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ASTRONOMERS ENVISION A 'HIGH-DEFINITION *HUBBLE*' TO LOOK FOR LIFE BEYOND EARTH

Over the past two decades, NASA's *Hubble Space Telescope* and other powerful observatories have collectively made extraordinary breakthroughs in our understanding of the universe: from black holes, to dark energy, to extrasolar planets, and cosmic evolution.

Despite these breathtaking advances, humanity's most compelling questions remain unanswered: Are we alone in the universe? Or, are other inhabited Earth-like worlds common in our galaxy? What's more, how did life emerge from a chaotic cosmic beginning?

A new study issued today by the Association of Universities for Research in Astronomy (AURA), based in Washington, D.C., describes a visionary, innovative, and revolutionary path forward to answering these and other timeless questions that are considered game-changers in our understanding of our place in the cosmos.

"When we imagine the landscape of astronomy in the decade of 2030, we realize it is at last within our grasp to make a monumental discovery that will change mankind forever. We hope to learn whether or not we are alone in the universe," said AURA President Matt Mountain.

AURA spearheaded the study of space-based options for ultraviolet (UV) and optical astronomy in the era following the *James Webb Space Telescope*'s mission (planned for launch in 2018). AURA brought together a team of research scientists, astronomers, and technologists to assess a future space observatory that can significantly advance our understanding of the origin and evolution of the cosmos and whether extraterrestrial life is an integral part of cosmic history.

The AURA report describes the scientific and technological case for building a "super-*Hubble*" space telescope that would view the universe with five times greater sharpness than *Hubble* can achieve, and as much as 100 times more sensitivity than Hubble to extraordinarily faint starlight.

These powerful capabilities would allow the observatory, called the *High-Definition Space Telescope (HDST)*, to look for signs of life on an estimated several dozen Earth-like planets in our stellar neighborhood. It could provide the first observational evidence for life beyond Earth.

The scientific research enabled by the *Hubble Space Telescope* has had a profound and revolutionizing impact on most areas of astronomy over the past 25 years.

Similarly, as a general-user space observatory, the *HSDT* would engage the world's best and brightest scientists to make transformational advances in astronomy across a wide swath of research areas, from the solar system, to stellar evolution, to the farthest observable horizon of the universe. No doubt, unexpected and profound discoveries are in store, as happened with *Hubble*.

Though the report does not address a specific design for the *HDST*, its mirror would have to be at least 12 meters (39 feet) across to conduct a robust survey of nearby habitable planets. This would be accomplished by combining up to 54 mirror segments together to form a giant aperture. The construction of the *Webb telescope*'s 18-mirror mosaic provides an important engineering pathway to demonstrating proof-of-concept for this type of space observatory architecture.

The *HDST* would be located at the Sun-Earth Lagrange 2 point, a gravitationally stable "parking lot" in space located 1 million miles from Earth. The telescope would have a suite of instruments: cameras, spectrographs, and a coronagraph for blocking out a star's blinding glare so that any dim, accompanying planets can be directly imaged. The construction would be modular so that astronauts or robots could swap out instruments and other subsystems. As with *Hubble*, this would ensure an operational lifetime spanning decades.

The motive for the *HDST* is driven in part by the discoveries of NASA's prolific planet hunter, the *Kepler* space observatory. *Kepler*'s discovery of over 1,000 confirmed exoplanets provides a statistical database that predict Earth-like worlds should be common in our galaxy, and hence nearby to us and within observational reach of the *HDST*.

A 12-meter-diameter space telescope outfitted with a coronagraph could look for planets around an estimated 600 stars within 100 light-years of Earth. The *Kepler* statistics predict that 10 percent of nearby stars would host Earth-sized planets within the habitable zones of their stars, where temperatures are optimum for life, as we know it.

The *HDST* would spectroscopically characterize the atmospheres of these planets. The abundance of water vapor, oxygen, methane, and other organic compounds in the atmosphere could be evidence of an active biosphere on the surface of a planet.

Looking far beyond our local stellar neighborhood, the *HDST* would search for the origins of the chemistry of life in an evolving universe. The super-telescope's UV sensitivity would be used to map the distribution of hot gases far outside the perimeter of galaxies. This would show the structure of the so-called "cosmic web" that galaxies are embedded inside, and how chemically enriched gases flow in and out of a galaxy to fuel star formation.

The *HDST*'s unexcelled sharpness at ultraviolet and optical wavelengths would allow astronomers to see the stellar and nebulous contents of galaxies billions of

light-years away with the same crispness that *Hubble* sees inside galaxies just tens of millions of light-years away. The *HDST* could pick out stars like our Sun located 30 million light-years away! A sharp view of visible contents of the entire universe would immediately become accessible to us via this super-*Hubble*'s "high-definition" vision.

Within our own solar system, *HDST* would provide images of weather and surfaces on the outer planets and their moons far beyond today's capabilities. *HDST* would also provide detailed data on the interaction of each of the outer planets with the solar wind and give planetary scientists the ability to search for remote, hidden members of our solar system ranging in size from dwarf planets to ice giants like Neptune.

Though such a telescope is envisioned for the 2030s, it is not too early to start planning the science needs and technological requirements. Planning for the *Hubble Space Telescope* began in the 1970s, two decades before its launch. In addition, concept studies for the *Webb* telescope began two decades ago.

The *HDST* is needed to complement the powerful capabilities of a new generation of ground-based telescopes. Planned for the early 2020s are behemoth visible-infrared observatories, such as the Thirty Meter Telescope, the 39-meter European Extremely Large Telescope, and a planned Giant Magellan Telescope. Already in operation is the Atacama Large Millimeter/submillimeter Array (ALMA) radio telescope in northern Chile.

The *HDST* would be able to study extremely faint objects that are 10 to 20 times dimmer than anything that could be seen from the ground with the planned large, ground-based telescopes. It could also observe ultraviolet wavelengths that are blocked by Earth's atmosphere. The large ground-based telescopes, in turn, would be as good or better than *HDST* for measuring the spectra of objects. The *HDST* would have comparable clarity at UV/optical wavelengths as the giant ground-based telescopes get in the near infrared and as ALMA gets at millimeter wavelengths. This would allow astronomers to obtain incredibly clear views of the cosmos over a very broad electromagnetic spectral range.

"The monumental endeavor of building the *HDST* is going to take a continuing partnership between NASA, science, technology, and U.S. and international space missions to build the next bridge to humanity's future," Mountain said.

AURA is a consortium of 40 U.S. institutions and four international affiliates that operates world-class astronomical observatories. AURA's role is to establish, nurture, and promote public observatories and facilities that advance innovative astronomical research. In addition, AURA is deeply committed to public and educational outreach, and to diversity throughout the astronomical and scientific workforce.

AURA carries out its role through its astronomical facilities, which include many ground-based telescopes as well as the Space Telescope Science Institute in Baltimore, Maryland (STScI). STScI conducts the science mission for NASA's Hubble Space Telescope, will conduct the science mission for the upcoming James Webb Space Telescope and the proposed *Wide-Field Infrared Space Telescope*. STScI also houses the Mikulski Archive for Space Telescopes (MAST), a NASA-funded project to support the astronomical community with a variety of astronomical data archives.

Access the full report and graphics at:
http://www.hdstvision.org

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