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Astrophysics

Cosmic expansion mystery solved?

The rate at which the universe is expanding has been one of the most controversial numbers in cosmology for years, but we may finally have a resolution, finds **Leah Crane**

A COSMIC mystery that is one of the most significant open questions in physics may finally have been solved. The two main methods of measuring the universe's rate of expansion have long been in disagreement with one another – but they seem to be coming together.

The rate of the universe's expansion is measured by a parameter called the Hubble constant. For years, the two ways we work it out have been in tension, which led some cosmologists to believe that we didn't understand something fundamental about the universe – perhaps the nature of dark energy or an unknown field.

The first way of measuring the Hubble constant is based on tiny fluctuations in the cosmic microwave background (CMB), the relic light left over from the big bang. These fluctuations can be used alongside our best model of the cosmos to calculate the expected current rate of the universe's expansion. The CMB method gives a Hubble constant of 67 kilometres per second per megaparsec, suggesting the rate of expansion increases by 67 km/sec for every megaparsec of distance from Earth (1 megaparsec is about 3.26 million light years).

The other method is called the local distance ladder. It involves using objects at different distances from Earth – different "rungs" of the ladder – to measure the expansion of the area of space that is relatively near to us. The ladder's two main rungs have generally been Cepheid stars and type Ia supernovae, each of which have extremely reliable absolute luminosities that we can compare with their apparent brightness to determine how far away they are. The local distance ladder has long yielded a Hubble constant of about 73 km/sec/Mpc. The difference between the two measurements is called the Hubble tension.

"My big concern in the distance scale was that when you only have one method, you have no way to tell what the systematic uncertainties are in that method," says Wendy Freedman at the University of Chicago.

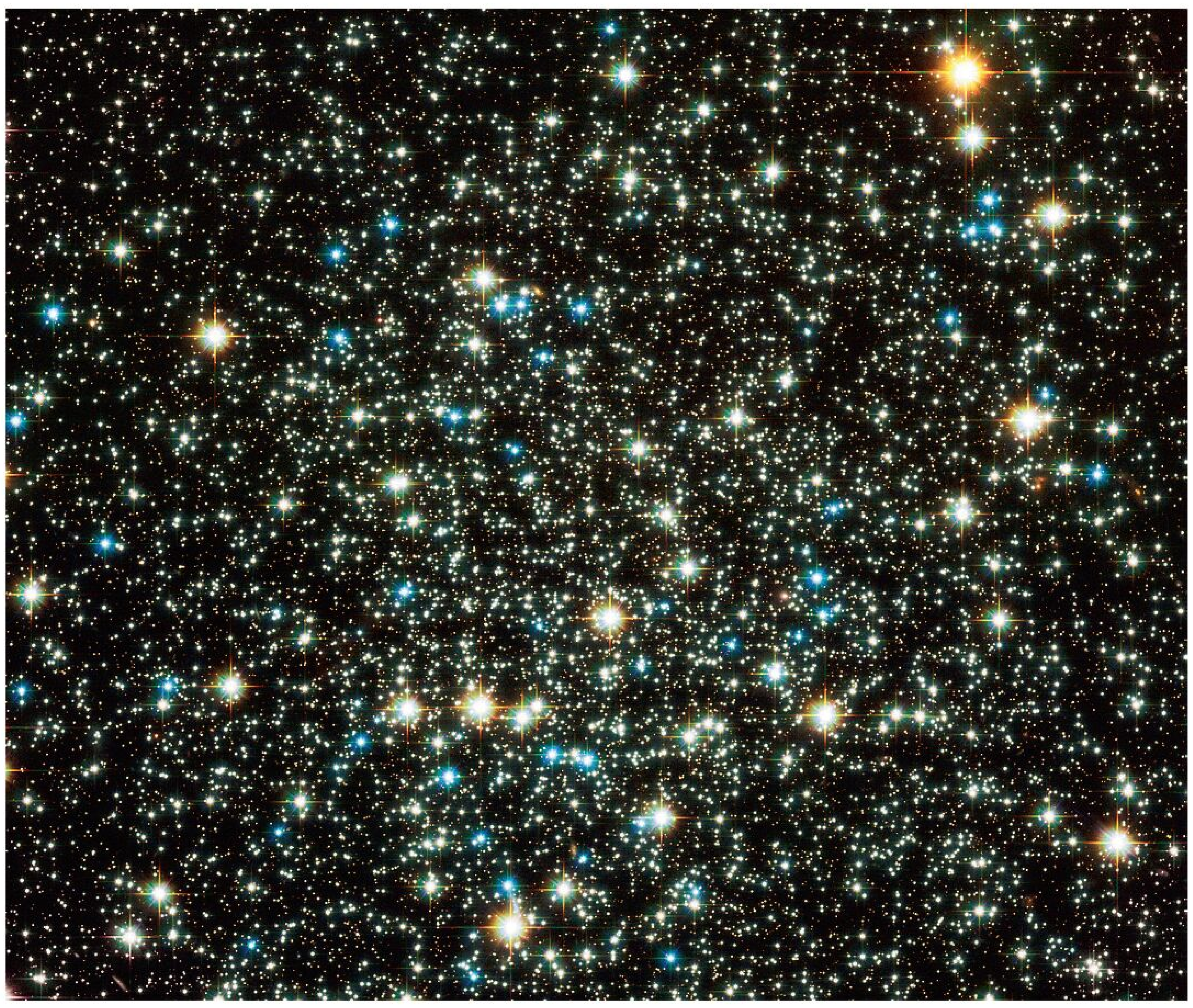
"The difference between a Hubble constant of 73 and 69 is small, but these things are really important"

Freedman and her colleagues have used the James Webb Space Telescope (JWST) to add two more methods to the local distance ladder. They observed two other types of stars – carbon stars and so-called tip of the red giant branch stars – each of which have predictable luminosities based on their mass. They also observed more Cepheids with the high resolution of JWST as well as reanalysing all the archival data from the Hubble Space Telescope previously used in local distance ladder measurements.

Using this more precise distance ladder, they calculated a Hubble constant of about 69 km/sec/Mpc, which is consistent with the CMB measurements. "The difference between a Hubble constant of 73 and 69 is small, but these things are really important to get right," says Freedman.

She presented this work at a meeting of the American Physical Society in California on 6 April. "These much more precise data are not screaming out saying you really need new physics," she says. "We are finally converging now – it's really exciting."

Not all cosmologists agree that the problem is on its way to being resolved. "If the Hubble tension disappears, that would be very important. It would mean our 'end-to-end' test of cosmology passes finally," says Daniel Scolnic at Duke University in North Carolina. "However… this doesn't feel like the current state we are in." He points out that the number of galaxies observed with JWST is relatively small and other groups have come up with a higher figure for the Hubble constant based on JWST data, rather than the lower one Freedman's team found.



ESA/HUBBLE & NASA

The further galaxies are from Earth, the faster they are moving away from us

Getting close

Adam Riess at Johns Hopkins University in Maryland, the head of one of those groups, is also sceptical. "I do not believe the Hubble tension has changed, but I do know there is a difference in the way we are analysing supernovae… one that produces a difference in the Hubble constant," he says. "I don't think it would be fair or accurate to define the size of the tension from the lowest (or highest) measure."

The numbers are becoming very close, says Rocky Kolb at the University of Chicago. "I suspect that one group is underestimating their errors… I do not feel there is a viable explanation to resolve the tension, if it exists."

The fact remains that it is hard to reconcile current cosmological models with the higher Hubble constant found in previous local distance ladder measurements, says Lloyd Knox at the University of California, Davis. "[These new results] looked to me like a big step toward this resolution," he says.

Freedman and her colleagues are still calculating the uncertainties of their measurement. For now, although it leans towards matching the CMB Hubble constant, it isn't inconsistent with previous local measurements. It will take more attempts with more methods to put the Hubble tension to bed, says Freedman. "Is this the end of the tension? Nothing dies that simply," she says. "But these data are pointing the way." ■