A UV-optimized Hubble-class Observatory
Astrophysics, Planetary Science

Overview:

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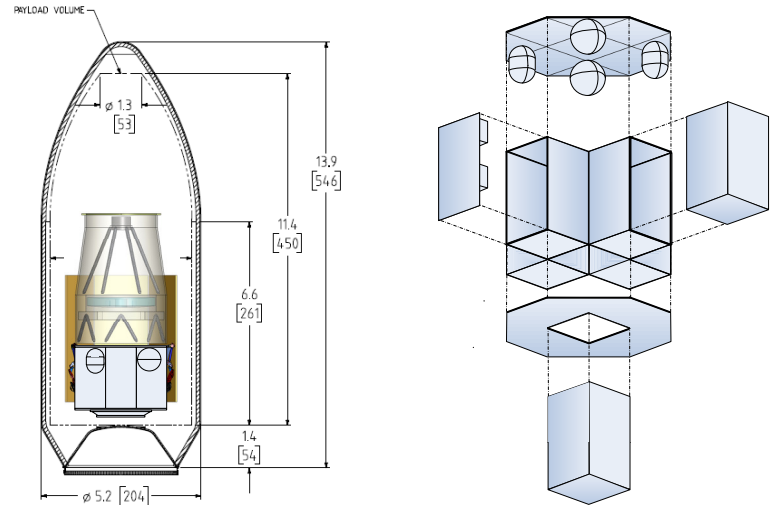
Goals of the Proposed Concept

Take advantage of advances in reflective coatings, diffraction gratings and detectors to enable imaging and spectroscopy of astrophysical and solar system targets with greater discovery power than HST, especially at ultraviolet wavelengths where large improvements are possible.

Provide opportunities for multiple generations of PI developed instrumentation and science investigations, enabled by robotic servicing..

Graphic:

An observatory with several science instruments that are accessible by robotic in-orbit servicing can be launched by a Falcon 9 with a 5m fairing.



Description:

Briefly describe the concept, implementation and operations approach.
UV optimized telescope with fresh, modern optical coatings, possible ion-polishing, compatible with visible wavelengths, multiple specialized instruments using modern components and detectors, PI-led developments, LEO, room temperature, serviceable, pointed observations, GO and community survey projects, archive.

What observations/tests will be carried out?
Imaging and spectroscopy of astrophysical and solar system objects, including quasar emission lines, IGM absorption line systems, exoplanet emissions, solar wind interactions with outer planets and moons

Identify and describe the readiness level of key technologies.
APRA technology investigations are under way for enhanced UV coatings, higher QE FUV photocathodes and NUV CCDs, lower noise and higher dynamic range FUV detectors . Laboratory and sounding rocket experiments will establish appropriate TRL.

External collaboration opportunities and dependencies: International collaboration on science instruments, launch vehicle and operations are possible, but not mandatory. Scientific and operational synergies with HST, JWST, WFIRST and others.

Human exploration capabilities: Modular design enables servicing for repairs and instrument upgrades using robotic, tele-robotic or human agents.

Value to NASA:

What are the benefits of the proposed concept?
Ensures access to critical UV wavelengths post-HST. Achieves large increase in sensitivity over HST, Explorer and sounding rocket payloads. Provides capabilities in visible not addressed by JWST or WFIRST. Appeals to large professional and public communities. Uses mature HST/JWST infrastructure for planning, operations, data management, EPO.

How does this concept advance Agency objectives across science, technology and human exploration?
Applications to Cosmic Origins, Physics of the Cosmos and Exoplanet Exploration. Technologies for advanced normal incidence optics, detectors and supporting technologies. Opportunities for engagement of robotic and human capabilities for maintenance and upgrades, via HST-like servicing.

Concept name: A UV-optimized Hubble class observatory

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Qualification Statement: Dr. Ebbets has 32 years of experience in space astronomy, including 27 years at Ball Aerospace. He has served as a calibration scientist, systems engineer and member of the Investigation Definition Teams for three science instruments for NASA's Hubble Space Telescope. He was Ball's Project Scientist for NGST/JWST mission concept studies, the successful proposal with TRW, and was their representative to the JWST Science Working Group. Dennis has been the Business Development Manager for astrophysics since 2005, and was the study manager for Origins Probes, Visions Missions and Astrophysics Strategic Mission Concept Studies. Ebbets leads RFI responses, and develops concepts and teams for proposals for ROSES, Explorers, SOFIA and other opportunities. He advises and influences Ball's Internal Research and Development projects having relevance to future astrophysics missions.

Concept summary:

NASA can use the available optical system to create an HST-class multipurpose observatory to advance its scientific goals in Astrophysics and Planetary Science. The implementation will create essential and beneficial relationships with NASA's technology development and human spaceflight communities. The performance of the telescope and instruments should be optimized for ultraviolet and visible light that will complement the capabilities that will be provided by JWST and WFIRST at longer wavelengths. This is an opportunity to apply modern technologies for UV reflective optical coatings, diffraction gratings and detectors that have been developed with NASA-funded APRA investigations. These technologies will require additional TRL enhancement through the SAT and suborbital programs prior to their use in the observatory described here. The combination of advances regarding the telescope and instruments can be expected to achieve factors of 10 – 50 increase in the discovery power (characterized by larger effective area and lower background equivalent flux for high-resolution spectroscopy at the wavelengths of important UV diagnostic lines) over current HST instruments. This powerful and versatile observatory will serve large community and will produce a valuable archive.

Components used:

NASA has possession of three subsystems; the Telescope Subsystem (TSS), the Outer Barrel Assembly (OBA) and the Payload Radiator Subsystem (PLRSS). The TSS can be used with relatively minor refurbishments. The primary and secondary mirror coatings will be chemically removed and a modern coating with higher UV reflectivity will be applied to each. Modern ion polishing techniques may be used to provide a surface quality appropriate for UV wavelengths. Sensors, actuators and electronics will be designed and built for control of the secondary mirror. Interfaces for new science instruments will be incorporated into the Aft Metering Structure. Since a UV-optical telescope operates at room temperature, the OBA may be used "as is". Some forward extension may be added as a stray light baffle for astronomical observations. The PLRSS will be studied for instrument accommodation, but a new structure and thermal control subsystem probably will be needed to meet the requirements and configurations of the payload. The available ground support equipment will be taken advantage of to the greatest extent possible. Instrument specific test and calibration equipment will be developed to support I&T.

Configuration and operation of the resulting system:

The observatory will resemble the Hubble Space Telescope in both physical and programmatic ways, a familiarity that will reduce risk. Science instruments will be selected by an AO process using PI-led development teams. A Low Earth Orbit, possibly a polar, sun-synchronous (similar to WISE) can be reached with an affordable commercial launch vehicle such as Falcon 9, whose 5m fairing provides adequate volume. LEO is compatible with the thermal design of the telescope, allows efficient communications and operations, and enables servicing, using autonomous or tele-robotic agents or human astronauts. The new observatory can make extensive use of the infrastructure for science and mission operations that exist for HST, JWST and WFIRST. There will be fertile opportunities for international participation via instruments, operations, launch services and scientific research.

Scientific, technical or operational benefits:

Pursuing this concept will fulfill NASA's intention to study a UV-optical mission as expressed in the December, 2012 Astrophysics Division Implementation plan. The New Worlds New Horizons Decadal Survey recommended technology development and concept studies leading to a future mission to provide observatory class capabilities for science investigations and instrumentation that have been demonstrated on sounding rockets and Explorers.

This observatory will enable scientific investigations in both astrophysics and planetary science:

- UV spectroscopy of the IGM, CGM, ISM, QSO and AGN environments (astrophysics)
- UV spectroscopy of exoplanet atmospheres, host stars of potentially habitable exoplanets, protoplanetary disks (astrophysics)

- Spectroscopic mapping of redshift distribution of quasars between $0.5 < z < 2$ as a probe of Baryon Acoustic Oscillations (astrophysics)
- UV imaging of aurorae and magnetospheres of Jupiter and Saturn (planetary science)
- UV imaging of Earth's magnetosphere/solar wind interaction above the stratopause (heliophysics)
- Coronagraphy for high contrast imaging of exoplanet systems and astrophysical targets (astrophysics)
- Wide FOV visible imaging for surveys of KBO and Oort Cloud populations (planetary science)
- High spatial resolution NUV & visible imaging – ACS Hi Res channel for astrophysics and planetary science

Designing the observatory to be a cooperative target for robotic servicing involves modularity that increases procurement flexibility, eases I&T, engages NASA's space operations and servicing community, and fosters new technology for interfaces, tools, etc.

Primary concept goal category: Astrophysics