Media release

Discovery of a Giant Arc in distant space adds to challenges to basic assumptions about the Universe

UCLan PhD student discovers a giant arc of galaxies 9.2 billion light years away

The discovery of a giant, almost symmetrical arc of galaxies – the Giant Arc – spanning 3.3 billion light years at a distance of more than 9.2 billion light years away (in the constellation of Boötes the Herdsman) is difficult to explain in current models of the Universe, and adds weight to other large structures which stretch the size that has previously defined an "average" part of space.

PhD student Alexia Lopez and adviser Roger Clowes, from the Jeremiah Horrocks Institute, University of Central Lancashire (UCLan), together with collaborator Gerard Williger (University of Louisville, USA), have made the discovery using singly-ionised magnesium (Mg II) absorption systems towards quasars from the Sloan Digital Sky Survey (SDSS).

Mg II absorption systems typically arise in gas around galaxies or in galaxy groups. Based on statistics of the space around the Giant Arc, there is a probability of less than 0.0003% that the group of Mg II absorbers in the Giant Arc is a chance alignment, or a significance of more than 4.5 sigma, based on two different statistical tests. Physicists and astronomers often publish results at 3 to 4 sigma significance, with 5 sigma being even better accepted.

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 nearby Universe. This new discovery of the Giant Arc adds to an accumulating set of (cautious) challenges to the Cosmological Principle.

The Cosmological Principle – the fundamental base of cosmology – postulates that matter is homogeneous on the largest scales. This means that matter should be evenly distributed and smooth on sizes bigger than clusters and superclusters of galaxies. Studying the large-scale structure of the Universe at different epochs can help cosmologists understand the distribution of matter, which is crucial for testing homogeneity, and ultimately the Cosmological Principle.

The discovery of the Giant Arc adds to the number of structures on scales larger than those thought to be "smooth", and therefore pushes the boundary size for the Cosmological Principle. The growing number of large-scale structures over the size limit of what is considered theoretically viable is becoming harder to ignore. According to cosmologists, the current theoretical limit is calculated to be 1.2 billion light years, which makes the Giant Arc almost three times larger. Can the standard model of cosmology account for these huge structures in the Universe as just rare flukes, or is there more to it than that?

The researchers made the discovery by observing the intervening Mg II absorption systems backlit by quasars, which are remote super-luminous galaxies that emit extraordinary amounts of energy and light.

Alexia Lopez, from UCLan, said: "A quasar acts like a giant lamp shining a spotlight through other galaxies, with the light eventually reaching us here on Earth.

"We can use telescopes to measure the spectra of these quasars, which essentially tells us the journey that the quasar light has been through, and in particular where the light has been absorbed. We can locate where the quasar light has passed through galaxies by a signature Mg II doublet feature, which is a distinctive pair of absorption lines in the spectra. From this easily identified absorption "fingerprint", we can map low luminosity matter that would usually go unseen due to its faint light emitted in comparison to the quasars.

"When viewed on such a large scale, we expect to see a statistically smooth distribution of matter across the Universe based on the Cosmological Principle introduced by Einstein (to make the maths easier) that the Universe is isotropic and

homogeneous. It means that the night sky, when viewed on a sufficiently large scale, should look the same, regardless of the observers' locations or the directions in which they are looking. The key question is: what is "sufficiently large"?

"The Giant Arc we are seeing certainly raises more questions than answers as it may expand the notion of "sufficiently large". We also note that the Giant Arc appears very symmetrical, although that is as seen from our particular location and its degree of symmetry has still to be quantified.

"We are seeing the Giant Arc now, but in reality the data we're looking at show the Universe as it was half its lifetime ago, because the light has been en route, travelling towards, us for billions of years. It was so long ago that the Universe at the time was about 1.8 times smaller than it is now."

Alexia Lopez has presented her work on the Giant Arc at the 238th virtual meeting of the American Astronomical Society, 7-9 June 2021.

ENDS

Notes to editors

Figure captions -

Figure 1. The Giant Arc. 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 Giant Arc is centred on this figure spanning -600 to +400 Mpc on the x-axis.

Figure 2. A schematic of the Mg II absorption method. Bright background quasars shine light through the gas around galaxies. Some of the light from the quasar is then absorbed by the gas and leaves a signature feature behind in the quasar spectrum. We can use this information to map the matter distribution in distant space.

Figure 3. The Giant Arc in Mg II (grey contours) with neighbourhood quasars superimposed (blue contours). A tentative association can be seen between these two datasets.

Giant Arc animation – A 3D roll-around of the GA. The red spheres represent the Mg II members in the GA and the blue spheres represent the Mg II members in the rest of the field.

Alexia's email: missalexia.lopez@gmail.com

The University of Central Lancashire (UCLan) in Preston was founded in 1828 as the Institution for the Diffusion of Knowledge. Since those early days it has grown into one of the UK's largest universities with a staff and student community approaching 38,000 and an employment-focused course portfolio containing over 350 undergraduate programmes and nearly 250 postgraduate courses. The University has an established research reputation with world-leading or internationally excellent work taking place within the areas of Business, Health, Humanities and Science.

As a truly global institution with an established campus in Cyprus, UCLan's student body includes 120 nationalities and its partnership network extends to 125 countries. In 2021 the Center for World University Rankings placed UCLan in the top 6.8 percent of all worldwide universities.

The University has a strong focus on continually improving the student experience. According to the 2020 Student Welfare League Table, UCLan is ranked first for the money invested into student wellbeing services. Its soon-to-be-completed masterplan redevelopment has created an attractive and inviting, world-class campus in Preston which is helping to create jobs, kick-start regeneration and attract inward investment into the City.

For more information contact:

Lyndsey Boardman

PR Officer University of Central Lancashire

T: 01772 894116 E: leboardman@uclan.ac.uk