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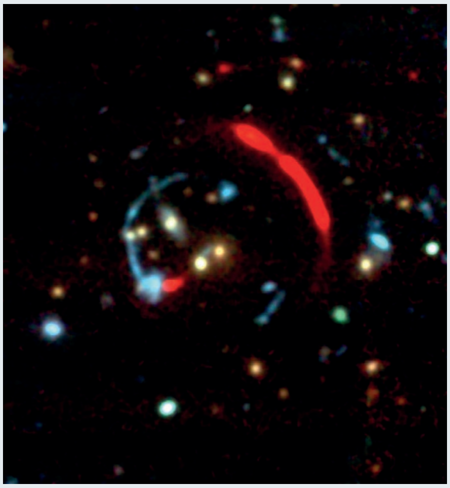
EARLY UNIVERSE

Through the looking glass

The Multi Unit Spectroscopic Explorer (MUSE), a relatively new addition to the Very Large Telescope, has already produced impressive results due to its unprecedented ability to instantaneously acquire more than 1.5 million spectra within its one-square-arcminute field of view of the sky. Renske Smit and colleagues (*Mon. Not. R. Astron. Soc.* http://doi.org/bzqw; 2017) used MUSE, together with data from the Hubble Space Telescope and SINFONI — another spectrograph on the Very Large Telescope — to look at galaxies hiding behind a massive local cluster of galaxies, which acts as an enormous magnifying glass due to its gravitational field. The large wavelength coverage of the spectrograph and its integral-field capability mean that data can be used to create composite images combining both continuum emission and emission lines (pictured).

Exploiting gravitational lensing magnification factors of up to 145 times, Smit *et al.* studied the spectra of galaxies at redshifts of about five (when the Universe was just one billion years old). A particular focus of their study was a star-forming galaxy with four multiple lensed



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images, three of which apparently combine to form a prominent arc (pictured in red). The kinematics and spatial distribution of the emission from excited hydrogen, as well emission and absorption of metals such as carbon, indicate that young, metal-poor stars are driving a strong outflow, off which Lyα photons are resonantly scattered, escaping the dense intergalactic medium to reach our telescopes.

Furthermore, the detection of carbon emission at rest-frame ultraviolet wavelengths was a surprise, given its relative absence in local analogues of this type of galaxy. However, as the authors note, their results indicate that the C IV doublet line may become increasingly common at higher redshifts, where young and metal-poor stellar populations start to dominate. Observations of this emission line doublet may therefore prove instrumental in the upcoming era of the James Webb Space Telescope for the study of galaxies during the epoch of reionization, at even higher redshifts (>7), where most Lyα photons would be absorbed by the still largely neutral intergalactic medium.

Apart from the study of this interesting galaxy, Smit *et al.* also used this data set to blindly detect similarly far-away galaxies through their Lyα emission, which would be redshifted into MUSE's bandpass due to their distance from us. The authors manage to find 14 new high-redshift candidate galaxies, the farthest one a mere 800 million years after the Big Bang. This impressive feat improves on previous blind surveys by almost an order of magnitude in terms of the required exposure time.

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