Deep Realistic Extragalactic Model (DREaM): Simulating a Roman Ultra-Deep Field

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Roman Science Team Community Briefing





THE EPOCH OF REIONIZATION



Image Credit: Brant Robertson Adapted from Robertson et al. 2010





REIONIZATION QUESTIONS

- HOW? What were the sources of reionization? Galaxies, stars, AGN, decaying particles, primordial black holes...
 WHEN? — What was the timeline of reionization? Happened sometime between z=6 and z=9.
- 3. WHERE? What was the topology of reionization?
 - How "patchy" was reionization? Did high or low density regions ionize first?



To answer questions about reionzation, we need surveys that are: I. DEEP enough to image faint high-redshift galaxies and 2. WIDE enough to see the environments around galaxies

A ROMAN ULTRA-DEEP FIELD?

- Roman has an enormous field of view, making it ideal for WIDE and DEEP galaxy surveys!



Wider HST **Observations**





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SDSS observations

Roman

Image Credit: NASA, ESA, Anton M. Koekemoer (STScI)







Cosmic Variance

THE WIDE FIELD OF VIEW



Image Credit: Brant Robertson Adapted from Robertson et al. 2010





Synthetic catalogs make predictions of what a survey will detect.

PREPARATION - Design survey, predict science returns, develop pipelines ANALYSIS - Understand systematics, completeness corrections

DEEP REALISTIC EXTRAGALACTIC MODEL (DREaM) arXiv:2110.10703

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GOALS:

Provide community with a synthetic data set for wide, deep galaxy surveys

Quantify the science returns of a 1 deg² Roman Ultra-Deep Field



ROMAN ULTRA-DEEP FIELD - SCIENCE GOALS

Galaxy Catalog at the Epoch of Reionization

(80x larger than deep part)

- Large census of galaxies
- Probe the environment around individual galaxies

Also: galaxy-halo connection, stellar mass functions, galaxy scaling relations, emergence of quiescent galaxies, and more...

A I deg² UDF would be ~300x larger than HUDF and 20x than JADES



Abundance Matching







Morphologies



METHODS

Spectra Modeling



DREaM GALAXY CATALOG www.nicoledrakos.com/dream

CATALOG CONTAINS

Positions (redshift, RA, DEC)

Galaxy Masses and SFRs

Morphologies

Roman and JWST photometry

Spectral modelling parameters

Dark matter halo properties

And More...

CATALOG REPRODUCES

Halo Mass Function

Stellar Mass Function

Luminosity Functions

Galaxy Clustering

Cosmic Star Formation Rate Density

Fundamental Metallicity Relation

And More...



DREGM IMAGE



	6 <z<8< th=""><th>8<z<10< th=""><th>z>10</th></z<10<></th></z<8<>	8 <z<10< th=""><th>z>10</th></z<10<>	z>10
All HST + ground	~10 ³	~150	~5
JADES	8 x 10 ³	2 x 10 ³	300
ROMAN UDF	105	2 x 10 ⁴	2 x 10 ³

ROMAN UDF - NUMBER COUNTS

THE UV LUMINOSITY FUNCTION

Are there enough faint galaxies to reionize the universe?



Uncertainties dominated by limited volume/cosmic variance



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ROMAN UDF - NUMBER COUNTS

UV Luminosity Function

BLACK POINTS: Bouwens 2021 Data

BLUE LINES: Catalog (with completeness correction)

A Roman UDF will be able to constrain the UVLF to 1% on faint end!

- z ~ 10
- M_{UV}<-17



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SUMMARY OF FINDINGS

What will a I deg² Roman UDF measure?

Number Counts

- >10⁴ galaxies during the Epoch of Reionization (z>7) • Furthest quiescent galaxy to date? • More than 10³ galaxies above redshift 10

UV Luminosity Function

- Within 1% on faint end
- $M_{UV} < -17$ at redshift 10



Synthetic Catalog Has Many Uses

Predict Science Returns

- Reionization
- Galaxy—halo connection
- Galaxy evolution
- Stellar mass functions
- Scaling relations

APPLICATIONS

Quantify Systematics

- Source blending
- Line confusion
- SED fitting
- WFI systematics
- Processing issues/low-surface brightness
- Secondary analysis/photo-z studies



- Epoch of Reionization is the next frontier in galaxy surveys.
 - Is there enough radiation from galaxies to ionize the universe?
 - What is the environment around faint, early galaxies?
- Roman can help answer these questions!
- Synthetic galaxy catalogs such as the Deep Realistic Extragalactic Model (DREaM) galaxy catalogs are important to design, interpret and prepare for these future studies

SUMMARY





