

## Keep *Hubble* Alive with SM5

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*Hubble* is entering its 20<sup>th</sup> year of success, but conventional wisdom says it will shut down before the next Decadal Survey. Inescapably, Astro2010 will shape the *Hubble* endgame and render verdicts on aspects of the *Hubble* experience. That is, the committee must envision *some* sort of future for the many frontiers of science where *Hubble* defines the present state of research. So heavy is this responsibility with respect to the legacy of a transformative observatory, and to the continued progress of its community, that the process seems to call for novel perspectives—the long view, and some out-of-the-box thinking. I hope to contribute to these perspectives by invoking two less-well-known aspects of Lyman Spitzer’s historic vision for *Hubble*.

From its conception in a 1946 memorandum of the RAND Corporation,<sup>1</sup> Lyman Spitzer was the father of the *Hubble Space Telescope*. Later, he acted as midwife through the long years of selling *Hubble* to the community and to Congress. Afterwards, he worked tirelessly to make *Hubble* a reality, participating in its definition, design, and construction. After launch in 1990 and the devastating discovery of spherical aberration, Spitzer was a key player in formulating the optical correction, and seeing the solution installed by astronauts on the first servicing mission in 1993.<sup>2</sup>

### *Satellite servicing*

Spitzer was promoting telescope servicing as far back as a year after President Kennedy’s decision to send Americans to the Moon. “A substantial crew,” he wrote in 1962, “would be required to assemble the device, get it into operation, and possibly even to produce the final mirror figure. Remote operation might be advantageous most of the time, but maintenance visits at least yearly would be required, since it would be expected that such a powerful and costly tool would be kept in operation for many decades.”<sup>3</sup>

*Hubble* has proven the benefits of telescope servicing in a most spectacular manner. Spherical aberration could not have been fixed if the telescope had not been designed for servicing. Since the first repair mission, *Hubble* has been serviced three additional times (up to now—April 2009). Many failed or aging parts have been replaced, and new

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<sup>1</sup> Spitzer, L. 1990, “Astronomical Advantages of an Extra-terrestrial Observatory,” *Astronomy Quarterly*, 131–142. (Reprint with commentary of the RAND 1946 Memorandum.)

<sup>2</sup> Spitzer was a member of the *HST* Strategy Panel. See Brown, R. A., and Ford, H. C. 1990, “A Strategy for Recovery, Report of the HST Strategy Panel,” (STScI: Baltimore). [http://ftp.stsci.edu/pub/ExInEd/electronic\\_reports\\_folder/recovery.pdf](http://ftp.stsci.edu/pub/ExInEd/electronic_reports_folder/recovery.pdf)

<sup>3</sup> Spitzer, L. 1962, “The Beginnings and Future of Space Astronomy,” *American Scientist*, 50, 473–483. <http://66.93.118.195/sco/NRCWhitePaper/Spitzer1962.pdf>

instruments with advanced performance have been installed. Astronomers have used *Hubble's* added life and improved capabilities to harvest a cornucopia of discoveries. In May 2009, SM4 astronauts will visit *Hubble* again to make repairs and install a new spectrograph and a new camera. They will leave *Hubble* more powerful than ever before.

When we think about the future of telescope servicing, it is useful to recall that, just a few years ago, NASA seriously considered a totally robotic implementation of SM4. Furthermore, NASA's Constellation system is expected to provide powerful options for telescope servicing by a mix of robot and human capabilities.<sup>4</sup>

### *Extrasolar planets*

The second less-familiar aspect of Lyman Spitzer's early vision for *Hubble* was his interest in direct detection of extrasolar planets. In the same 1962 paper, he wrote:

One problem of particular interest that will be emphasized here, as an important part of the long-range program, is the detection of planets around other stars. This is a matter of very great philosophical and cultural as well as scientific interest. Our view of man and his place in the universe naturally depends very much on whether planetary systems like our own are exceptional or whether they occur very frequently throughout the Galaxy. In fact, in many ways, the question of how frequently stars are accompanied by planets capable of supporting life is fully as important as the over-all structure of the universe, i.e., whether space is flat or curved.

The detection of other planets, however, is an extraordinarily difficult problem. Not only are planets intrinsically very faint, they are necessarily very close to a star if they can be detected at all, and light from the central star, scattered or diffracted in the telescope system, inevitably tends to mask the very faint planetary light.

In 1997, the year Lyman Spitzer died, NASA reviewed a *Hubble* instrument proposal for a coronagraph with wavefront correction to directly detect extrasolar planets. NASA designated the proposal "selectable," although it was not selected, because of budget constraints. (The proposed cost was \$40M, less than a tenth the cost of a Probe-class mission today.)

A *Hubble* coronagraph with deformable mirrors for wavefront correction could directly image and spectroscopically characterize about one-third of the approximately 344 giant extrasolar planets known in 2009 from radial-velocity discoveries. None of them has yet been studied in reflected light. Counting the eight planets in the Solar System, this achievement would increase by two orders of magnitude the number of planets for which

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<sup>4</sup> Cepollina, F. et al. 2008, "Renewing the Partnership between Astronomy and the Human Space Flight Program: A National Strategy."  
[http://www.stsci.edu/~RAB/RenewingPartnershipFINAL\\_RAB.pdf](http://www.stsci.edu/~RAB/RenewingPartnershipFINAL_RAB.pdf)

the true mass, equilibrium temperature, reflectivity, rotation rate, and atmospheric composition are known to science.

A *Hubble* coronagraph with wavefront correction could also conduct a census of exozodiacal dust systems around nearby stars; determine the dynamical architectures of multiple-planet systems by measuring the relative orbital inclinations; study quasar feeding zones; investigate a variety of circumstellar phenomena, such as around young stellar objects or protoplanetary nebulae; and advance the coronagraphic technology needed for tackling terrestrial planets.

Compared with a Probe-class coronagraphic mission with an off-axis telescope, a *Hubble* coronagraph would have some performance disadvantage due to diffraction by the central obscuration and spider. The larger aperture compensates somewhat.

The *Hubble* opportunity has the further advantage of being a working reality: an understood observatory, already in space, with available instrument slots on the focal plane of a superb, stable telescope, all on an operating spacecraft.

### *Keep It Alive*

Until its successor appears, *Hubble* will remain unrivaled in its performance domain. At wavelengths below 1 micron, it provides a steady diffraction-limited point spread function over a wide field of view. In the ultraviolet, it offers high sensitivity. Astronomers have used—and should continue to use—these capabilities to reveal the contents, phenomena, and workings of the universe to the limits of a 2.4 meter aperture.

Why would we turn it off?

*I urge Astro2010 to consider recommending additional servicing of Hubble, including new, competitively selected instruments.*

*I urge Astro2010 to recommend servicing—or at least compatibility with servicing—as a strategic option for the space telescopes of the future.*