Data Introduction

Deep Impact: High-Resolution Instrument Infrared Spectrometer (HRII) Data

Instrument Operations

The High-Resolution Instrument, a 10.5-meter focal length telescope with a 30-cm aperture, feeds light to both a visible CCD camera and an infrared spectrometer with a dichroic beamsplitter. The infrared spectrometer is a 2-prism, long-slit spectrometer with an infrared detector. The spectral range of the spectrometer is 1.05 to 4.83 μm. The instrument has acquired scientific data of many targets throughout the prime and extended missions.

The readout array of the infrared detector is 1024^2 with four electrically independent quadrants, each quadrant with a separate readout amplifier, but by design only two of the quadrants are illuminated, and thus the largest data frame is 1024 pixels by 512 pixels. The boundary between the two data quadrants is often noticeable in the raw data, but is generally well removed with calibration. The fast readout direction is along the spectral direction, while the slow readout is along the slit in the spatial direction. Therefore, each spatial pixel's full spectrum has approximately the same time history. The detector has five reference rows on each edge of each frame. These reference rows are flagged in the data quality map in the calibrated data products and should not be interpreted as part of the imaged scene or should be used with caution. In addition, header information is written in the first 100 bytes of the image. The instrument can be read out in full, binned, and binned sub-frame modes, down to 512 spectral by 64 spatial pixels, centered on the illuminated part of the detector. The binning, which occurs in the processing board, is always applied to a 2 x 2 pixel region and the result, an average of the 4 pixels, is the data value saved onboard the spacecraft. The exposure times are dependent on the readout time of the detector, and thus the area of the detector to be read out. The minimum exposure is 0.71 seconds for the binned sub-frame 2 mode (BINSF2). The minimum exposure for the full frame modes is 2.86 seconds (UBFF and BINFF). A spectral attenuator covers the central third of the entrance slit that reduces the long wavelength flux beyond 2.7 μm, especially that from a warm nucleus, which would otherwise saturate the detector. The top and bottom thirds are unfiltered and can be used to image faint coma features. The anti-saturation filter, as it is generally referred to, and its edges are clearly seen in the raw data and are often noticeable to a lesser extent in the calibrated data, even after the transmission response function has been accounted for.

The observing strategy for the infrared instrument was typically to build up a two-dimensional spatial image of a targeted scene by slewing the spacecraft in the direction perpendicular to the long slit at a rate of 10 micro-radians (the width of the short dimension of the slit) per integration time. This would result in a predefined commanded number of frames that, when stacked in order along a new third dimension, would create a 2-D image of the scene, without smear or overlap, but with very small spatial gaps in the scene between frames due to the readout timing. The scan would contain spectral information for each spatial pixel and the radiance values in the calibrated spectra are averaged over the region scanned during the frame integration time. The frames are archived in PDS individually and not as scans but can be identified from their filenames as part of a scan because each scan acquired on a given day of year will have a unique exposure ID for that day and a frame running number within the scan. For example, hi10110402_4000202_001_rr.fit is the 1st frame of the scan with exposure ID 4000200 and hi10110402_4000202_030_rr.fit is the 30th (and last) frame of the scan. The scans can be reproduced by the data user. Note that in some instances, single frames were acquired instead of scans, the scan rate was selected to be different than 10 micro-radians per exposure time, or the spacecraft motion was along the slit and not perpendicular to it. These details can be found in supporting documentation in the data set.

Reading the Data

The data are all stored as FITS files with detached PDS labels, one label and one FITS file for each exposure. Filenames are chronologically ordered. The first part of the filename is "hi" (for HRI-IR) followed by a time stamp (the calendar date and start time of the frame truncated to yymmddhh for all calibrated data). The second part of the filename is the observation sequence number (aka exposure ID) of the image as used in our documentation and in spreadsheets that list the files. The third numerical group is the frame number within a given commanded scan with the same exposure ID. For calibrated data, this is followed by a 1 or 2 letter code to indicate type of product – R for Radiance or RR for Reversible Radiance (I/F images are not provided in HRI-IR data sets).

Each raw image consists of two data objects. The first data object is the image, while the second (aka FITS extension 1) is a quality factor image flagging bad pixels. Each calibrated image product consists of five data objects. The primary image itself (floating point in the calibrated data), an array of quality factors (one-byte integers), a wavelength map, a spectral bandwidth map, and an array of the signal-to-noise ratio (floating point). The pixels in each of the four additional arrays have a one-to-one correspondence to every pixel in the primary image.

If your favorite analysis environment is IDL, you can use the package readpds.pro, which is available at PDS-SBN (http://pdssbn.astro.umd.edu/tools/). If you type "data = readpds(<filename.lbl>)", it will read the data, including all extensions, into an IDL structure containing all the parts of the data product. To see the various pieces, type "help, /struct, data" and it will list the pieces of the highest level of the structure. Some of those will be themselves be structures and you can type, "help, /struct, data.piece1" to find out what is in the sub-structure piece1. If your favorite environment is ISIS, there is a routine pds2isis, although we have not exercised this routine.

PDS does not explicitly support FITS, but if your favorite analysis environment is based exclusively on FITS, you can read the FITS file directly (with extension .fit), ignoring the PDS label (the file with .lbl extension), but you need to be aware that PDS does not validate or officially support the FITS standard. We strongly encourage the use of the freely available routine fv (http://heasarc.gsfc.nasa.gov/ftools/fv/) to read the entire file and determine which extensions are of interest.