

**UV/Visible Telescope
with Hubble Disposal**
Category: Astrophysics

POC: Dominic Benford, NASA / Cosmic Origins Program Office
Dominic.Benford@nasa.gov 301.286.8771
Benford is the Chief Scientist for the COR Program Office.

1.0 Submission Overview

Our primary objective is to convey a sense of the significant advances possible in astrophysics investigations for major Cosmic Origins (COR) program goals with a 2.4m telescope asset outfitted with one or more advanced UV/visible instruments. Several compelling science objectives were identified based on community meetings; these science objectives drove the conceptual design of instruments studied by the COR Program Office during July-September 2012. This RFI submission encapsulates the results of that study, and suggests that a more detailed look into the instrument suite should be conducted to prove viability and affordability to support the demonstrated scientific value. This study was conducted in the context of a larger effort to consider the options available for a mission to dispose safely of Hubble; hence, the overall architecture considered for the mission we studied for the 2.4m telescope asset included resource sharing. This mitigates combined cost and risk and provides naturally for a continued US leadership role in astrophysics with an advanced, general-purpose UV/visible space telescope.

This submission's objectives:

- Illustrate potential great advances in capability
- Describe compelling science objectives
- Propose an instrument suite for study
- Demonstrate compatibility with larger context

Several compelling science objectives were identified based on community meetings; these science objectives drove the conceptual design of instruments studied by the COR Program Office during July-September 2012. This RFI submission encapsulates the results of that study, and suggests that a more detailed look into the instrument suite should be conducted to prove viability and affordability to support the demonstrated scientific value. This study was conducted in the context of a larger effort to consider the options available for a mission to dispose safely of Hubble; hence, the overall architecture considered for the mission we studied for the 2.4m telescope asset included resource sharing. This mitigates combined cost and risk and provides naturally for a continued US leadership role in astrophysics with an advanced, general-purpose UV/visible space telescope.

2.0 Astrophysics Enabled by a UV/Visible Instrument Suite

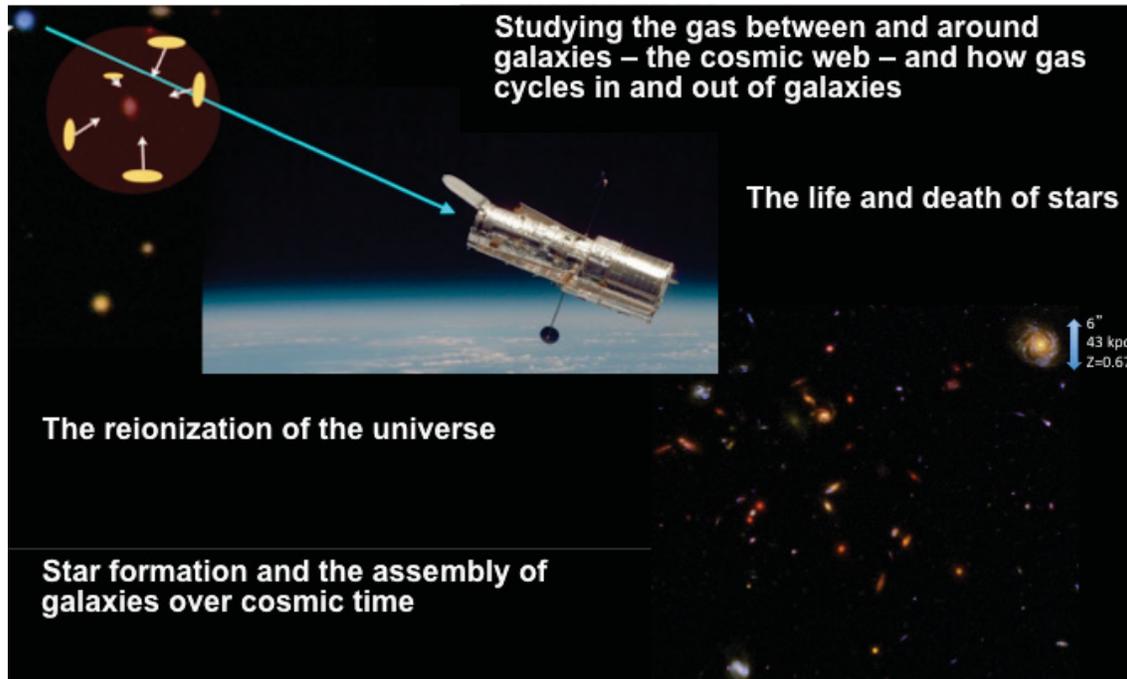
2.1 LYMAN-ULTRAVIOLET SPECTROSCOPY

The Hubble Space Telescope (HST) is the world's leading facility for UV spectroscopy, currently with the COS instrument. At Lyman-UV (900-1200Å) wavelengths, its sensitivity is compromised by the inefficiency of its Al/MgF2 coating. One possible implementation of a 2.4m telescope asset for UV/visible astrophysics would aim at optimizing the system for Lyman-UV spectroscopy with an improved reflective coating. Our design study concluded that the effective area of such a telescope could exceed 11 times HST's, thereby enabling new science on fainter and more distant objects than is currently feasible. The spectrometer would operate at the Cassegrain focus to minimize reflective losses.

A rationale supporting this instrument can be found in the 2010 Decadal Survey: "The imperative of understanding the history of the 'missing baryons,' as well as the evolution of stars and galaxies, requires ultraviolet (UV) spectroscopic observations that are more sensitive, and at shorter wavelengths, than are possible with the new COS on HST." Physically, the Lyman-UV lines trace physical properties that can probe young, hot stars; measure the star formation rate in galaxies; quantify stellar age and metallicity; and map out the intergalactic gas that feeds galaxy growth.

2.2 WIDE-FIELD IMAGING FOR SURVEYS

Again, HST provides the standard for comparison in wide-field UV and visible imaging from space. The 2.4m telescope asset provides a similar diameter and hence angular resolution to HST, but with the potential for a greatly increased field of view when using its three-mirror anastigmatic (TMA) design. A camera using large format mosaics (32K×32K, as compared to 4K×4K in WFC3) and with a slightly coarser pixel scale of 0.1" would provide a field of view of



A Hubble-class telescope equipped with highly capable instruments in the UV/visible would address a wide range of science questions. Of the 20 questions posed by the Decadal Survey Science Frontiers Panels, nine of them indicate a “strong impact” from the suggested UV/visible telescope, and a further three more have some impact.

20'×54', 150 times greater than HST's. With this, new surveys of unprecedented depth and sensitivity will be possible.

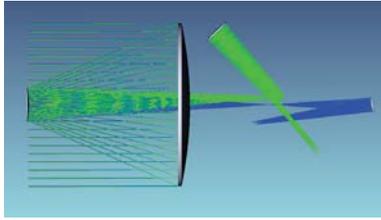
That an instrument such as this would serve to support major science goals was noted by the Decadal Survey: “Key advances could be made with a telescope no larger than Hubble but equipped with high-efficiency UV and optical cameras having greater areal coverage than Hubble's.” Very wide field imaging will provide a huge range of new capability, including broader surveys of star formation over significant areas and numbers of sources, but also enabling deeper surveys of galaxies with far greater statistics. Furthermore, such a capability provides the promise of a UV complement to the synoptic surveys envisioned for future ground-based facilities studying variable & transient sources.

2.3 MULTI-OBJECT UV/VISIBLE SPECTROSCOPY

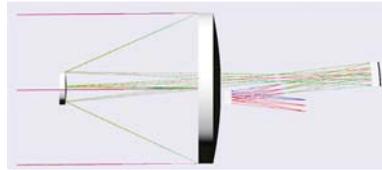
A bottleneck for detailed investigation of large numbers of sources to determine their physical, chemical, and kinematic aspects has been the slow improvement of highly capable multi-object spectrometers on space-based facilities. JWST will feature a multi-object spectrometer using an array of micro-shutters as a field selector. What it can achieve in the near-infrared can be implemented very well in the UV/visible on a 2.4m telescope. Whereas HST/STIS could provide near-UV spectroscopy at very high resolution on a single object, a multi-object spectrometer could provide a similar capability on hundreds to thousands of objects. For example, individual galaxies bright enough for spectroscopy have a density of more than 1 per arcmin², so the fiducial instrument we studied, with a field of view of 94 arcmin², would have 100 times the capability of COS. Such an instrument could survey even more sources at a time, for instance in a dense star cluster. At lower spatial densities, surveying UV absorption along multiple sightlines will reveal the reionization history of the universe, a major question that cannot be easily addressed with current capabilities.

3.0 Proposed UV/Visible Instrument Suite

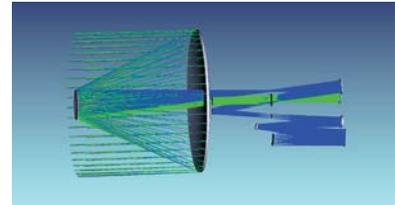
The proposed instrument suite for further study is best considered as a set of options with some intercompatibility. For the Lyman-UV spectroscopy, the telescope would require recoating with an advanced SiC coating to provide excellent throughput at 900Å. A small-field, single-object spectrometer would then be the primary instrument, but this does not preclude – and in fact would likely benefit from – a context imager that could make use of the wider field of view. In this configuration, the mission would thus have both a Cassegrain and a TMA focus. Similarly, the multi-object spectroscopy would have as its primary instrument a spectrometer with a field of around 10'×10'; a significant amount of focal plane is still available in addition to this which could be used for a wide-field imager of roughly 20'×20' extent.



Lyman-UV Spectrometer



Wide-field UV/visible imager



Multi-object spectrograph

One advantage of operating this mission in a Hubble-like orbit is that such proximity should make serviceability a compelling option. In our study we included accommodation for hardware that would enable servicing to upgrade the instruments. For example, a minimal-cost mission might include only one of the proposed instruments, later replaced to offer new capability.

4.0 UV/Visible Telescope in the Larger Context

It is natural to consider any astrophysics use of the 2.4m telescope asset in the context of HST and its present capabilities. HST remains the most productive scientific instrument in NASA's panoply of achievements, and is likely to remain so for many years. The instrument suite we propose builds on this legacy and increases the potential capability provided to astronomers by orders of magnitude. This will allow continued and more advanced UV science investigations into the era beyond HST, with a rich capacity for new discoveries available to the broadest community.

As mentioned earlier, the study that led to this RFI submission was concerned with pairing the 2.4m telescope asset with the as-described instrument suite along with the mission to dispose of HST. This sharing of resources, including launch vehicle and perhaps spacecraft bus, are estimated to save between \$200M and \$300M from the cost of the UV/visible mission.

All technologies needed for the UV/visible mission are mature. Investments being made through SAT and other means that will advance the capabilities of detectors and optics can improve the performance and implementations beyond what we currently envision.

The Decadal Survey contains clear language endorsing the science and capability of the proposed UV/visible telescope. Specifically, the report calls out the imperative for UV spectroscopy for multiple science questions, using the words “very important”. It also recognizes imaging in that “Key advances could be made with a telescope no larger than Hubble but equipped with high-efficiency UV and optical cameras having greater areal coverage”. Of the 20 questions posed by the Decadal Survey's Science Frontiers Panels, nine of them indicate a “strong impact” from the suggested UV/visible telescope, while three more have some contribution. This substantial backing for a UV/visible telescope makes a powerful argument for considering it as one of the options for a purpose for the 2.4m telescope asset.

UV/Visible Telescope with Hubble Disposal Astrophysics

Overview:

POC: Dominic Benford, NASA / COR Program Office
Dominic.Benford@nasa.gov 301.286.8771

Key collaborators in concept development: Mooni Ahmed, Mark Brumfield, Gerry Daelemans, Bill Danchi, Gabe Karpati, Alexander Kutyrev, Dave Leisawitz, Rick Lyon, John MacKenty, Harvey Moseley, Susan Neff, Marc Postman, Dino Rossetti, Jason Tumlinson

Our primary objective is to convey a sense of the significant advances possible in astrophysics investigations for major Cosmic Origins program goals with a 2.4m telescope asset outfitted with one or more advanced UV/visible instruments. We conducted a brief mission concept study in the context of a larger effort of a mission concept to dispose safely of Hubble. The shared resources of a Hubble disposal mission with a UV/visible telescope offers a reduced-cost option for a highly capable observatory for astrophysics in the coming decade.

Description:

Our mission concept centers around a suite of advanced UV/visible instruments (cameras and spectrometers) to enable science capability one to two orders of magnitude greater than current Hubble. This suite is partially interchangeable and a subset would be installed initially.

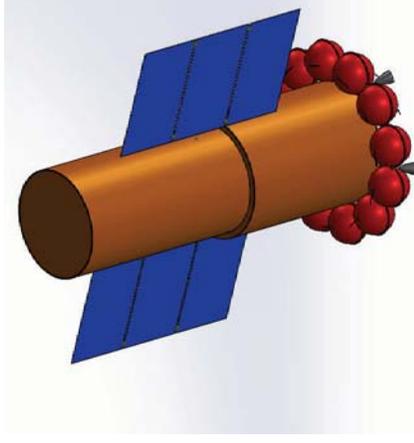
The driving science investigations of this capable facility included: finding baryonic matter in galaxy halos with UV spectroscopy; high resolution imaging with wide field of view for distant galaxies and star forming regions; the physics of galaxy evolution with UV spectroscopy; variable/transient source measurements with UV/visible spectrophotometry.

All technologies assumed (e.g., mirror recoating, UV detectors, multi-slit selector, operations, disposal, serviceability) have heritage from HST, FUSE, or JWST. No further technology is required.

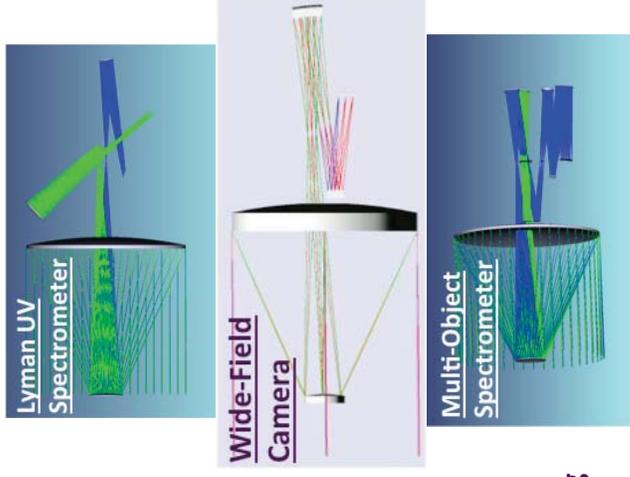
This concept was developed as an extension of a Hubble disposal mission, hence inherits its shared potential for cross-cutting collaboration, for instance solar electric propulsion or telerobotic operations.

In LEO, human serviceability is a natural consideration for such a major facility. We included accommodation for this in our concept development. The instrument complement can thus evolve with time.

Graphic:



Mission Sketch; 3m ϕ , 9m long



Value to NASA:

Our concept, to use the 2.4m telescope assets for a UV/visible telescope associate with the Hubble disposal mission, offers multiple benefits to NASA and astrophysics. Its synergy with Hubble disposal provides continuity of UV/visible access for astronomers, while reducing costs. The capability is 10x-100x Hubble for certain applications with an estimated Probe-scale price tag. Straightforward serviceability allows collaboration across NASA enterprises. The compelling science advances contribute to major science goals for the Cosmic Origins Program and address recommendations of the 2010 Decadal Survey.

The Decadal Survey endorses the science and capability of the proposed UV/visible telescope: UV spectroscopy is “very important”. It says “Key advances could be made with a telescope no larger than Hubble but equipped with high-efficiency UV and optical cameras having greater areal coverage”. Of the 20 questions posed by the Decadal Survey’s Science Frontiers Panels, nine of them indicate a “strong impact” from the suggested UV/visible telescope, while three more have some contribution.