

Astrowatch

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Hubble misses 90% of distant galaxies

A team of astronomers has estimated that the number of galaxies in the observable universe is around two trillion (2×10^{12}), which is 10 times more than could be observed by the Hubble Space Telescope in a hypothetical all-sky survey. Although the finding does not affect the matter content of the universe, it shows that small galaxies unobservable by Hubble were much more numerous in the distant, early universe.

Asking how many stars and galaxies there are in the universe might seem a simple enough question, but it has no simple answer. For instance, it is only possible to probe the observable universe, which is limited to the region from where light could reach us in less time than the age of the universe. The Hubble Deep Field images captured in the mid-1990s gave us the first real insight into this fundamental question: myriad faint galaxies were revealed, and extrapolating from the tiny area on the sky suggested that the observable universe contains about 100 billion galaxies.

Now, an international team led by Christopher Conselice of the University of Nottingham in the UK has shown that this number is at least 10 times too low. The conclusion is based on a compilation of many published deep-space observations from Hubble and other telescopes. Conselice and co-workers derived the distance and the mass of the galaxies to deduce how the number of galaxies in a given mass interval



A region of the sky observed by Hubble reveals some of the most distant and faint galaxies visible with current technology, but a new study suggests that this is the tip of the iceberg.

evolves over the history of the universe. The team extrapolated its results to infer the existence of faint galaxies, which the current generation of telescopes cannot observe, and found that galaxies are less big and more numerous in the distant universe compared with local regions. Since less-massive galaxies are also the dimmest and therefore the most difficult to observe at great distances, the researchers conclude that the Hubble ultra-deep-field observations are missing about 90% of all galaxies in any observed area in the sky. The total number of galaxies in the observable universe, they

suggest, is more like two trillion.

This intriguing result must, however, be put in context. Critically, the galaxy count depends heavily on the lower limit that one chooses for the galaxy mass: since there are more low-mass than high-mass galaxies, any change in this value has huge effects. Conselice and his team took a stellar-mass limit of one million solar masses, which is a very small value corresponding to a galaxy 1000 times smaller than the Large Magellanic Cloud (which is itself about 20–30 times less massive than the Milky Way). The authors explain that were they to take into account even smaller galaxies of 100,000 solar masses, the estimated total number of galaxies would be seven times greater.

The result also does not mean that the universe contains more visible matter than previously thought. Rather, it shows that the bigger galaxies we see in the local universe have been assembled via multiple mergers of smaller galaxies, which were much more numerous in the early, distant universe. While the vast majority of these small, faint and remote galaxies are not yet visible with current technology, they offer great opportunities for future observatories, in particular the James Webb Space Telescope (Hubble's successor), which is planned for launch in 2018.

● **Further reading**
C.J. Conselice 2016 *ApJ* 830 83.

Picture of the month

It could be a landscape on the Moon, but in fact this spectacular view shows the Comet 67P/Churyumov–Gerasimenko. The image was captured by the OSIRIS camera aboard ESA's Rosetta spacecraft, which was launched on 2 March 2004 and reached the comet after more than 10 years of interplanetary travel (*CERN Courier* October 2014 p17). This is one of the last images taken by the mission, and was recorded from a distance of 16 km during the spacecraft's final descent onto the comet on 30 September 2016. This was the date chosen by ESA to perform a controlled impact of the two-tonne spacecraft onto the comet's surface. The highlight of the mission was the release of a small lander called Philae, which was sent out onto the comet on 12 November 2014. The lander, however, bounced on the surface and came to rest in a shadowy place, which prevented proper communication and illumination of its solar panels. Its fate was confirmed only recently when Philae was finally spotted on its side in a dark crack, in a Rosetta image released on 5 September.

ESA/Rosetta/OSIRIS for OSIRIS Team

