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NICMOS Related Software Development at the ST-ECF

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Abstract. In collaboration with the STScI and with the NICMOS Investigation Definition Team we have been developing software to predict aspects of NICMOS performance and to analyze NICMOS grism data. Quick look analysis software has been developed to extract spectra from NICMOS grism images and matching direct images to support ground testing and in-orbit verification. The TinyTim point spread function generation package has been modified to produce NICMOS PSFs for various instrumental modes. Software for creating simulated data has been developed in order to test various analysis procedures. A "grism spectra extraction pipeline" has been produced which allows the location, extraction, and calibration of grism spectra from NICMOS frames with a minimum of human intervention. Tools to convert between units and photometric systems are available.

1. Introduction

NICMOS (Near Infrared Camera and Multi-Object Spectrometer) will be installed in the Hubble Space Telescope (HST) during the Second Servicing Mission in February 1997.

Software is being developed at the STScI to ensure the proper calibration of data obtained with NICMOS. Software is also being developed within the NICMOS Investigation Definition Team (IDT, PI Rodger Thompson) to support the IDT science program.

Among the operating modes of NICMOS is a grism spectrum mode. While this mode is not being considered one of the primary operating modes, it nonetheless provides a very important scientific capability, and has the highest potential for serendipitous discovery. A strategy for a routine parallel grism survey has thus been developed.

In collaboration with the NICMOS IDT and with the STScI, the ST-ECF has been developing software to support the NICMOS grism mode from ground testing to routine pipeline calibration. This includes interactive tools for the examination of grism and associated direct frames, for computing point spread

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functions, and a component of pipeline calibration for the automatic detection and extraction of grism spectra. A Web-based tool has been produced for magnitude/flux conversion.

2. NICMOSLook

NICMOSLook is an interactive tool to extract spectra for individual sources on a NICMOS grism image. A matching direct image of the same field is used to determine the location of sources and, therefore, the zero point for the wavelength scale for each individual spectrum.

The tool is implemented as an IDL widget. After loading the grism image and the direct image, both images can individually be displayed and manipulated. The user can locate objects in various ways: with the cursor, by supplying object coordinates, or by setting a threshold for an automatic object search.

Spectra can be extracted for any user-selected object or for all objects at once. The dispersion and distortion spectra are read from a database. There are several options for the spatial weighting of the spectra. The weights can be supplied by the user. Predefined weight functions are equal weights or weights computed from simulated point spread functions (see below).

The output of NICMOSlook are wavelength calibrated spectra, which are plotted on the screen and can be saved as PostScript files or ASCII data files.

3. TinyTim for NICMOS

The detection of objects on grism images, weighted extractions of grism spectra, deconvolution of images and spectra, and simulations of imaging data all require at least approximate knowledge of PSFs. One part of the ST-ECF NICMOS project was therefore to develop the capability to easily create PSFs for the NICMOS filters and grisms.

The TinyTim software is well known to anybody who ever worked on pre-COSTAR data. Originally written by John Krist at the STScI, it can generate theoretical point spread functions for the FOC and the WF/PC, both before and after the first refurbishment mission in late 1993, supporting image restoration work and other analysis for which knowledge of the PSF is needed (Krist 1994).

TinyTim has been modified at the ST-ECF to produce PSFs for the various operating modes of NICMOS. These PSFs are being used by NICMOSLook (see above) and by the grism spectrum extraction pipeline (see below) to extract spectra from grism frames, in particular for spectra in crowded fields with overlapping objects.

The modifications made include the addition of the NICMOS optical system geometry (focal ratios, pixel sizes, position of the NICMOS cameras in the HST focal plane, etc.) and the incorporation of the additional pupil obscuration introduced by the "cold masks."

The original TinyTim used stellar spectral type as a simple way of specifying the spectral energy distribution of the source. This is clearly not appropriate for an infrared system and, after discussion with the NICMOS PI, it is planned to incorporate three ways of specifying SEDs: a blackbody of a given temperature, a powerlaw of a given slope, and a user-specified spectrum.

4. Simulated Data

It is obvious that for the testing of any data analysis software, a good set of representative data is required.

There are two distinctly different aspects to this exercise: on the one hand the data have to be similar to, if not identical with, the expected actual data in terms of structure, header, keywords, etc. Although we made considerable efforts to anticipate the expected configuration, we expect to have to make considerable changes.

On the other hand, the simulated data have to be representative in terms of the pixel content. Different data sets corresponding to different configurations of NICMOS, different roll angles of the HST, and different degrees of crowding in the field were constructed.

5. The Grism Spectrum Extraction Pipeline

The interactive grism extraction tool NICMOSlook described above is a convenient tool to extract spectra from small numbers of grism images. However, a routine extraction of spectra from large number of NICMOS grism images requires a tool which extracts spectra without human interaction. Such a need may arise from large survey-type grism programs, for archival research, or for programs where grism images contain a larger number of objects which are not the primary object of interest. Ideally, such a grism extraction can be run at the same time as the STScI pipeline data reduction.

Establishing the requirements for such a software package, we quickly found that we did not have the resources to write it from scratch. On the other hand, it soon became evident that most of the individual steps needed for the reduction have been coded before in one way or the other. The challenge was to harvest as much as possible of this available functionality and to combine it into a package which would meet the requirements of minimum human intervention and operational resilience. Currently, we are implementing such a grism extraction "pipeline" (called calnicc as it requires the STScI developed calnica and calnicb pipeline steps) as an IDL program, which calls C modules where necessary.

The capabilities of the program are the following. Objects are identified and classified as stars or galaxies using a neural network approach implemented as the SExtractor program (Bertin & Arnouts 1996). The wavelength calibration of the extracted spectra are performed using the position of the objects as determined by the SExtractor program as the zero point, and using parameterized dispersion relations. After extractions of the spectra, they are corrected for the wavelength dependence of the quantum efficiency of the detector. The flux scale is then computed using the standard NICMOS flux calibration data. The extracted spectra will automatically be checked for artifacts from bad data and contamination from nearby objects. All spectra will be automatically searched for emission and absorption lines. In addition, the continuum emission will automatically be determined. The final data products are binary FITS tables with the spectra, error estimates, object parameters derived from the direct imaging, and details of the spectrum extraction process.

6. NICMOS Tools

The near infrared is the region where the Magnitudes meet the Janskys. In order to support the work on the NICMOS related software, and to provide tools for the community to construct observing programs for NICMOS, the ST-ECF developed a Web-based unit converter.

Taking advantage of recent developments among Web browsers, in particular of the emergence of Java (Arnold & Gosling 1996) and Javascript, we decided to implement the tool in Javascript. This has the advantage that the functionality can be invoked through the Web, but that the computational load is exported to the client, thus offloading the host. The tool is available at: http://ecf.hq.eso.org/nicmos/tools/nicmos_units_tool.html. Details of design and implementation are given in another poster paper (Micol et al. 1997).

When invoked from a Web browser capable of handling Javascript, the user is presented with a form-type interface.

Three are the input fields: Magnitude, Flux, or NICMOS. Correspondingly the user can select the associated units:

- Photometric system (CIT or UKIRT) and band (from V to Q) for the Magnitude;
- Some of the most used units for the Flux;
- Janskys and $Jy/arcsec^2$ are the units for NICMOS.

As in a spread sheet, whenever an input field is changed, the other two will be automatically computed according to the chosen units.

For better user-friendliness, two fill-in forms are provided: one for point sources and the other for extended sources. Both the forms have the same functionality and layout.

References

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