Filabres: a New Pipeline for the Automatic Data Reduction of CAFOS Direct Imaging

Nicolás Cardiel,[1] Enrique Galcerán,[1,2] Jaime Alonso-Hernández,[1] Sergio Pascual,[1] José Manuel Alacid,[3] Enrique Solano,[4] Miriam Cortés-Contreras,[4] María Teresa Ceballos,[5] Jesús Aceituno,[6] and Santos Pedraz[6]

[1]*Departamento de Física de la Tierra y Astrofísica, Universidad Complutense de Madrid, Spain;* `cardiel@ucm.es`

[2]*GMV Innovating Solutions, Spain*

[3]*Isdefe, Spain*

[4]*Centro de Astrobiología (CSIC–INTA), Spain*

[5]*Instituto de Física de Cantabria (CSIC–UC), Spain*

[6]*Observatorio de Calar Alto, Spain*

Abstract. Filabres is a new Python pipeline created with the idea of performing the automatic reduction of direct images obtained with the instrument CAFOS, placed at the 2.2 m telescope of the Calar Alto Observatory. The goal is to provide useful reduced images through the Calar Alto Archive hosted by the Spanish Virtual Observatory. The behaviour of the data reduction is easily defined through a set of reduction rules set in a configuration YAML file, specifically built for the considered instrument and observation mode. The software has been designed to allow the future inclusion of additional observing modes and instruments. Filabres is publicly available through GitHub and its documentation is hosted at Read The Docs.

1. Introduction

An automatic data pipeline is normally required to reduce large data sets, where the interactive approach is typically unaffordable in terms of human resources and/or time. When focusing on data acquired with a particular multipurpose instrument, important benefits of an automatic data pipeline are:

- Availability of calibrations that for any reason were not acquired in a given observation program, but which are available in other programs.

- Homogeneous data treatment and reduction: this facilitates the reuse of archived data.

- Allows the study of the temporal evolution of the instrument performance.

Filabres (see Fig. 1) has born as an initial effort to incorporate such automatic data reduction for direct images obtained with CAFOS, the Calar Alto Faint Object Spectrograph, located at the 2.2 m telescope of the Calar Alto Observatory (`https://www.caha.es`). The goal is to provide those reduced images through the Calar Alto Archive (`http://caha.sdc.cab.inta-csic.es/calto`) hosted by the Spanish Virtual Observatory (`https://svo.cab.inta-csic.es`).
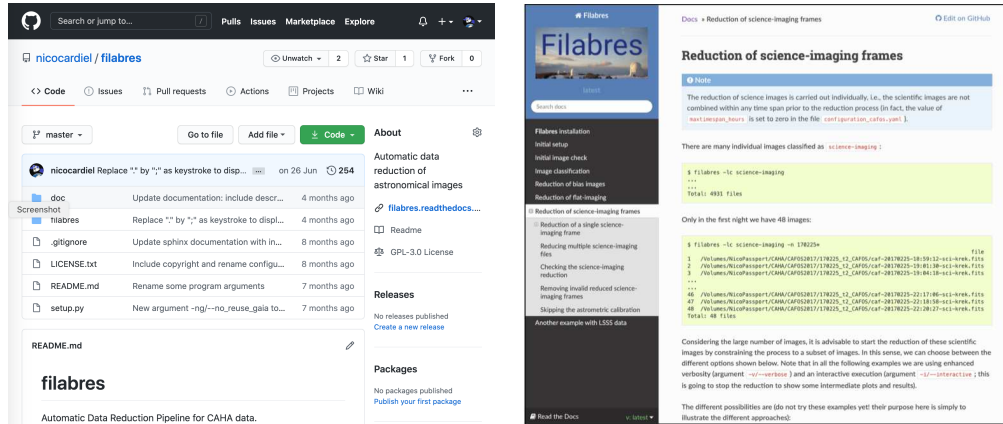
Figure 1.   Filabres source code is available through GitHub (left panel, `https://github.com/nicocardiel/filabres`), and its documentation is hosted at Read the Docs (right panel, `https://filabres.readthedocs.io`).
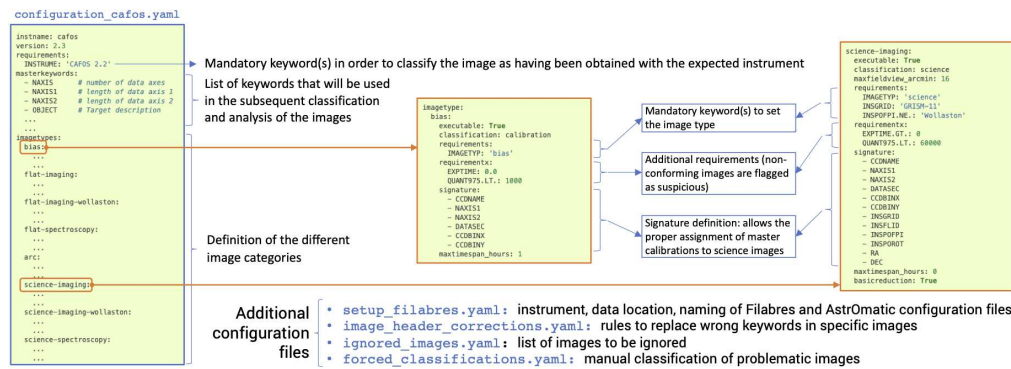

Figure 2.   Auxiliary files used to define the automatic image classification. A particular signature, including relevant FITS keyword values, is associated to each image type, which facilitates the identification of the calibration images that must be employed to reduce the considered image.

2. How Filabres works

The typical workflow with Filabres consists of the following steps:

1. Image classification: bias, flat-imaging, arc, science- imaging, etc., are classified within each observing night. The automatic image classification (see Fig. 2) is carried out following the rules provided in the instrument configuration file (written in YAML format). This file defines the rules using a hierarchical strategy, based on header keyword values and statistical measurements (predefined image quantiles) performed on the image data themselves. The derived classification is stored in an independent JSON file for each night that works as a database for the subsequent work.

2. Reduction of calibration images (bias, flat-imaging) and generation of combined master calibrations as a function of the modified Julian Date. This information is stored in additional JSON files that allows the quick retrieval of the required calibrations for the reduction of the science images.
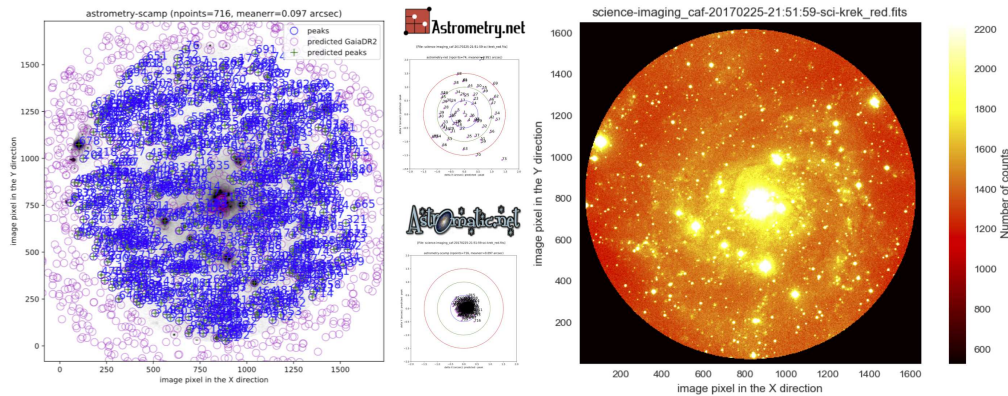
Figure 3. The astrometric calibration of the images is performed in two steps: an initial SIP gnomic projection calibration is obtained with the help of the utilities provided by the Astrometry.net software package, employing Gaia DR2 sources as reference, leading to typical astrometric errors of ∼ 1 arcsec. This initial calibration is refined, following the TPV World Coordinate System, by the combined execution of SExtractor and scamp, from the AstrOmatic.net software suite, which provides typical astrometric errors ∼ 0.03 arcsec.

3. Basic reduction of individual science images, making use of the corresponding master calibrations (closest in time to the observation of the science target). The main reduction steps considered here are: bias subtraction, flatfielding of the images, and astrometric calibration. The latter is performed with the help of additional software tools: Astrometry.net (Lang et al. 2010) and by AstrOmatic.net (Bertin & Arnouts 1996; Bertin 2006) (see Fig. 3).

Although the software has been developed to reduce science images obtained with the instrument CAFOS in imaging mode, the flexibility of the instrument configuration file should allow the reduction of images obtained with different observation modes and instruments.

3. CFC: Cafos Photometric Calibration

A complementary Python pipeline is under development for obtaining an astrometric and photometric catalogue of CAFOS images observed with SDSS filters. For the extraction of sources it uses SExtractor and PSFex, and for the photometric calibration it uses SDSS DR12 or APASS DR9. CFC follows a series of steps to remove spurious and saturated sources as well as artifacts in the resulting catalogue. It also contains useful parameters like the FWHM, ellipticity and an extended/point-like classification.

4. Access to the reduced data

The reduced CAFOS images corresponding to the period ranging from January 2008 to July 2019 are already available through the Calar Alto Archive hosted by the Spanish Virtual Observatory. Since the archive is integrated within the Virtual Observatory, it is possible to quickly visualize the reduced data using, for example, the widely-used VO tool Aladin (Bonnarel et al. 2000). This allows the immediate comparison with available data from well- known surveys and databases (see Fig. 4).

Figure 4.   The data reduced with Filabres is already available through the Calar Alto Archive hosted by the Spanish Virtual Observatory (left panel). In the example shown we compare the CAFOS observation of the planetary nebula NGC 2371 (left image in the lower right panel) with the PanSTARRS DR1 image (right image in the same panel).

References

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