The third GRavitational lEnsing Accuracy Testing challenge

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(on behalf of the GREAT3 collaboration; arXiv:1308.4982)

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1. SCIENTIFIC MOTIVATION

Weak gravitational lensing (WL) is one of the most promising methods for understanding the accelerated expansion of the Universe, due to its sensitivity to all matter (including dark matter) and thus, indirectly, to dark energy, which changes the rate of structure growth. WL measurements involve estimating tiny but coherent distortions in galaxy shapes, a challenge problem in light of the larger (and coherent) distortions due to the Point Spread Function, or PSF.

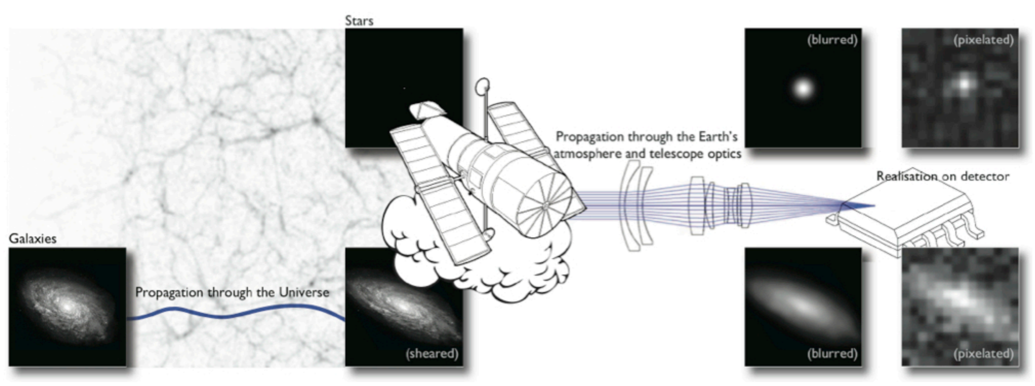
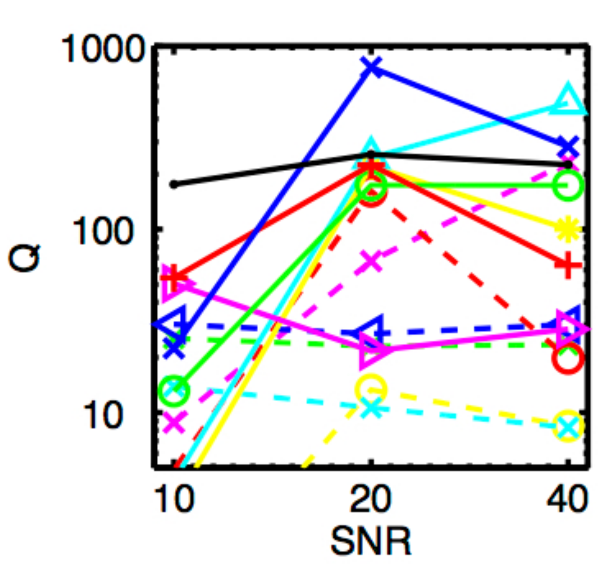


Image credit: Kitching et al. (2011)

2. THE GOAL OF LENSING COMMUNITY CHALLENGES

Using simulations with a known WL shear (distortion), we can learn about the efficacy of our methods to estimate the shear despite the PSF, and how they depend on galaxy/PSF properties.

From Bridle et al. (2010): how accuracy of WL shear estimation for methods in GREAT08 depends on the signal-to-noise ratio of the galaxy detection. The decrease in accuracy at low SNR is an illustration of noise rectification bias.



The goal is to ensure that our methods of estimating shear are sufficiently accurate for upcoming, large WL surveys that will constrain cosmological parameters to %-level precision.

Contact Info

For more information:

- on GREAT3: http://great3challenge.info
- on GalSim: https://github.com/GalSim-developers/GalSim

Acknowledgement

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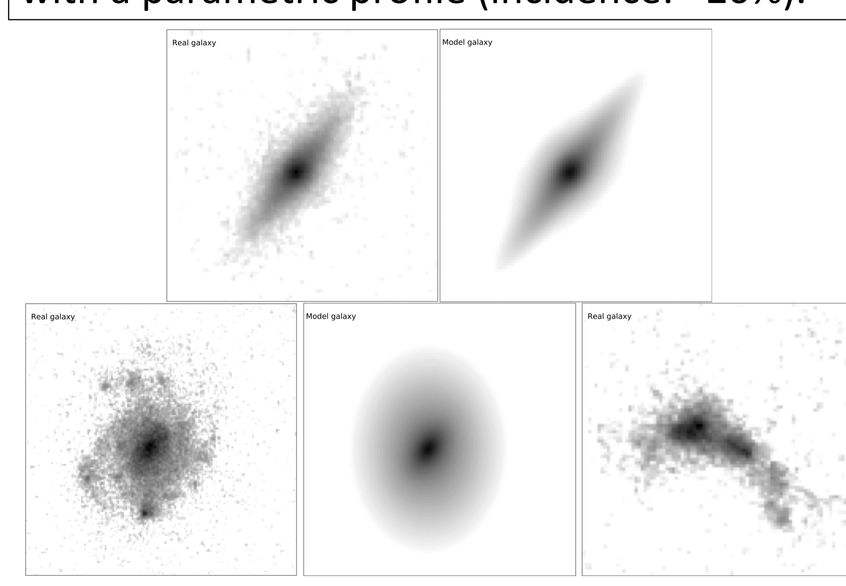
3. THE THREE QUESTIONS THAT GREAT3 WILL ADDRESS

A. Are shear measurement methods sensitive to *realistic galaxy morphologies*? Use training data from the Hubble Space Telescope (HST) to check.

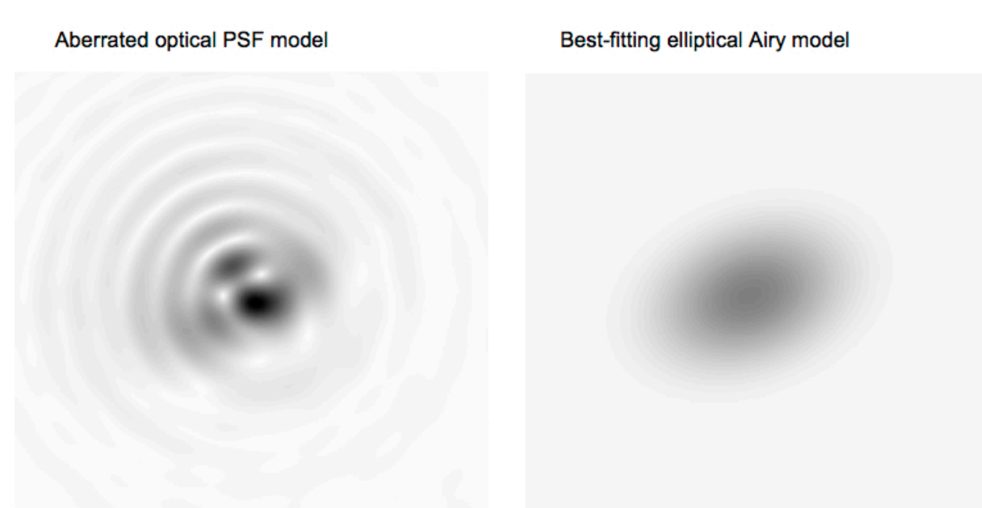
Top: Simple galaxy, which can be fully modeled with a parametric profile (incidence: ~20%).



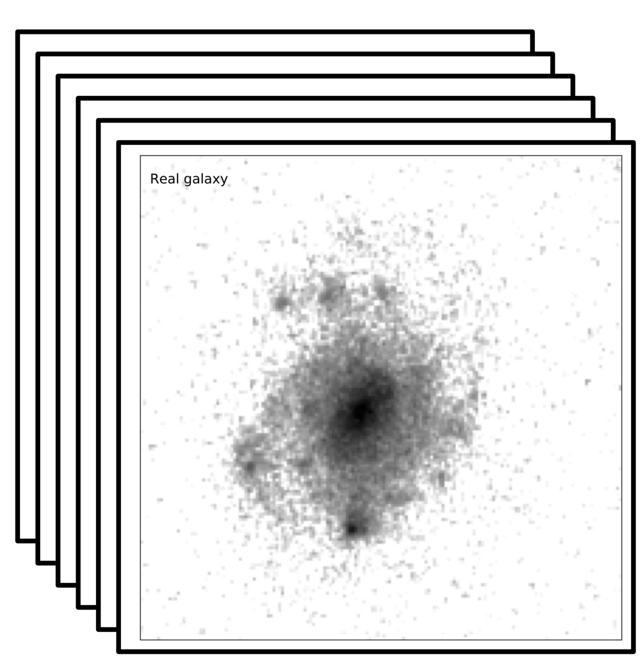
Bottom left: galaxy for which broad features can be fit by simple models, but substructure is clearly present (incidence: ~50%).

Bottom right: irregular galaxy, no simple model (incidence: ~30%).

B. What is the impact of *realistic uncertainty in the point-spread function (PSF)*, for a physically realistic PSF profile?



C. What is the effect of *multi-exposure image combination* (almost always necessary) on the shape measurement process?



4. CHALLENGE STRUCTURE/TIMELINE

Participants can submit to any/all of 20 branches, which include the following 2 x 2 x 5 options:

- Shear type within a simulated image:
  1. Constant
  2. Random realization of a shear power spectrum
- Data type:
  1. Ground
  2. Space
- Problem:
  1. "Control" branch: none of the three tests.
  2. "Realistic galaxy" branch: includes the realistic galaxy test.
  3. "Realistic PSF" branch: includes the test of realistic PSFs.
  4. "Multiple exposure" branch: includes only the test of multiple exposure combination.
  5. "Everything" branch: includes all three problems that the challenge is designed to test.

Participants must submit their estimate of the constant shear or the shear power spectrum. Each branch has its own leaderboard, and the challenge winner will be chosen using ranking statistics based on the top few scores for each method. The first-place prize is a laptop, and the second place prize is a tablet computer (or computing equipment to equivalent value).

October 2013:
Public release of simulations
Challenge starts

January 6 & 7, 2014:
Mid-challenge meeting
at Edinburgh

April 30, 2014:
End of challenge

May 2014:
GREAT3 wrap-up meeting
at Carnegie Mellon University

5. POTENTIAL OF GALSIM/FUTURE WORKS

Our goal of making simulations to test particular effects (§3) has led to some simplifications. On the other hand, using GalSim (an open-source image simulation software for generating GREAT3), one can test

- Star/galaxy separation (GREAT3 provides star and galaxy images separately),
- Blending issues by using non-gridded galaxies (GREAT3 is gridded galaxies),
- Selection bias due to the correlation between selection criteria and PSF/galaxy shapes.

Possible extensions of GalSim to make simulations more realistic:

- Instrument/detector specific effects
  - Charge transfer inefficiency
  - Non-linearity
  - Crosstalk
  - Optics/detector distortions
- Wavelength-dependent effects (color gradient)
- Flexion

Comments/suggestions are welcome!