University of Central Lancashire
UCLan

Media release

A Big Ring on the Sky

A *second* ultra-large structure – the *Big Ring on the Sky* - has been discovered in the same cosmological neighbourhood as the earlier discovery of the *Giant Arc on the Sky*.

UCLan PhD student Alexia Lopez has discovered the *Big Ring on the Sky* at the same redshift (z ~ 0.80) and only ~ 12 degrees from her previous discovery of the Giant Arc. Individually and together, these two ultra-large structures seem to defy explanation in our current understanding of cosmology.

In recent years there have been several discoveries by different cosmologists of very large large-scale structures in the universe that appear to challenge our understanding of the universe. For example, these structures may be so large that they represent prima facie challenges to the Cosmological Principle - the fundamental assumption of homogeneity and isotropy, upon which the standard theoretical framework depends.

One such very striking ultra-large structure was the **Giant Arc on the Sky**, which was discovered by PhD student Alexia Lopez, and presented at the AAS meeting #238 in 2021. Now, in a remarkable development, Alexia has discovered a *second* very striking ultra-large structure – the **Big Ring on the Sky** – in the same cosmological neighbourhood as the Giant Arc. The Big Ring and the Giant Arc are at exactly the same cosmological redshift, z ~ 0.802, and are separated on the sky by only 12 degrees. If the Giant Arc extended into an even greater ring, it would contain the Big Ring. However, they are not strictly concentric.

The Big Ring appears as an almost circular ring (or annulus). Its diameter is ~1.3 billion ly, with a circumference 4.1 billion ly that is comparable to the length of the Giant Arc (3.3 billion ly). If we could step outside and see it directly, the diameter of the Big Ring would need about 15 full Moons to cover it.

Neither of these two ultra-large structures is easy to explain in our current understanding of the universe. And their ultra-large sizes, distinctive shapes, and cosmological proximity must surely be telling us something important – but what exactly

One possibility is that the Big Ring could be related to Baryonic Acoustic Oscillations (BAOs). BAOs arise from oscillations in the early universe and today should appear, statistically at least, as spherical shells in the arrangement of galaxies. However, Alexia's detailed analysis of her discovery is not really compatible with the BAO explanation: the Big Ring is too large and is not spherical.

Other explanations might be needed, explanations that depart from what is generally considered to be the standard understanding in cosmology. One possibility might be a different theory – Conformal Cyclic Cosmology (CCC) – which was proposed by Nobel-prize winner Sir Roger Penrose. Rings in the universe could conceivably be a signal of CCC.

Another explanation might be the effect of cosmic strings passing through. Cosmic strings are filamentary 'topological defects' of great size, which could have been created in the early universe. Another Nobel-prize winner, Jim Peebles, recently hypothesised that cosmic strings could have a role in the origin of some other peculiarities in the large-scale distribution of galaxies.

Furthermore, the Big Ring challenges the Cosmological Principle, as did the Giant Arc previously. And if the Big Ring and the Giant Arc together form a still larger structure then the challenge to the Cosmological Principle becomes even more compelling.

Such large structures – and there are others found by other cosmologists – challenge our idea of what an ‘average’ region of space looks like. They exceed the size limit of what is considered theoretically viable and they pose potential challenges to the Cosmological Principle.

Alexia said: “The Cosmological Principle assumes that the part of the universe we can see is viewed as a ‘fair sample’ of what we expect the rest of the universe to be like. We expect matter to be evenly distributed everywhere in space when we view the universe on a large scale, so there should be no noticeable irregularities above a certain size.

“Cosmologists calculate the current theoretical size limit of structures to be 1.2 billion light-years, yet both of these structures are much larger – the Giant Arc is almost three times bigger and the Big Ring’s circumference is comparable to the Giant Arc’s length.

“From current cosmological theories we didn't think structures on this scale were possible. We could expect maybe one exceedingly large structure in all our observable universe. Yet, the Big Ring and the Giant Arc are two huge structures and are even cosmological neighbours, which is extraordinarily fascinating. ”

The Big Ring appears as an almost perfect ring on the sky, but Alexia’s further analysis reveals that it has more of a coil shape, like a cork-screw, that is aligned face-on with Earth. The Giant Arc, which is approximately 1/15th the radius of the observable universe, shows as an enormous, nearly symmetrical, crescent of galaxies in the remote universe. It is twice the size of the striking Sloan Great Wall of galaxies and clusters that is seen in the relatively nearby universe.

Alexia said: “The Big Ring and Giant Arc are the same distance from us, near the constellation of Boötes the Herdsman, meaning they existed at the same cosmic time when the universe was only half of its present age. They are also in the same region of sky, at only 12 degrees apart when observing the night sky.”

“Identifying two extraordinary ultra-large structures in such close configuration raises the possibility that together they form an even more extraordinary cosmological system” Alexia added.

“This data we’re looking at is so far away that it has taken half the universe’s life to get to us, so from a time when the universe was about 1.8 times smaller than it is now. The Big Ring and the Giant Arc, both individually and together, gives us a big cosmological mystery as we work to understand the universe and its development.”

Alexia, together with adviser Dr Roger Clowes, both from UCLan’s Jeremiah Horrocks Institute, and collaborator Gerard Williger from the University of Louisville, USA, discovered the new structure by looking at absorption lines in the spectra of quasars from the Sloan Digital Sky Survey (SDSS).

Using the same method that led to the discovery of the Giant Arc, they observed the intervening Magnesium-II (MgII) absorption systems in the spectra of quasars. The quasars are point-like sources, and when scientists measure the light from the quasars using spectroscopy they can locate the distinctive absorption features, indicating intervening gas and matter. The MgII absorption features are indicative of star formation regions, e.g., galaxies and galaxy clusters. Therefore, these very-distant, very-bright, quasars act like giant lamps shining a spotlight through distant, but much fainter, intervening galaxies that otherwise would go unseen.

The discovery of the Big Ring used a more recent and larger MgII database than the discovery of the Giant Arc. An advantage of the MgII method is that the redshifts (implying distances), are more accurate than those from other methods, and hence reduces blurring effects. Possibly this reduced blurring helps to explain the prominence of the Big Ring and the Giant Arc.

Alexia has presented her findings on the Big Ring at the 243rd meeting of the American Astronomical Society (AAS) on the 10 January. The AAS invites researchers with potentially ground-breaking findings to share their work with the global astronomy community.

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Notes to editors

Figure 1

The Big Ring. The grey contours represent the Mg II absorbers, which indicate the distribution of galaxies and galaxy clusters. The blue dots represent the background quasars (or ‘spotlights’). The BR is centred close to 0 on the x-axis, spanning roughly -650 to +650 on the x-axis (equivalent to 1.3 billion light years).

Figure 2

An artistic impression of what the Big Ring (shown in blue) and Giant Arc (shown in red) would look like in the sky. Background image credit: Stellarium.

About the University

- The University of Central Lancashire (UCLan) is an international, multi-campus University tracing its roots back to 1828 and leading the way in modern learning today.
- We started life in the city of Preston, and are spending £200 million on giving our Preston Campus a world-class makeover. This includes our new £35 million Engineering Innovation Centre, and our stunning new Student Centre, which provides second-to-none care for our students. Both buildings overlook University Square, a focal point for community events and an iconic gateway linking together the city and the University.
- We’ve also grown to include campuses in Burnley (East Lancashire), Westlakes (West Cumbria) and Blackburn (Training 2000). And in 2012 we became the first British university to establish an overseas campus in Cyprus.
- Today we’re one of the UK’s largest universities, with a colleague and student community approaching 38,000 and an alumni network of over 200,000 people worldwide.
- Our employment-focused course portfolio – with more than 350 undergraduate programmes, nearly 200+ postgraduate courses and rich array of CPD courses - means we offer the skills and experience that industry needs. We’ve also joined forces with Training 2000, one of the largest Group Training Associations in the UK, and are set to become the leading provider of apprenticeships at all levels in the North West.
- Our University is Lancashire’s largest provider of graduate level qualifications and we have established links with global businesses, police constabularies, NHS trusts and more than 1,000 regional enterprises across a variety of sectors.

- Our community is made up of students from more than 100 countries around the world. And we are partnered with 123 institutions across the globe, making us a truly international University.
- We are ranked in the top 7% of universities worldwide (Center for World University Rankings 2022-23), and have a fantastic reputation for graduate outcomes, with 90% of international UCLan graduates in work or further education (HESA graduate outcomes, 2019-20).
- On the world stage, our research teams work collaboratively with major international organisations, from the United Nations to NASA. From helping to produce the world's first photograph of a Black Hole, to proving the links between firefighting and cancer, our researchers are delivering accessible, powerful and impactful research
- We pride ourselves on universally supporting our people, being actively liberating, inherently innovative and proudly spirited to face whatever life throws at us. These values are woven into the fabric of who we are and will always be.
- You can find us at uclan.ac.uk, or on our Twitter, Facebook, LinkedIn or Instagram pages.

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