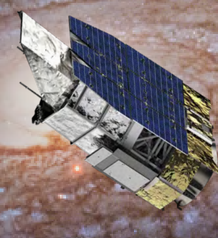
ROMAN SPACE TELESCOPE

Galaxies by the Millions

NASA's Nancy Grace Roman Space Telescope will have the power to collect an unprecedented volume of high-resolution near-infrared imaging and spectroscopic observations of galaxies across vast fields of view and spans of time, providing the large data sets needed to understand how different types of galaxies form, grow, interact with their environments, and evolve over time.



Hubble-Like Resolution ~0.1'' **Near-Infrared Imaging and Spectroscopy** 0.48–2.3 μm **Expansive Field of View** 0.281 deg^2 **All Data Nonproprietary** ~4 PB/yr

Complementing Other Observatories HST, JWST, Rubin, Gaia, Euclid, TESS, and more **Propelling Future Discoveries** All of Astrophysics

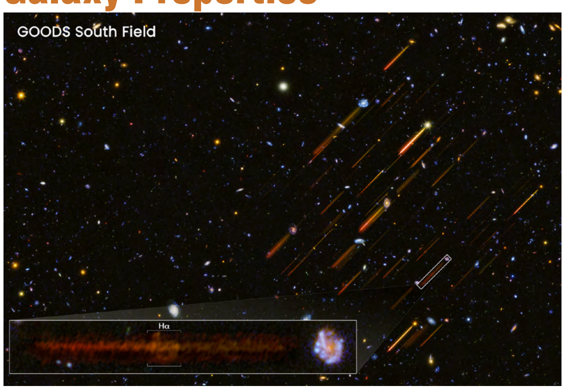
Galaxy Formation and Evolution

Galaxies at different stages of formation at $z = 5.79$ (top left) to $z = 0.49$ (bottom right) from the Hubble Ultra Deep Field 2004. (NASA, ESA, and the HUDF Team)

Roman will enable observations of hundreds of millions of galaxies at numerous stages of development, providing imaging and spectroscopy required to build a clear and detailed picture of how different types of galaxies form and evolve. Roman will provide:

- Large data sets with homogeneous observing conditions needed to identify statistically significant correlations between various galaxy properties as a function of mass, environment, and redshift
- Potential High Latitude Wide Area Survey covering ~2,000 deg^2 with NIR imaging and spectroscopy over the same fields of view
  - ◊ Imaging depth (5σ) of 26.9, 26.95, 26.9, and 26.25 in Y, J, H, and F184 filters
  - ◊ Grism (1.00–1.93 μm) spectroscopy depth of 1.0×10^{-16} ergs/s/cm^2 at 1.80 μm (5σ)
  - ◊ Estimated detection rate of 27 million galaxies per month, with a total of more than one billion galaxies over the full survey
  - ◊ Survey definition to be identified through a community-driven open process
- Immediate open access to all mission data via the Mikulski Archives for Space Telescopes (MAST), and funding opportunities for new observations and archival research programs

Galaxy Properties



Portion of Hubble GOODS-South ACS and WFC3 observations with a representative overlay of slitless spectroscopy. (NASA, ESA, J. DePasquale, STScI; Pascal Oesch, University of Geneva; Mireia Montes, UNSW)

With its 0.11'' resolution, two slitless spectroscopy modes covering 0.75–1.93 μm, and survey speeds 100–1000× Hubble, Roman will provide the large datasets needed for unprecedented statistical analysis of galaxy populations and evolutionary relationships across multi-dimensional parameter space. Roman will enable:

- Extragalactic surveys for measurements of redshift, luminosity, color, size, shape, clumpiness, and clustering from 10^8–10^9 galaxies over the mission lifetime
- Grism observations to provide robust spectroscopic redshifts for >100 million galaxies, and to create spatially resolved maps of Hα surface brightness, dust extinction, mass-to-light ratio, and metallicity at ~1 kpc resolution
- Detection of ~14 million Hα galaxies at $1 < z < 1.9$, and 1.5–2.0 million [OIII] galaxies at $z \approx 1.8$–2.8 (up to $z = 4.2$ with SFR >200 $M_\odot$/yr)
- Modeling of spectral energy distributions, including spectral lines from grism spectra, to measure SFR, stellar mass, dust extinction, mass-to-light ratio, and metallicity
- Detection of 10^4 galaxy-galaxy strong lenses (~10/deg^2) for mass density profile models of luminous and dark matter in foreground galaxies of $z = 1$–2 and $M^* = 10^{10}$–10^{12} $M_\odot$

Galaxies, Black Holes, and AGN

Multi-wavelength image of active radio galaxy Centaurus A. (X-ray: NASA/CXC/SAO; optical: Rolf Olsen; infrared: NASA/JPL-Caltech; radio: NRAO/AUI/NSF/Univ. Hertfordshire/M. Hardcastle)

Roman will facilitate a more complete census of black holes, quasars, and AGN, and a more comprehensive understanding of the coevolution of supermassive black holes and their host galaxies. Roman will enable:

- Surveys with the potential to reveal the mass of accreting black holes at peak growth of $z \approx 2$–7, as well as the clustering and properties of their host galaxies
- Studies of the effects of black hole accretion on the growth of galaxies via feedback mechanisms at $1 < z < 7$
- Investigations of the AGN/star-formation relationship in the most massive galaxies
- Characterization of differences in clustering amplitude of obscured and unobscured AGN to probe AGN unification scenarios and possible correlations with galaxy evolution
- Discovery of ~2600 quasars at $z > 7$ to track the assembly of 10^9-$M_\odot$ black holes during the Epoch of Reionization
- Characterization of the faint end of the quasar luminosity function at $z > 3$–4
- Detection of strongly lensed quasars to map mass distribution of lensing systems, as well as properties of their host galaxies

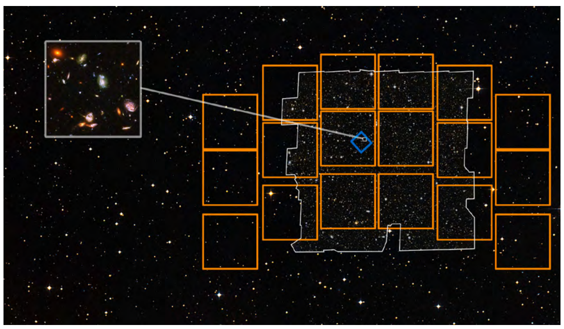
Galaxies and their Environments

Optical/infrared Hubble image of galaxy cluster Abell S1063, showing intracluster light and lensed background galaxies. (NASA, ESA, M. Montes, and the HFF team)

Roman's ability to capture vast swaths of the sky will provide insights into the relationships between galaxies and their environments over a wide range of scales, building a better understanding of how a galaxy's environment affects its properties, growth, and evolution. Roman will make it possible to:

- Test models of galaxy evolution by measuring clustering as a function of galaxy properties
- Survey galaxies at z = 1–2 and combine grism redshift data with weak-lensing imaging data to create the densest map of structure on linear scales of 11–12 Mpc
- Investigate links between galaxies, AGN and supernova feedback mechanisms, and dark matter halos at $z > 1$ as a function of galaxy mass
- Detect dwarf galaxies in large enough numbers to provide constraints on dark matter models and compare to cosmological simulations
- Map substructure in galaxies' stellar halos to track past accretion history
- Survey galaxy groups and clusters to identify environmental influences on galaxy properties
- Use strong and weak gravitational lensing to map dark matter on spatial scales of 10–50 kpc within galaxy clusters to compare to simulated dark matter profiles from cosmological models and better understand interactions between mass components in merging/colliding clusters

High Redshift Galaxies

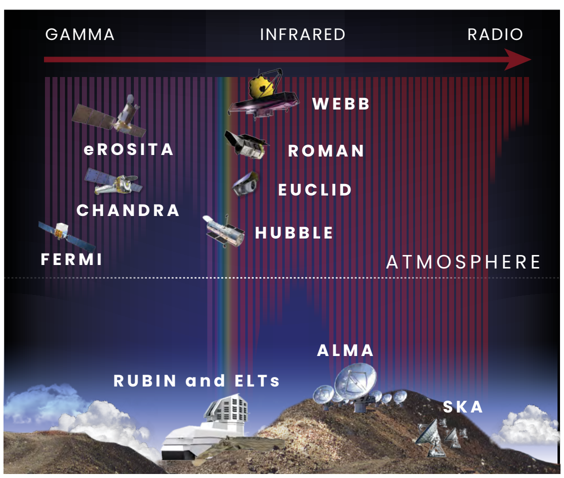


Footprint of an example Roman Ultra Deep Field (orange) compared to the Hubble Ultra Deep Field (blue), and wider, shallower Hubble observations (white) (NASA, ESA, DSS, and Anton M. Koekemoer, STScI)

Roman's unique combination of near-infrared sensitivity, high resolution, and extreme survey speed will dramatically increase our sample of galaxies and quasars in the early universe, providing the data needed to revolutionize our understanding of early star formation, the Epoch of Reionization, and the early structure of the universe. Roman will enable:

- Potential extragalactic wide-area survey with estimated detection of 2.8×10^5 galaxies of ≤26.5 mag at $z = 8$; 7.5×10^4 galaxies at $z = 9$; and 1.9×10^4 galaxies at $z = 10$
- Discovery of high-z Ly-α emitting galaxies ($8 < z < 15$), Lyman-break galaxies, AGN, and quasars to determine their luminosity functions and investigate their impact on cosmological reionization
- Detection of Ly-α and Hα emission features to constrain SFR, amount of ionizing radiation, and escape fraction from the neutral intergalactic medium, and to understand their impact on structure formation
- Treasury-scale observation programs with survey speeds 10^2–$10^3\times$ Hubble, including potential Roman Ultra Deep Field and Wide Deep Grism programs for probing galaxies in the early universe

Synergies



Wavelength range of select space and ground-based observatories to complement Roman in the 2020s (A. James, P. Jeffries, STScI)

Roman's power to capture high-resolution near-infrared observations of hundreds of millions to billions of galaxies and their environments over a wide range of redshifts will complement the capabilities of other observatories, including Rubin, Euclid, eRosita, Webb, and Hubble.

- Combining data from Roman, Rubin, and Euclid will improve photo-z measurements by mitigating systematic errors arising from incomplete wavelength coverage, low resolution, blending, and biases in galaxy sample selection.
- The combined broad wavelength coverage will enable better SED modeling and more accurate determinations of galaxy properties such as star-formation rate and stellar mass.
- Synergies with radio, optical, and X-ray observatories will advance our understanding of obscured and unobscured AGN and the coevolution of AGN with their host galaxies.
- Cross-correlating Ly-α emitting galaxy positions mapped by Roman and neutral hydrogen mapped by SKA can be used to probe conditions of the Epoch of Reionization.
- Roman's ability to conduct deep surveys of large regions of the sky will increase the statistical probability of finding rare objects, which can then be observed with additional telescopes for higher-resolution spectroscopy and panchromatic imaging.

STScI

Learn more about the Roman Space Telescope

STScI website: **www.stsci.edu/roman**

Mission/partner websites: **www.stsci.edu/roman/about.html#Partners**

For more about how Roman will explore the universe, see **www.stsci.edu/roman/documentation**

Previously known as the Wide Field Infrared Survey Telescope (WFIRST), the Nancy Grace Roman Space Telescope was named in May 2020 in honor of NASA's first Chief of Astronomy.

October 2021