Cosmic Origins Science
With a Large UVOIR Space Telescope

Ultraviolet, Ultra faint, Ultra precise

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Epochs and Science where LUVOIR is uniquely suited to rewrite key chapters in the story of cosmic origins

Adapted from AURA Report by Kate Whitaker (U. Mass. Amherst) & Marc Postman
How Did the Milky Way Form from its Earliest Seeds?

Epoch
z = 1 - 8

Resolution
30-100 pc

Milky Way Progenitor at z = 2

With unique 100 parsec resolution in the optical at all redshifts, LUVOIR can resolve the building blocks of galaxies: individual star forming regions and dwarf satellites, including progenitors of the present-day dwarf spheroidals.

These high-resolution images will complement spectroscopy from 30m class ground-based telescopes and ALMA of the galaxies and their molecular gas. LUVOIR will spatially resolve SFR, Hα/Hβ, BPT diagnostics, HeI/Hβ, etc.

*JWST is optimized for longer infrared wavelengths than this, and is still awesome!
How Do Galaxies Grow, Evolve, and Die?

Epoch
$z = 1 - 8$

Resolution
30-100 pc

entire sky observed @ 1" resolution

number of spatial resolution elements in the observed field

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How Do Galaxies Grow, Evolve, and Die?

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How do galaxies transition to quiescence?
What are the dynamics of flows into and out of galaxies?
How (and where) does the baryonic lifecycle evolve?
UV Access is Essential!

UV spectral features provide the some of the best, and often unique, constraints on:

- Ionization state of ISM, IGM
- Structure in ISM, IGM
- Sources of ionization
- Gas Temperature
- Metallicity of ISM, IGM
- Gas Density
- Star formation rate
- Gas kinematics and outflows

High spectral resolution is often required to make such measurements ($R > 20,000$).
Using powerful and unique multi-object UV spectroscopy, LUVOIR will be able to map the “faintest light in the Universe” emitted from gas filaments entering galaxies and energetic feedback headed back out.
With the same UV multiplexing, LUVOIR will also be able to map (in nearby galaxies, like M51 shown here) the properties of young stellar clusters and, using them as background sources, the outflows they drive into the ISM and IGM in nearby galaxies.

These observations **require** UV capability and a 10 - 15 meter aperture.
How Does Star Formation History Create the Diversity Shapes and Sizes of Galaxies?

Volume < 100 Mpc
Resolution 1 - 10 pc

Star formation history sets both chemical evolution and planet formation rates. Visible bands provide best discrimination. Requires diffraction limited optical imaging and high PSF stability.

Aperture Driver: ≥10 m needed to resolve stellar pops down to 1 M☉ out to the nearest giant ellipticals.

LUVOIR could also determine robust star-count IMFs down to 0.1-0.2 M☉ throughout the Local Group, including hundreds of new ultra faint dwarf galaxies to be mapped by LSST.
What is the Dark Matter? How Does Light Trace Mass? How Does Dark Mass Move?

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<th>Distance</th>
<th>Speed</th>
<th>Example</th>
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<tr>
<td>10 pc (nearest stars)</td>
<td>10 cm s⁻¹</td>
<td>Exoplanet detection</td>
</tr>
<tr>
<td>100 pc (nearest SF regions)</td>
<td>1 m s⁻¹</td>
<td>Exoplanets in disks</td>
</tr>
<tr>
<td>10 kpc (entire MW disk)</td>
<td>100 m s⁻¹</td>
<td>dissipation of star clusters</td>
</tr>
<tr>
<td>100 kpc (MW halo)</td>
<td>1 km s⁻¹</td>
<td>DM dynamics in dwarf sats.</td>
</tr>
<tr>
<td>1 Mpc (Local Group)</td>
<td>100 km s⁻¹</td>
<td>3D motions of all LG galaxies</td>
</tr>
<tr>
<td>10 Mpc (Galactic Neighborhood)</td>
<td>500 km s⁻¹</td>
<td>cluster dynamics</td>
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LUVOIR should be able to measure proper motions to ~ microarcsec / year precision over a ten-year baseline.

At this level, virtually everything on the sky moves - every star in the Milky Way and Local Group and every galaxy in the Galactic Neighborhood.

System driver: Extremely well-calibrated detector pixel positions and low-noise detectors are needed to centroid objects to less than 1 thousandth of a pixel. A concept like the one being studied by Shao at JPL would enable this level of accuracy.
Simulating Your LUVOIR Science:

https://asd.gsfc.nasa.gov/luvoir/tools/

HDI Photometric ETC
Basic exposure time calculator for optical photometry in multi-band images.

LUMOS Spectroscopic ETC
Simple exposure time calculator for UV spectroscopy.

UV MOS Visualizer
See the impact of UV multi-object spectroscopy on the study of stellar clusters and their feedback.

High-Resolution Imaging
Examples of astronomical objects viewed with different sized telescopes.

https://asd.gsfc.nasa.gov/luvoir/tools/