Technological Challenges for a UV-optical flagship mission

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Astrophysics Roadmap Town Hall

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Agility to Innovate, Strength to Deliver

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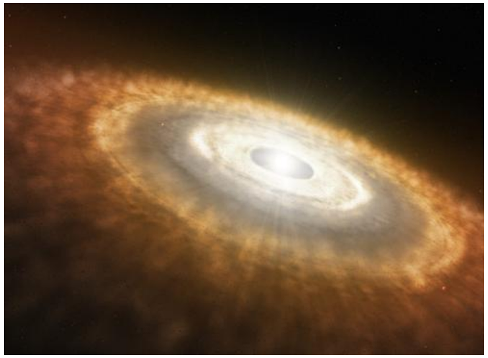
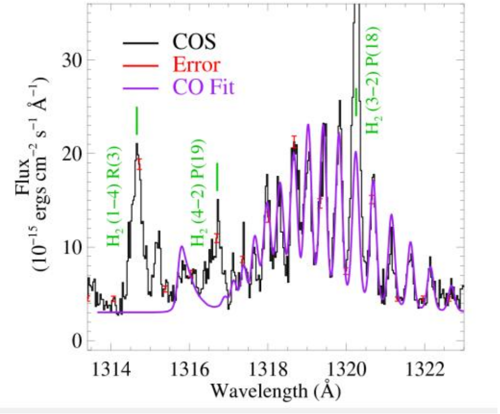
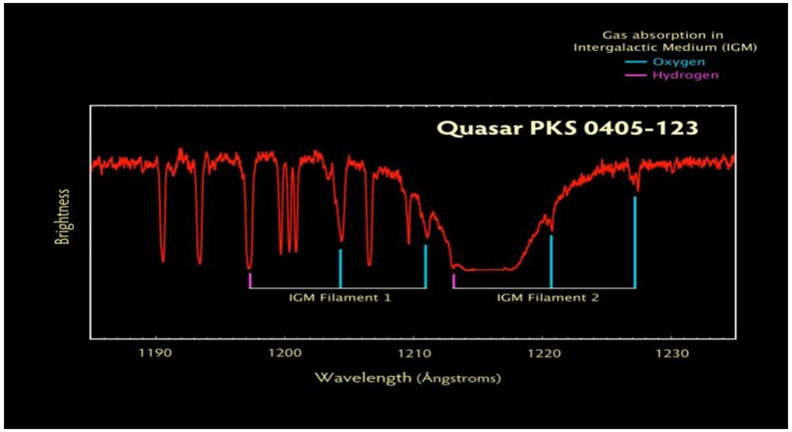
A UV-Optical flagship will address major science themes for NASA's Astrophysics Division

Exoplanets and circumstellar disks

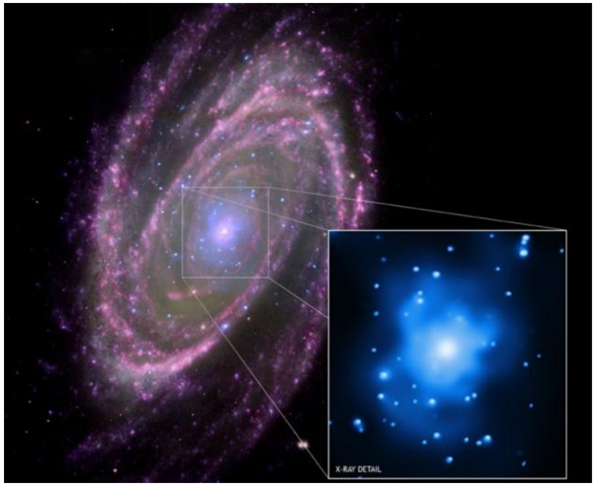




Structure and composition of the Intergalactic and Circum-Galactic Medium



Gravitationally lensed high redshift galaxies



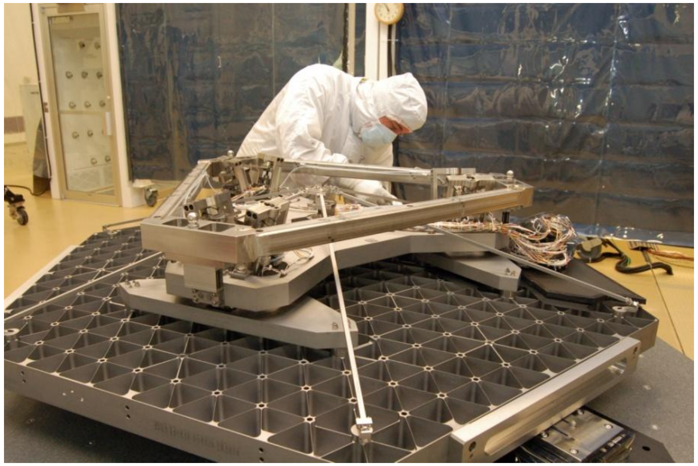
Stellar populations, Galaxies, AGN, Quasars, black holes

A large primary aperture enables both high sensitivity and fine spatial resolution

- If larger than practical for a monolith it requires segmentation
- If larger than LV fairing it requires deployment or assembly
- The full benefits of large size also require stability, precise alignment, precise pointing control
- These issues were resolved for JWST operating in IR. UV-optical solutions may need different approaches, or at least higher precision performance.

Segments should be a net simplification to the system

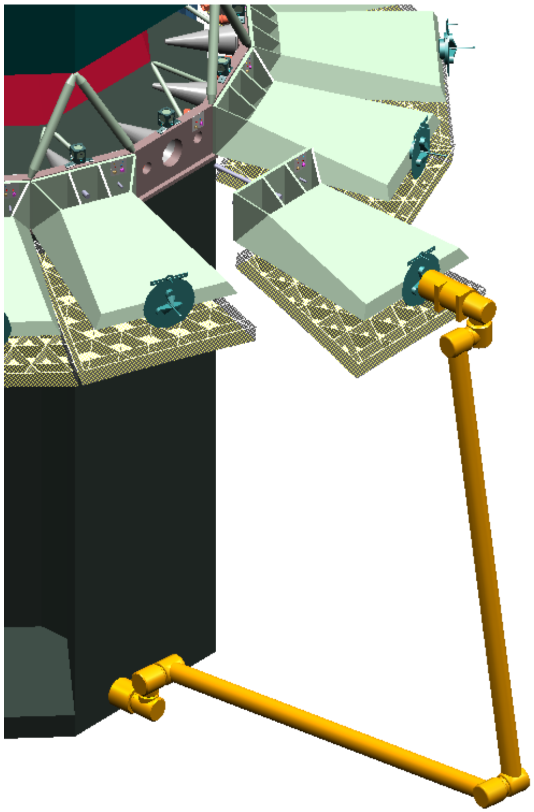
- Size & shape
- Total number
- Materials
- Manufacturing flow
- Test approach
- Facilities
- Schedule
- Cost



- Control authority
- Sensors
- Actuators
- Structures
- Complexity, reliability

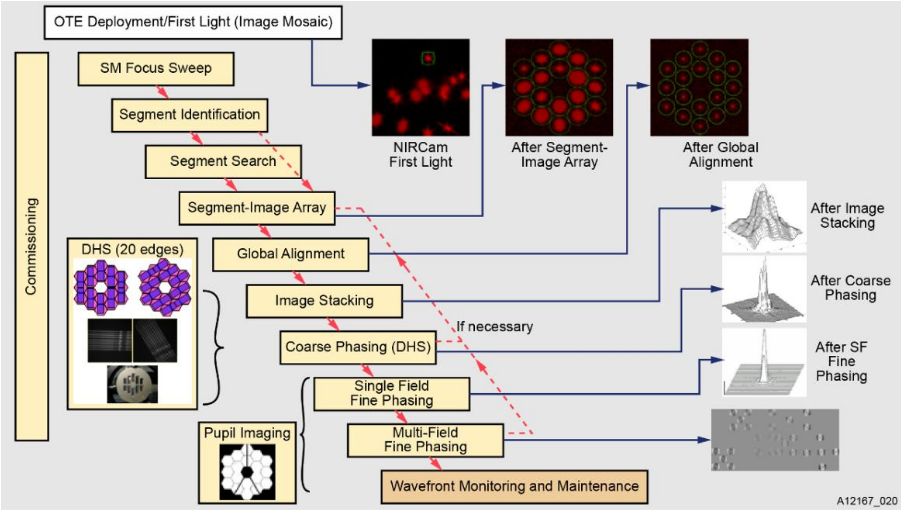
In-space assembly may have advantages for a large system

- Geometry that provides the most efficient packaging for launch is independent of arrangement of components in the assembled telescope
- Service module that provides launch accommodation does not need to be a precise optical bench. It is a rack for storage & transportation
- Structures and mechanisms that provide precise optical alignments in space do not have to bear launch loads
- Requirements for deployment of components are allocated to robotic arms instead of distributed to multiple subsystems with hinges, actuators, sensors, latches, etc.



Wavefront Sensing and Control enables precise image quality

JWST sequence



- Angular resolution of large diameter telescope
- Stability for coronagraph
- Symmetry for gravitational lensing
- Uniformity of PSF over FOV

- System architecture
- WF Sensing instrumentation
- Signal processing algorithms
- Actuators
- Range and resolution
- Update frequency
- Real time & autonomous ?
- Interaction with thermal, pointing etc.

Fine guidance and jitter control prevents smearing of the images

- For D=20m and λ=500nm, λ/D=5mas
- Drift & Jitter must be a small fraction of this

- Separate Fine Guidance Sensors, HST, JWST
- Or Guide signal on science focal plane, Kepler

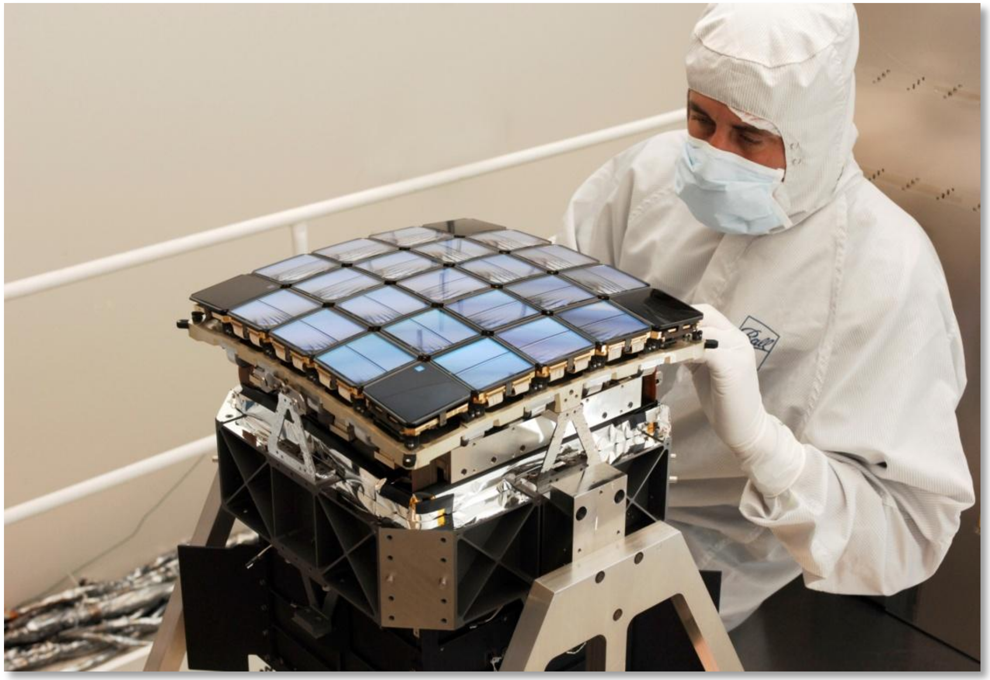
- Body-point entire observatory
- Or use a Fine Steering Mirror

- Interactions with structural, thermal, pointing and WFC subsystems

Large Focal Plane Arrays will be needed for resolution and FOV

- If 5 mas pixels
- 1 Gpx = 32K x 32K
- 158 arc sec FOV

- Detector technologies
- Modules
- FPA architecture
- Alignment
- Electronics, Cables
- Mass, Volume, Power
- Thermal
- Data rate and volume
- Serviceability, replacement



The Kepler Focal Plane Array
42 1K x 2K CCDs in 21 modules
4 CCDs for fine guidance
Curved Schmidt focal surface

A few other things

- **Science instruments and components**
  - — **Starlight suppression**
  - — **Integral Field and Multi-object spectroscopy**

- **Management and transmission of high data volumes**
  - — **Lasercom will be of interest to many future applications**
  - — **Avoid limitations faced by HiRISE, Kepler etc.**

- **Formation flying to enable consideration of an external starshade**

There are good reasons to consider in-space servicing

- **Replacement of limited-lifetime items**
- **Replenishment of expendables**
- **Restoration of degraded or failed components**
- **Infusion of advanced technologies**
- **New generations of instruments, capabilities**
- **Extension of mission lifetime**

DARPA's Orbital Express mission demonstrated proximity operations, autonomous rendezvous & soft capture, removal and installation of ORUs, fluid transfer.

These capabilities have wider applicability

- Other users of large aperture visible light imaging could participate in technology development
  - Earth Science & Solar System science
  - Defense & intelligence applications
- Robotic assembly and servicing
  - Applicable to many large systems, not just telescopes
  - Could assist or be supervised by astronauts
- Modularity allows partnerships with many stakeholders, including other nations

Summary

- A flagship-class UV-optical observatory will be scientifically compelling
- Interesting size will require modularity, segmentation, deployment, assembly etc.
- JWST has faced many of the issues, but UV optical requirements will be more challenging
- Technologies will be applicable to systems and missions beyond astrophysics
- This roadmap can identify a flow of development
- ROSES SAT is a mechanism for funding and managing technology development
- Challenging missions will have a coolness factor that will motivate public interest and support