation that first requires that each pixel be assigned a wavelength. The direct image is used to determine the position, size, and orientation of objects in the field and to select which objects to extract from the grism image. This information is stored in an Aperture File which is then used to isolate which pixels should be considered in the spectroscopic image in order to assemble a Pixel Extraction Table (PET). The latter can be modified by several aXe tasks (for example to flat-field, determine the background level, or flag possible spectral contamination from nearby spectra), as shown in Figure 1, before it is used to produced binned, calibrated 1D spectra.

### 3. Examples

aXe was designed to be used with a variety of slitless images. Once a proper configuration file has been created, defining things such as the shape of the spectral trace and the wavelength calibration relation, the extraction can proceed as outlined in Figure 1. In Figure 2 we show the results of using aXe on an ACS HRC observation of a Wolf-Rayet star. This image contains multiple dispersive orders which are oriented at -38 degrees with respect to the horizontal. Both orders were extracted using aXe and the results are shown below the direct and grism images.

### 4. Supported Platforms and Availability

aXe is written in standard C and has been successfully compiled and run under Solaris 7, and 8, Red Hat Linux 7.x, and MacOSX 10.x. This software should be easily compiled on any platforms for which GSL (Gnu Scientific Library) and CFITSIO are already available.

aXe 1.10 binaries and source code were released in November 2002 and are available from the ST-ECF web pages at <http://www.stecf.org/software/aXe/>. aXe 1.0 has also been distributed as part of Pyraf/STSDAS 3.0. The STSDAS version, while not the most recent version, provides the user with IRAF parameter files to control the various aXe tasks.

### References

- Pirzkal et al. 2001, ST-ECF Newsletter, 29, 5
- Pirzkal et al. 2002, aXe User Manual 1.1

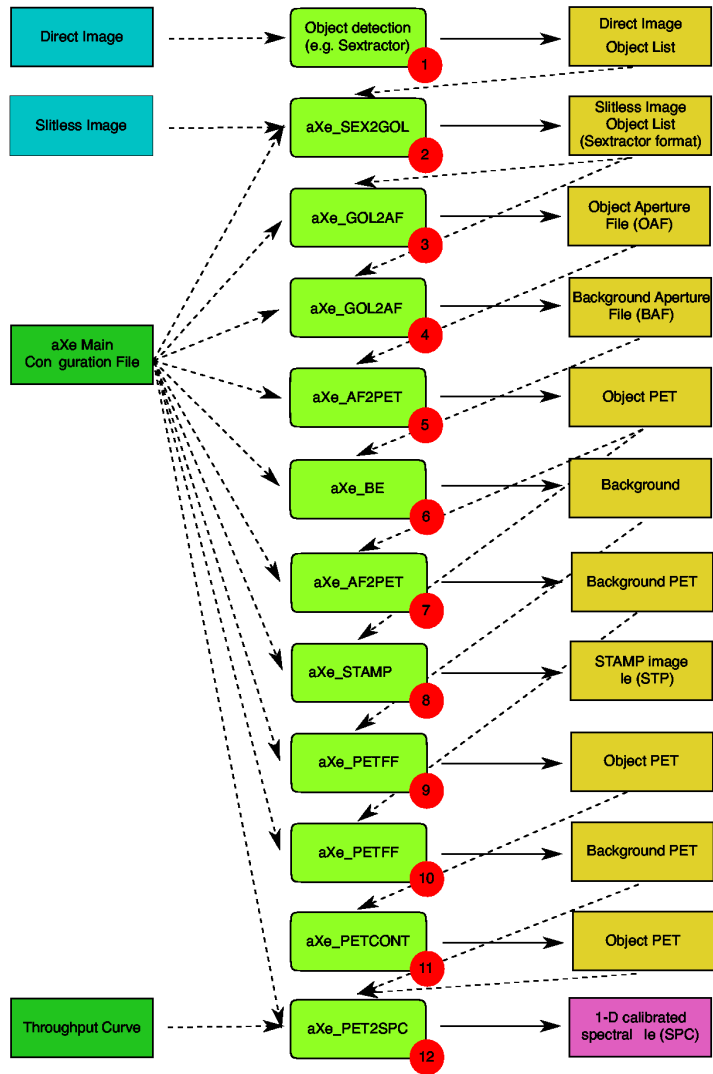


Figure 1. The extraction process using aXe. This figure shows how one can use a sequence of aXe tasks to produce background subtracted, flat-fielded, wavelength and flux calibrated 1D spectra starting with a pair of direct and slitless observations of the same field.

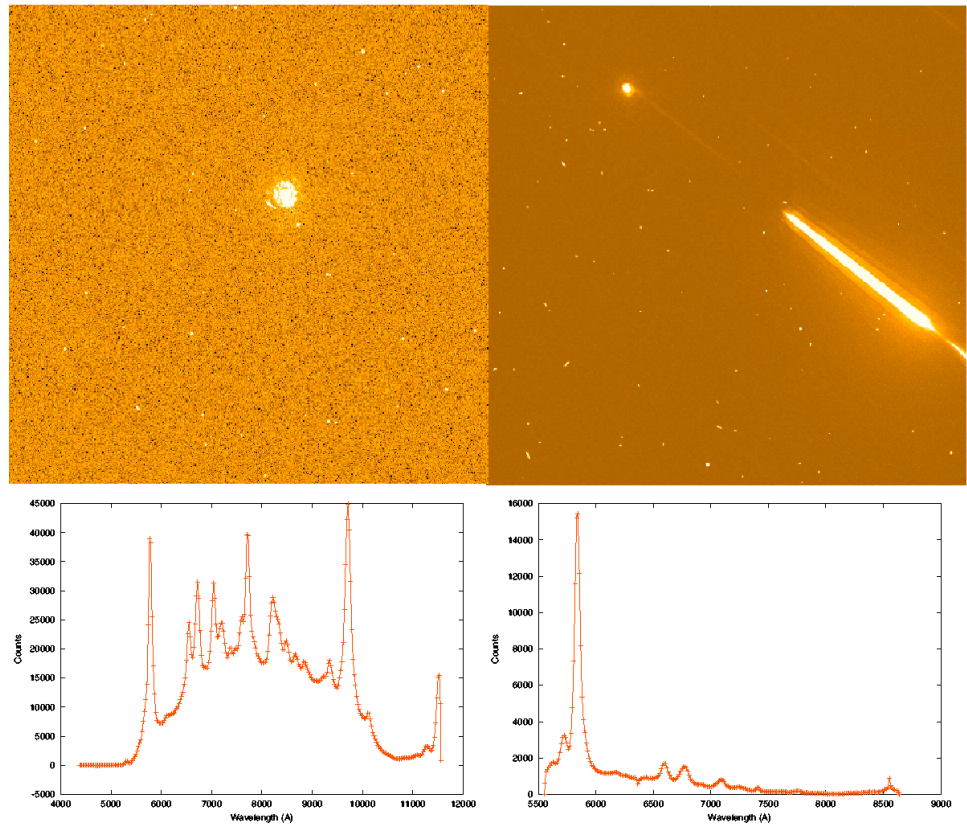


Figure 2. Extracted spectra (1st order on the left, 2nd order on the right) of a Wolf-Rayet star observed using the High Resolution Channel on the Advanced Camera for Surveys (ACS) on HST from the direct (top left) and grism (top right) images above.