UNIVERSITY of the WESTERN CAPE

IDIA Inter-University Institute for Data Intensive Astronomy

PRESS RELEASE
11 April 2016

Astronomers in South Africa discover mysterious alignment of black holes

Findings by University of Cape Town and the University of Western Cape offer glimpse of early universe to be revealed when SKA is operational.

Deep radio imaging by researchers in the University of Cape Town and University of the Western Cape has revealed that supermassive black holes in a region of the distant universe are all spinning out radio jets in the same direction – most likely a result of primordial mass fluctuations in the early universe, a new paper in MNRAS reports today.

The new result is the discovery – for the first time – of an alignment of the jets of radio galaxies over a large volume of space, a finding made possible by a three-year deep radio imaging survey of the radio waves coming from a region called ELAIS-N1 using the Giant Metrewave Radio Telescope (GMRT).

The radio jets are produced by the supermassive black holes at the centres of these galaxies, and the only way for this alignment to exist is if supermassive black holes are all spinning in the same direction, says Prof Andrew Russ Taylor, joint UWC/UCT SKA Chair, Director of the recently-launched Inter-University Institute for Data Intensive Astronomy and principal author of the study.

“Since these black holes don’t know about each other, or have any way of exchanging information or influencing each other directly over such vast scales, this spin alignment must have occurred during the formation of the galaxies in the early universe,” he notes.

This implies that there is a coherent spin in the structure of this volume of space that was formed from the primordial mass fluctuations that seeded the creation of the large scale structure of the universe.

With study co-author – and UCT PhD student currently working at the National Radio Astronomy Observatory, Socorro, New Mexico, USA – Preshanth Jagannathan , the team discovered the alignment after the initial image had been made. Within the large-scale structure, there were regions where the spin axes of galaxies lined up.

The finding wasn’t planned for: the initial investigation was to explore the faintest radio sources in the universe, using the best available telescopes – a first view into the kind of universe that will be revealed by the South African MeerKAT radio telescope and the Square Kilometre Array (SKA), the world’s most powerful radio telescope and one of the biggest scientific instruments ever devised.

Earlier observational studies had previously detected deviations from isotropy in the orientation of galaxies. But these sensitive radio images offer a first opportunity to use radio jets to reveal alignments of radio galaxies on physical scales of up to 100 Mpc. And measurements from the total intensity radio emission of AGN jets have the advantage of not being affected by propagation effects such as scattering, extinction and Faraday Radiation, which may be an issue for optical and polarimetric studies.

The presence of alignments and certain preferred orientations can shed light on the orientation and evolution of the galaxies, relation to large scale structures and the motions in the primordial matter fluctuations that gave rise to the structure of the Universe.

So what could these large-scale environmental influences during galaxy formation or evolution have been? There are several options: cosmic magnetic fields; axionic fields post-inflation; and cosmic strings are only some of the possible candidates that could effect an alignment in galaxies even on scales larger than galaxy clusters.

It would be interesting to compare this implication with predictions of angular momentum structure from universe simulations, the study authors note.

UWC Prof Romeel Dave, SARChI Chair in Cosmology with Multi-Wavelength Data, who leads a team developing plans for universe simulations that could explore the growth of large scale structure from a theoretical perspective, agrees: "This is not obviously expected based on our current understanding of cosmology. It's a bizarre finding."

This discovery is a mystery, and it's going to take a while for technology and theory alike to catch up.

Such imaging projects are in the planning stages for the SKA and its precursor telescopes, the South African MeerKAT array and the Australian SKA Pathfinder (ASKAP).

"GMRT is one of the largest and most sensitive radio telescope arrays in the world," notes Prof Taylor, "but we really need MeerKAT to make the very sensitive maps, over a very large area and with great detail, that will be necessary to differentiate between possible explanations. It opens up a whole new research area for these instruments, which will probe as deeply into the universe and as far back as we can go – it's going to be an exciting time to be an astronomer."

Looking Forward

So what does this all mean? Well, as you may have heard, it's a mystery – and that always means something.

A large-scale spin distribution has never been predicted by theories – and when an unknown phenomenon like this occurs there's a challenge that theories about the origins of the universe are challenged to need to account for them and an opportunity to find out more about the way the universe works.

"We're beginning to understand how the large structure of the universe came about, starting from the Big Bang and growing as a result of disturbances in the early universe, to what we have today," says Prof Taylor, "and that helps us explore what the universe of tomorrow will be like."

Acknowledgements
The study authors thank the staff of the GMRT – run by the (US) National Centre for Radio Astrophysics of the Tata Institute of Fundamental Research, Mumbai, India – that made their observations possible. They also thank the US National Radio Astronomy Observatory for providing support in the form of the Reber Doctoral Fellowship.

Contacts

Patricia Lucas
Tel: (021) 650 5428 Fax (021) 650 5628
Cell: 076 292 8047
E-mail: pat.lucas@uct.ac.za
University of Cape Town
Rondebosch
Website: www.uct.ac.za

Aidan van Den Heever
Tel: (021) 959 9566
Cell: 072 332 2055
E-mail: pat.lucas@uct.ac.za
University of the Western Cape
Bellville
Website: www.uwc.ac.za

BACKGROUND INFORMATION/NOTES TO EDITORS

Radio astronomy is the study of astronomical objects and occurrences at radio frequencies – sources include stars, galaxies, radio galaxies, pulsars and others. Deep radio imaging constructs images of deep space based on these radio observations.

The Giant Metrewave Radio Telescope is an array of radio telescopes at metre wavelengths. It is operated by the National Centre for Radio Astrophysics, part of the Tata Institute of Fundamental Research, Mumbai, India. The world's largest interferometric array at the time of its building in 1995, it is a very versatile instrument for investigating a range of radio astrophysical problems.

The Square Kilometre Array will collect and process vast amounts of radioastronomical data, and will stimulate cutting-edge advances in high-performance computing. Producing the thousands of dishes required for the SKA within the project's time scales will also demand an entirely new way of building highly sophisticated and sensitive scientific instruments – which should lead to new innovations in manufacturing and construction. South Africa's MeerKAT telescope is an SKA precursor – a "pathfinder" telescope. It consists of 64 dish-shaped antennas, and is temporarily the most powerful radio telescope in the southern hemisphere. MeerKAT (and Australia's SKA Pathfinder, ASKAP) form part of SKA Phase 1.

Several large-scale environmental influences could have influenced spatial alignment during galaxy formation or evolution. **Cosmic magnetic fields** arise as a result of huge densities, volumes or motions of electrically charged material, such as the gas that pervades the Milky Way or the outflows of material from the energetic centres of galaxies. **Axionic fields** are the fields associated with hypothetical elementary particles that are of interest as a possible component of cold dark matter. And **cosmic strings** are hypothetical 1-dimensional topological defects which may have formed during a symmetry breaking phase transition during the earliest moments of the universe's evolution, just after cosmological inflation.

The Inter-University Institute for Data-Intensive Astronomy, launched in September 2015 and headed by Prof Russ Taylor, is a multi-university partnership – including UWC and UCT – that will develop crucial capacity for big data management and analysis, a spin-off of the Square Kilometre Array project.