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Space Telescopes

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Space telescopes have been a dominant force in astrophysics and astronomy over the last two decades. As Lyman Spitzer predicted in 1946,[1] space telescopes have opened up much of the electromagnetic spectrum to astronomers, and provided the opportunity to exploit the optical performance of telescopes uncompromised by the turbulent atmosphere.

The Hubble Space Telescope (HST) has come to symbolize the great space telescopes of the last two decades. Launched with a spherical aberration problem, astronauts restored HST's promise of diffraction-limited imaging from space. Since that first servicing mission, HST has made major breakthroughs in many fields of astrophysics, extending far beyond the original scientific goals of the telescope and achieving iconic status as its images became part of the fabric of popular culture.

Surpassing their initial science goals is a common theme for many space telescopes, which have opened up new areas of the electromagnetic spectrum and delivered significant new capabilities such as orders of magnitude improvement in sensitivity. These space telescopes have consistently delivered above and beyond their original scientific goals. Excellent examples include the study of the high redshift universe by the HST, the characterization of exoplanet atmospheres by the Spitzer Space Telescope (SST), and the study of black holes by the Chandra X-Ray Observatory.

The newest space telescopes have continued to open up new spectral windows. The Herschel Space Observatory for the first time provided visibility into the far-infrared to submillimeter wavelengths from space. The Fermi Gamma-Ray Space Telescope discussed in this special section has opened up the 30 MeV to 10 GeV sky with capabilities that permit a wide range of observations of astrophysical phenomena. In addition to observatories conducting detailed studies of astrophysical phenomena, space telescopes for survey applications continue to make ground-breaking observations as well. The Kepler mission just recently announced the ground-breaking discovery of Kepler-22b, the first earth mass planet found in the habitable zone of a solar-like star.

The impact of these space telescopes is not limited to their science goals. Space telescopes push the envelope in many technical areas, but especially optical systems and sensors. The early decision to fly HST with charge-coupled-device (CCD) detectors, rather than the established TV camera technology, spawned much of the early development of CCDs. HST, SST, and James Webb Space Telescope (JWST) have similarly driven the development of infrared arrays to ever larger formats and higher performance. In the realm of large optics, space telescopes have driven not only optical performance, but also wavefront sensing and control technologies.

This special section of *Optical Engineering* is devoted to space telescopes. It focuses on the design and implementation of major space observatories from the gamma-ray to far-infrared, and highlights the scientific and technical breakthroughs enabled by these telescopes. The papers accepted for publication include reviews of major space telescopes spanning the last two decades, in-depth discussions of the design considerations for visible and x-ray telescopes, and papers discussing concepts and technical challenges for future space telescopes.

Reference

1. L. Spitzer, Jr., "Report to project RAND: Astronomical advantages of an extraterrestrial observatory," (1946) reprinted in *NASA SP-2001-4407: Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Vol. V: Exploring the Cosmos*, Chapter 3, Document III-1, p. 546 (2001). http://history.nasa.gov/SP-4407/vol5/ExploreUnknown.pdf

Mark Clampin is currently the James Webb Space Telescope Observatory project scientist at Goddard Space Flight Center. He was a coinvestigator on the Advanced Camera for Surveys (ACS) science where he served as the ACS detector scientist with responsibility for the ACS flight focal planes. Previously, he was a scientist at STScI, where he gained ten years of experience with HST servicing missions, instrument commissioning, and science operations at STScI. He served as manager of the ACS instrument group at STScI from inception through the successful completion of SM3B servicing mission orbital verification for ACS. In this capacity he managed development of the ACS ground system, including its data processing pipeline, observer support, and instrument-calibration planning. He is the principal investigator of the Exosolar Planetary Imaging Coronagraph (EPIC), a technology demonstration for exoplanet missions. He is a member of the team that discovered the exoplanet Fomalhaut-B using the Advanced Camera for Surveys on the Hubble Space Telescope. In 2008 he served as symposium cochair for the SPIE Astronomical Telescopes and Instrumentation meeting held in Marseille, France.

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Kathryn Flanagan is a senior scientist at the Space Telescope Science Institute, where she is head of the mission office for the James Webb Space Telescope (JWST). She is responsible for the development and operations of the Science and Operations Center for this NASA mission. She earned her bachelor's degree and PhD in physics at MIT, where she began working in the field of x-ray astronomy, with a special interest in supernova remnants and the development of new instruments for space. She became part of the science research staff at the Harvard-Smithsonian Center for Astrophysics and MIT, and has worked on flight instruments for the Einstein Observatory, the Chandra X-ray Observatory, and future missions such as the International X-ray Observatory. She has been active in education, first as a Peace Corps volunteer teaching math and physics in the Democratic Republic of the Congo, and later as Director for Education and Public Outreach for MIT's Kavli Institute for Astrophysics and Space Research. She has participated in NASA's advisory structure, cochairing strategic planning documents, and serving on the Astrophysics Subcommittee. She joined the Space Telescope Science Institute in 2007 to lead the JWST mission office.

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