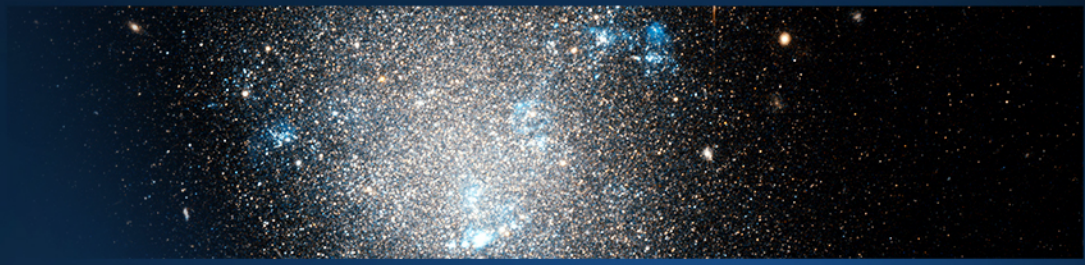
HabEx

Habitable Exoplanet Observatory

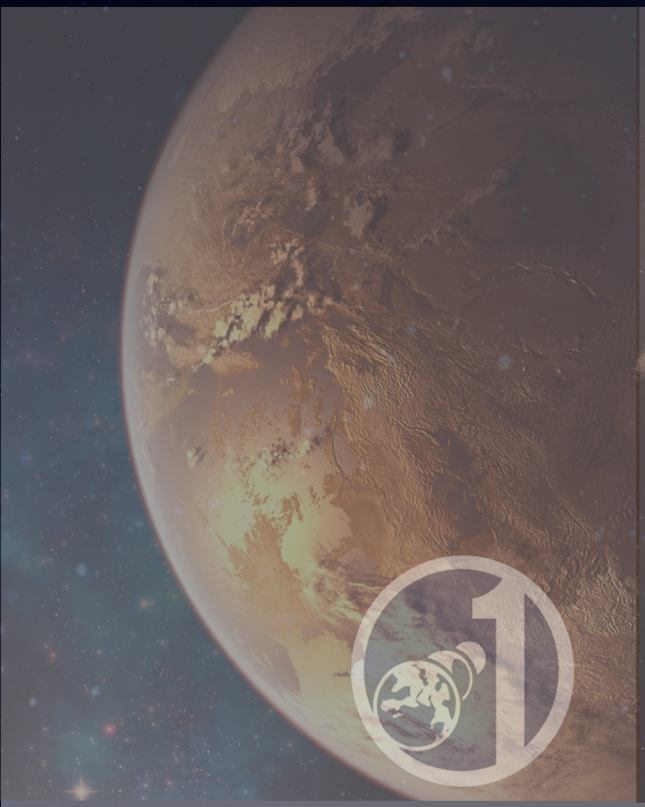


Observatory Science with HabEx

Alina A. Kiessling, Deputy Study Scientist
Jet Propulsion Laboratory, California Institute of Technology

HabEx

Science Goals

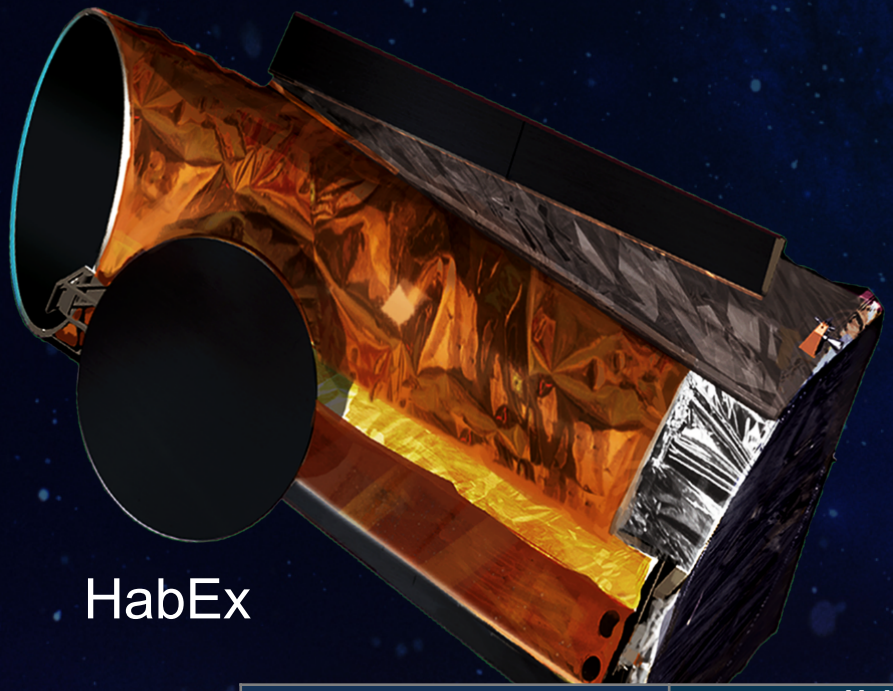


Seek out nearby worlds and explore their habitability

Map out nearby planetary systems and understand their diversity

Enable new explorations of astrophysical systems in the UV to near-IR

The Next-Generation UVOIR Great Observatory



HabEx

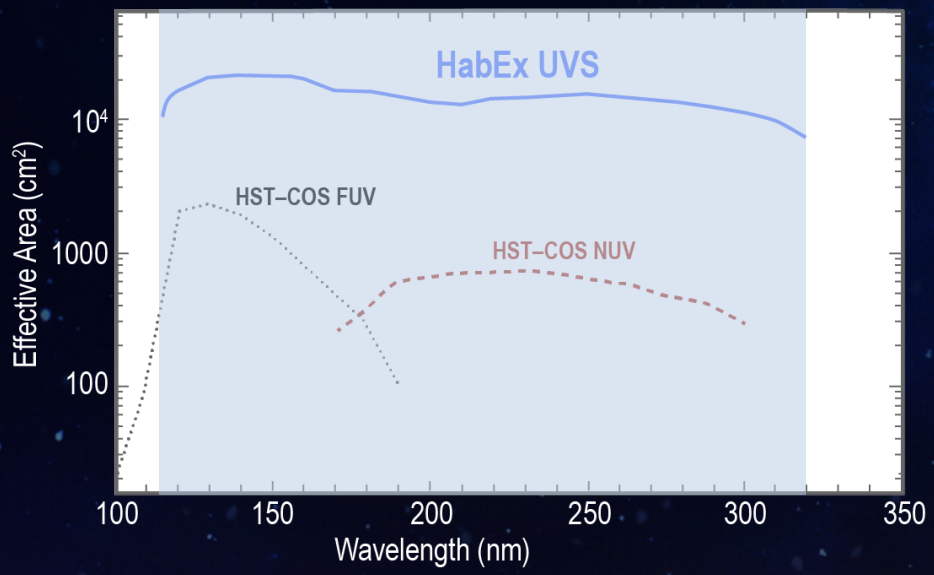
HST

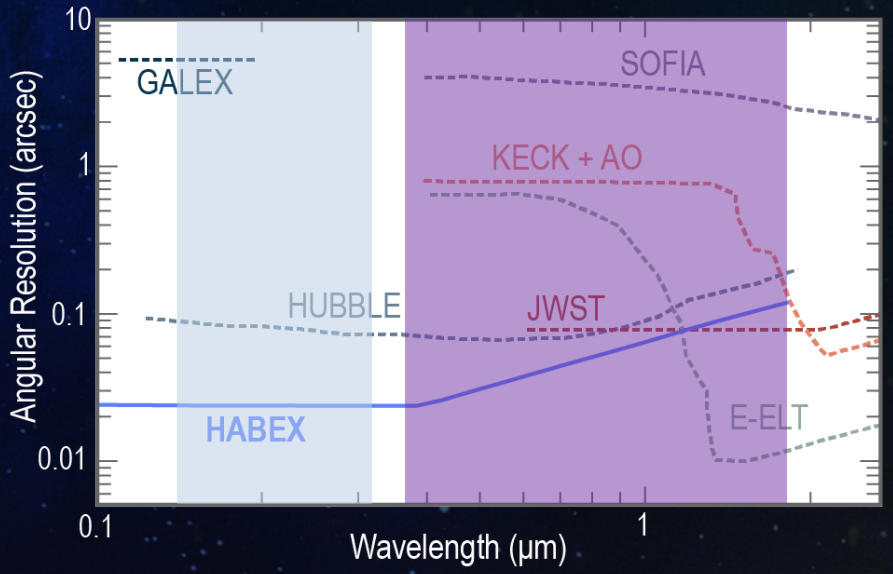
	HabEx	HST
Aperture	4.0 m unobscured	2.4 m obscured
Diffraction Limit	400 nm	500 nm
Slew Rate (180 deg)	20 min (typical), 5 min (max)	~30 min (max)
Pointing Accuracy	0.7 mas	5 mas (typical), 2 mas (best)
Spatial Resolution	25 mas	50 mas
Effective Area* (@200 nm)	10,000 cm^2	700 cm^2
Micro-shutters	Yes	No
Serviceable	Yes/Robotic	Yes/Astronaut

* Effective area is clear aperture multiplied by throughput and quantum efficiency

Exceptional Resolution and Collecting Area

The HabEx Wide Field Ultraviolet Camera (HWUC)



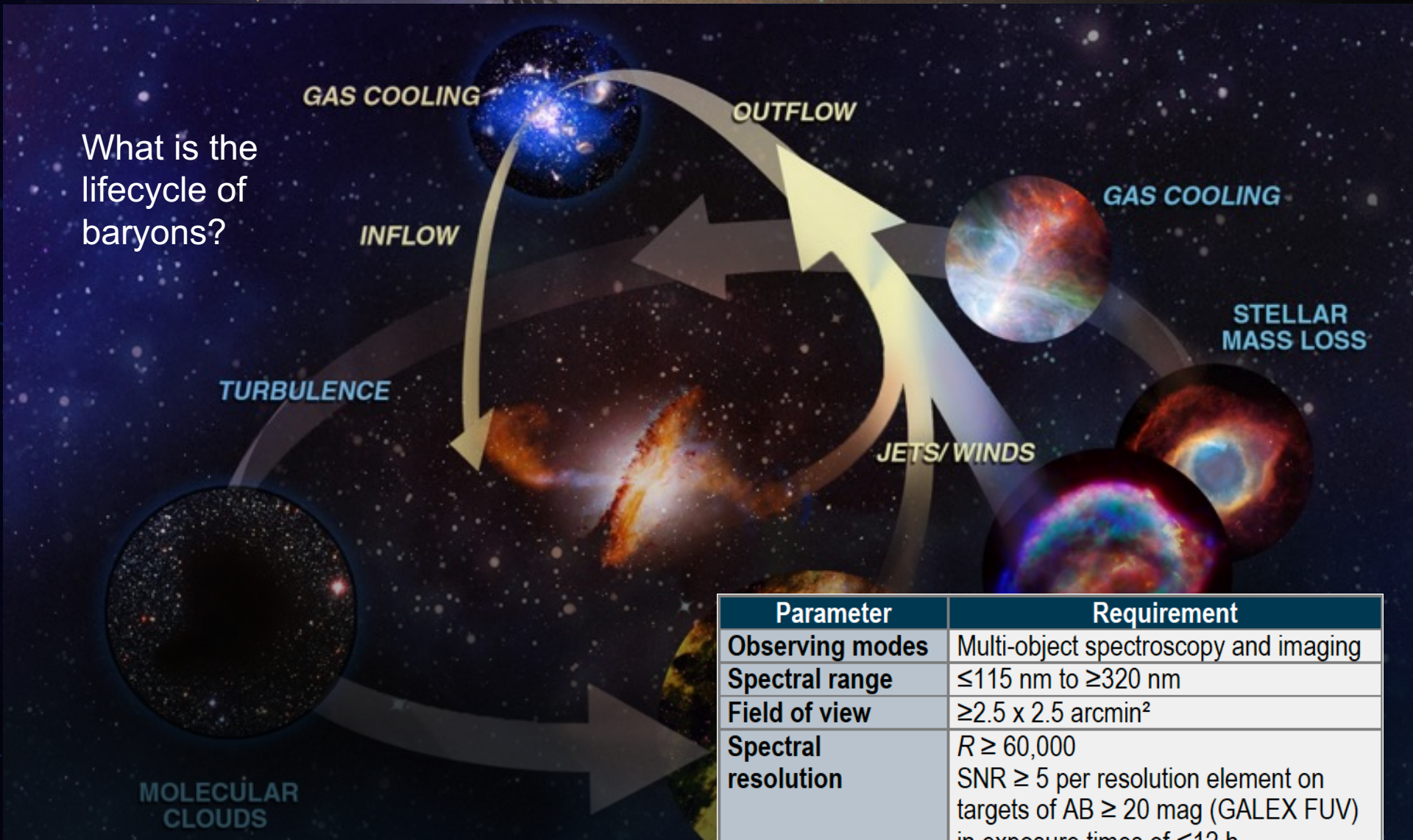


How Does HabEx Use These Capabilities?

- *Extragalactic astrophysics*
- *Galactic astrophysics*
- *Solar system science*

Extragalactic Astrophysics

What is the lifecycle of baryons?

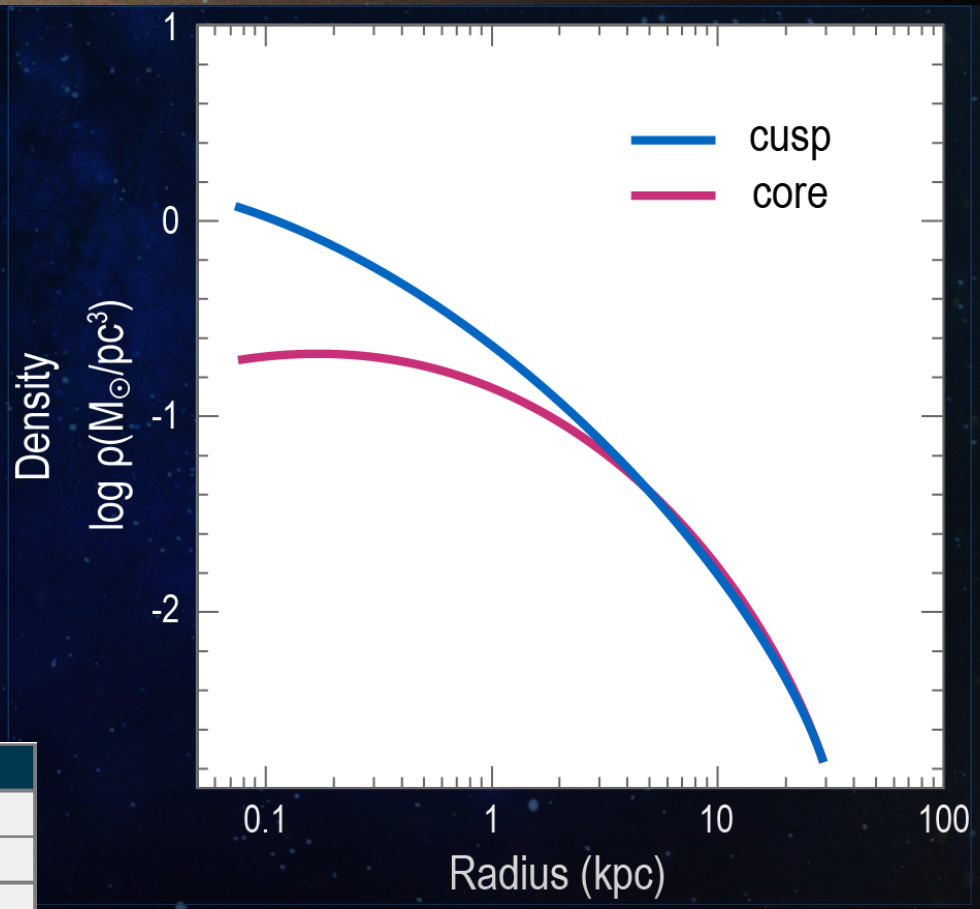


Parameter	Requirement
Observing modes	Multi-object spectroscopy and imaging
Spectral range	≤115 nm to ≥320 nm
Field of view	≥2.5 x 2.5 arcmin²
Spectral resolution	$R \geq 60{,}000$ SNR ≥ 5 per resolution element on targets of AB ≥ 20 mag (GALEX FUV) in exposure times of ≤12 h
Angular resolution	≤0.3 arcsec

Ultraviolet Spectrograph (UVS)

HabEx

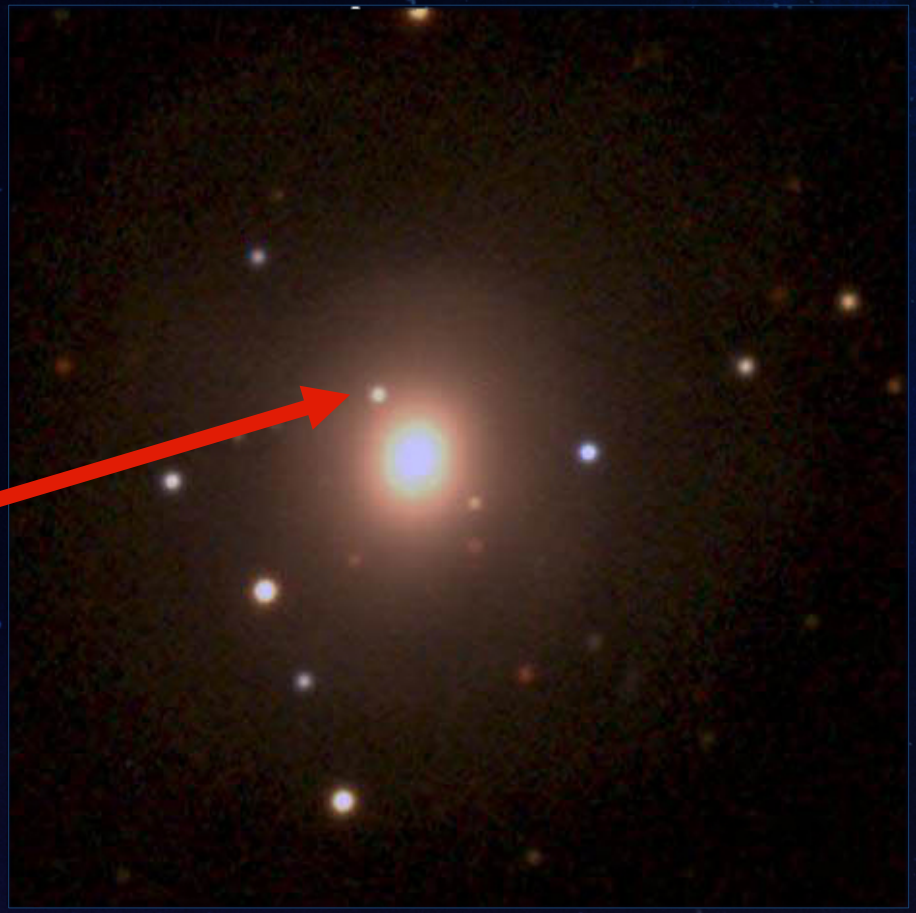
Extragalactic Astrophysics



Parameter	Requirement
Observing mode	Broadband imaging
Wavelength range	Visible broadband filter (V)
Angular resolution	≤0.05 arcsec
Field-of-view	≥2 × 2 arcmin^2
Sample size	≥10 dwarf galaxies
Signal-to-noise	SNR ≥ 5 for point sources of V ≥ 30 mag in exposure times of ≤2 h per dwarf galaxy

HabEx Workhorse Camera (HWC)

Multi-messenger follow-up



Credit: Dark Energy Survey

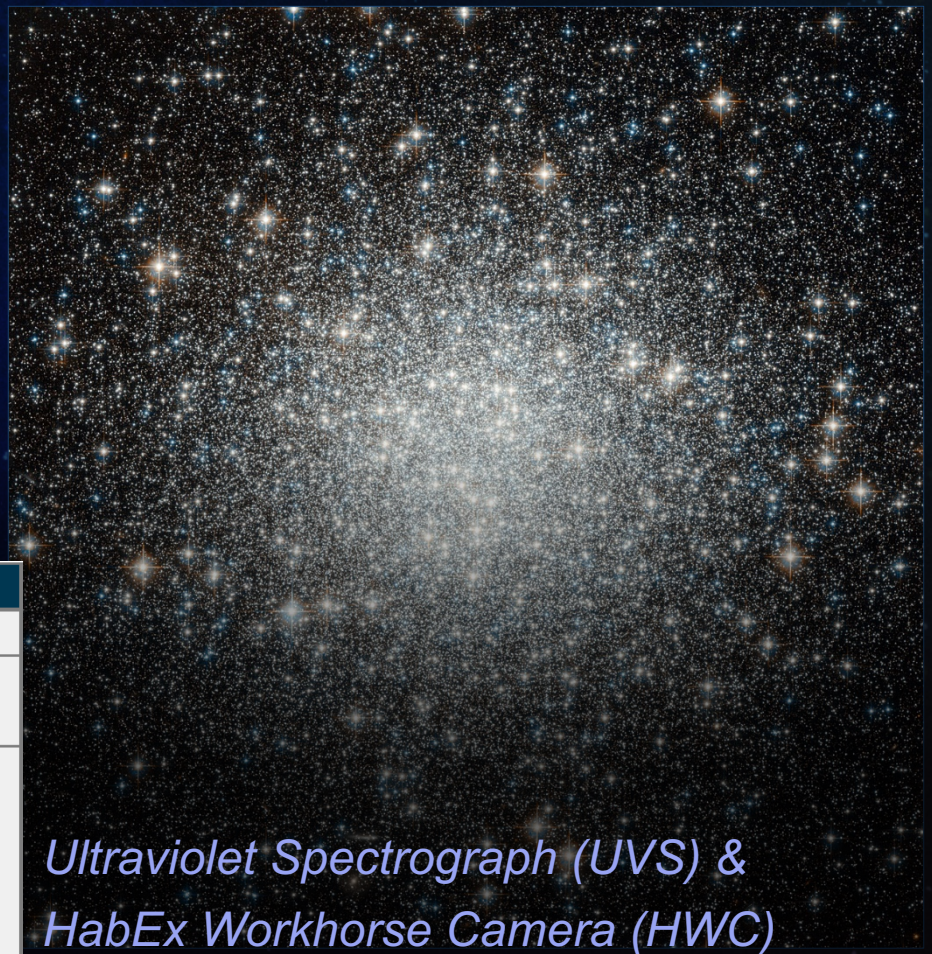
Ultraviolet Spectrograph (UVS) &
HabEx Workhorse Camera (HWC)

Galactic Astrophysics

How do globular clusters form and evolve?

HST

HabEx



Parameter	Requirement
Observing mode	Multi-object spectroscopy
Spectral range	UV: ≤150 nm to ≥320 nm Visible: ≤0.37 μm to ≥1.0 μm
Multi-object spectroscopy	$R \geq 1{,}000$ SNR ≥ 3 per 0.5 nm effective resolution element for V ≥ 25 mag in exposure times of ≤10 h per instrument
Sample size	≥400 stars

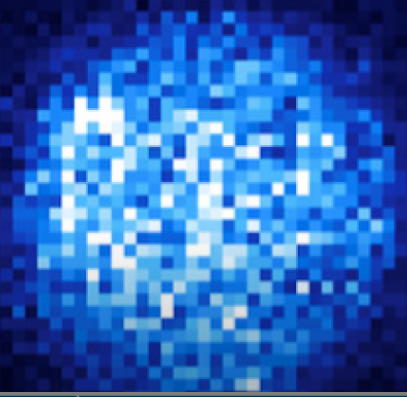
Ultraviolet Spectrograph (UVS) & HabEx Workhorse Camera (HWC)

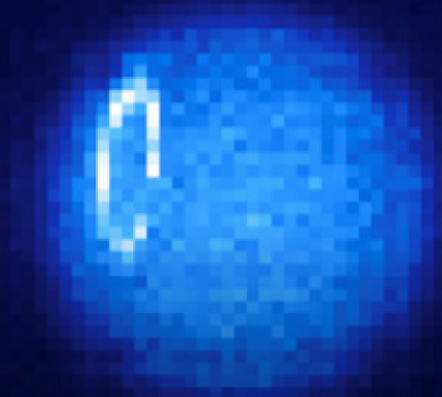
Solar System Science

How do stars and planets interact?

HST/STIS 1000 sec.

HabEx 1000 sec.





Uranus Simulation

Parameter	Requirement
Observing mode	Time-resolved imaging
Wavelength range	≤115 nm to ≥162 nm SNR ≥ 3 for an auroral surface brightness ≤100 Rayleigh in an exposure time of ≤10 m
Field-of-view	≥1 × 1 arcmin^2
Angular resolution	≤0.05 arcsec
Tracking	Non-sidereal

Ultraviolet Spectrograph (UVS)

Observatory Science Goal and Objectives

To enable new explorations of astrophysical systems from the solar system to galaxies and the universe by extending our reach in the UV through near-IR.

Objectives

09 To probe the lifecycle of baryons by determining the processes governing the circulation of baryons between the gaseous phase of the intergalactic medium (IGM), circumgalactic medium (CGM), and galaxies.

10 To determine the sources responsible for initiating and sustaining the metagalactic ionizing background (MIB) across cosmic time.

11 To probe the origin of the elements by determining the properties and end states of the first generations of stars and supernovae.

12 To address whether there is a need for new physics to explain the disparity between local measurements of the cosmic expansion rate and values implied by the cosmic microwave background (CMB) using the standard Λ cold dark matter (ΛCDM) cosmological model.

13 To constrain dark matter models through detailed studies of resolved stellar populations in the centers of dwarf galaxies.

14 To constrain the mechanisms driving the formation and evolution of Galactic globular clusters.

15 To constrain the likelihood that rocky planets in the HZ around mid-to-late-type M-dwarf stars have potentially habitable conditions (defined as water vapor and biosignature gases in the atmosphere) by surveying ≥ 5 systems assuming an average transit duration of 1 h.

16 To constrain the range of possible structures within transition disks and to probe the physical mechanisms responsible for clearing the inner regions of transition disks, surveying ≥20 transition disks.

17 To probe the physics governing star-planet interactions by investigating auroral activity on gas and ice giant planets within the solar system.

Observatory Science Goal and Objectives

To enable new explorations of astrophysical systems from the solar system to galaxies and the universe by extending our reach in the UV through near-IR.

Objectives (Simplified)

09 What is the Lifecycle of Baryons?

10 What Caused the Reionization of the Early Universe?

11 What are the Origins of the Elements?

12 What is the Local Value of the Hubble Constant?

13 What is the Nature of Dark Matter?

14 How do Globular Clusters Form and Evolve?

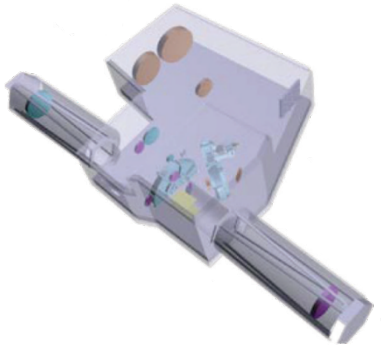
15 Are there Potentially Habitable Planets around M-Dwarf Stars?

16 Constraining Planet Formation Mechanisms.

17 How do Stars and Planets Interact?

Backup

HabEx Instruments

		
	Workhorse Camera (HWC)	**UV Spectrograph (UVS)**
Purpose	Multipurpose, wide-field imaging camera and spectrograph for observatory science	High-resolution, UV imaging and spectroscopy for observatory science
Instrument Type	Imager and spectrograph	High-resolution imager and spectrograph
Channels	Visible: 0.37–0.975 µm - Imager + grism with R = 1,000 Near-IR: 0.95–1.8 µm - Imager + grism with R = 1,000	UV 115–320 nm (with 115–270 nm available at $R \leq 1{,}000$) R = 60,000; 25,000; 12,000; 6,000; 3,000; 1,000; 500; imaging
Field of View	3 × 3 arcmin^2	3 × 3 arcmin^2
Features	Microshutter array for multi-object spectroscopy - 2 × 2 array, 171 × 365 apertures	Microshutter array for multi-object spectroscopy - 2 × 2 array, 171 × 365 apertures