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The "stecf" IRAF Layered Package

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Abstract. We have collected together many of the astronomical applications developed as IRAF tasks at the Space Telescope European Coordinating Facility (ST-ECF) into a new IRAF layered package called "stecf". This package contains several subpackages. One contains a variety of image restoration algorithms including multiple channel and photometric variants of the Richardson Lucy method. In addition a wholly new package ("impol") for the reduction of polarimetric imaging from HST (and ground-based instruments) is made available. Software for the post-pipeline processing of HST NICMOS data, with particular emphasis on the association and pre-processing of images to be used for grism spectral extraction and a "quicklook" grism spectral extraction tool, originally for HST STIS data, are also included.

1. Introduction

For many years the ST-ECF has developed IRAF tasks and packages for HST and related data analysis. Up to now these have been distributed in an *ad hoc* manner and supported at various levels. To allow wider and more efficient distribution and to bring all components to a uniform level of quality and documentation we have decided to combine these components into a standard-format IRAF package to be called "stecf". The "stecf" package will be made available as part of the next release of STSDAS as well as on the IRAF archive site and its mirrors and from the ST-ECF Web pages[1]. This paper gives an overview of the contents of the packages and examples of their use along with pointers and links to further information. The brief descriptions here cover an improved photometric restoration method, grism reduction software and a grism "quicklook" spectrum extraction tool as well as a more complete description of a new package for the reduction of imaging polarimetry data. Other tasks will be added in the future.

2. *stecf.cplucy* – Enhanced Two-channel Photometric Restoration

To address the problem of point-source photometry in restored images Lucy (1994) suggested a two-channel photometric restoration method in which the

[1] http://www.stecf.org/software

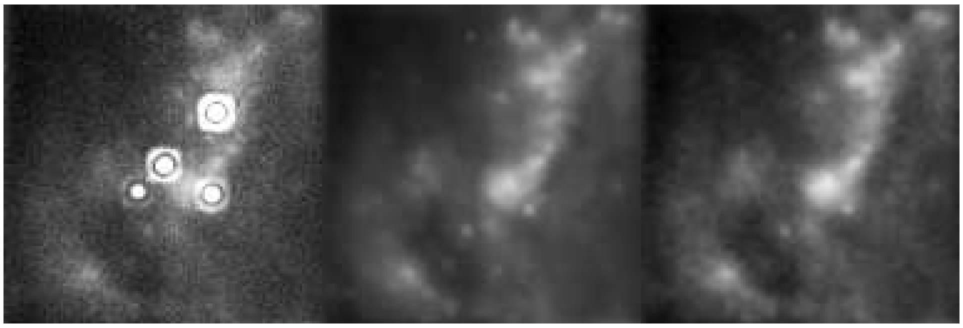

Figure 1. An example of the application of CPLUCY. The image at the left is a simulated HST/NICMOS image with bright point-sources and structured background. The stars are at random sub-pixel positions. The centre image shows the true background intensity distribution and on the right the CPLUCY reconstructed background channel is shown.

points are represented as $\delta-$functions in one channel and the background, constrained to be smooth by an additional entropy constraint, in the other. This method was implemented and made available as PLUCY in the **stsdas.contrib** package. PLUCY has the significant disadvantage that the stars were forced to be at the centres of pixels. This led either to artifacts due to inexact alignment or required the use of unreasonably large sub-sampled images. In the new CPLUCY implementation the stars can be at arbitrary x, y sub-pixel positions but the entropy constraint on the background, used by PLUCY, is retained. A superior new approach to this problem (GIRA, Pirzkal et al. 2000) is being developed and CPLUCY may be viewed as an intermediate code. Figure 1 shows an example of the application of CPLUCY to a simulated HST/NICMOS image.

3. *stecf.nictools* – NICMOS GRISM Tools

The *stecf.nictools* package[2] is a collection of IRAF **cl** scripts to group, process and co-add NICMOS direct and grism images. It was written to help the processing of NICMOS grism images *after* they have been calibrated with the STScI pipeline **calnica** and *before* spectra are extracted with the ST-ECF software NICMOSlook or **calnicc**. It is also useful for simple co-adding (shift and add) of direct images.

4. *stecf.slitless* – a Slitless Spectroscopy Quick-look Tool

Slitless is an IRAF task originally written to allow the "quicklook" extraction of spectra from STIS direct/grism HST image pairs. It allows a user to perform unweighted non-flatfielded extraction and wavelength calibration with a minimum of user interaction: specific objects or a region of interest are selected in

[2]`http://www.stecf.org/instruments/nicmos/nictools/`

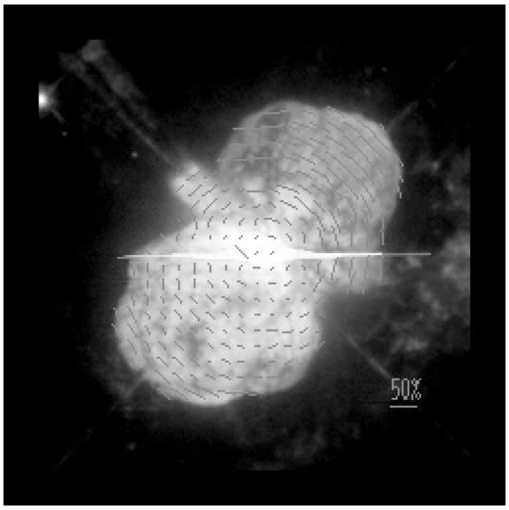

Figure 2. An example of the output from *stecf.impol* showing polarization vectors plotted on an HST WFPC2 F673N filter image of the Homunculus nebula surrounding η Carinæ.

the direct image, and the task automatically computes and selects, based on the camera and grism modes that were used, the appropriate section to extract from the associated grism image. The level of background to subtract at each wavelength can be determined interactively or by using some preset grism regions near the spectrum. Optionally, a Data Quality image extension can be used to avoid extracting flagged pixels. Slitless is configured to work primarily with the STIS G750L grism mode, but more modes can be defined by the user using a simple grism dispersion configuration file.

5. *stecf.impol* – an IRAF Imaging Polarimetry Reduction Package

The impol package consists of five tasks to reduce, simulate and plot imaging linear polarimetry data taken with the HST instruments with polarizing facilities - currently FOC, NICMOS and WFPC2. The tasks are written to require minimum user interaction so that specialist knowledge is not required to produce scientifically useful polarization results. Starting from well-aligned input images, along with statistical error maps, images of the total signal (Stokes parameter I), the normalized Stokes parameters Q/I and U/I, the linear polarization and position angle of the E vector and their propagated errors are produced.

5.1. *stecf.impol* – Features

- All the instrumental set-up, such as filters, polarizers, rotation angles, etc. are read from the image headers'
- Many input images ($3 < N < 64$) can be processed'
- HST instruments FOC, NICMOS and WFPC2 are handled; ACS will be added in the near futuré

- Data from non-HST instruments with polarization analyzers can be added by including a table file listing the instrument polarization properties,
- Output images can be rebinned to increase the polarization signal-to-noise per output pixel,
- Polarization vector maps can be flexibly plotted with user choice of vector size, density of vectors and range of plotted magnitudes. Maps can be over-plotted on images using standard IRAF facilities,
- Output error images have fully propagated statistical errors from the input error images. The bias on the polarization values for large fractional polarization errors is corrected.

5.2. *stecf.impol* – Package Tasks

hstpolima: Reduce linear polarization data for HST instruments (currently FOC, NICMOS and WFPC2 are supported). A set of well-aligned input images is required and the corresponding statistical error images. Images for the three Stokes parameters (I, Q and U), the linear polarization and position angle and their error images are output.
hstpolpoints: Reduce linear polarization data for HST instruments for a set of circular apertures. From a set of input images and the error frames, the linear polarization results (and errors) are returned as an STSDAS table.
hstpolsim: Produce simulated polarization input data frames for HST instruments from images of the total signal, the linear polarization and the position angle of the polarization vectors. The output images can have noise added. Images of the statistical errors are also produced for full compatibility with the input required by hstpolima.
polimodel: Produce model linear polarization and position angle images given a total signal image. The polarization variation is specified by a power law and the position angles are oriented at right angles to the direction to the centre. Random noise variations in polarization and position angle can also be included.
polimplot: Plot a polarization vector map with flexible control over vectors and labeling. Linear polarization and position angle images are required. A vector map can be over-plotted on the total signal image. Figure 2 shows an example.

There is a web page[3] briefly describing the package and giving example polarization maps for HST and model data. A directory of demos is also available allowing simulated data with FOC, NICMOS and WFPC2 and a non-HST instrument to be produced for a model bipolar reflection nebula.

References

Lucy, L. B. 1994, in "The Restoration of HST Images and Spectra-II", R. Hanisch & R. White (eds), 79

Pirzkal, N., Hook, R. N., & Lucy, L. B. 2000, this volume, 657

[3]`http://www.stecf.org/software/impol/`