Editorial

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Early results on the early Universe

Check for updates

Reports of four galaxies from when the Universe was 2% of its current age are as exciting as they are puzzling — leading scientists to question our galaxy formation and evolution models.

CREDIT: NASA, ESA, CSA, STSCI

Ever since US President Joe Biden presented JWST's image of SMACS 0723 (cropped NIRCam image pictured) to an astonished public on 11 July 2022, superlative after superlative has been splashed all over the news: deepest, farthest, oldest, brightest. For once it was completely justified: the telescope had exceeded all expectations. And expectations were high after years of delay and significant overspending. NASA administrator Bill Nelson captured the loaded atmosphere at a televised press briefing on 12 July saying that the telescope "will help to uncover the answers to questions we don't even yet know to ask".

And indeed, the first photometric deep-field images showed galaxies that were brighter and more distant than expected, assuming the photometric fitting could be trusted. A flood of papers appeared on arXiv reporting galaxies at redshift 11 to 20. These were thought to be the earliest galaxies ever imaged, and the unexpected brightness levels suggested they could be up to ten times more massive than cosmological models would predict. But how did they grow so big and so quickly after the Big Bang? Is ΛCDM wrong?

The answer is more mundane, and goes back to the hardware: the near-infrared camera NIRCam is more sensitive than expected at the longest wavelengths, hence the images appear brighter in the reddest part of the spectrum. With all new instruments, observational limits have to be determined after a period of commissioning in their intended setting. The JWST team had known about the possibility of recalibration post-deployment. And indeed, when the pre-launch analysis pipeline was updated after JWST arrived at L2, 1.5 million km away, many of the measured redshifts came down by about 20%. But these photometric redshifts remained tentative, awaiting spectroscopic confirmation.

JWST has both photometric and spectroscopic capabilities, but it wasn't until October 2022 that the NIRSpec near-infrared spectrograph was scheduled to begin deep pointing observations. In this issue of *Nature Astronomy*, two papers from the JWST Advanced Deep Extragalactic Survey (JADES) highlight the powerful combination of NIRCam and NIRSpec in the search for the first galaxies.

In their Article, Brant Robertson and colleagues used NIRCam in nine infrared colours to observe the area previously captured by the Hubble Space Telescope's Ultra Deep Field, an oft-studied patch of sky. Not only did JADES encompass a much wider field at these wavelengths, but the images are also deeper and sharper than ever. With photometric estimates of the redshift, the team found several early-epoch candidates and determined their star-formation rates, sizes and other properties. Emma Curtis-Lake and colleagues, in their Article, then confirmed their distances spectroscopically with NIRSpec, which observed 250 galaxies. Besides a more accurate redshift, NIRSpec also provides information on the properties of the gas and stars within these faint galaxies.

Four galaxies in particular fall in the redshift range of 10.3 to 13.2, which is unprecedented. We're seeing galaxies from when the Universe was 2% of its current age. These galaxies are young, metal-poor and small, with bright, hot and densely packed stars. They also developed earlier than expected from the standard model of structure formation. As explained by Pieter van Dokkum in an accompanying News & Views, these results suggest that "the birth of the first galaxies may have been so early that it lies beyond even JWST's powers". But is this the only 'first light' from nascent galaxies to be found? The Milky Way, for instance, formed after redshift 10, so watching the birth and subsequent growth of similar galaxies to our own is entirely within the scope of JWST. For older galaxies, we just need to find other questions to ask, and to build new models to explain high-redshift observations such as these JADES results.

Closer to home, in the 5 to 27 microns wavelength range, the Mid-Infrared Instrument (MIRI) has given us stunning images of interstellar gas and dust, nebulae and more, in vivid detail. It has also been in the news recently due to a performance issue with MIRI's medium-resolution spectrometer (MRS) (the instrument has photometric and spectroscopic modes). Less light at the longest wavelength is getting through, compared with when it was first switched on last year. According to George Rieke, who leads the MIRI science team, the main concern is "whether this drop in signal has nearly played out or whether it continues to drop with time". He adds that "the instrument checked out with more throughput than expected and so the MRS is still operating better than predictions" at almost all wavelengths. Only time will tell whether the throughput levels out at the longest wavelength.

Again, we see that with MIRI, JWST is outperforming expectations. The increased sensitivity means that some higher-order physics left out of models and simulations may need to be included to reproduce the new observations. This is scientific progress at speed, with monthly — if not weekly — advances that interrogate our understanding of the cosmos and seek answers to new sets of questions using innovative tools. One thing we know for certain, more surprises from JWST are in store: the future of the study of our past is very bright.

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