WHAT POTENTIAL USERS SHOULD KNOW ABOUT GPI DATA

Ken Hinkle, Jayadev Rajagopal, and Dick Joyce
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ABSTRACT—GPI is an extreme AO imager combined either with an integral field spectrograph or a polarimeter. The standard mode of operation employs a coronagraphic stop to achieve extremely high contrast images of the near-object field. The integral field spectrograph is of the design employing micro-lenses. As a result the data consist of images containing thousands of very low-resolution spectra or, in the case of polarimetry, thousands of dots. Data of this type cannot be reduced with standard tools. A GPI data pipeline written in IDL is provided by Gemini. With some interaction with the Gemini support team and a co-investigator with an IDL license we were able to reduce spectroscopic and polarimetric GPI data with this pipeline. The reduction process is non-trivial and it is not possible to glean information from the data until it is reduced.

INTRODUCTION

A good introduction to the design of GPI can be found in Macintosh et al. 2006, Proc. SPIE, 6272. GPI is a highly complex astronomical instrument. However, there are a few salient points the user needs to understand. The field is reimaged on a focal plane mask. The mask contains a hole that the brightest part of the point source passes through. The rest of the field is reflected and passes through an integral field 256 x 256 element lenslet array. Each lenslet has a field of view of about 14.3 by 14.3 milli-arcseconds in the Y band. Each lenslet will correspond to a pixel in the final image. Either a dispersing prism or a Wollaston prism follows the lenslet array. The result is 256 x 256 separate spectra or 256 x 256 x 2 images of the field recorded on the detector. The approximate mapping of the data onto the detector is given at

http://www.gemini.edu/sciops/instruments/gpi/gpi_data_format.png

In the spectroscopy mode the images are separated by 4.5 pixels spatially and 22.5 pixels spectrally with >41000 spectra recorded. The FOV is ~3 arc seconds at a Strehl of ~0.9. The occulting mask covers the central diameter of about 0.2 arcseconds.

For the spectra the resolution is about 40 with the coverage of one atmospheric window. The Wollaston prism is used in conjunction with a quarter wave plate so each image is a double dot indicating the amount of light in each of two circular polarizations.

In either case the user is faced with the colossal job of reassembling >41000 spectra (Figure 1) or >82000 dots into an image. This is an infeasible task to take on using the standard set of data reduction tools. However, the builders of GPI provide a pipeline. This is clearly an exhaustive effort and overall is well done. However, as is the case for many pipelines in our attempt to reduce a single observation we uncovered a number of snags.

THE PIPELINE LANGUAGE – IDL

The first hurdle is that the pipeline is written in IDL. We strongly advise that it be executed on a machine with an IDL license. There is a compiled executables version of the pipeline that uses the IDL Runtime virtual machine. This has been made available for users who do not have their own copies of IDL. Two of us attempted to run the standalone pipeline on machines without IDL. One machine was LINUX and the other a Mac. We were able to get the initial part of the setup running on the Mac but could make no progress at all on the LINUX machine. Our feeling was that the standalone pipeline is likely quite dependent on details of the machine configuration. Furthermore the standalone version is as stated above compiled executables. In using the pipeline it was necessary to make some adjustments to the IDL code. Based on this, the fact that we (although admittedly computer novices) were not able to get the compiled executables to run, and given the overall complexity of the data we strongly recommend against planning to use the standalone option. We recommend only the use of the IDL pipeline on a computer with an IDL license and furthermore we recommend that the co-I reducing the data have some experience with IDL.

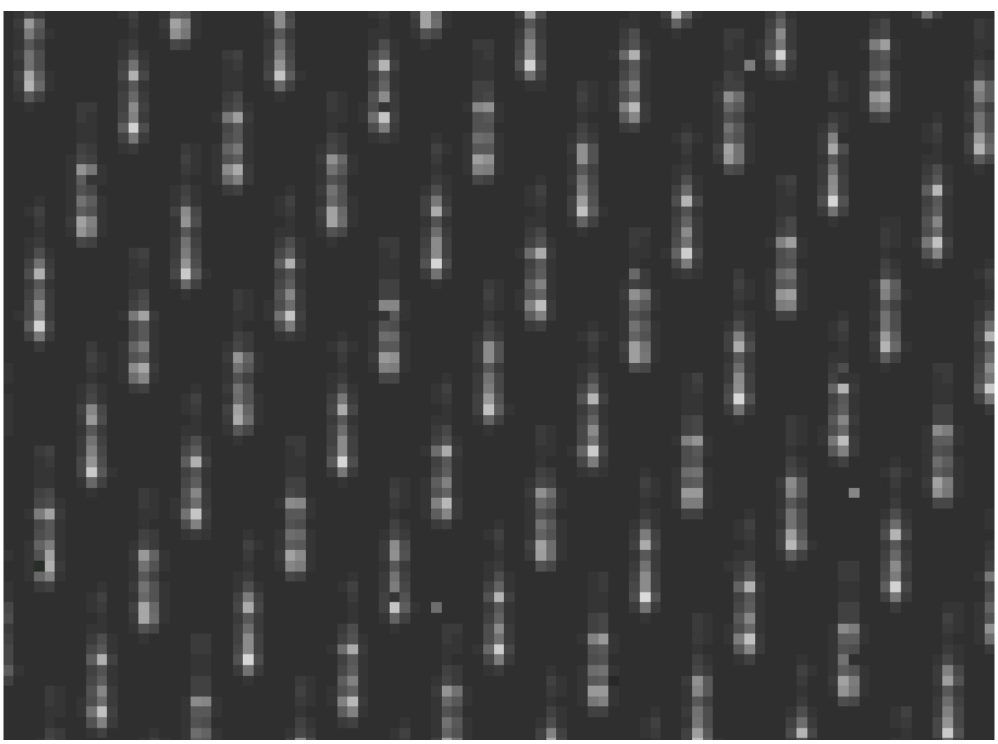

Figure 1 – A detail of GPI extreme AO data taken using the dispersing grating.

USING THE PIPELINE

The pipeline documentation can be found at

http://docs.planetimager.org/pipeline/

The Gemini Data Reduction Forum is the in principal the main conduit for support. In our exploration of the software we reduced a science verification observation and our contact was the Gemini GPI support team. There are extensive release notes on

http://docs.planetimager.org/pipeline/installation/relnotes.html

This page contains links to the known issues with the data reduction. Note that manual adjustments to the reduction process are likely. This reflects the experimental nature of the data reduction pipeline.

A tutorial for the spectroscopic pipeline can be found at

http://docs.planetimager.org/pipeline/usage/tutorial.html

and for the polarimetry pipeline at

http://docs.planetimager.org/pipeline/usage/tutorial_pol.html

As described in the tutorial, the pipeline is based on recipes to reduce files. A recipe includes a list of input ingredients (data files) and a list of actions (primitives) to be applied on those files. Each primitive is an elementary algorithm. As in IRAF the primitives can function on a single file or a set of files. For instance, Subtract Dark acts on one file at a time, while Combine 2D images will merge all the files from the list resulting in a single output file. The special primitive Accumulate Images divides the two categories of primitives. All the primitives before are applied to each file, then Accumulate Images gathers up the results, and any primitives after are applied to the entire set.

A recipe editor is provided to carry out these functions. This GUI provides the recipe templates and allows the templates to be edited. The documentation is relatively sparse and at times we found it necessary to read the IDL code that ran the primitives to fully understand their function.

The reduction depends on a coordinate system and dispersion relation extracted from the calibration spectra. As described in the tutorial inspect the grid to make sure the individual images are aligned with the grid. Tweaking the grid will be necessary.

BUGS

Overall the tutorial was a good guide to the pipeline if nothing unusual happened. Clearly the most used mode for the developer was the coronagraphic-spectroscopic imaging mode. We found the fewest problems using this. In the polarimetry mode the reduction code contains debugging stops. The documentation for polarimetric observations is clearly sparser than for the spectroscopy mode. It is not obvious how to use the pipeline to reduce direct imaging (coronagraph removed) observations.

We did encounter two problems that were unexpected show stoppers:

For Mac version 10.7.5 and GPI version 1.1.1 IDL depended on have the parallel processor switch off for spectroscopy but on for polarimetry.

The polarimetry code appears not to be as mature as the spectroscopy code. We found that there were debugging stops in the code. It was necessary to read the IDL to find these and remove them.

We encountered problems with the final calibration of the images. For the spectroscopic data we were not able to generate good calibration templates for the spectrum. These are needed to aline the 256 x 256 microlensed spectra. This could be because the arc-lamp calibration spectra supplied with our observations were not of high enough S/N. The arc-lamp spectra are taken between target observations to account for flexure. The pipeline manual provides insufficient information about the alignment process (Figure 2) and we finally need calibration files generated by the Gemini Scientist to proceed. In the polarimetry mode we encountered similar problems with documentation on the centering correction of the images.

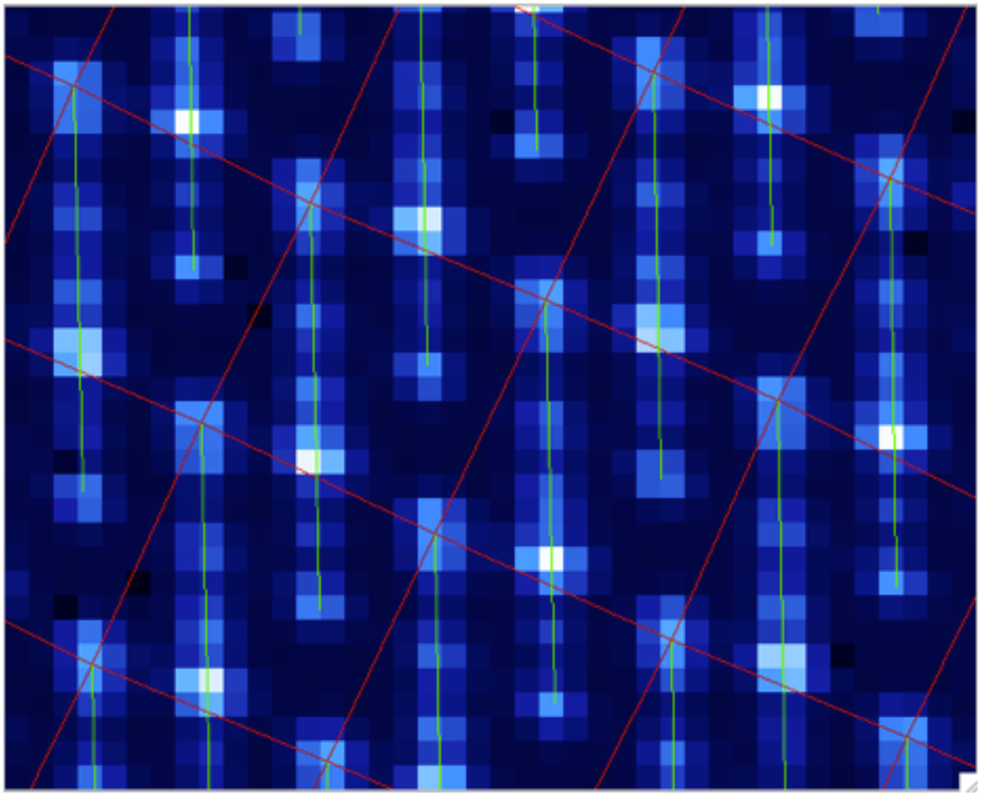

Figure 2 – Spectra with the calibration coordinate grid applied (red). The green lines are the locations of the individual lenslet spectra.