A new theory to explain Abell 3827's hazy and askew gravitationally lensed galaxies

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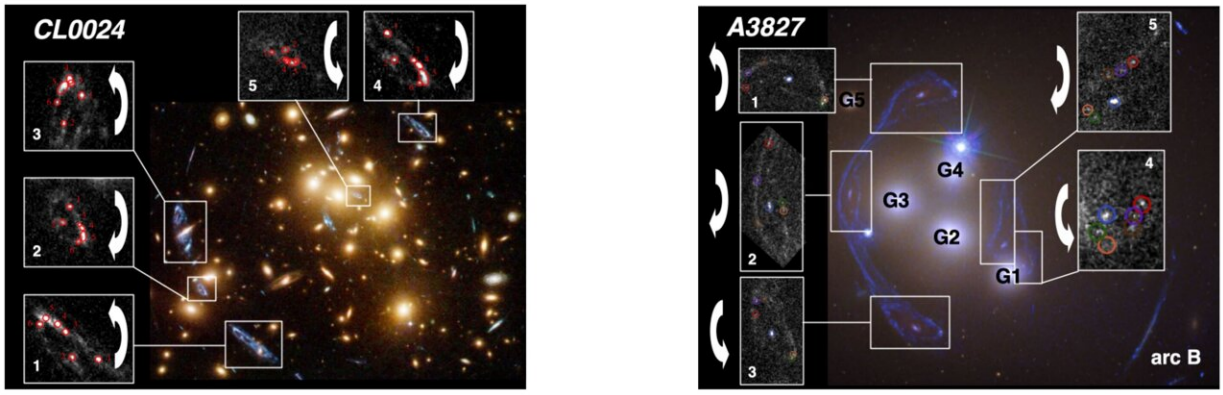

Comparison of multiple-image configurations between CL0024 (left) and A3827 (right). Relative parities (white arrows) in CL0024 are in agreement with standard cusp and fold configurations in single-plane lensing (see Wagner et al. (2018); Lin et al. (2022) for details), while relative orientations in A3827 cannot be brought into agreement with that. For instance, the transformation from image 1 to image 2 in A3827 still requires a clockwise rotation of 90 degrees compared to the transformation between image 1 and image 2 in CL0024. The central galaxies are labeled G1–4 with G5 being the closest member galaxy outside the multiple-image configuration. These galaxies were labeled N1–4 and N6 in Massey et al. (2015). Brightness features in A3827 (colored circles) are obtained with our persistent-feature extraction pipeline (Lin et al. 2022) as detailed in Section 2. Image credits: CL0024 adapted from Wagner et al. (2018), A3827 color image from Massey et al. (2015), details of multiple images from HST/WFC3 F336W filter band (program GO-12817). Credit: *Monthly Notices of the Royal Astronomical Society* (2023). DOI: 10.1093/mnras/stad2800

A trio of astrophysicists, two from Carnegie Mellon University and the third from Bahamas Advanced Study Institute and Conferences, is proposing a new theory to explain the unique lensing seen with Abell 3827—a galaxy cluster approximately 1.3 billion light-years away. In their paper published in *Monthly Notices of the Royal Astronomical Society*, Joyce Lin, Richard Griffiths and Jenny Wagner, describe their new theory and explain how it might help better understand the nature of dark matter.

Abell 3827 is a designation for a cluster of hundreds of galaxies, as viewed from Earth—just four of the galaxies are clearly prominent. Situated approximately 1.3 billion light-years away, the cluster has represented an opportunity for astrophysicists to study dark matter due to its unique lensing properties.

Prior research has suggested that the visible part of the cluster makes up just 10% of its mass—the rest is believed to be dark matter. Prior research has also found that because of the nature and arrangement of the galaxies in the cluster, it serves as an unusually large gravitational lens. Such lensing has resulted in the formation of what looks like a glowing blue ring around the edges of the cluster.

Abell 3827 was discovered just two years ago by a team studying data from the Hubble Space Telescope. Since that time, astronomers have been debating the number of images that can be seen when looking at it—estimates range from four to eight. The difficulty in pinning down the exact number is due, it is believed, to gravitational distortion of the light emitted by the stars that make up the galaxies, by unseen dark matter.

It has also been noted that some of the distortion is likely related to rotation, which some have claimed is an example of self-interacting dark matter. In this new effort, the research trio is proposing that some of the

characteristics of Abell 3827 are due to the morphology of the lensing.

They suggest that the lensing seen with the cluster is due to its three-dimensional characteristics—a major departure from prior theories which describe lensing as thin and flat. In their theory, Abell 3827's lensing is shaped more like a waffle, with different parts having different amounts of thickness—a characteristic that could explain why the cluster appears to look stretched more in some parts than others.

Notably, for their theory to hold water, the galaxies making up the cluster must not all be the same distance from Earth—the research team believes that three of the major four galaxies are all nearly the same distance while the fourth is perhaps tens of millions of light-years closer.

More information: Joyce Lin et al, Much ado about no offset—characterizing the anomalous multiple-image configuration and the model-driven displacement between light and mass in the multiplane strong lens Abell 3827, *Monthly Notices of the Royal Astronomical Society* (2023). DOI: 10.1093/mnras/stad2800 . On *arXiv*: doi.org/10.48550/arXiv.2306.11779