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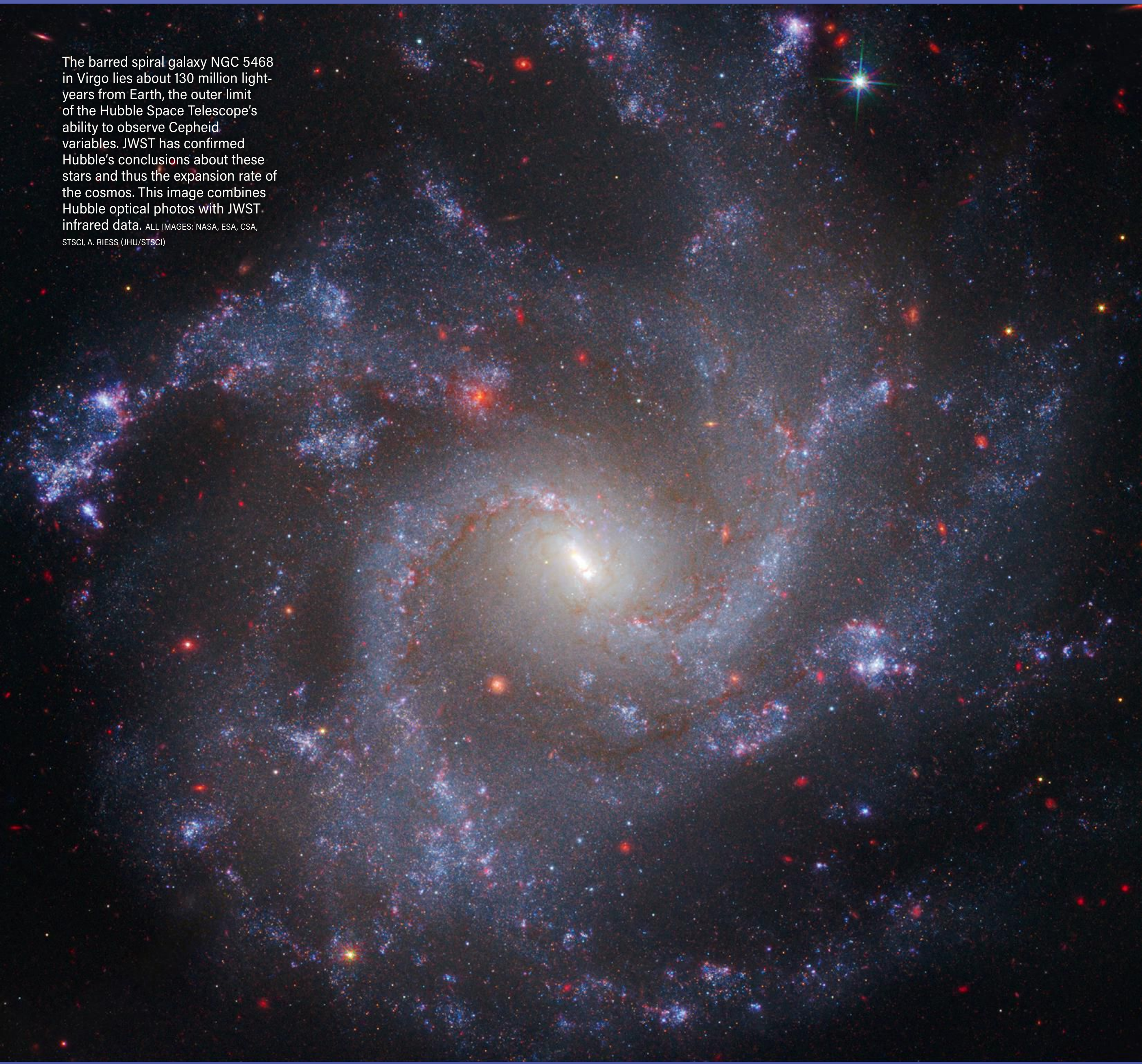
TROUBLE AT THE HEART OF



JWST and Hubble agree: The universe is expanding faster than theorists predict. BY RICHARD TALCOTT

COSMOLOGY

NUMBERS TURN UP EVERYWHERE in astronomy, though none plays a bigger role than the Hubble constant (H_0, pronounced "H-naught") — the current expansion rate of the universe. The speed at which the cosmos expands plays a fundamental role in revealing the universe's size, age, history, evolution, and ultimate fate.

In the past decade, researchers studying the motions of distant galaxies with both the Hubble Space Telescope and ground-based instruments have found H_0 equals 73.0 kilometers per second per megaparsec (km/s/Mpc; 1 megaparsec equals 3.26 million light-years) with an error of no more than 1.0 km/s/Mpc.

But cosmologists also can predict what the current expansion rate of the universe should be based on the standard model of cosmology. Applying the model to measurements of the cosmic microwave background yields an H_0 of 67.4 km/s/Mpc accurate to within 0.5 km/s/Mpc — two precise yet mutually incompatible values.

ENTER JWST

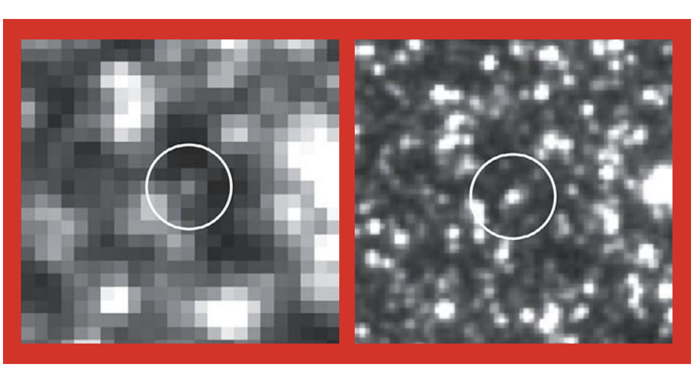
Scientists keenly waited for the James Webb Space Telescope (JWST) to weigh in on this so-called "Hubble tension." The powerful infrared instrument has confirmed Hubble's findings and removed any doubt that the problem might lie with observations.

To measure the universe's expansion rate, astronomers construct a "distance ladder." Cepheids form the ladder's first rung. These highly luminous suns vary predictably: Intrinsically brighter stars take longer to complete a cycle. Scientists calibrate this period-luminosity relation in the Milky Way with independent distance measurements, and then extend it to more distant galaxies. Researchers can monitor Cepheids accurately out to spiral galaxy NGC 5468, some 130 million light-years from Earth.

A specific type of supernova creates the ladder's second rung. Type Ia supernovae occur when a white dwarf siphons too much material from a companion and explodes. All such white dwarfs weigh about 1.4 solar masses, so the explosions peak at a similar luminosity, some 100,000 times greater than a typical Cepheid. If you observe Cepheids and supernovae in the same galaxies, you can calibrate the exploding stars to extend the distance ladder hundreds of times farther away.

The best views of Cepheids come in the near-infrared because those wavelengths pass untouched through intervening dust. Unfortunately, Hubble's resolution in the near-infrared is only decent. When it observes distant galaxies, the light of an individual Cepheid often blends with those of its neighbors. JWST's superior resolution nearly eliminates this problem.

Nobel laureate Adam Riess of Johns Hopkins University and the Space Telescope Science Institute led a team of researchers that studied more than 1,000 Cepheids in five galaxies that have hosted eight Type Ia supernovae. "We've now spanned the whole range of what Hubble observed, and we can rule out a measurement error as the cause of the Hubble tension with very high confidence," said Riess in a press release. The team published its results in the Feb. 10 issue of *The Astrophysical Journal Letters*.



Hubble's modest resolution in the near-infrared means that the light from a Cepheid variable blends with those of nearby stars (left). A sharper JWST image of the same field (right) shows an uncorrupted view of this Cepheid.

TENSION MOUNTS

The results focus attention back on the standard model of cosmology, known as Lambda Cold Dark Matter. The lambda refers to the cosmological constant in Einstein's general theory of relativity; it is the dark energy that exerts a repulsive force on space. Cold dark matter means that the universe's mass consists mostly of slow-moving dark matter particles.

"With measurement errors negated, what remains is the real and exciting possibility that we have misunderstood the universe," said Riess. This could mean that dark energy's strength changes with time, yet-to-be-discovered particles influence cosmic expansion in unknown ways, or that general relativity needs revision. The quest for an answer will keep observers and theorists busy for a long time.

Contributing Editor ***Richard Talcott*** *wrote in the July issue about JWST's discovery that dwarf galaxies likely reionized the early universe.*