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Validation of Data Reduction Interactive Pipeline for FORCAST on SOFIA

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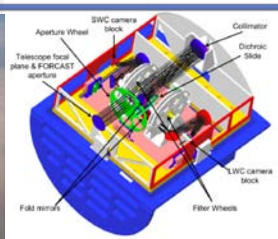
Introduction

The Stratospheric Observatory for Infrared Astronomy (SOFIA) is a heavily modified Boeing 747SP aircraft equipped with 2.5 meter reflecting telescope. Among the suite of instruments is the Faint Object Infrared Camera for the SOFIA Telescope (FORCAST), which features two cameras for short (5-25 microns) and long (25-40 microns) wavelength detection. The Data Reduction Interactive Pipeline (DRIP) was developed to process and reduce all FORCAST data using IDL procedures. Our current mission, in collaboration with the Data Processing System group, is to validate the DRIP output and ensure that the highest quality data is provided for imaging and the astronomical community.

SOFIA

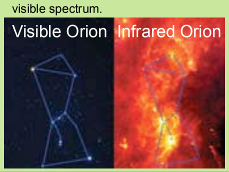


FORCAST

Infrared Astronomy Background

Why Infrared?

Viewing the sky in infrared reveals remarkable details not seen in the visible spectrum.

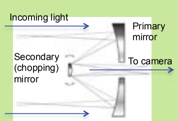


The problem with Infrared

- Everything gives off infrared radiation
- Including the atmosphere and the telescope itself
- Background radiation is commonly many times brighter than the object we wish to view.
- Background radiation is also constantly changing.
- Imagine trying to view a candle through a flaming tube.

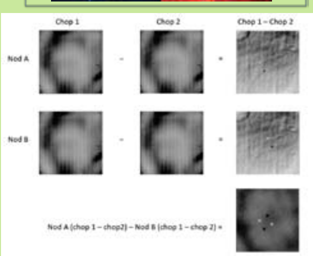
Fixing the Problem: Chopping and Nodding

Chopping:
- A small mirror in the telescope oscillates back and forth at about ten times per second
- Two images are created
- Subtraction of these images eliminates atmospheric background radiation

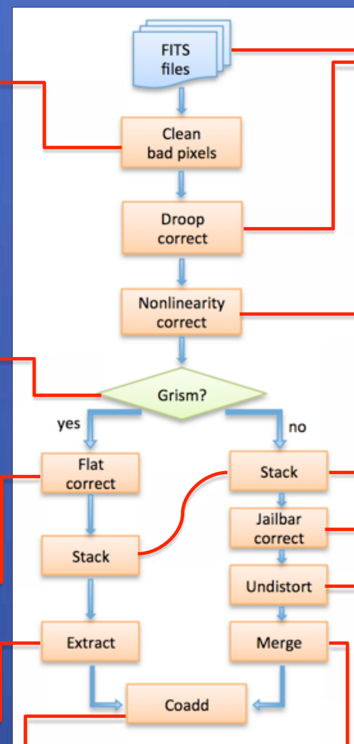


Nodding:
- The telescope shifts slightly or "nods"
- Two images are created
- Subtraction of these images removes telescope background radiation

Note:
- A positive and negative images of the source remain after chopping and nodding
- See the diagram on the left

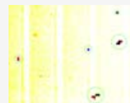


The Data Reduction Interactive Pipeline (DRIP)



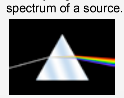
Taking raw data from FORCAST and making it useful!

Infrared telescopes often contain "bad pixels," or spots in the detector that don't have the same response as the rest. DRIP uses a mask to locate and replace bad pixels with values derives from surrounding pixels.



Bad pixels in actual FORCAST data

A grism is the combination of a prism and a diffraction grating. FORCAST can optionally use a grism when taking data for the purposes of analyzing the spectrum of a source.



A flatfield correction is meant to remove pixel-to-pixel variations in gain, dark current, responsivity, and variation in illumination. Offsets are calculated by dividing each pixel by the median pixel value.

DRIP extracts spectral data from an image by an optimal extraction algorithm for a point source or by full extraction (sums the rows along a full slit) for an extended source.

Lastly, DRIP combines multiple observations of the same source by shifting and combining the image.

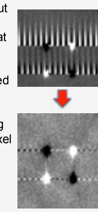
Flexible Image Transport System (FITS) files are what FORCAST outputs as raw data and is the format of choice for astronomers.

The FORCAST array exhibits linear offset created by signal on the array itself. Droop correction removes this offset by multiplying each pixel by a correction factor derived from changes during small time intervals.

Infrared detectors are inherently nonlinear in response. How responsive each pixel is depends on the intensity of the source. DRIP calculates background level for a sub image and then applies a linearity correction factor to the entire image.

To achieve background subtraction, DRIP "stacks" or combines the chop/nod images. (See chopping and nodding.)

FORCAST readout circuitry has residual signal that persists in every sixteenth pixel forming lines called "jailbars." DRIP attempts to fix these by replacing each sixteenth pixel with the median value in that row. Spectral analysis does not require jailbar removal.



The optics and geometry of the cameras themselves naturally distort the image slightly. DRIP corrects this using lab data.

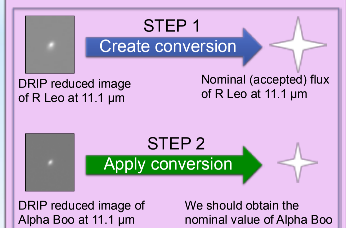
By merging frames from the FITS images, DRIP produces images with multiple positive and negative source images depending on the chop/nod mode used when data was collected.

Validation of DRIP

The Goal:
- We must ensure that DRIP correctly cleaned the raw FORCAST data
- To do this we compare new results with old results

Calibration stars:
- Stars that we know a lot about
- Have little variation
- SOFIA observes at least a couple per flight

The Strategy:
- Use DRIP on a calibration star with known photometric flux, that is, the total amount of light from a source
- Create a conversion from DRIP output to the photometric flux of that star
- Apply the same conversion to the DRIP output of a different calibration star
- Check to see that the photometric flux obtained from DRIP matches the expected value of the star



Method:
- We will calibrate the DRIP output of R Leo to its nominal flux value
- Then see if we can obtain the the nominal flux values of Alpha Boo, R Cas and T Mic
- This will be done with all data with matching wavelengths.

Acknowledgements:

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References:

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