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The Hubble Space Telescope Is Still Awesome

Hubble is going strong despite its decades in space and next-generation successors **BY PHIL PLAIT**

ON APRIL 24, 1990, HUMANITY LAUNCHED a scientific revolution.

I mean “launched” literally: on that date the space shuttle *Discovery* roared into the sky with the Hubble Space Telescope nestled in its cargo bay. The telescope was on a mission destined to forever change our view of the universe.

Hubble wasn’t the largest telescope ever—its 2.4-meter mirror is actually considered small these days—but being above the atmosphere gave it superpowers. Our air boils and roils, blurring the views from ground-based instruments. It glows, too—dimly but enough to limit how faint an object astronomers can see. And our air absorbs most ultraviolet and infrared light—interesting wavelengths, cosmically speaking. Getting up, up and away from all that atmosphere

Phil Plait is a professional astronomer and science communicator in Virginia. He writes the *Bad Astronomy Newsletter*. Follow him on Beehiv.

The Hubble Space Telescope was deployed by the space shuttle *Discovery* on April 25, 1990.

made Hubble one of the most important telescopes ever built.

It revolutionized astronomy. Hubble saw objects fainter than had ever been observed before. The telescope homed in on the speed of universe expansion, watched weather changes on the outer planets and proved that every big galaxy has a supermassive black hole at its heart, just to name three amazing feats off the top of my head. The major breakthroughs and discoveries that came out of this magnificent satellite are so numerous, really, that even listing them here would be excessive (and a bit tedious, if incredible astronomical exploration could ever be tedious).

Yet despite these successes, I see a lot of chatter online (and even in the news) somewhat cavalierly dismissing Hubble, saying NASA’s James Webb Space Telescope (JWST) is Hubble’s “replacement.” That’s not just unfair; it’s wrong. JWST was never intended to supplant

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the Hubble telescope, and in fact it can't, given that it was designed for very different observations.

Hubble is optimized to observe the universe in visible light, the kind of light we see with our eyes. It can also detect some wavelengths in the ultraviolet and infrared ranges, but Hubble can't see most of those parts of the spectrum. JWST detects infrared light at much longer wavelengths, where different astrophysical processes dominate.

JWST is a much larger telescope, true. It has a 6.5-meter-wide mirror, so it collects about seven times as much light as Hubble. In general, a bigger mirror also means higher resolution, or a better ability to see fine details. Yet that also depends on the wavelength observed, and in fact, at their respective best, Hubble beats out JWST by a smidgen. But that's not really the point; both are exceptional telescopes that are at the forefront of the types of observations each can do.

Understanding Hubble's power in visible light serves to underscore one key field where JWST's infrared vision exceeds it: glimpsing the universe's first galaxies.

Hubble's deepest observations showed that there was an unexpected richness of galaxies in the distant universe, but the telescope has a limit. The more distant a galaxy is, the more redshifted its light becomes as cosmic expansion sweeps the galaxy farther away from us. At some point the bulk of the galaxy's light is emitted in infrared, where Hubble cannot see it—but where JWST is able to see keenly. That is why the newer observatory has been so prolific in breaking distance records and giving us unprecedented views into the early universe.

There is an irony here. The idea for a space telescope was first proposed by astronomer Lyman Spitzer in 1946, and in the 1960s astronomer Nancy Grace Roman began advocating for NASA to build one—she later became known as the “mother of Hubble,” and a space telescope planned for launch

this year is named after her. Delays and budget overruns plagued the Hubble project, however, and in the end it wound up costing more than \$10 billion and launching much later than originally planned. The same thing happened with JWST; initially proposed to cost less than \$1 billion and launch by 2004, its final cost was also about \$10 billion, and it didn't go up until 2021. In this way, both telescopes have a similar history.

From a different point of view, though, their history is extremely different. Hubble launched with a flawed mirror, one just a micron or two too flat at the edges—far less than the thickness of a human hair but more than enough to ruinously blur the telescope's vision. I remember those fuzzy years well: during my Ph.D. research, I spent quite a bit of time working with software that mathematically corrected some of Hubble's out-of-focus images. Thankfully this problem was bypassed with the launch of corrective optics in 1993, and later instruments had built-in corrections to make sure observations were focused.

Few people today seem to even know about that difficult time (there were congressional hearings looking into NASA's mistake!), and many now focus

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only on Hubble's success. And that's fine, I suppose, as long as the lessons learned prevent similar screwups in subsequent space telescopes.

In JWST's case, they mostly did. That \$10-billion figure I gave is only half right; when the costs of that telescope are compared with Hubble's in inflation-adjusted dollars (especially if you factor in the costs of Hubble's servicing missions by space shuttle, which you should), the much larger JWST is

actually cheaper despite its delays and technical woes. And of course, all that money bought a telescope that performed nearly flawlessly from the start, even after a seemingly impossible Rube Goldberg–esque series of steps to get it operational in space.

JWST's primary mission was planned to go on for more than five years, a time point it will reach in 2027, but its expected lifetime is at least 20 years thanks to careful management of its onboard supply of fuel. Note that Hubble's primary mission was meant to last only 15 to 20 years, and it's now in its 36th year in space. It's made more than 1.7 million observations since launch, too.

So Hubble is hardly obsolete. In terms of cameras, instruments and even its solar panels, it's much better now than when it launched. Admittedly, its aging gyroscopes, necessary to keep the observatory pointed accurately, have had numerous mission-plaguing failures. But engineers on the ground have found ways to squeeze every last drop of efficiency from Hubble's sole operating gyro.

NASA has a habit of making its missions last much longer than their nominal lifetime. The Chandra X-ray Observatory is in the 26th year of its five-year

mission, the Spitzer Space Telescope lasted for 11 years past its “use by” date, and the Fermi Gamma-ray Space Telescope is still operating after twice its original mission time.

If JWST lasts as long as Hubble, I'll be happy to see it still peering at the infrared sky in 2057. Hubble may be long gone by then, but we hope we'll have other grand observatories in space at that time, not so much replacing it as carrying on its legacy. ●