

Data Analysis Introduction

— Optical Imaging —



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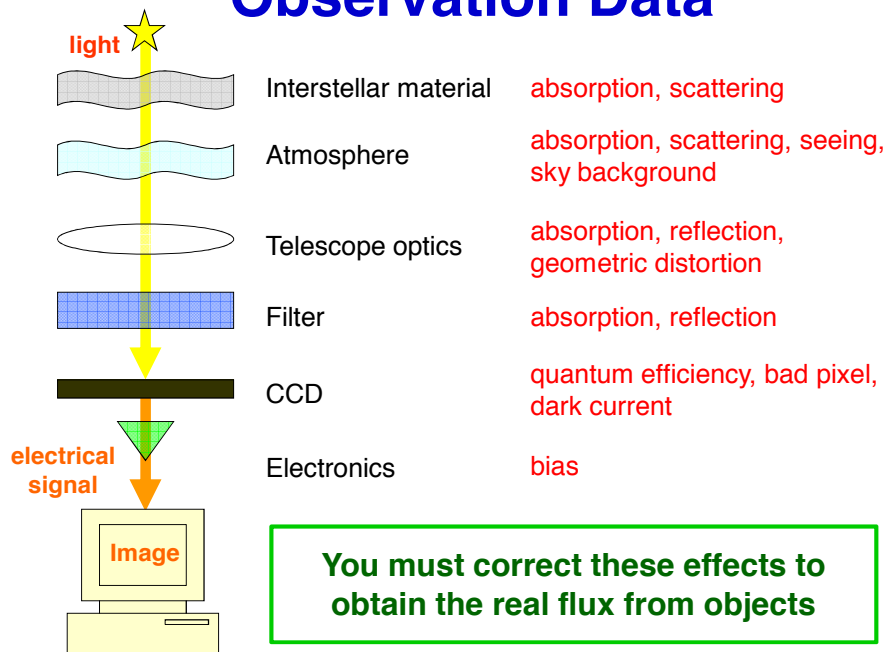


Imaging Observation

- Measure the light from celestial objects and understand their physics
- Take images of objects with a specific wavelength band
 - magnitude, color, shape
 - spatial distribution
 - time variation (light variation, proper motion)



Observation Data

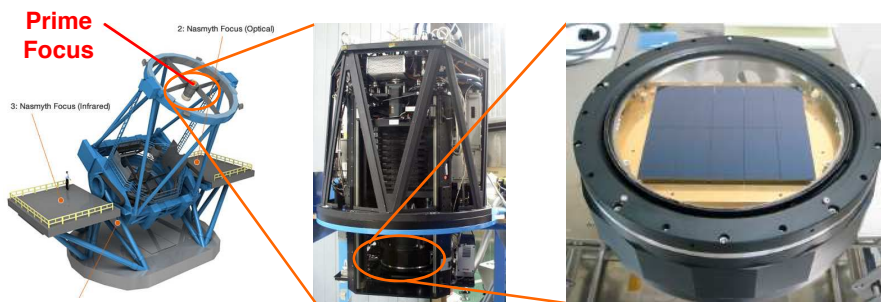


Optical Images

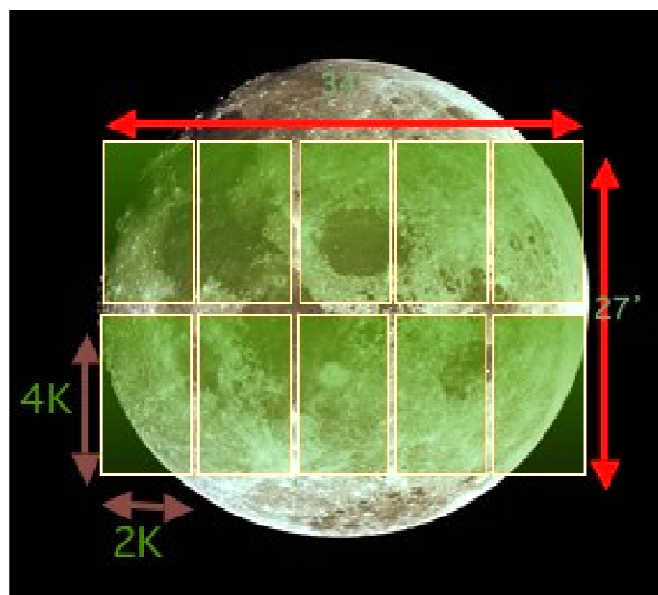
- In this tutorial, reduction processes of imaging data are explained through a case of Subaru Prime Focus Camera (**Suprime-Cam**)
- A series of the following procedures is useful for general imaging data
 - Additional processes, such as dark correction and linearity correction, may be required
 - In case of infrared data, the basic idea is equal except for some specific processing

Suprime-Cam

- Optical wide-field imaging camera mounted on the prime focus of Subaru Telescope
- A mosaic of ten 2048 x 4096 CCD chips
- 34' x 27' field of view with a pixel scale of 0.20"



Suprime-Cam's FOV



Software

IRAF (Image Reduction and Analysis Facility)

General purpose software system for the reduction and analysis of astronomical data

SExtractor (Source Extractor)

Detection of light sources and measurements (position, shape parameters, and photometry)

SDFRED (Suprime-cam Deep Field REDuction)

Image reduction software specific to Suprime-Cam data

SDFRED1: For data taken before June 2008

SDFRED2: For data taken after July 2008

<http://subarutelescope.org/Observing/Instruments/SCam/sdfred/index.html.en>

Reduction Procedure in SDFRED

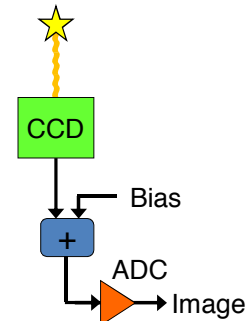
Step	Purpose	Command
1.	Renaming of the data files	<code>namechange.csh</code>
2.	Overscan and bias subtraction	<code>overscansub.csh</code>
3.	Making flat frames	<code>mask_mkflat_HA.csh</code>
4.	Flat fielding	<code>ffield.csh</code>
5.	Distortion correction	<code>distcorr.csh</code>
6.	PSF size equalization	<code>psfmatch_batch.csh</code>
7.	Sky subtraction	<code>skysb.csh</code>
8.	Masking out AG probe	<code>mask_AGX.csh</code>
9.	Masking out bad regions	<code>blank.csh</code> , ...
10.	Alignment and scaling	<code>makemos.csh</code>
11.	Coadding	<code>imcio2a</code>

Bias Subtraction

- A bias level is added to the signal to ensure that the Analog-Digital Converter (ADC) always receives a positive value

- Bias images are created by zero-second exposures

- In case of Suprime-Cam, the bias level can be assumed to be equal to that of the overscan

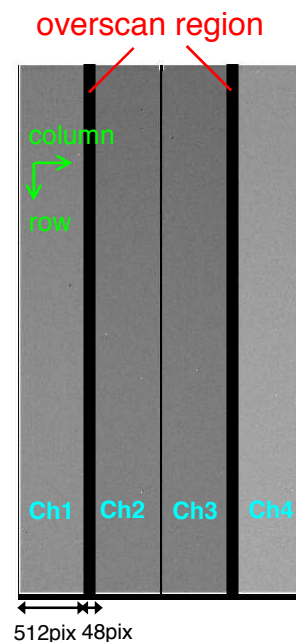


Bias Subtraction

- Overscan regions are rows/columns along the image edge that are not exposed to light

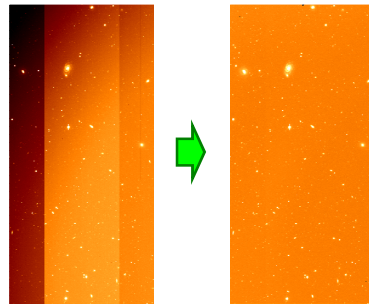
- The bias level of Suprime-Cam is estimated from the overscan in each column

- **overscansub.csh** subtracts the estimated bias level and removes the overscan regions from specified image files



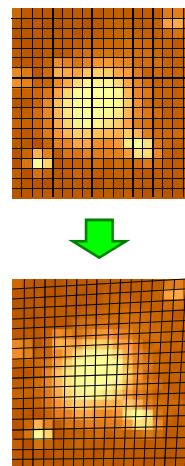
Flat Fielding

- Flat fielding corrects the difference in sensitivities between pixels in a frame and the effect of vignetting of the telescope optics
- Flat frames are obtained from a uniform light source
- Three basic types of flats: object flats (blank fields), twilight flats, and dome flats
- Bias-subtracted science frames must be divided by the flat frame



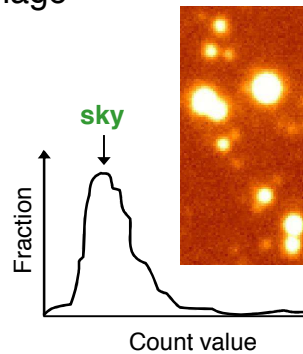
Geometry Correction

- The Suprime-Cam data has significant geometric distortion due to telescope optics
- **distcorr.csh** corrects the field distortion based on the specific parameters to Subaru's prime focus
- This task also corrects the distortion due to the differential atmospheric dispersion at once



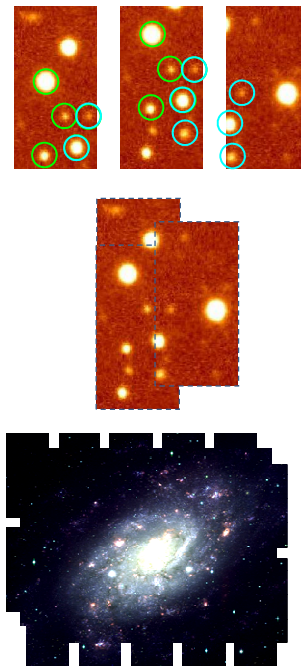
Sky Subtraction

- Sky background light caused by such as atmospheric radiation and zodiacal light is added to object images
- Because sky level varies with time and field, it has to be estimated from each image
- Sky values are determined from the mode of pixels within a specified grid
- **skysb.csh** computes the sky level and subtracts it from the image

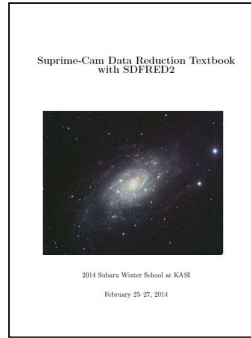


Mosaicing

- Coadding multiple images
 - reduce the chip gaps and defects
 - improve signal-to-noise ratio (S/N)
- **psfmatch_batch.csh** attempts to match the PSF size of all images
- **makemos.csh** determines the shifts, rotations, and flux scales of different images
- **imcio2a** combines the images into a final combined image



See the data reduction textbook for details.



Enjoy your data analysis !