Spectroscopic Data Reduction Pipeline for the Goodman High Throughput Spectrograph

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Abstract

The Goodman High Throughput Spectrograph (Goodman Spectrograph) [1] is a highly versatile instrument in operation at the SOAR Telescope on Cerro Pachón, Chile. It is capable of doing low to mid-resolution spectroscopy in a range from 3200 Å to 9000 Å. The data reduction pipeline is conceived as an easy-to-run software, that can process an entire night worth of data by execution of a simple command, with the least amount of arguments, from a terminal window. It is written almost entirely in Python, following several Python standard conventions. We aim towards using exclusively standard Python packages, such as AstroPy and AstroPy-affiliated packages, while at the same time allowing for fast and efficient computing. In its present form the pipeline produces fully reduced, wavelength-calibrated spectra. Flux calibration will be an add-on option for a later release.

Future Work

The *TODO* list is large and the users and community input is very important to help us decide were to focus our efforts. A list of the most prominent changes are listed below. From the software point of view:

Structure: The current static structure is confusing. There is a development version that includes a modified static structure more according to an AstroPy Affiliated Package.

Tests: Implement integrated test code.

Workflow: Review the current workflow and propose an update.

User Manual: Although we have a fully functional user manual we need feedback regarding how clear it is for non-regular users.

AstroPy: One of our important goals is to develop software that is compliant with the current and future standards of Python programming. AstroPy is a good example, in fact when our software gets in a more mature level, we want to collaborate.

From the scientific point of view:

Extraction: The current spectrum extraction is in fact a simple sum of counts in a rectangular region. We will implement fractional pixel extraction as well as the Optimal Extraction algorithm [2] [3].

Operation: We are planning to develop a *Live reduction pipeline* that can process data as it comes from the telescope, that will allow observers to take better and quicker decisions.

Telemetry: We are developing a system to store the parameters of the wavelength solution polynomial with the intention to validate new solution and eventually detect problems with the instrument.

WCS: We implemented part of the FITS standard for writing wavelength solutions but we are aware of new developments in this regard and we are looking forward to implement them in our software.

Flux Calibration: This is one of our top promises for the community.

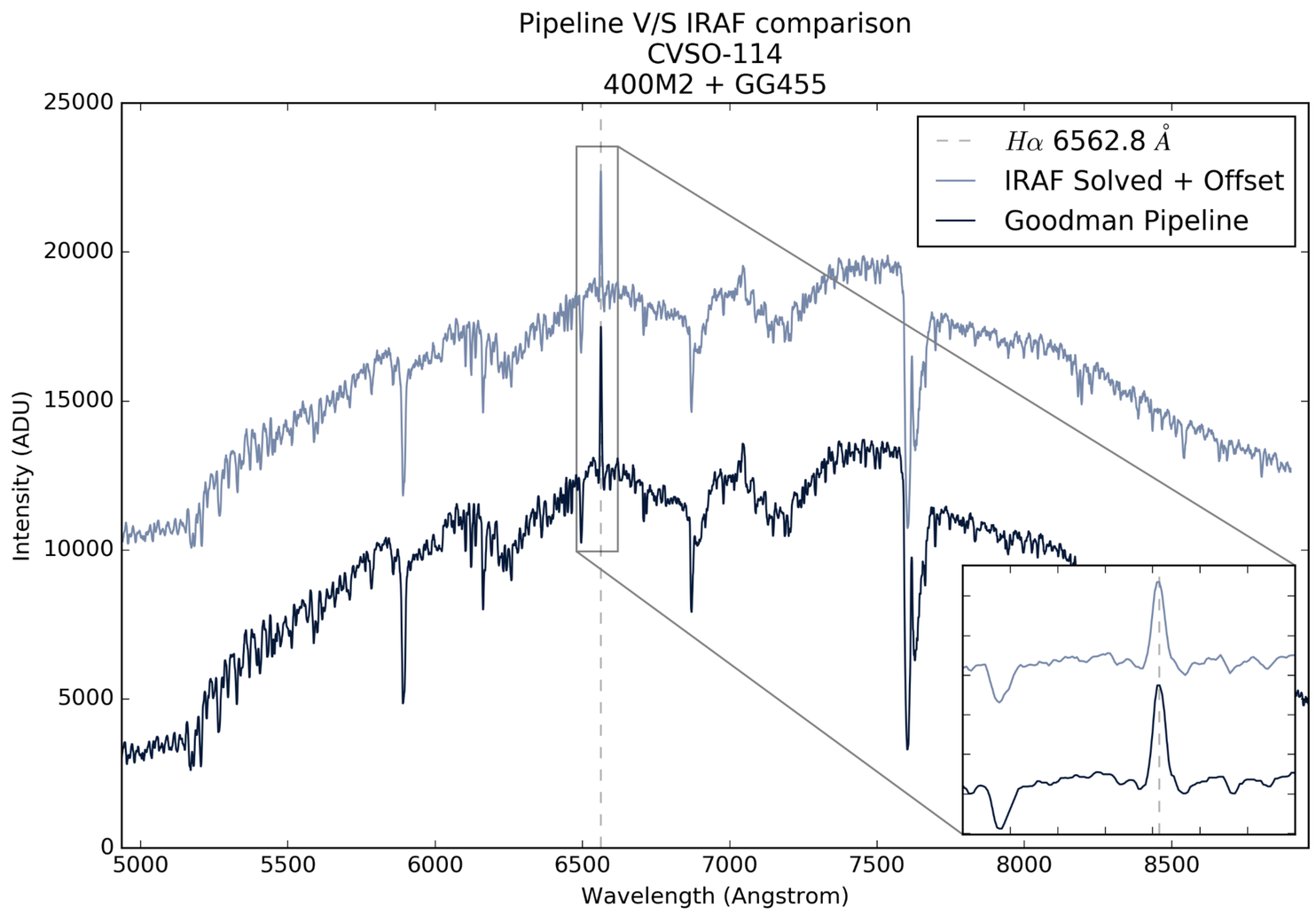

Figure 1. The same spectrum was processed using IRAF as well as the pipeline. The pipeline operated fully automatic.

Pipeline Concept & Status

We aim to develop an easy to use software. A user should be able to run it with the least amount of command line arguments yet it should allow a large enough flexibility to be usable in a wide range of configurations just as the Goodman Spectrograph does. Also it should be built as a library in order to reuse the code in slightly different applications.
In general we consider most of this as achieved but in the spirit of objectivity we are still quite far from a final version. There are two scripts that are the command-line terminal user interface.

redccd: Does the initial 2D/Image processing. It has been tested for spectra images.

redspec: Does the spectroscopic analysis from where `redccd` left it. Up to the spectrum extraction it works automatically only. Potential users have requested the addition of interactive modes for selecting custom apertures for extraction. We might, but keep in mind that we are not developing a replacement for IRAF. For wavelength calibration `redspec` can work in interactive or automatic mode. In fact both methods work very well. For most common use cases the scripts can be called without any arguments.

Task	Time (seconds)
redccd	155
redspec	32
Total	187

Table 1. Quick stop-watch timing of each script. This is a full night, with 105 raw images (redccd) from which 48 are usable by redspec that at the end will leave 40 wavelength calibrated images, some comparison lamps are included.

Interactive (Å)	Automatic (Å)	Slit Size
0.368	0.340	0.84”
0.296	0.521	1.03”

Table 2. Comparison of typical values for the RMS error for one of the nights used to evaluate the performance of the pipeline.

Results

After one year of development we have achieved most of our goals. Figure 1 shows a comparison with IRAF where you clearly see a very good match. It is important to emphasize that the pipeline worked fully automatic. Table 1 summarizes a timing test for the pipeline fully automatic as well. The computer used has an Intel i7 processor with 32GB of RAM. For the same night tested the average RMS error was 0.62 Å considering three spectra observed in a spectroscopic mode that has not been fully testing, therefore the wavelength solution obtained is deficient. Removing them drops the error to 0.51 Å. In terms of the code itself we did not succeed in having a purely Python code since LaCosmic [5] did not provide satisfactory results, we implemented DCR [4] written in C but it is not intended to be a Python Extension, so the integration into the pipeline workflow was not so simple. We have released the first beta version and our plan is to release a second beta version before the end of the year. The pipeline version 1.0 will come once we implement the flux calibration.

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