Do galaxies follow Darwinian evolution?

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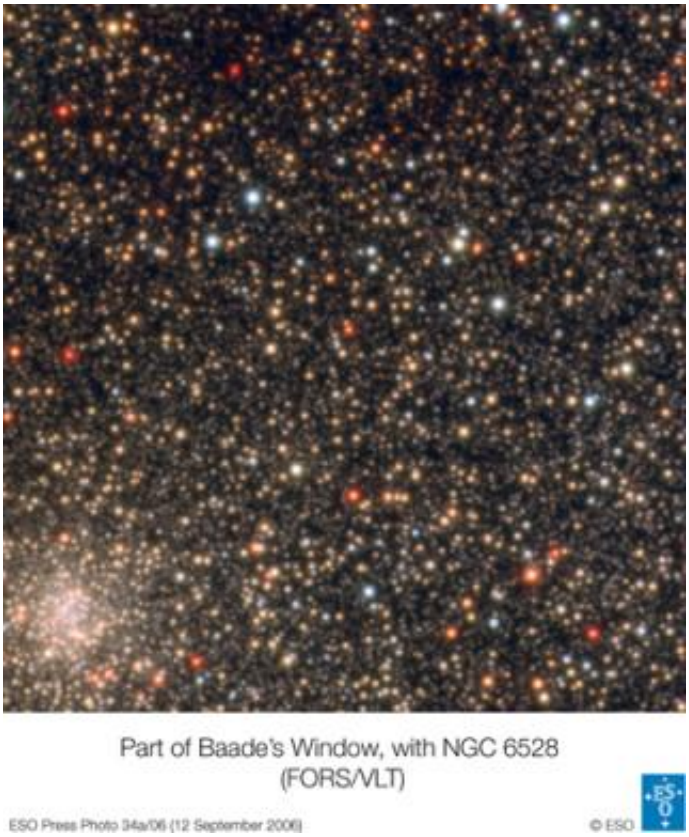

Part of one of the four regions of the sky in the direction of the Galactic Bulge in which the astronomers measured the iron and oxygen abundances in stars. This particular field is in the vicinity of the so-called 'Baade's Window', a region with relatively low amounts of interstellar "dust" that could block the sight, allowing astronomers to peer into the central parts of the Milky Way galactic centre and beyond. The globular cluster NGC 6528 is visible in the lower left corner. The image is a colour composite, based on images obtained in the B-, V-, and I-filters with the FORS instrument on the ESO VLT. The images were extracted from the ESO Science Archive and processed by Henri Boffin (ESO). North is to the right and East on top. Credit: ESO

Using VIMOS on ESO's Very Large Telescope, a team of French and Italian astronomers have shown the strong influence the environment exerts on the way galaxies form and evolve. The scientists have for the first time charted remote parts of the Universe, showing that the distribution of galaxies has considerably evolved with time, depending on the galaxies' immediate surroundings. This surprising discovery poses new challenges for theories of the formation and evolution of galaxies.

The 'nature versus nurture' debate is a hot topic in human psychology. But astronomers too face similar conundrums, in particular when trying to solve a problem that goes to the very heart of cosmological theories: are the galaxies we see today simply the product of the primordial conditions in which they formed, or did experiences in the past change the path of their evolution?

In a large, three-year long survey carried out with VIMOS, the Visible Imager and Multi-Object Spectrograph on ESO's VLT, astronomers studied more than 6,500 galaxies over a wide range of distances to investigate how their properties vary over different timescales, in different environments and for varying galaxy luminosities. They were able to build an atlas of the Universe in three dimensions, going back more than 9 billion years.

This new census reveals a surprising result. The colour-density relation, that describes the relationship between the properties of a galaxy and its environment, was markedly different 7 billion years ago. The astronomers thus found that the galaxies' luminosity, their initial genetic properties, and the environments they reside in have a profound impact on their evolution.

"Our results indicate that environment is a key player in galaxy evolution, but there's no simple answer to the 'nature versus nurture' problem in galaxy evolution," said Olivier Le Fèvre from the

Laboratoire d'Astrophysique de Marseille, France, who coordinates the VIMOS VLT Deep Survey team that made the discovery. "They suggest that galaxies as we see them today are the product of their inherent genetic information, evolved over time, as well as complex interactions with their environments, such as mergers."

Scientists have known for several decades that galaxies in the Universe's past look different to those in the present-day Universe, local to the Milky Way. Today, galaxies can be roughly classified as red, when few or no new stars are being born, or blue, where star formation is still ongoing. Moreover, a strong correlation exists between a galaxy's colour and the environment it resides in: the more sociable types found in dense clusters are more likely to be red than the more isolated ones.

By looking back at a wide range of galaxies of a variety of ages, the astronomers were aiming to study how this peculiar correlation has evolved over time.

"Using VIMOS, we were able to use the largest sample of galaxies currently available for this type of study, and because of the instrument's ability to study many objects at a time we obtained many more measurements than previously possible," said Angela Iovino, from the Brera Astronomical Observatory, Italy, another member of the team.

The team's discovery of a marked variation in the 'colour-density' relationship, depending on whether a galaxy is found in a cluster or alone, and on its luminosity, has many potential implications. The findings suggest for example that being located in a cluster quenches a galaxy's ability to form stars more quickly compared with those in isolation. Luminous galaxies also run out of star-forming material at an earlier time than fainter ones.

They conclude that the connection between galaxies' colour, luminosity

and their local environment is not merely a result of primordial conditions 'imprinted' during their formation - but just as for humans, galaxies' relationship and interactions can have a profound impact on their evolution.

Results from this study are published in volume 458 (1) of *Astronomy & Astrophysics*, "The VIMOS VLT Deep Survey: The build-up of the colour-density relation", by O. Cucciati et al.

Source: European Southern Observatory