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MORIS: Visible-NIR Instrument Integration at the IRTF

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Abstract

NASA's 3-m Infrared Telescope Facility (IRTF) on Mauna Kea, HI plays a leading role in obtaining ground-based Solar System observations. MORIS (the MIT Optical Rapid Imaging System [1]) was developed to provide high-speed optical imaging capabilities, primarily for stellar occultations and extrasolar planetary transits. To expand the IRTF's capabilities for planetary observations, we have upgraded the MORIS system to significantly improve its photometric capabilities and image quality. Further, we have developed integrated software to allow simultaneous operation of MORIS with SpeX, the low- to mid-resolution near-infrared (NIR) spectrograph and imager [2].

1. Instrument details

MORIS is currently a PI instrument at the IRTF. It is based on POETS, the Portable Occultation Eclipse and Transit Systems developed by MIT and Williams College [3]. The primary component is an Andor iXon 897 camera, which has high quantum efficiency in the visible wavelength range (> 90% from roughly 480 nm to 700 nm), low read noise (~6 e-/pixel in 1 MHz conventional mode), low dark current (<0.001 e-/pixel/sec), and the capability to operate in electron multiplying mode. The camera is thermoelectrically cooled, typically operating at -70º C.

The camera has a range of available readout amplifiers: 1 MHz (16 bit) and 3 MHz (14 bit) in conventional mode or 1 MHz, 3 MHz, 5 MHz, and 10 MHz (all 14 bit) in electron multiplying (EM) mode. Each amplifier has multiple gain conversion settings. Full-frame readout rates range between 3.5 Hz (1 MHz) and 35 Hz (10 MHz), and binning or subframing can increase the cadence to a few hundred Hz. There is a 10-slot filter wheel currently containing filters of Sloan *g', r', i', z'*, Johnson *V, VR*, two long-pass-red filters, an open slot, and one space reserved for a visitor filter. Data cubes, or individual frames, can be triggered to several-nanosecond accuracy using the Global Positioning System.

In 2010, the MORIS optical path was completely redesigned and refabricated, introducing additional baffling and a pupil stop into the foreoptics that effectively eliminates scattered light, and dramatically improved image quality.

For the past decade, SpeX has been a popular and versatile IRTF facility instrument for NIR planetary science observations. MORIS is mounted at the side-facing exit window of SpeX. A choice of two dichroics, cutting on at either 0.8- or 0.9-micron, can be inserted into the SpeX beam to reflect the visible light to MORIS. In order to obtain simultaneous observations with MORIS and SpeX, combined control of both instruments is required.

Figure 1. MORIS mounted on the side-facing exit window of the blue SpeX cryostat. The foreoptics box is anodized black, and the gray Andor camera extending from the bottom of the box is protected by a yellow frame.

2. Visible-NIR integration

We have developed a new graphical user interface (GUI) for MORIS on a Linux platform. This interface is very similar to those used to control the other IRTF instruments, allowing MORIS to be utilized for various imaging tasks including guiding, provides a conduit for telescope information to be passed to the MORIS image headers, and makes data storage and backup consistent with the IRTF protocols. Particularly important for science applications is the ability to simultaneously control both MORIS and SpeX from a single command line macro that can be customized for different observing programs. Such a macro may contain commands to set the exposure parameters for both MORIS and SpeX (in either spectroscopic or imaging mode), change filters, and offset the telescope position. A significant feature is the ability to simultaneously trigger exposures on both MORIS and SpeX.

3. Science projects

Expected scientific applications of the integrated MORIS-SpeX setup include multi-wavelength stellar occultation observations, broadband two-channel colorimetry of small solar system objects (e.g. asteroids and Kuiper Belt Objects), and supplemental imaging and guiding capabilities for spectroscopic observations.

For example, on 23 June 2011, a stellar occultation by Charon and Pluto was observed using MORIS imaging (at 0.3-sec cycle times) and SpeX low-resolution spectroscopy (~1.5-sec cycle times). These observations provided very high-quality, multi-wavelength data of a full occultation by Charon and an atmospheric graze by Pluto.

We will present details of the MORIS instrument upgrade, results from MORIS-SpeX stellar occultation observations, and examples of MORIS-SpeX asteroid colorimetry.

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