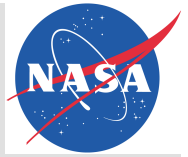


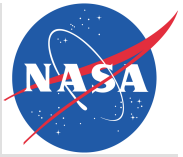
GalSim for WFIRST

@SDT Meeting April 2, 2014

Jason Rhodes (JPL)

With Thanks to Rachel Mandelbaum (CMU) and Mike Jarvis (UPenn) and the GalSim/GREAT3 teams

GalSim- **Gal**axy **Sim**ulation Software



Motivation:

- Needed software that could meet all requirements of the Great3 challenge
- Existing options (Skymaker, ImSim, etc.) did not do everything we needed.
- The closest match was Gary Bernstein's simages/sbprofile program.
- This became the basis of GalSim

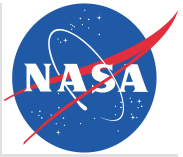
Technical Requirements:

- Accurate handling of coordinate transformations (**shear**, dilation, rotation)
- Accurate convolution, using both photon shooting and Fourier transforms.
- Flexibility in specifying types of PSF, galaxy, noise, image parameters, etc.

Code Requirements:

- Open source.
- Modular structure .
- Intuitive Python layer wrapping fast C++.
- Even more intuitive configuration file interface.
- Useful for many projects. Not just Great3.
- https://github.com/GalSim-developers/GalSim

Capabilities (Aug 2013)



PSF profiles:

- Gaussian
- Moffat
- Kolmogorov
- Airy (with optional central obscuration)
- OpticalPSF (incl. defocus, astigmatism, coma, trefoil, spherical, obscuration, struts)

Galaxy profiles:

- Exponential
- Sersic (incl. DeVaucouleurs as special case)
- RealGalaxy (from a catalog of 28,000 COSMOS galaxies with I<23.5)
- InterpolatedImage (can use any provided image as a starting profile)
- Sum (can add multiple components arbitrarily)

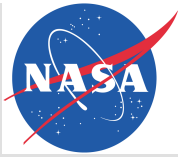
Each profile can be:

- sheared
- dilated
- rotated
- shifted
- scaled in flux
- added to another profile
- convolved with another profile
- deconvolved by another profile

Lensing

- Realistic shear models
  - NFW halo model
  - Cosmological (or other) power spectrum
  - Can specify E and B power spectra separately
- These also include the corresponding convergence field so magnification and shear can be done consistently.

Options for Drawing images



—Can use FFT or photon shooting
  - Caveat: Photon shooting doesn't work when deconvolving. This includes RealGalaxy profiles.

—Can place postage stamps in tiles or randomly.

—Can apply offsets from the center of the postage stamp.

—Can set parameters that trade off accuracy vs. speed

- Noise models:

—Gaussian noise

—Poisson noise

—CCDNoise includes Poisson photon noise (with optional gain) and Gaussian read noise.

—Variable Gaussian Noise (sigma different for each pixel)

—Correlated Noise

- Can also whiten images to remove existing correlated noise.

GREAT3

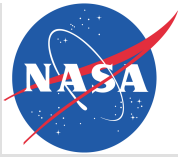
- Latest community challenge in a process started in 2004
- STEP1, STEP2, GREAT08, GREAT10
- GREAT3 promises to reach the shear measurement accuracy needed by WFIRST, LSST, and Euclid

http://www.great3challenge.info/

- GREAT3 runs from October 2013 to April 30, 2014
- 2 meetings already, final meeting at CMU May 27-29
  - Registration is open!
  - https://web.campusservices.cmu.edu/conferences/registration.taf?ID=GREAT32014

GalSim has been a resounding success and now represents the defacto standard

Beyond GREAT3



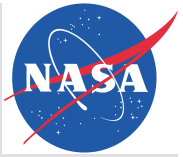
- Survey specific modules
  - DES module includes two PSF estimators used by DES pipeline and a different output format.
  - Planned modules for LSST, KIDS, HSC.
- Blending
  - using Galsim to study blending effects for LSST
- Euclid using GalSim for initial validation of shear pipelines

HSC, Euclid, LSST, DES using GalSim in some form or another

Planned Featured

- Real WCS transformations [Issue #364] ✓
- Flexion [Issue #361] ?
- More general treatment of optical wavefront [Issue #379]
- AtmosphericPSF
- Color dependencies ✓
- Image artifacts

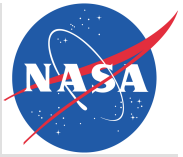
FY14 GalSim/WFIRST work



Done by Rhodes and Mandelbaum, using students

1. Make and distribute a WFIRST GalSim module
2. Put in WFIRST wavelength dependent PSF effects
   - A primary weak lensing systematic
   - Most of the underlying work has been done recently in LSST context
   - We will adapt and expand existing work
3. Including realistic H4RG detector effects
   - IPC, non-linearity, reciprocity failure
   - Will be informed by ongoing work at JPL and GSFC/DCL
   - Will be easily configured with new characteristics from future detectors
4. Multi-wavelength galaxy models
   - Current training set is single band (F814 HST)
   - Will modify GalSim to more easily incorporate wavelength galaxy information
   - Pave way for NIR basis set

Future GalSim/WFIRST work



1. Process archival HST NIR data for inclusion in GalSim
   - Importance of this reinforced by recent changes in n_{eff} due to move from COSMOS basis (optical) to CANDELS NIR
   - Processing input data is non-trivial

2. Include image persistence as a detector effect in GalSim
   - Requires adding exposure history

3. Work with IPAC to release GalSim package for WFIRST that maximizes usefulness for Project, SDT, and community

4. Work with Scott Gaudi (and others?) to make GalSim useful for microlensing studies

5. You tell me?