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FOR ALL-SKY ASTROPHYSICS

Reader's Digest

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Publication stories about CAASTRO research

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CAASTRO Education & Outreach


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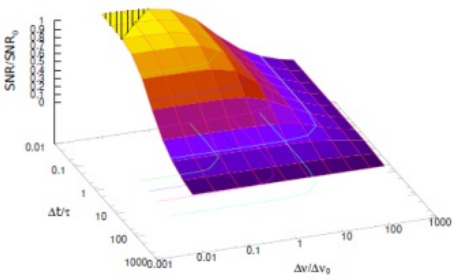
Flexible algorithm efficiently detects single-pulse radiation

Preparing processing pipelines for the data rates and volumes of the SKA and its pathfinder instruments, Curtin-based researchers have now expanded and improved previous work on a real-time reconstruction algorithm for single-pulse fast transient detection surveys. Radio emission in bursts of short duration (explosions, collisions, collapses) is severely modified by its passage through the interstellar and intergalactic medium.

The team, including CAASTRO members Dr Jean-Pierre Macquart and Dr Cathryn Trott, demonstrate the excellent performance of their new incoherent de-dispersion algorithm that maximises the signal-to-noise ratio of the detected signals by flexible selection of data samples for the de-dispersion.



In their paper, they also identify an optimum up to which increased temporal and spatial resolution in measurements aids signal detection but beyond which any gains do not balance out the increased computational demands. This analysis is now applicable to future experiments, for instance the Commensal Real-Time ASKAP Fast Transients (CRAFT) survey that is aimed at detecting milli-second timescale signals in a 30 square degree patch of sky, using the Australian Square Kilometre Array Pathfinder (ASKAP).

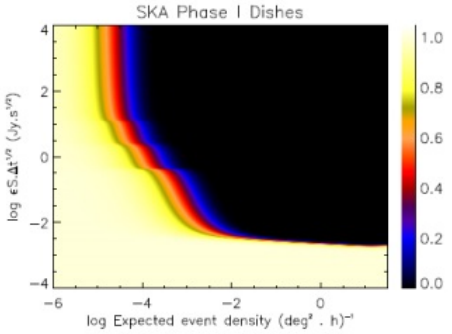
Publication details:

N. Clarke, J.-P. Macquart, C. M. Trott in The Astrophysical Journal – Supplement Series 205 "*Performance of a novel fast transients detection system*"

An analysis of different sub-second radio burst searches

V-FASTR – the fast transient search in radio wavelengths using the Very Long Baseline Array in North America – has the capability to potentially detect and localise mysterious milli-second timescale radio bursts from as-yet unknown locations in the Universe. Efforts by the V-FASTR team and similar experiments can now use and benefit from a sophisticated framework that accounts for the various characteristics of the bursts (e.g. luminosity, distance) and instruments (e.g. field of view, sensitivity) into account to provide analysis and interpretation of experimental results.

In a recent publication, CAASTRO researcher Dr Cathryn Trott and her colleagues describe this new framework and outline its benefits for past and future experiments. One major benefit is the ability to scale results to a common standard and compare them. In their paper, they demonstrate how V-FASTR data in the 20cm band can be combined with data from the Allen Telescope Array "Fly's Eye" fast transient survey in California. Using their new framework, the researchers were also able to analyse the system specifications of SKA Phase 1 (250-dish array, 100km baseline) and predict constraints on burst detection rates.



Looking more closely at V-FASTR's performance in the 20cm band, the experiment settings are not far off an expected detection of a burst event. The V-FASTR researchers are now awaiting new data with great interest.

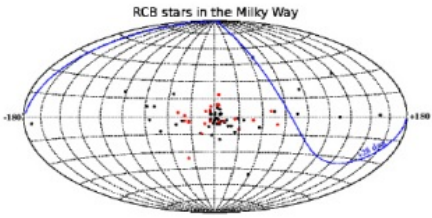
Publication details:

C. M. Trott, S. J. Tingay, R. B. Wayth, D. R. Thompson, A. T. Deller, W. F. Brisken, K. L. Wagstaff, W. A. Majid, S. Burke-Spolaor, J.-P. Macquart, D. Palaniswamy in The Astrophysical Journal 767 "*A framework for interpreting fast radio transients search experiments: applications to the V-FASTR experiment*"

More rare supergiant stars on our Galaxy's map

Hydrogen-deficient and carbon-rich, with an atmosphere of 99% helium, it is assumed that the so-called R Coronae Borealis stars (RCBs) are the result of CO and He white dwarves merging. Only 55 of these stars used to be known in our Galaxy but a new publication by CAASTRO researcher Dr Patrick Tisserand at the ANU in Canberra, along with his overseas colleagues, has now boosted this number to 76 in the Milky Way, plus 22 in the Magellanic Clouds.

The team used the "ASAS-3 south" (All Sky Automated Survey, located at Las Campanas Observatory) optical dataset – resulting from observations made between 2000 and 2010 – to identify candidate stars. In their analysis, the team applied four independent techniques that exploited different properties, such as light curve variability, or drew on different candidate catalogues. As the final step of their follow-up, they obtained spectroscopic measurements of 104 RCB candidates with the Wide Field Spectrograph at Siding Spring Observatory in New South Wales. The spectroscopic success rate was ~90% for bright RCBs (magnitude ~13, corresponding to distances of ~20 kiloparsec), and the team also confirmed two previously known RCB candidates.



It appears as if RCBs are mainly located in the Galactic bulge. A few of the new discoveries reveal high infra-red excesses which means that they have a dusty shell surrounding them. In addition to their analysis of RCBs, the researchers also looked for so-called DY Per stars, carbon-rich supergiants which might be the cooler counterpart of RCBs; they found two new candidate DY Per stars in the ASAS-3 data.

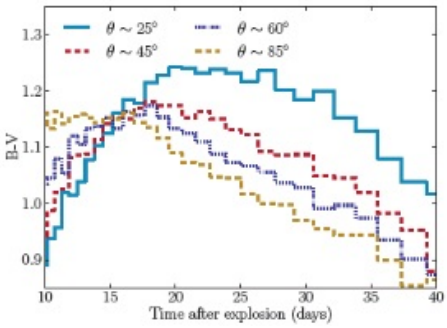
Publication details:

P. Tisserand, G. C. Clayton, D. L. Welch, B. Pilecki, L. Wyrzykowski, D. Kilkenny in Astronomy & Astrophysics 551 "*The ongoing pursuit of R Coronae Borealis stars: ASAS-3 survey strikes again*"

Detectability of supernova emission varies with viewing angle

While supernovae – the result of stars collapsing under their own gravity – are well described and understood, it is less clear under which circumstances these events are also associated with the emission of relativistic jets, observed as Gamma-Ray Bursts. Since these jets are launched along the poles of the Black Holes formed in supernovae, their detection is orientation-dependent. In a recent publication, CAASTRO's former PhD student Sharon Rapoport, her ANU supervisors, and international colleagues simulated a range of different scenarios to take the mass and composition of the star, viewing angle of the observer (orientation), and timescale of the supernova into account to predict the detectability of the jets.

Their simulations recreate 50 days after the collapse and show that supernovae progress differently depending on their initial composition (which affects density) and assumed expansion velocities (which are faster along the poles than along the equator). The team also found a consistent relationship between light curve properties and the observer's orientation. Light curves peaked around 20 days after the supernova, but pre-peak light curves were brighter for observing lines of sight aligned with the pole-axis. The simulations also revealed a rapid colour evolution from blue to red, corresponding to higher velocities by lighter elements being transformed into metal.



Having identified the viewing angle as a key factor in analysing light curves, these simulations now caution us in our estimates of energy and mass being ejected in supernovae. The results also provide a guide as to what properties we should be closely examining in future observations of supernovae and associated emissions, to further improve our models and understanding of these extreme physical processes.

Publication details:

S. Rapoport, S. A. Sim, K. Maeda, M. Tanaka, M. Kromer, B. P. Schmidt, K. Nomoto in The Astrophysical Journal 759 "*A theoretical color-velocity correlation for Supernovae associated with Gamma-Ray Bursts*"

Heavier galaxies cluster more in denser regions of the Universe

The near-infrared 6dF Galaxy Survey (6dFGS; UK Schmidt Telescope in Siding Spring Observatory) is one of the largest (76,833 galaxies) and most complete (92% on average) galaxy surveys to study galaxy formation in the local Universe (median redshift of z = 0.05). A team of researchers in Australia and the US used 6dFGS data to analyse how the clustering of galaxies depends on stellar mass. Clustering was estimated relative to a random, unclustered distribution which followed the same angular and redshift selection function as the galaxy sample. Selecting four volume-limited sub-samples of 6dFGS galaxies, they found that more massive dark matter halos tend to host galaxies with higher stellar mass.

Ex-ICRAR/UWA PhD student Florian Beutler and his supervisors, CAASTRO Chief Investigators Dr Chris Blake and Prof Lister Staveley-Smith, and other colleagues further examined the relationship between dark matter halo mass and satellite galaxies. Using the Halo Occupation Distribution model, they determined that the satellite fraction of 6dFGS galaxies declines with increasing stellar mass. In their simulations, only those dark matter halos that already contained a central galaxy could host a satellite galaxy.

The researchers also tested the predictions made by previously published models ("Munich model" by Croton et al. 2006 and "Durham model" by Bower et al. 2006) that are based on the "Millennium Simulation" and take gas cooling, star formation,

and feedback processes into account. All of the "mock" 6dFGS catalogues created by these two models contained about 40% fewer galaxies than the real data with "Munich" under-predicting and "Durham" slightly over-predicting the satellite fraction.

Publication details:

F. Beutler, C. Blake, M. Colless, D. H. Jones, L. Staveley-Smith, L. Campbell, Q. Parker, W. Saunders, F. Watson in Monthly Notices of the Royal Astronomical Society 429 "*The 6df Galaxy Survey: Dependence of halo occupation on stellar mass*"

Indian array proves a valuable test-bed for SKA transient survey

Using the Giant Metre-wave Radio Telescope (GMRT) in India and Graphics Processing Unit powered supercomputing at Swinburne University in Melbourne, the research team around our Curtin Associate Investigator Dr Ramesh Bhat was able to develop a transient detection pipeline. In their recent paper, they defined optimal observing strategies at frequencies of 325 and 610 MHz, where the GMRT offers highest sensitivity, processing 151 Terabytes of data from a 360 square degree patch of the sky.

The GMRT comprises 30 telescopes distributed over many square kilometres, so it constitutes a very good test-bed for operations with the Square Kilometre Array (SKA) – but the GMRT is located in an environment that is much more prone to radio frequency interference (RFI) than the SKA sites. The team exploited the GMRT's software backend option of recording raw voltage data (in two polarisations) from the individual array elements; they then de-dispersed the data and searched for transient events by imaging known sources such as the Crab Pulsar.

In evaluating differences in the detection sensitivity of telescope elements, the researchers found that grouping the full telescope array into coherently summed sub-arrays and comparing the radio signals arriving at each sub-array greatly aided RFI identification and removal. A grouping into four sub-arrays delivered the best results by filtering out RFI and false alarms (due to receiver noise) but preserved the full imaging capability and sensitivity of the full telescope. The

pipeline is intended to become part of a commensal program to run on the GMRT.

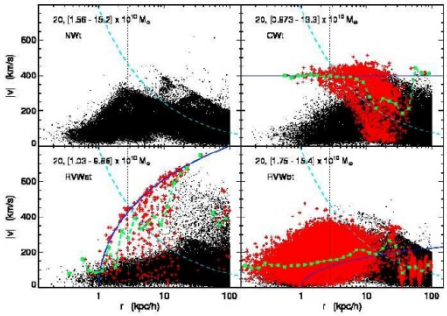
Publication details:

N. D. R. Bhat, J. N. Chengalur, P. J. Cox, Y. Gupta, J. Prasad, J. Roy, M. Bailes, S. Burke-Spolaor, S. S. Kudale, W. van Straten in The Astrophysical Journal – Supplement Series 206 "*Detection of Fast Transients with Radio Interferometric Arrays*"

Galactic outflows remove metals and suppress star formation

Galactic winds are thought to be the main mode of transport for metals from star-forming regions to deposit in gas-rich regions of galaxies. While this sort of energy feedback is important to be accounted for in galaxy evolution simulations, physical and chemical processes are usually not resolved at the scale of cosmological simulations. This paper by Barai and colleagues, including a CAASTRO University of Melbourne member, Dr Edoardo Tescari, presents a hydrodynamic cosmological simulation that includes a kinetic feedback mechanism where supernova energy gives a velocity kick to gas particles at outflow speeds relative to the distance from the galactic centre.

The team tested two different cosmological volumes and four different outflow scenarios. As suggested by results from observational studies, their model also explores the relationship between outflow speed and galaxy mass. The results were found to provide a good match to observational data with regard to dependency of the star formation rate on galaxy stellar mass. In the "no wind" and "variable wind dependent on halo mass" scenarios, the amount of galactic gas was decreased in more massive halos, and there was a higher central concentration of metals originating from star formation. The "variable wind independent on halo mass" scenario produced the clearest galactic disks. All four scenarios indicated that the thermal properties of the intergalactic medium were unaffected by different wind conditions.



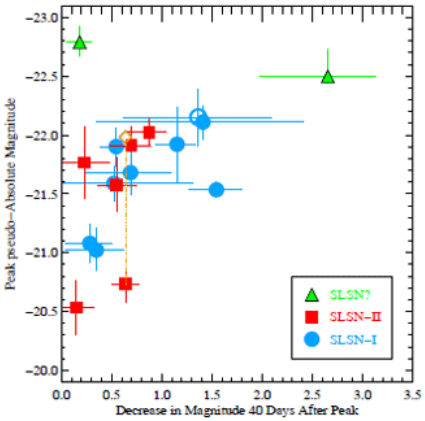
These simulations have confirmed that galactic winds lead to metal-enrichment of the outflowing gas and a suppression of star formation in the galaxy, both of which were strongest in the "constant wind" scenario. In addition, they produced interesting features such as pristine gas infall along cosmological filaments that "feed" the galactic centre. Dr Tescari's simulations make use of supercomputing facilities at CAASTRO's partner institution, the National Computational Infrastructure (NCI).

Publication details:

P. Barai, M. Viel, S. Borgani, E. Tescari, L. Tornatore, K. Dolag, M. Killedar, P. Monaco, V. D'Odorico, S. Cristiani in Monthly Notices of the Royal Astronomical Society 430 "*Galactic Winds in Cosmological Simulations of the Circumgalatic Medium*"

How often do stars explode as exceptionally bright supernovae?

It is not yet clear what gives rise to supernovae with a peak brightness many times the average, so-called superluminous supernovae (SLSNe), but since they are observable from further away than normal supernovae, a better understanding of these events might also make them a valuable additional 'standard candle' for distance measurements in the Universe. Using survey data from the ROTSE-IIIb telescope at the McDonald Observatory (Texas, US) that covered 500 square degrees of sky, a small team of international researchers – including CAASTRO member Dr Fang Yuan (ANU) – has now calculated the volumetric rate of SLSNe.



Having identified five suitable events, the first step in their calculations was to produce light curve templates and estimate pseudo-absolute magnitude distributions for both hydrogen-poor SLSN Type I and hydrogen-rich SLSN Type II. Monte Carlo simulations were then used to determine the efficiency of different surveys on the telescope in "shortlisting" candidates in a given volume of sky. For the pooled SLSN-like data and at a redshift of 0.2 (local volume), the team calculated a volumetric rate of 199 events Gpc^{-3} yr^{-1} h^3 which, due to the small sample size, is subject to large statistical (199 +137 / -86) and systematic (199 +65 / -41) errors.

Their results approximately match the local rate of sub-energetic, long-duration gamma-ray bursts but are exceeded by the estimated rate of core collapse supernovae by a factor of 400 to 1300. These new calculations now offer an opportunity to determine the origin of SLSNe by comparing them with the formation rate of stars in the critical mass range at similar redshifts. And since peak magnitudes of SLSN Type I were found to be tightly clustered (M = -21.7 ±0.4), these events might be a promising 'standard candle' once sufficient sample sizes have been reached.

Publication details:

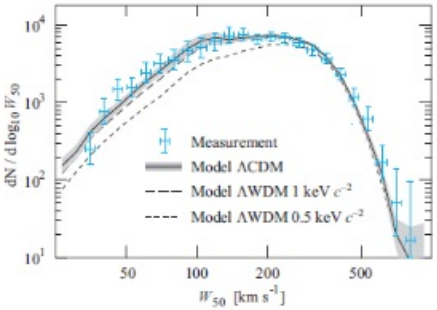
R. M. Quimby, F. Yuan, C. Akerlof, J. C. Wheeler in Monthly Notices of the Royal Astronomical Society 431 "*Rates of Superluminous Supernovae at z ~ 0.2*"

Hydrogen emission useful in measuring temperature of Dark Matter

To more accurately constrain Dark Matter models, an international research team, led by CAASTRO member Dr Danail Obreschkow (ICRAR-UWA), recently published a detailed analysis of galaxy rotation values as obtained by observational and simulated data. Obreschkow et al. compared data from HIPASS (HI Parkes All Sky Survey), a blind search for HI emission, with simulations from S3-SAX, the first semi-analytic cosmological model of resolved HI emission lines of galaxies based on the Millennium simulation.

Key to their comparison was to apply the same set of selection criteria to both data sets, such as limits of galaxy inclination angles, which reduced the number of samples available in each set but yielded a high level of confidence into the statistics of HI line profiles. They counted and binned the number of galaxies according to specific properties: HI linewidth, circular velocity, and HI mass.

All three properties were found to be reasonably consistent across the two data sets. Linewidth stood out as the best match where only the largest values in the observational data were identified as confused sources: galaxies in the same telescope beam with HI line profiles overlapping in frequency. HI mass counts were moderately consistent with a small bump at ~4 x 10^8 solar masses – which was found to be a feature of this particular semi-analytic model, absent in other models building on the Millennium simulation. Only velocity values differed more strongly, with sources at low velocities



(<50km s^{-1}) having been identified as optically faint or irregular with a wrongly identified inclination angle.

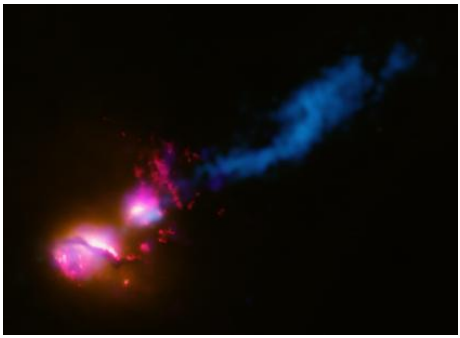
Source counts were generally in better agreement than space densities, due to the fact that, at the high end of the velocity function, HIPASS was dominated by gas-poor, fast-rotating, early-type galaxies, simply not detectable by HIPASS. The research team then compared their HI linewidth results with three different Dark Matter models (Cold Dark Matter and two Warm Dark Matter of different particle mass). If all free parameters were independently constrained, HI linewidth could be used to differentiate between models and was best aligned with the Cold Dark Matter model.

Publication details:

D. Obreschkow, X. Ma, M. Meyer, C. Power, M. Zwaan, L. Staveley-Smith, M. J. Drinkwater in The Astrophysical Journal 766 "*Confronting Cold Dark Matter predictions with observed galaxy rotations*"

High frequency X-ray and radio emission from AGN not correlated

Our Sydney based researcher Dr Davide Burlon, together with other CAASTRO members and colleagues from Australia, Italy, and the US, looked for counterparts of X-ray sources at high radio frequencies to better understand and characterise the core properties of Active Galactic Nuclei (AGN). It had previously been suggested that radio and X-ray emissions were correlated, indicating that all X-ray emitting AGN were also radio emitters, at least at low radio frequencies, with some of these sources (~10%) launching relativistic radio jets ('blazars'). The research team used six years of X-ray data from the Burst Alert Telescope (BAT), mounted on the Swift satellite and currently providing the deepest unbiased scan of the sky at 15-55keV, and data from the Australia Telescope Compact Array AT20G survey, one of largest blind surveys from the ground at 20GHz. Both of these surveys cover vast areas of the sky (AT20G ~20,000 square degrees of the southern sky).



The team's Bayesian cross-matching algorithm found 37 matching AGN in the two data sets. Of these sources, 19 were identified as local Seyfert galaxies that are traditionally considered to be radio-quiet but are radio emitting at low levels; the other 18 sources were distant blazars. The apparent relation between X-ray and radio luminosities could be exclusively attributed to the distance of these sources. The team also tested for an effect of angular resolution but filtering their

results down to the 21 most "compact" AGN still did not reveal any correlation.

In their recent publication in the Monthly Notices of the Royal Astronomical Society, the researchers conclude that the absence of such a correlation must be a genuine core property. Only an estimated ~20% of X-ray sources actually had radio counterparts, of which, not surprisingly, blazars had a higher detection rate of ~65% compared to Seyfert galaxies at ~14%.

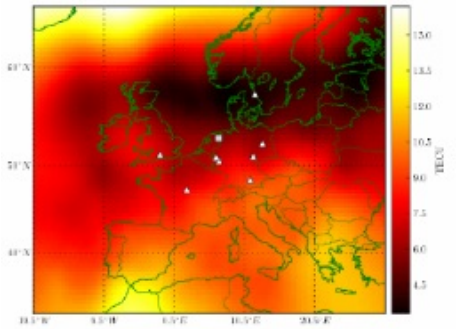
Publication details:

D. Burlon, G. Ghirlanda, T. Murphy, R. Chhetri, E. Sadler, M. Ajello in the Monthly Notices of the Royal Astronomical Society 431 "*The AT20G view of Swift/BAT selected AGN: high frequency radio waves meet hard X-rays*"

Telescope arrays measure how ionosphere affects pulsar signals

Precise measurements of the effect of the Interstellar Medium and the Earth's ionosphere on incoming radio waves, so-called Faraday Rotation, promise to be a powerful tool to map the structure of the Galactic magnetic field. In a recent publication in the journal Astronomy & Astrophysics, an international research team provides evidence that their approach to measuring Faraday Rotation will be applicable to Phase I of the Square Kilometre Array at low radio frequencies, using pulsars, without the need for Global Positioning System receivers at each observation station.

CAASTRO members Dr Martin Bell and Prof Michael Kramer contributed to LOFAR commissioning and are co-authors on this publication. The team presents their publicly available, Python-based code ionFR and demonstrate its performance in calculating rotation measures from the position of the source in sky, the geographic location of the observing site, the date of observation, and a ionospheric map (e.g. from the Center for Orbit Determination in Europe or the Royal Observatory of Belgium, as used here). Results from the model are compared to observational data for pulsars from two observing sessions (in 2009 and 2011) with LOFAR, the Low-Frequency Array for Radio Astronomy, and the Westerbork Synthesis Radio Telescope (in 2005 and archival data), both located in The Netherlands.



The researchers found their model agreed well with the observations from both instruments, generating an error of less

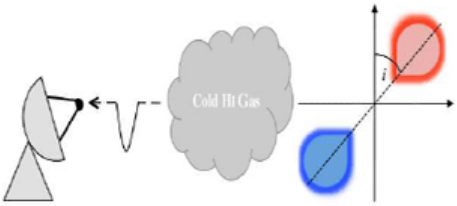
than 0.1 rad m^{-2}. All measurements are consistent with previously published data for these particular pulsars but are more precise. The study therefore convincingly verifies ionF as a tool to derive Faraday Rotations from interferometric imaging data. This is an important contribution to pre-SKA science and highlights the need for high-precision calibration procedures for the analysis of data from next generation radio telescopes.

Publication details:

C. Sotomayor-Beltran, C. Sobey, J. W. T. Hessels, G. de Bruyn, A. Noutsos, A. Alexov, J. Anderson, A. Asgekar, I. M. Avruch, R. Beck, M. E. Bell, M. R. Bell, M. J. Bentum, G. Bernardi, P. Best, L. Birzan, A. Bonafede, F. Breitling, J. Broderick, W. N. Brouw, M. Brüggen, B. Ciardi, F. de Gasperin, R.-J. Dettmar, A. van Duin, S. Duscha, J. Eislöffel, H. Falcke, R. A. Fallows, R. Fender, C. Ferrari, W. Frieswijk, M. A. Garrett, J. Griessmeier, T. Grit, A. W. Gunst, T. E. Hassall, G. Heald, M. Hoeft, A. Horneffer, M. Iacobelli, E. Juette, A. Karastergiou, E. Keane, J. Kohler, M. Kramer, V. I. Kondratiev, L. V. E. Koopmans, M. Kuniyoshi, G. Kuper, J. van Leeuwen, P. Maat, G. Macario, S. Markoff, J. P. McKean, D. D. Mulcahy, H. Munk, E. Orru, H. Paas, M. Pandey-Pommier, M. Pilia, R. Pizzo, A. G. Polatidis, W. Reich, H. Röttgering, M. Serylak, J. Sluman, B. W. Stappers, M. Tagger, Y. Tang, C. Tasse, S. ter Veen, R. Vermeulen, R. J. van Weeren, R. A. M. J. Wijers, S. J. Wijnholds, M. W. Wise, O. Wucknitz, S. Yatawatta, P. Zarka in Astronomy & Astrophysics 552 "*Calibrating High-Precision Faraday Rotation Measurements for LOFAR and the Next Generation of Low-Frequency Radio Telescopes*"

Detection of hydrogen depends on geometry of illuminating source

Reservoirs of neutral hydrogen gas in galaxies provide the raw fuel for star formation in the Universe. Over the past decade several groups have used studies of the 21-cm wavelength absorption of radio emission in clouds of atomic hydrogen (HI), to claim that the density of HI gas is somehow anti-correlated with the extent of the radio emission from the centre of the host galaxy. In a new study, researchers based at CAASTRO's node at The University of Sydney and at CSIRO, have shown that this correlation can instead be explained by simple geometric arguments.



These previous studies claim that smaller radio sources could arise in a denser absorbing medium, where the radio-emitting plasma jets are either trapped (the frustration scenario) or are yet to reach their full extent (the youth scenario). This interpretation of the observational data, however, relies on the assumption of a common gas temperature for each galaxy in order to convert the measured absorption strength into a gas density.

By considering the factors that determine the observed depth of the absorption, the team found that it is not necessarily driven by a trend in the gas density, reliant on the assumption of a common temperature, but simply that the intercepted area of background radio emission changes with source size. Their model consisted of a double-lobed radio source in which the lobe sizes, shapes and separations could be varied. It also allowed the density and "clumpiness" of the absorbing medium to be varied. From this, the observed data were best reproduced by lobes that resembled one of the two Fanaroff & Riley

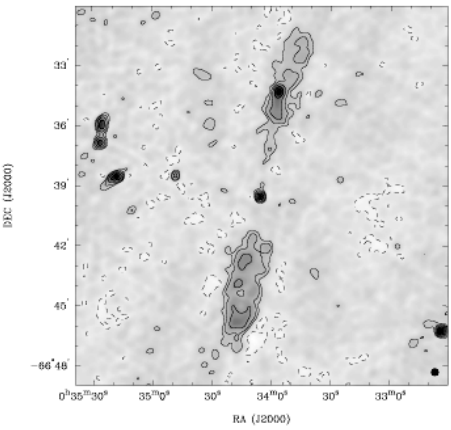
classifications (i.e. FRI and FRII) and a non-uniformly dense absorbing medium. A peak in the detection of 21-cm absorption was found for a radio emission extent of 100 – 1000 Parsec, this 'resonance' thereby suggesting that this is the typical size of an absorbing cloud.

Publication details:

S. J. Curran, J. R. Allison, M. Glowacki, M. T. Whiting, E. M. Sadler in the Monthly Notices of the Royal Astronomical Society 431 "*On the H I column density–radio source size anti-correlation in compact radio sources*"

Can Giant Radio Galaxies teach us about cosmology?

In a recent publication by Jurek Malarecki, our Deputy Director Prof Lister Staveley-Smith's PhD student at ICRAR-UWA, CAASTRO partner Prof Ravi Subrahmanyan (Raman Research Institute in India), CAASTRO Affiliate Dr Alan Duffy (University of Melbourne), and their co-authors tested whether the morphology of giant radio galaxies can give insights into Warm-Hot Intergalactic Medium (WHIM) gas. The WHIM has been predicted to contain half the baryons in the Universe but has not yet been conclusively detected. Giant galaxies might be a suitable tool to study WHIM gas due to their large extent and assumed older age, implying more interaction with the gas and potential disruptions in galaxy evolution and perturbations to their morphology.



The team limited their radio observations at 2.1 GHz with the Australia Telescope Compact Array to galaxies of redshift up to 0.15 to also allow for optical spectroscopic observations. In their sample of twelve giant radio galaxies, they found varied morphologies, some of which indicated restarted nuclear activity and some of which showed faint extended emission beyond the previously known source, possibly revealing relic emission from a previous active phase. The team also observed three of the galaxies with the AAOmega spectrograph on the Anglo-Australian Telescope and identified two as Type II Seyfert galaxies and one as an early-type galaxy.

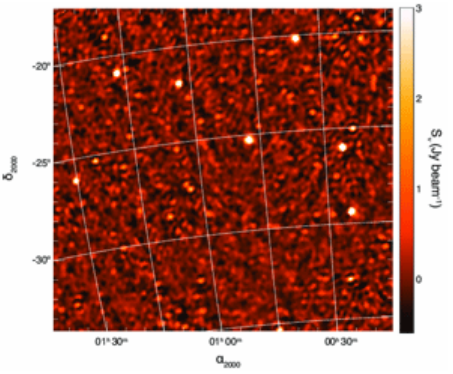
While the Lorentz factor, a measure of electron energy, is usually calculated from X-ray data, the co-authors used their sample of giant radio galaxies to calculate the pressure in galaxy lobes, assuming these galaxies were old enough to have reached equilibrium. Their calculations produced pressures that extend below the X-ray inferred values from observations of galaxy filaments and temperatures in excess of $10^{6.5}$ Kelvin. The conclusion from this is that giant radio galaxies in equilibrium are likely a minority in Universe. Surveys with the Australian SKA Pathfinder will be able to detect fainter giant radio galaxies and address their relevance for cosmology.

Publication details:

J. M. Malarecki, L. Staveley-Smith, L. Saripalli, R. Subrahmmanyan, D. H. Jones, A. R. Duffy, M. Rioja in Monthly Notices of the Royal Astronomical Society 432 "*Giant Radio Galaxies: I. Intergalactic Barometers*"

New study improves data calibration for MWA polarisation surveys

Low frequency radio telescopes have recently been developed to search for and ultimately detect faint signals from the Epoch of Reionisation (EoR) during the first billion years of the Universe's history. A publication by members of the Murchison Widefield Array (MWA) consortium presents an analysis of the instrument's early smaller prototype ("32T"). The large field of view of the MWA and its capability to observe at frequencies below 200 MHz fill a gap left by previous surveys that have never been able to generate wide-band data on polarised Galactic diffuse emission and extragalactic radio sources. Galactic and extragalactic polarised emission is important to characterise and account for when searching for signals from the EoR.



The present zenith drift-scan observations covered a 2400 square degree field of view and were made at a central frequency of 189 MHz, with images being produced from 5-minute segments ("snapshots") that were then processed and combined into mosaics. The team detected 137 radio sources with flux densities above 4 Jy. From previous studies it was expected that a number of these sources would be polarised but the team's data analysis only identified a single polarised source (PMN J0351-2744) while all other sources exhibited polarisation fractions below 2%, as compared to 7% in previous surveys at 1.4 GHz.

The team also analysed the Rotation Measure of the well-studied radio Galaxy Fornax A but did not detect point source polarisation. Diffuse polarised emission, however, was abundant in 20° strips of Galactic latitude and showed up in patchy and filamentary patterns. This survey, which was sensitive up to angular scales of ~4°, revealed a polarisation peak of ~13 K and Faraday depths between 0-10 rad m^{-2}. Based on these measurements, the emission appears to arise from within a few hundred parsecs of Earth and may be the result of vorticity or shear in the local Interstellar Medium. Overall, this study confirmed that continuous improvements to the data processing and calibration procedures can make it possible to remove polarised foreground signals to detect the EoR.

Publication details:

G. Bernardi, L.J. Greenhill, D.A. Mitchell, S.M. Ord, B.J. Hazelton, B.M. Gaensler, A. de Oliveira-Costa, M.F. Morales, N. Udaya Shankar, R. Subrahmanyan, R.B. Wayth, E. Lenc, C.L. Williams, W. Arcus, S.B. Arora, D.G. Barnes, J.D. Bowman, F.H. Briggs, J.D. Bunton, R.J. Cappallo, B.E. Corey, A. Deshpande, L. deSouza, D. Emrich, R. Goeke, D. Herne, J.N. Hewitt, M. Johnston-Hollitt, D. Kaplan, J.C. Kasper, B.B. Kincaid, R. Koenig, E. Kratzenberg, C.J. Lonsdale, M.J. Lynch, S.R. McWhirter, E. Morgan, D. Oberoi, J. Pathikulangara, T. Prabu, R.A. Remillard, A.E.E. Rogers, A. Roshi, J.E. Salah, R.J. Sault, K.S. Srivani, J. Stevens, S.J. Tingay, M. Waterson, R.L. Webster, A.R. Whitney, A. Williams, J.S.B. Wyithe in The Astrophysical Journal 771 "*A 189 MHz, 2400 square degree polarization survey with the Murchison Widefield Array 32-element prototype*"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