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

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THE EPOCH OF REIONIZATION

- Big Bang
- Dark Ages
- Recombination
- Reionization
- Galaxies form
- Present day

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

1. **HOW? — What were the sources of reionization?**
   Galaxies, stars, AGN, decaying particles, primordial black holes…

2. **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 reionization, we need surveys that are:

1. **DEEP** enough to image faint high-redshift galaxies and

2. **WIDE** enough to see the environments around galaxies

*Roman* has an enormous field of view, making it ideal for **WIDE** and **DEEP** galaxy surveys!
THE WIDE FIELD OF VIEW

Roman Camera Field of View
CV ~ 12%

Reionized Bubbles
15 h⁻¹ Mpc

Roman Camera Field of View

HST WFC3 or JWST NIRCAM
CV ~ 33%

CANDELS-Wide GOODS-S+ERS
CV ~ 20%

85 h⁻¹ comoving Mpc @ z~7

Cosmic Variance

Image Credit: Brant Robertson
Adapted from Robertson et al. 2010
SYNTHETIC GALAXY CATALOGS

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 deg\(^2\) Roman Ultra-Deep Field
Galaxy Catalog at the Epoch of Reionization

A 1 deg$^2$ UDF would be $\sim 300x$ larger than HUDF and 20x than JADES (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...
Abundance Matching

Light Cone
METHODS

Morphologies

Spectra Modeling

\[ \log_{10}(M_{\text{bol}}/M_\odot) = 8.46 \]

\[ \log_{10}(M_{\text{bol}}/M_\odot) = 11.02 \]
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…
<table>
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<th></th>
<th>6&lt;z&lt;8</th>
<th>8&lt;z&lt;10</th>
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<tr>
<td>All HST + ground</td>
<td>~10^3</td>
<td>~150</td>
<td>~5</td>
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<tr>
<td>JADES</td>
<td>8 x 10^3</td>
<td>2 x 10^3</td>
<td>300</td>
</tr>
<tr>
<td>ROMAN UDF</td>
<td>10^5</td>
<td>2 x 10^4</td>
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Are there enough faint galaxies to reionize the universe?

Uncertainties dominated by limited volume/cosmic variance
A Roman UDF will be able to constrain the UVLF to 1% on faint end!

- $z \sim 10$
- $M_{UV} < -17$
SUMMARY OF FINDINGS

What will a 1 deg$^2$ Roman UDF measure?

Number Counts
- $>10^4$ galaxies during the Epoch of Reionization ($z>7$)
- Furthest quiescent galaxy to date?
- More than $10^3$ galaxies above redshift 10

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

Synthetic Catalog Has Many Uses

Predict Science Returns

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

Quantify Systematics

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

• **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.
Thank you!