The James Webb Space Telescope

...your space telescope after Hubble

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Challenger Space Center of Arizona — Sep 24, 2011
Background: *HST*'s Astronomical Revolution

*Hubble Space Telescope* provides darker sky background, higher resolution, and access to wavelengths inaccessible from the ground (absorbed by Earth’s atmosphere).
Background: *HST’s Astronomical Revolution*

- *HST* discovered that **all** large galaxies have a supermassive black hole at their center...
Background: *HST*’s Astronomical Revolution

... even our own Milky Way Galaxy and our nearest big neighbor, M31, the Andromeda Galaxy
Background: *HST*’s Astronomical Revolution

*HST* gave us sharp views of star bursting galaxies, interacting galaxies, ...
Background: *HST*’s Astronomical Revolution

... and allowed us to trace galaxy assembly and subsequent evolution over the past 12 billion years
Background: *HST’s* Astronomical Revolution

- Recipe for a Universe ... *Dark Energy*???
**HST (and WMAP)’s Astronomical Revolution**

- Start with a Big Bang, inflate, let simmer until transparent

*NASA / WMAP Science Team*
**HST (and WMAP)’s Astronomical Revolution**

- Let rise and cool through the Dark Ages until stars and quasars ignite, the IGM gets reionized

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**Time since the Big Bang**
- 0 yr
- 380 million yr
- 1 billion yr
- 13.7 billion yr (present)

**Redshift, z**
- 0
- 1
- 2
- 6

**Key Phases**
- **Recombination / seeds of structure**
- **Cosmic Dark Ages / structure growth**
- **First Objects start shining**
- **Young Galaxies / Reionization of the Universe**
- **Galaxy Evolution / Emergence of the Hubble Sequence**

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**WMAP**

**JWST**

**HST**

Composite: (c)2011 R.A. Jansen

*NASA / WMAP Science Team / R.A. Jansen*
Background: *HST*'s Astronomical Revolution

- 12 billion years of cosmic history in one picture

*GOODS South Field • WFC3 ERS
Hubble Space Telescope
WFC3/UVIS/IR
ACS/WFC*

*NASA, ESA, R. Windhorst (ASU), P. McCarthy (CIW), & R. O’Connell (UVa)*
Background: HST’s Astronomical Revolution

HST gave new insights into the star formation process within the Milky Way...
Background: *HST’s Astronomical Revolution*

*HST/WFC3 ‘Mystic Mountain’*

*NASA, ESA, M. Livio and the Hubble 20th Anniversary Team (STScI)*
Background: HST’s Astronomical Revolution

... and in nearby galaxies like the Small Magellanic Cloud (and beyond)
But ...

- The *Hubble Space Telescope* will not last much beyond 2015

- *HST* is **blind** at wavelengths further into the near- and mid-infrared (cannot see light emitted by the first stars and proto-galactic clumps, or peer into dense star forming regions)

- *HST* is **not big enough** to detect the faint light from the first stars (even if it could see at longer wavelengths), and not big enough to characterize the atmospheres of Earth-like exoplanets in Earth-like orbits around their parent star.
The **James Webb Space Telescope**

- Enter *Hubble’s successor: The James Webb Space Telescope (JWST)*, to be launched in 2018.

**JWST** (then called the *Next Generation Space Telescope*) was the top-priority recommendation of the NRC’s 2000 *Decadal Survey in Astronomy & Astrophysics* (2010 *Decadal Survey* recommendations assume **JWST**)

- designed to detect light from the first stars and to trace the evolution of galaxies from their formation to the present
- designed to characterize the nearest Earth-like exoplanets and their atmospheres (presence of water vapor!)
- designed as a *multi-purpose observatory* (NASA Flagship mission) for the entire astronomical community

✓ allows rapid response to new discoveries, use for science not imagined in the design stages of the mission (*HST*’s biggest discoveries were not the science for which it was built; same will be true for **JWST**)

✓
Comparison of JWST and HST

Sizes: 21.3 ft (6.5 m; JWST) versus 7.9 ft (2.4 m; HST)
Comparison of *JWST* and *HST*

In the near-infrared, *JWST* will have higher angular resolution than *HST*.

*John Mather, JWST Q&A Session, Sep 21 2011*
Comparison of *JWST* and *HST*

Orbit: 932,000 miles (*JWST*) versus 350 miles (*HST*); launch to L2 by Ariane 5
JWST deployment: advanced origami

Unfolding the JWST – 1
(or see movie: ”JWST_DeployAnimation-longversion”)
JWST deployment: advanced origami

Unfolding the JWST – 2
JWST deployment: advanced origami

Unfolding the JWST – 3
JWST deployment: advanced origami

Unfolding the JWST – 4
JWST deployment: advanced origami

Unfolding the JWST – 5
JWST deployment: advanced origami

Unfolding the JWST – 6
What will JWST look like?

Rendering of the fully deployed JWST
What will JWST look like?

Perspective view from the rear of the fully deployed JWST
What will JWST look like?

View from the side of the fully deployed JWST
What will JWST look like?

Perspective view from below the fully deployed JWST
**JWST’s Scientific Instruments**

**Instrument Overview**

**Fine Guidance Sensor (FGS)**
- Ensures guide star availability with >95% probability at any point in the sky
- Includes Narrowband Imaging Tunable Filter
- Developed by Canadian Space Agency & COM DEV

**Near Infra-Red Camera (NIRCam)**
- Detects first light galaxies and observes galaxy assembly sequence
- 0.6 to 5 microns
- Supports Wavefront Sensing & Control
- Developed by Univ. of AZ & LMATC

**Mid-Infra-Red Instrument (MIRI)**
- Distinguishes first light objects; studies galaxy evolution; explores protostars & their environs
- Imaging and spectroscopy capability
- 5 to 27 microns
- Cooled to 7K by Cyro-cooler
- Combined European Consortium/JPL development

**Near Infra-Red Spectrograph (NIRSpec)**
- Measures redshift, metallicity, star formation rate in first light galaxies
- 0.6 to 5 microns
- Simultaneous spectra of >100 objects
- Developed by ESA & EADS with NASA/GSFC Detector & Microshutter Subsystems
JWST Science Topics (for starters)

● Solar System:
  ➤ *JWST*/MIRI: Spectra of gas giant planets, Kuiper Belt (Trans-Neptunian) Objects down to 25 magnitude; measure temperatures and dynamics; determine origins

● Debris Disks:
  ➤ *JWST*/MIRI: resolve structure of the emission by circumstellar silicate dust grains

● Exoplanets:
  ➤ *JWST*/NIRSpec: measure phase curves of exoplanets around nearby M-dwarf stars; detect/measure water features in atmospheres of ‘ocean planets’.
JWST Science Topics

JWST will Study Planets Both within our Solar System and Around other Stars

Uranus over wavelength ranges and sensitivities in the IR unmatched from the ground.

First spectra of the atmospheres of super Earths around nearby stars, unachievable from the ground.

Jonathan Lunine, JWST Q&A Session, Sep 21 2011
**JWST Science Topics (for starters) (cont’d)**

- **Stars and Star Clusters:**
  - *JWST/NIRCam:* measure stellar mass function down to the hydrogen burning limit (which separates true stars from ‘failed’ stars or brown dwarfs) throughout our Galaxy

- **Galaxy Evolution:**
  - *JWST/NIRSpec+MIRI:* measure escape fraction of ionizing light from star forming galaxies; importance for ionization budget of the Universe

- **First Objects:**
  - *JWST* will be able to see back in time to redshifts >7 (where the wavelengths of the light are stretched so far that *HST* can no longer detect it) and detect the first objects and explosions in the Universe
JWST Science Topics (for starters) (cont’d)

- Dark Energy:
  - JWST/NIRCam will accurately measure the change in expansion rate of the Universe and so help determine the nature of the mysterious Dark Energy.
Independent Comprehensive Review Panel (ICRP) report finds no technical hurdles
JWST Development Status

Hardware Fabrication Completion Percentages

- Primary Mirror Segments: 100%
- Aft Optics System Bench: 95%
- Primary Mirror Support Structure: 75%
- Tertiary Mirror: 100%
- Fine Steering Mirror: 100%
- Secondary Mirror: 95%
- Secondary Mirror Supports: 90%
- Spacecraft Bus: 25%
- Sunshield Membranes: 10%
- Science Instrument Module & Science Instruments: 90%

As of 9/1/2011

Eric P. Smith, JWST Q&A Session, Sep 21 2011
JWST Development Status

Family Portrait

- C1
- B2
- B7
- C2
- C1
- C2
- A5
- B8
- B7
- A6
- A5
- A4
- B3
- C5
- C3
- B6
- A1
- C3

Mirror segment has completed all thermal testing

Secondary
Tertiary
Fine Steering

Eric P. Smith, JWST Q&A Session, Sep 21 2011
JWST Development Status

JWST Sunshield Membrane Engineering Model

Eric P. Smith, JWST Q&A Session, Sep 21 2011
JWST Development Status

JWST mirror and support structure testing at NASA-MSFC and GSFC
JWST Development Status

● 11 new technologies invented from scratch early in JWST’s development process

● >75% of real flight hardware procured, in production, under testing, or completed (incl. contributions by international partners)

● Management/cost issues mitigated by elevating JWST to a division level (directly overseen by the NASA Associate Administrator)

➤ JWST continues to make great progress and is on track for a launch in 2018.
JWST Development Under Threat

Jul 2011: House voted on Appropriations Bill to reduce NASA’s 2012 Science budget (Earth Science, Planetary Science, Astrophysics, and Heliophysics) to $4B, explicitly terminating all funding ($431M) for JWST

➤ JWST would not be finished and launched;
➤ major threat to U.S. astronomy, loss of all its scientific opportunities and public excitement;
➤ lost JWST funding would not be reallocated to other missions, but be permanently lost to astronomy;
➤ damage to the international standing of NASA and the U.S. as an international partner: ESA (Europe) and CSA (Canada) contribute >$1B to JWST.

Sep 2011: Senate voted on its version of 2012 Appropriations Bill, proposing $5B for Science and explicitly restoring funding to JWST at a level ($530M) to allow launch in 2018.
Oct 2011? Final 2012 NASA budget to be determined in full conference of House and Senate

- JWST could still be canceled in a comprise between House and Senate
- Wide public support is needed to save JWST’s future.
What *you* can do to help save JWST: web links

- [http://www.savejwst.com/](http://www.savejwst.com/)
- [http://twitter.com/#!/saveJWST](http://twitter.com/#!/saveJWST)
- [http://www.facebook.com/SaveJWST](http://www.facebook.com/SaveJWST)
- [http://www.whitehouse.gov/contact](http://www.whitehouse.gov/contact)
- [http://savethistelescope.blogspot.com/](http://savethistelescope.blogspot.com/)

Learn more about JWST at:

- [http://jwst.nasa.gov](http://jwst.nasa.gov)
- [http://firstgalaxies.org/jwst/](http://firstgalaxies.org/jwst/)

Write your senator *Jon Kyl* and reps. *Jeff Flake* or *David Schweikert*