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Roman HLS Spectroscopic Survey Overview

Yun Wang
On behalf of the HLS Cosmology SIT
November 17, 2021

The Summary Paper of 5+years of Work

"The High Latitude Spectroscopic Survey on the Nancy Grace Roman Space Telescope"

Yun Wang, Zhongxu Zhai, Anahita Alavi, Elena Massara, Alice Pisani, Andrew Benson, Christopher M. Hirata, Lado Samushia, David H. Weinberg, James Colbert, Olivier Doré, Tim Eifler, Chen Heinrich, Shirley Ho, Elisabeth Krause, Nikhil Padmanabhan, David Spergel, Harry I. Teplitz

arXiv:2110.01829, ApJ, submitted

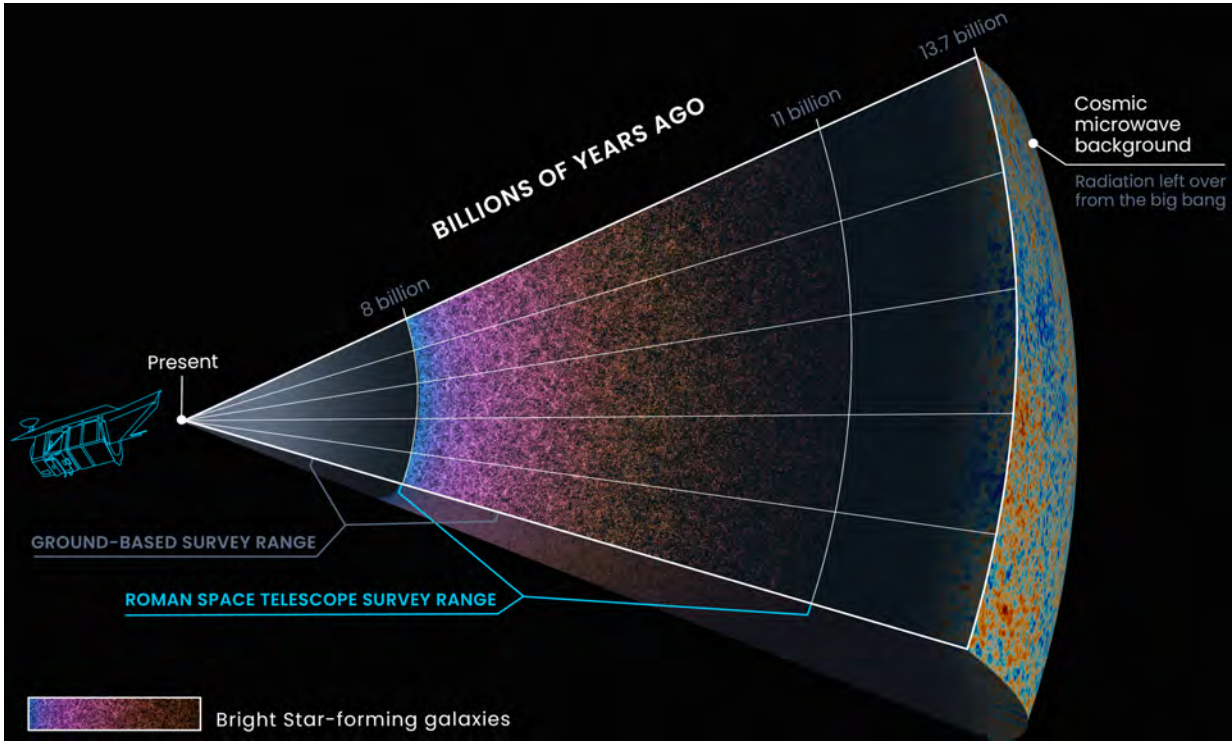
Included in Our work

- Derivations of science requirements from the Roman dark energy science goal and science objectives.
- Definition of a Reference HLSS meeting all of the Roman dark energy science requirements.
- Simulation of realistic galaxy mock catalogs and SEDs for galaxies in the Reference Roman HLSS based on Galacticus, a physical model of galaxy formation.
- Forecast of galaxy number densities and linear biases using the realistic Reference Roman HLSS galaxy mock, verifying that all Roman dark energy science requirements are met.
- Forecast of dark energy constraints from the Reference Roman HLSS, as well several possible alternative surveys with different characteristics.
- Pixel-level grism simulations for the Reference Roman HLSS using our realistic Roman galaxy mock and SEDs as input.
- Study of the observational systematics for the Roman HLSS.
- Study of the additional science from the Roman HLSS, utilizing higher-order statistics, void statistics, and small scale clustering, to significantly enhance dark energy constraints from Roman.

The Reference HLSS

Densely samples large scale structure with emission line galaxies.

- Survey redshift range: 1<z<3
- Survey area: ~2000 deg^2
- Survey depth: Hα line flux of 10^{-16} erg/s/cm^2 (6.5σ)
- Redshift uncertainty: $\sigma_z/(1+z)=0.001$
- Redshift measurement using at least 2 emission lines
  - Hα and [OIII] at 1<z<2 (~ 10M galaxies)
  - [OIII] and [OII] at 2<z<3 (~ 2M galaxies)



Data provided by Z. Zhai (Waterloo), Y. Wang (Caltech/IPAC), and A. Benson (Carnegie Obs), Data Visualization: J. DePasquale and D. Player (STScI)

Simulation of HLSS Data

*All our simulation products will be made publicly available:

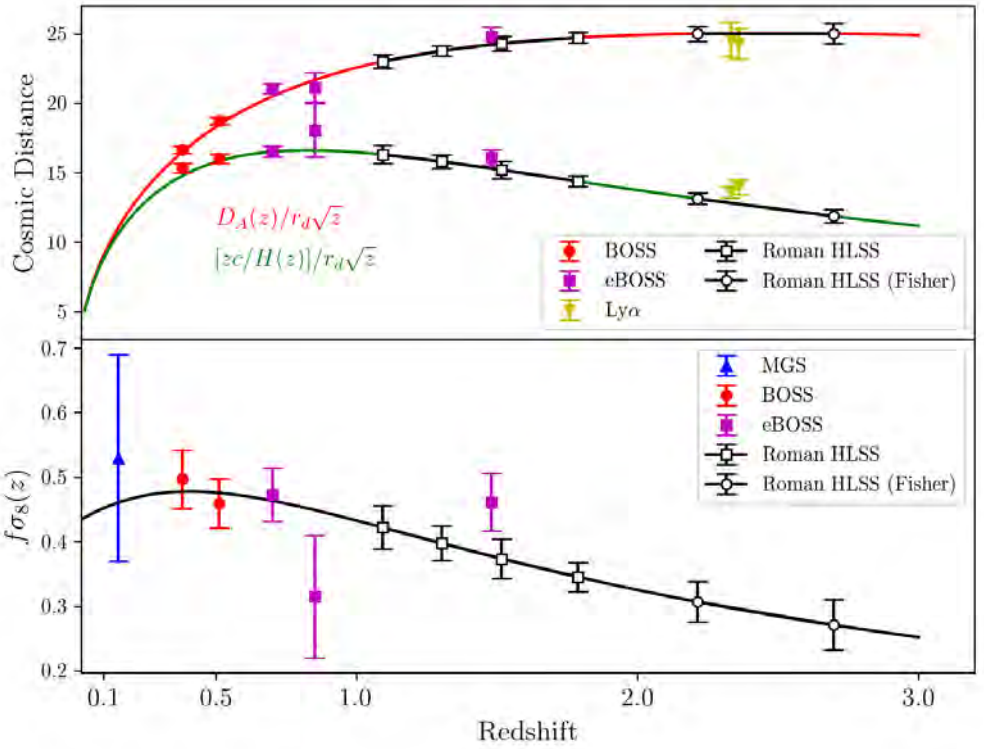
- Galaxy mocks based on Galacticus, a physical model of galaxy formation (see talk by Zhai):
  - 2000 deg^2 galaxy mock to facilitate realistic forecast of Roman dark energy constraints, deep enough to allow different flux cuts (required for studying alternative surveys to the Reference HLSS)
  - 4 deg^2 galaxy mock with Spectral Energy Distributions (SEDs) as input catalog for pixel-level grism simulations.
- Pixel-level grism simulations using our realistic Roman galaxy mock and SEDs as input (see talk by Alavi).

Reference HLSS Forecasts

*We have verified that all Roman dark energy science requirements are met.

Forecasts using the same method as applied to real data at 1<z<2, and Fisher matrix at 2<z<3

- $H(z)$: Hubble parameter, cosmic expansion history
- $f_g(z)$: grow rate of cosmic large scale structure
- Measuring both allows differentiation between dark energy and modified gravity as the cause for the observed cosmic acceleration.



Other forecasts:

- Voids (see talk by Pisani)
- Combined forecasts for the HLS (see talk by Eifler et al.)

A Closer Look at the Reference HLSS

- We will likely be able to utilize galaxy spectra with S/N=5, which significantly increases the Roman HLSS depth, enhancing its dark energy constraining power

2000 deg^2, ~ 6 mos of observing time

	10^{-16} ergs/s/cm^2 (6.5σ)				8.5×10^{-17} ergs/s/cm^2 (5σ)			
z	$H(z)s$	$D_A(z)/s$	$f_g(z)G(z)$	β	$H(z)s$	$D_A(z)/s$	$f_g(z)G(z)$	β
1.0-1.2	0.0177	0.0148	0.0599	0.0329	0.0173	0.0144	0.0552	0.0314
1.2-1.4	0.0173	0.0138	0.0629	0.0364	0.0166	0.0133	0.0579	0.0344
1.4-1.6	0.0175	0.0134	0.0663	0.0407	0.0166	0.0127	0.0609	0.0381
1.6-2.0	0.0150	0.0109	0.0684	0.0416	0.0135	0.0097	0.0625	0.0378
2.0-2.4	0.0300	0.0216	0.1026	0.0955	0.0246	0.0173	0.0874	0.0783
2.4-3.0	0.0401	0.0289	0.1445	0.1466	0.0308	0.0217	0.1148	0.1128

s: BAO scale (comoving sound horizon at the drag epoch).

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Forecasts for Alternative Surveys

- NASA will determine the HLSS that will be executed based on community input, which in turn which depend on the dark energy science landscape in the middle 2020s
- We considered these alternative surveys:

Medium Wide:

1.5×10^{-16} ergs/s/cm^2, 10,000 deg^2, 10 mos

z	$H(z)s$	$D_A(z)/s$	$f_g(z)G(z)$	β
1.0-1.2	0.0084	0.0071	0.0271	0.0158
1.2-1.4	0.0086	0.0070	0.0290	0.0182
1.4-1.6	0.0093	0.0072	0.0312	0.0215
1.6-2.0	0.0096	0.0073	0.0338	0.0254
2.0-2.4	0.0219	0.0165	0.0673	0.0701
2.4-3.0	0.0383	0.0287	0.1289	0.1393

Wide:

2×10^{-16} ergs/s/cm^2, 15,000 deg^2, 10 mos

$H(z)s$	$D_A(z)/s$	$f_g(z)G(z)$	β
0.0077	0.0064	0.0259	0.0148
0.0083	0.0067	0.0279	0.0177
0.0097	0.0076	0.0308	0.0226
0.0113	0.0089	0.0355	0.0299
0.0229	0.0176	0.0697	0.0733
0.0504	0.0385	0.1682	0.1830

Forecasts for Alternative Surveys

Medium Deep: Most compelling stand-alone Roman HLSS

4000 deg^2, ~ 18 mos of observing time, depth of 7×10^{-17} ergs/s/cm^2 (5σ):

z	$H(z)s$	$D_A(z)/s$	$f_g(z)G(z)$	β
1.0-1.2	0.0116	0.0099	0.0309	0.0200
1.2-1.4	0.0111	0.0091	0.0326	0.0219
1.4-1.6	0.0110	0.0085	0.0346	0.0242
1.6-2.0	0.0086	0.0062	0.0351	0.0233
2.0-2.4	0.0144	0.0100	0.0496	0.0456
2.4-3.0	0.0156	0.0106	0.0592	0.0572

Further Work Needed (Incomplete list)

- End-to-end data simulations (intense long-term technical work):
  grism sims → galaxy mocks (inc. all sys.)→ dark energy constraints

- Detailed modeling of observational systematics (long-term technical work):
  slitless effects, such as spectral overlap, line misidentification, etc

- Modeling of small scales to extract more cosmological information

- Study of higher-order statistics using realistic galaxy mocks

- Multi-probe analysis (BAO/RSD & WL) of realistic Roman galaxy mocks