Part of the universe's missing matter found

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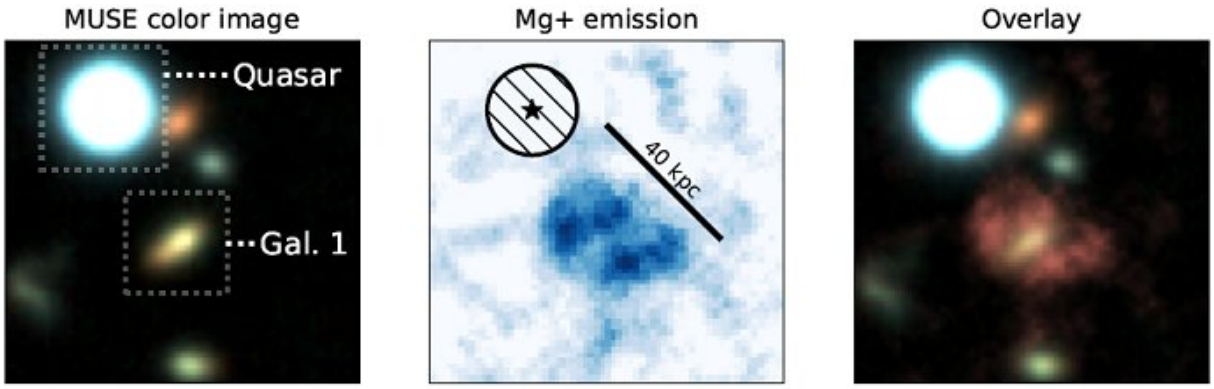

Observation of a part of the Universe thanks to MUSE. Left: Demarcation of the quasar and the galaxy studied here, Gal1. Center: Nebula consisting of magnesium represented with a size scale. Right: superimposition of the nebula and the Gal1 galaxy. Credit: © Johannes Zabl

Galaxies can receive and exchange matter with their external environment thanks to the galactic winds created by stellar explosions. Via the MUSE instrument from the Very Large Telescope at the ESO, an international research team, led on the French side by the CNRS and l'Université Claude Bernard Lyon 1, has mapped a galactic wind for the first time. This unique observation, which is detailed in a study published in *MNRAS* on 16 September 2021, helped to reveal where some of the universe's missing matter is located and to observe the formation of a nebula around a galaxy.

Galaxies are like islands of stars in the universe, and possess ordinary, or baryonic, matter, which consists of elements from the periodic table, as well as dark matter, whose composition remains unknown. One of the major problems in understanding the formation of galaxies is that approximately 80% of the baryons that make up the normal matter of galaxies is missing. According to models, they were expelled from galaxies into inter-galactic space by the galactic winds created by stellar explosions.

An international team led on the French side by researchers from the CNRS and l'Université Claude Bernard Lyon successfully used the MUSE instrument to generate a detailed map of the galactic wind driving exchanges between a young galaxy in formation and a nebula (a cloud of gas and interstellar dust).

The team chose to observe galaxy Gal1 due to the proximity of a quasar, which served as a "lighthouse" for the scientists by guiding them toward the area of study. They also planned to observe a nebula around this galaxy, although the success of this observation was initially uncertain, as the nebula's luminosity was unknown.

The perfect positioning of the galaxy and the quasar, as well as the discovery of gas exchange due to galactic winds, made it possible to draw up a unique map. This enabled the first observation of a nebula in formation that is simultaneously emitting and absorbing magnesium—some of the universe's missing baryons—with the Gal1 galaxy.

This type of normal matter nebula is known in the near universe, but their existence for young galaxies in formation had only been supposed.

Scientists thus discovered some of the universe's missing baryons, thereby confirming that 80–90% of normal matter is located outside of

galaxies, an observation that will help expand models for the evolution of galaxies.

More information: Johannes Zabl et al, MusE GAs FLOw and Wind (MEGAFLOW) VIII. Discovery of a Mgii emission halo probed by a quasar sightline, *Monthly Notices of the Royal Astronomical Society* (2021). DOI: 10.1093/mnras/stab2165

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