Weak lensing with WFIRST

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With many contributions from Olivier Doré, David Weinberg, and other members of the SIT “Cosmology with the WFIRST High-Latitude Survey”
The Observational Foundations of Dark Energy

Cosmological Constant, i.e. \textit{Dark Energy density}
Any explanation of cosmic acceleration expansion rate involves a fundamental revision of physics.

- At the very least, a dominant new energy component with exotic physical properties.
- Possibly a clue to extra dimensions, nature of quantum gravity, manifestation of string theory.

WFIRST seeks the next great cosmological discovery.
Two types of cosmological measurements

**Geometric**

Cosmic acceleration: pulls galaxies apart

**Growth of structure**

Gravity: draws galaxies together
WFIRST Dark Energy Surveys

**Weak Lensing** (2200 deg$^2$)
- High angular resolution
- Galaxy shapes in IR
- 380 million galaxies
- Photo-z redshifts
- 4 imaging filters

**Supernovae**
- High quality IFU spectra
- 5 day sampling of light curves
- 2700 SNe

**Redshift survey** (2200 deg$^2$)
- BAO & Redshift Space Distortions
- High number density of galaxies
- 16 million galaxies

Figure credit: LSST science book

Figure credit: ESA
WFIRST Dark Energy Surveys

**Weak Lensing** (2200 deg²)

- High angular resolution
- Galaxy shapes in IR
- 380 million galaxies
- Photo-z redshifts
- 4 imaging filters

Unique opportunities from space:
- Near-IR sensitivity over wide fields
- High stability observing (SN photometry, WL shape measurement)
- High angular resolution (WL shape precision, accuracy)
- High number density of galaxies
- 16 million galaxies

Figure credit: LSST science book

Figure credit: ESA
WFIRST dark energy strategy

WFIRST will use multiple methods that provide complementary information and allow cross-checks.

For all methods, the emphasis is on control of systematic uncertainties rather than maximizing statistics.

The observatory is powerful, and there is flexibility to adjust strategy relative to the current Design Reference Mission based on developments in the field.
Explaining the Origin of Cosmic Acceleration with WFIRST

Check out our public webpage: http://www.wfirst-hls-cosmology.org/
Who are we??

- Rachel Bean (Cornell)
- Andrew Benson (Carnegie)
- Peter Capak (Caltech/IPAC)
- Ami Choi (OSU)
- Olivier Doré (JPL/Caltech, PI)
- Tim Eifler (JPL/Caltech)
- Katrin Heitmann (ANL)
- George Helou (Caltech/IPAC)
- Shoubaneh Hemmati (IPAC/Caltech)
- Shirley Ho (LBL)
- Albert Izard (JPL)
- Bhuvnesh Jain (Penn)
- Mike Jarvis (Penn)
- Alina Kiessling (JPL/Caltech)
- Elisabeth Krause (Stanford)
- Chris Hirata (OSU, Weak lensing lead)
- Robert Lupton (Princeton)
- Niall MacCrann (OSU)
- Rachel Mandelbaum (CMU)
- Elena Massara (LBL)
- Alex Merson (Caltech/IPAC)
- Hironao Miyatake (JPL/Caltech)
- Nikhil Padmanabhan (Yale)
- Andres Plazas Malagon (JPL/Caltech)
- Eduardo Rozo (U. Arizona)
- Lado Samushia (U. Kansas)
- Mike Seiffert (JPL/Caltech)
- Charles Shapiro (JPL/Caltech)
- Melanie Simet (UCR/JPL)
- David Spergel (Princeton, CCA)
- Harry Teplitz (Caltech/IPAC)
- Michael Troxel (OSU)
- Anja von der Linden (Brookhaven)
- Yun Wang (Caltech/IPAC, Galaxy redshift survey lead)
- David Weinberg (OSU, Galaxy clusters lead)
- Ying Zu (OSU)
Cosmological parameters forecast chains

Please find below some cosmological parameters MCMC chains corresponding to the current survey of the WFIRST High Latitude Survey, combining weak-gravitational lensing (WL), cluster count (CC) and redshift space distortions (GRS). These chains were computed using the CosmoLike software Krause & Eifler 2016.

Multi-probe cosmology forecasts (incl SN from both SN type 1a and 1b) with realistic systematics budget

Includes contributions from other SITs (e.g., for supernova constraints)

LSST+ WFIRST Simulated Photometric Catalogs (Peter Capak, Shoubaneh Hemmati, Dan Masters, last updated on 08/02/17).

WFIRST+LSST simulated photometry catalog based on CANDELS, COSMOS, SXDS and VVDS.
The Impact of Interpixel Capacitance in CMOS Detectors on PSF shapes and Implications for WFIRST

Arun Kannawadi

McWilliams Center for Cosmology, Department of Physics, Carnegie Mellon University, Pittsburgh, PA 15213

The effect of detector nonlinearity on WFIRST PSF profiles for weak gravitational lensing measurements

A. A. Plazas\textsuperscript{a}, C. Shapiro\textsuperscript{a,b}, A. Kannawadi\textsuperscript{c}, R. Mandelbaum\textsuperscript{c}, J. Rhodes\textsuperscript{a,h,d}, & R. Smith\textsuperscript{b}

Detector models + simulations + forecast of cosmology performance of WFIRST

= Requirements on detector performance and on algorithms that will correct for defects
What are we doing now?

Disk galaxy polarization as a source of weak lensing selection bias?
(Chris Hirata at OSU, Brent Tan and RM at CMU)

- Edge-on disk galaxy polarization has preferred direction with respect to galaxy shape
- If mirror coatings, filters, or other parts of the instrument have polarization-dependent behavior, could lead to preferentially choosing disks aligned in a particular direction
- Simple toy model suggests this could be important enough to place a requirement on; further investigation is needed
Conclusions

• WFIRST dark energy constraints will come from multiple complementary cosmological measurements.
  ➔ Measurements take advantage of the unique opportunities of space-based data, e.g., by carrying out the first infrared lensing survey.
• SITs are already working on the deliverables needed for survey planning now (requirements on hardware for each science case, etc.)
  ➔ They will provide tools for the broader benefit of the community.
• WFIRST will take place in a broader cosmological context given other surveys happening in the 2020s
  ➔ Rich opportunities for carrying out precision cosmology and mitigating limiting systematics using the combination of the surveys.
  ➔ Groups are already hard at work on how to best take advantage of these opportunities and do amazing science.
• Work is well underway to ensure great weak lensing science with WFIRST