LSST in 10 minutes

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Introduction

• What is LSST?
  – The Legacy Survey of Space and Time is a photometric survey that will be carried at the Vera C. Rubin Observatory at Cerro Pachón (Chile). Planned to start in 2022.
It uses the 8.4-m mirror Simonyi telescope.

- Using the LSST Camera 3.2 Gpix. 189 CCD 4096x4096 pixel sensors.
- Field-of-view ~9.6 square-degrees (approx 40 full moons).
- 10 year survey in 6 different bands (filters): u, g, r, i, z, y.
- 37 billion stars and galaxies.
- 10 million transient alerts (supernovae, meteorites, planets, things that are variable in the sky)
- 20 TB of data every night! Expected ~15 PB database for the final data release.
**LSST: Science**

- 8 science collaborations.
- Map 30,000 square-degrees total.
- 90% of survey time to map uniformly \(~18,000\) square-degrees (wide-fast-deep survey).
- Main science drivers:
  - Dark matter and dark energy.
  - Solar system.
  - Transients/variable objects.
  - Milky way.

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Ivezic et al. 2019
Lochner et al. 2018
Lochner et al. 2018
Dark Energy Science with LSST

- Dark Energy probes:
  - Weak gravitational lensing.
  - Baryon Acoustic Oscillations and galaxy clustering.
  - Clusters of galaxies.
  - Strong gravitational lensing.
  - Supernovae.

Lochner et al. 2018
Gravity bends light.

Object shapes appear sheared to us due to the presence of matter.

Measuring shapes we can get information about the (mostly dark) matter distribution.

We repeat this at different cosmic times (tomography).

Weak Lensing: Challenges

- Galaxies aren’t round.
- Shapes are random at first order.
- We can still get information but we have noise due to the intrinsic variance in the shapes (shape noise).
- We need a lot of galaxies since the shear effect is typically 3-300 times smaller than the intrinsic shape.
Cosmic shear is one of the dark matter density tracers. But galaxies are also dark matter density tracers.

Initial density fluctuations are close to Gaussian. 2-point statistics can fully determine the field.

Combining 3 different (although correlated) 2 point statistics we can improve cosmological constraints:
- Shear-shear (cosmic shear).
- Shear-galaxy (galaxy-galaxy lensing).
- Galaxy-galaxy (galaxy clustering).

Error-bars for LSST should be ~10 times smaller.

DES Y1. Krause et al. 2018
3x2pt analysis challenges

- LSST will accurately determine shapes for 2 billion objects.
- This means that it will be systematics limited!
- Atmosphere and optics can introduce spurious shears.
- This imposes very strict requirements in image quality and the knowledge/determination of the point-spread-function (PSF).
3x2pt analysis challenges

- LSST will perform “low-resolution” tomography.
- More objects in the field, increases the probability of overlaps: Blending.

Left: DES Y6
Right: LSST Y10

Benítez et al. 2009
**LSST @FNAL**

- FNAL involved in Rubin Observatory project and different LSST Science Collaborations.
- Key Roles in Rubin/LSST Operations: Observatory operations, data production and data performance.
- Heavy involvement in LSST DESC:
  - Survey Simulations: Image Simulations (Montecarlo), ++
  - Dark Matter studies: Preparation for the search of Low Surface Brightness objects, ++
  - Cluster studies.
  - Strong Lensing studies.
  - Galaxy clustering/weak lensing/3x2pt: Contributions to analysis pipeline.
  - Blending studies: Forecasting of impact of blending and mitigation with overlapping observations.
  - Cross-correlations with CMB experiments: SPT, CMB-S4.
  - Transient/Gravitational wave follow-up.
  - And many others!