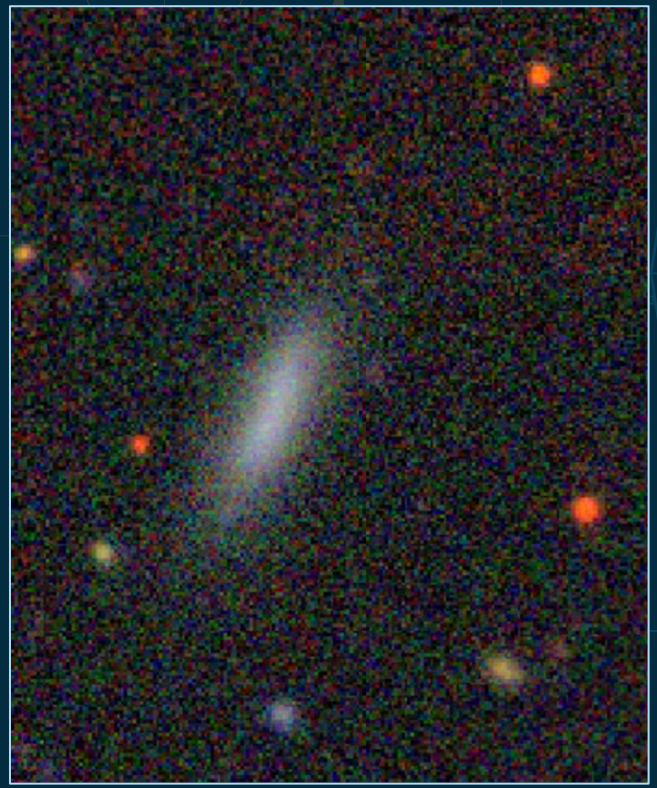
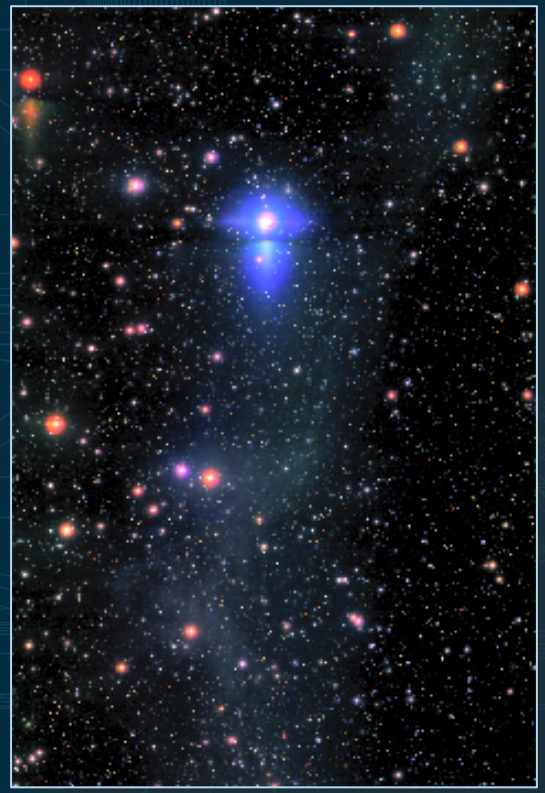
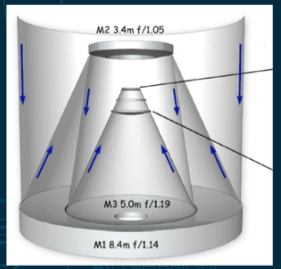
Measuring Images: Photometry

What makes these images look the way they do?





How do astronomical images come to be?



Credit: John Peterson (Purdue) and the PhoSim Team

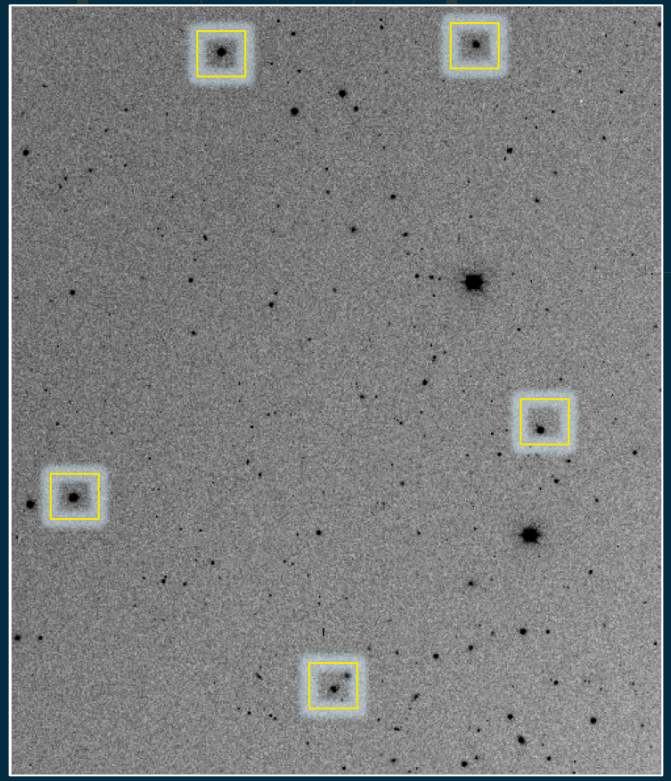

Optics
+Tracking
+Diffraction
+Detector Misalignments & Perturbations
+Lens Misalignments
+Mirror Misalignments Perturbations, & Micro-roughness
+Detector
+High Altitude Atmosphere
+Mid Altitude Atmosphere
+Low Altitude Atmosphere
+Pixelization
+Saturation & Blooming

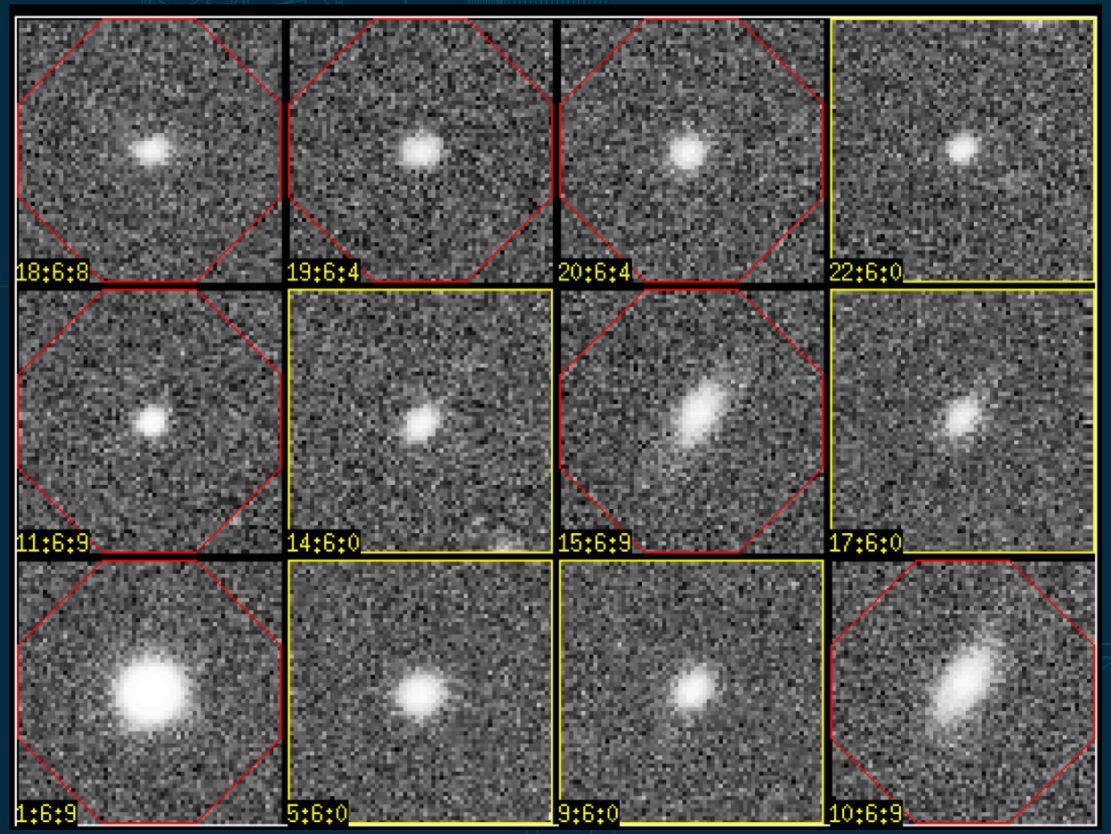
Modeling the PSF

- The simplest thing to do is to model the PSF with an analytic profile
  - Gaussian (or a linear combination of gaussians)
  - Moffat

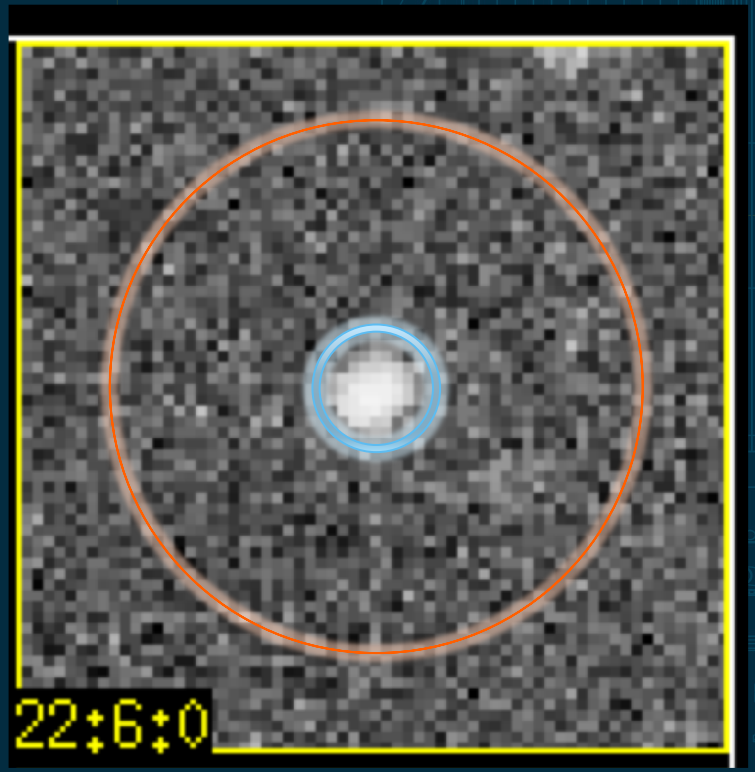
- More sophisticated methods
  - PCA analysis
  - Delta functions
  - Combinations

PSF Estimation in Practice





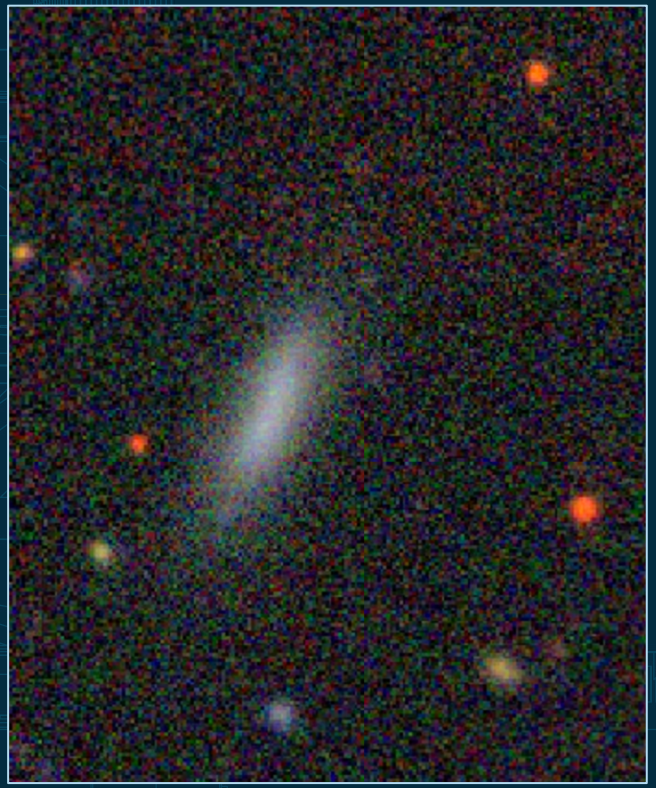
How should we measure the flux of an object?



Solution: Forward Modeling

What do astronomers care about?

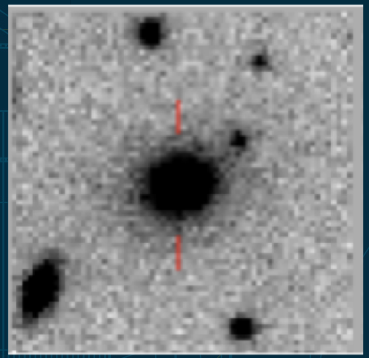
- What's on the image?
  - Stars (point sources)
  - Galaxies (extended objects)
- Where is it?
  - Relatively (in pixels, to ~few hundredths of a pixel)
  - Absolutely (coordinates on the sky)
- How bright is it?
- Is it changing in time?
- Is it moving?
- What is its shape?
  - Of a particular object
  - Statistically, for a class of objects

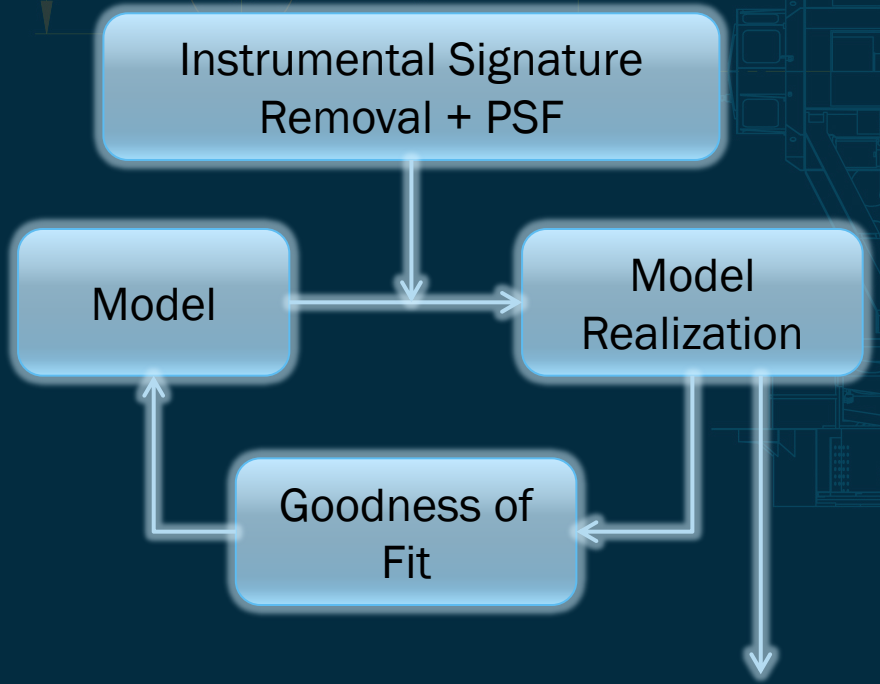


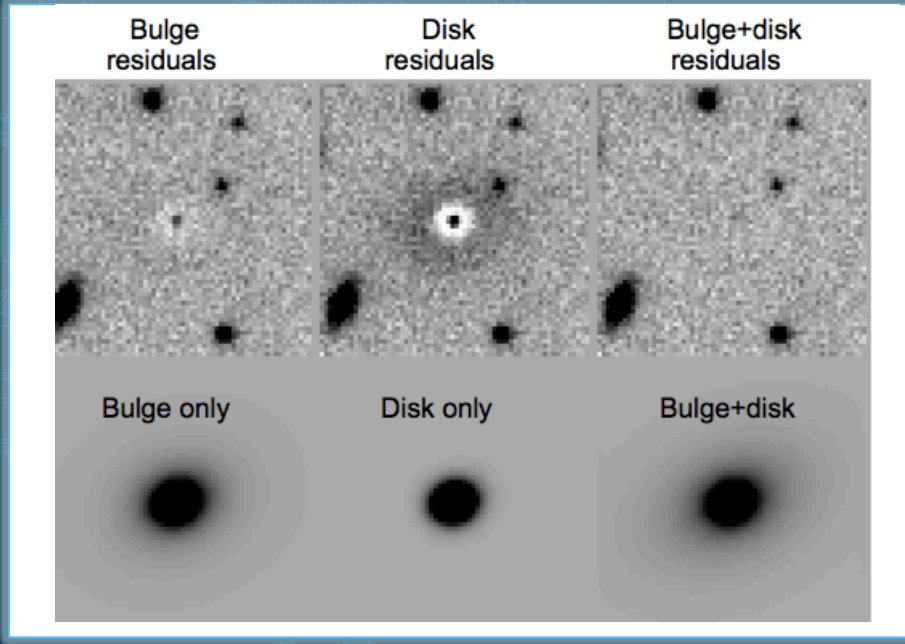
Learning by fitting models

Object characterization (models):

- Stars: Point Source model
- Galaxies: Double exponential models







1,231,051,050 rows (SDSS DR10, PhotoObjAll table)

~500 columns

Cataloging the Sky…

What we're doing is decomposing and modeling the sky in a way that makes physical sense.

… Modeling the Sky

What we're doing is decomposing and modeling the sky in a way that makes physical sense.

… or (Lossy) Compressing the Sky!

What we're doing is decomposing and modeling the sky in a way that makes physical sense.

But you may also think of this as developing a very fancy lossy compression technique.

Python tools for photometry

- We'll use ***astropy.photutils***
- It's a relatively new package, and still very much rough around the edges
  - Example: their example notebooks don't work on the most recent version.
- Expected to get better over time, good enough for simple use cases.
- Most widely used tools:
  - SExtractor (E. Bertin)
  - DAOPHOT (Stetson)
- Emerging state-of-the-art:
  - The LSST Data Management Software Stack (Python interfaces!)
  - But a ***very*** steep learning curve