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Advances in Space Research 53 (2014) 1647–1656

ADVANCES IN SPACE RESEARCH
(a COSPAR publication)

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Comprehensive data reduction package for the Immersion GRating INfrared Spectrograph: IGRINS

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Received 13 January 2014; received in revised form 28 February 2014; accepted 28 February 2014
Available online 10 March 2014

Abstract

We present a `Python`-based data reduction pipeline package (PLP) for the Immersion GRating INfrared Spectrograph (IGRINS), an instrument that covers the complete H- and K-bands in one exposure with a spectral resolving power of 40,000. The reduction steps carried out by the PLP include flat-fielding, background removal, order extraction, distortion correction, wavelength calibration, and telluric correction using spectra of A type standard stars. As the spectrograph has no moving parts, the PLP automatically reduces the data using predefined functions for the processes of order extraction, distortion correction, and wavelength calibration. Before the telluric correction of the target spectra, the intrinsic hydrogen absorption features of the standard A star are removed with a Gaussian fitting algorithm. The final result is the flux of the target as a function of wavelength. Users can customize the predefined functions for the extraction of the spectrum from the echellogram and adjust the parameters for the fitting functions for the spectra of celestial objects, using "fine-tuning" options, as necessary. Presently, the PLP produces the best results for point-source targets.

Keywords: Methods: data analysis; Techniques: spectroscopic

1. Introduction

IGRINS (Immersion GRating INfrared Spectrograph) is a cross-dispersed near-infrared spectrograph that uses a silicon immersion echelle grating as its main dispersing element. It covers all of the H- and K-bands in a single exposure with a resolving power of $R = \lambda/\Delta\lambda \sim 40,000$. The H- and K-bands echellograms consist of 23 and 20 orders, respectively (Fig. 1). Since the spectrograph has no moving parts, the transformation functions for the order extraction, distortion correction, and wavelength calibration vary very little from one exposure to the next. Hence, a deliberately designed pipeline is to provide stable quality of data reduction process with minimal human intervention.

The full IGRINS hardware and software system is described earlier (Yuk et al., 2010). The IGRINS software consists of six packages to be used before, in the middle of, and after the observation. To prepare the observation, one can use the Exposure Time Calulator (ETC) and a finding-chart produced with the Observational Preparation Package (OPP). During the observation, Housekeeping Package

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http://dx.doi.org/10.1016/j.asr.2014.02.024
0273-1177/

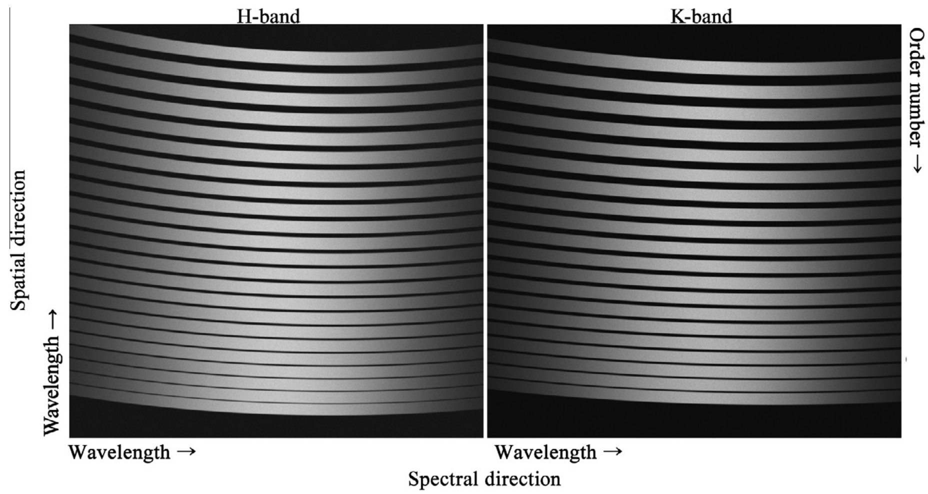

Fig. 1. Simulated IGRINS H- and K-bands flat echellogram. Echelle order number increases from top to bottom; wavelength increases from bottom to top and left to right. In each order, the spectral (dispersion) direction is along the horizontal axis, while the spatial direction is along the vertical axis.

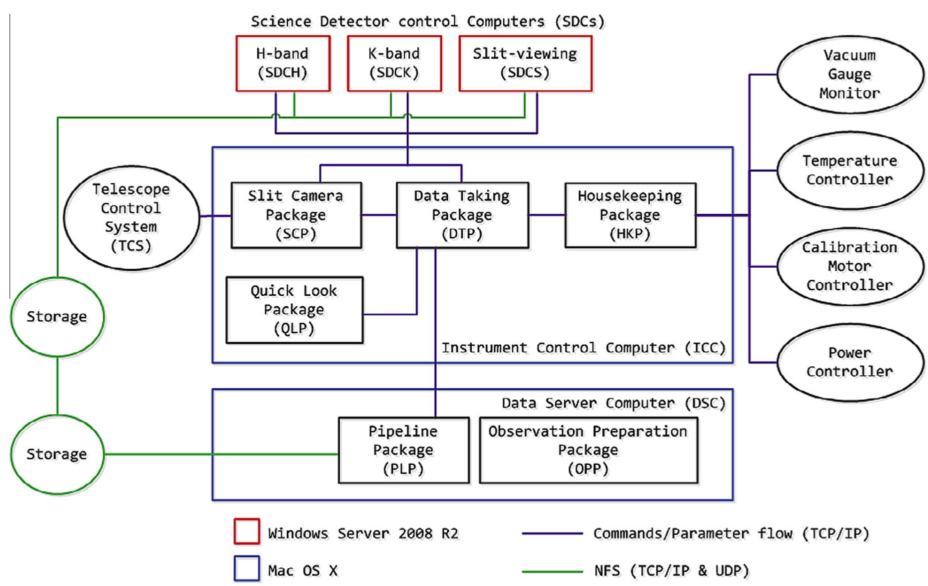

Fig. 2. System architecture diagram of the IGRINS software.

(HKP), Slit Camera Package (SCP), Data Taking Package (DTP), and Quick Look Package (QLP) conduct the observation. Afterwards, the data can be reduced by the Pipeline Package (PLP). This package can also be used during the night to help the observer to decide further observation strategies. A diagram of the overall configuration of the IGRINS system is shown in Fig. 2.

The PLP reduces the IGRINS data following the well-estabilished procedure for reduction of echellogram images: flat-fielding, background removal, order extraction, distortion correction, wavelength calibration, and telluric correction. As the spectrograph has no moving parts, the functions to represent the echellogram mapping are theoretically defined. The reduction processes of order extraction, distortion correction, and wavelength calibration can be run in an automated way using the predefined functions. The functions can then be revised in a "fine-tuning" mode that interacts with the user during the run.

To make use of the PLP, the observer should follow the standard observing sequences which requires assigning reduction group number to each echellogram, observing A0V type standard star, and using "Nod-on-Slit" mode for the stellar objects.

In the following sections, we write about the PLP from the standpoint of its architecture in Section 2, describe the standard observing sequence for IGRINS in Section 3, illustrate the detailed reduction process of the pipeline in Section 4, and summarize in Section 5. The "*pipeline*" hereafter refers to the PLP of the IGRINS software.

2. Architecture of the IGRINS *Pipeline*

All of the IGRINS software including the *pipeline* is written in `Python`[1] 2.7, which is freely available for many

[1] http://www.python.org/.