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<td>Arias</td>
<td>Maria</td>
<td><a href="mailto:maria.arias.de.saavedra@gmail.com">maria.arias.de.saavedra@gmail.com</a></td>
<td>Supernova Remnants at Low Frequencies</td>
<td>The LOw Frequency ARray (LOFAR) offers very interesting possibilities for the study of supernova remnants (SNR), whose steep spectral indexes render them more dominant at low frequencies. Apart from the potential to discover new SNRs thanks to its large field of view, LOFAR's sensitivity and angular resolution allow for more detailed studies of the closer, bigger SNRs than had been previously possible at this relatively unexplored radio window. We are currently studying two kinds of low frequency processes happening at LOFAR frequencies in SNRs: absorption (both internal and external free-free absorption), and intrinsic spectral differences caused by non-homogeneous populations of electrons, and shock physics. In this poster I intend to present our initial results from LOFAR imaging of three SNRs: Cassiopeia A, VRO42.05.01, and HB9. In the LBA, Cas A shows features of low frequency absorption from the unshocked ejecta in front of the synchrotron emitting shell. Part of our work is to disentangle this absorption from that of the interstellar medium along the line of sight. The other two are mixed-morphology SNRs, characterized by displaying thermal X-ray emission inside a radio shell. Some MMSNRs are known to have spectral index segregation, with faint steep spectral regions and bright flat spectral regions. We have HBA images of both VRO 42.05.01 and HB9 which we will compare to higher frequency images and molecular cloud catalogs to explore local variations in the spectral index and their correlation with density. This is part of a larger study of how SNRs expand in higher density environments.</td>
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<td>Solar Regions with Low Brightness Temperature in Microwaves and Very Long Waves</td>
<td>The attention to low brightness temperature regions (LTR, coronal-hole like structures, coronal partings) of the solar corona as some expected source of the slow solar wind appeared some years ago. Some authors suggest that LTR are associated with the areas of the depressed emission in soft X-rays and in EUV lines, as well as with the open-field regions. The analysis of microwave spectral polarimetric observations performed with Ventspils International Radio Astronomy Center (VIRAC) RT-32 radio telescope, Metsahovi Radio Observatory (MRO) VRO-14 radio telescope and Nobeyama Radio Heliograph (NoRH) showed the close association of LTR depressed microwave emissions in the chromosphere and lower corona with the open magnetic field on the periphery of two active regions. The analysis of LTR long waves emission observations with LOFAR is necessary to reconstruct the open-field structure, to evaluate the plasma density and to prove the assumption about the coronal plasma flow along open magnetic field lines to outer space crossing all layers of the corona. LOFAR solar observations provide a sufficient spatial resolution and accuracy to complement the microwave solar observations. The presentation discusses possibilities and eventual results of a joint analysis of microwave and LOFAR solar observations in order to clarify LTR general structures.</td>
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<td>Bonmassieux</td>
<td>Etienne</td>
<td><a href="mailto:etienne.bonmassieux@obspm.fr">etienne.bonmassieux@obspm.fr</a></td>
<td>On the variation of radio interometric calibration: Quality-based</td>
<td>Authors: Etienne Bonmassieux, Cyril Tasse, Oleg Smirnov, Philippe Zarka. We propose visibility weighting schemes based on calibration quality, as determined by the corresponding residual visibilities. We show the analytical work leading to the proposed weighting schemes, and test their impact on both simulated residuals and real data. Simulation results are consistent with my analytical predictions, and applying the weighting scheme to real data improves dynamic range at negligible computational cost.</td>
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<td>Botteon</td>
<td>Andrea</td>
<td><a href="mailto:botteon@ira.inaf.it">botteon@ira.inaf.it</a></td>
<td>LOFAR observation of the complex merger in Abell 1758</td>
<td>Diffuse radio emission in the intra-cluster medium (ICM) is observed in a number of merging galaxy clusters. Turbulence and shocks produced in the ICM can lead to the formation of steep synchrotron sources on Mpc scales known as radio halos and radio relics, respectively. In particular, a key prediction of turbulent re-acceleration models is the existence of a large population of radio halos with very steep spectrum that should become visible at low radio frequencies. LOFAR for the first time allows to study cluster-scale emission at low frequency with unprecedented resolution and sensitivity. Abell 1758 is a galaxy cluster in a complex merger state. X-ray and SZ observations revealed the presence of the two main cluster components, A1758N and A1758S, separated by 8 arcmin while literature radio data revealed the presence of a radio halo in the northern system A1758N. I will present the results from a LOFAR Tier 1 pointing on this cluster. The 150 MHz observation reveals the presence of a radio halo also in the southern A1758S system that is not detected with the GMRT at 330 MHz and with the VLA at 1.4 GHz. I will discuss the implications of the detection of this double radio halo for the models of particle acceleration in the ICM.</td>
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<td>Byrne</td>
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<td><a href="mailto:rbyrne@uw.edu">rbyrne@uw.edu</a></td>
<td>Precision Foreground Modeling for Southern Hemisphere Epoch of Reionization Measurements</td>
<td>A successful detection of the signal from the Epoch of Reionization (EoR) will require the utmost precision in every step of the measurement process. One critical component of an EoR measurement is the foreground model, which is used for instrument calibration and foreground subtraction. Improper and/or erroneous foregrounds for EoR experiments must include both point-like sources and diffuse emission. The Murrieta Widefield Array (MWA) in Western Australia is uniquely suited to foreground modeling because of its wide field of view and excellent UV coverage. We present progress toward a fully-polarized precision foreground model of a large swath of the Southern sky based on a data set taken with the MWA in late 2025. This model will include diffuse emission and could benefit upcoming Southern Hemisphere EoR experiments.</td>
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Revealing remnant radio galaxies in the Lockman Hole with LOFAR

In the study of radio galaxies, the phase after the jets have switched off, the remnant phase, is still very poorly understood and very few sources in this stage are known. Using LOFAR observations at 150 MHz, combined with public surveys at higher frequencies, we have performed an extensive search of remnant radio galaxies in the Lockman Hole region and we have identified 24 candidate sources. For the first time we have combined the classical ultra-steep spectrum criterion with morphological criteria for the selection. This helps us to identify remnants that cover the entire evolutionary sequence from when the core switches off to later stages of the evolution. Interestingly, we find that ultra-steep spectrum remnants represent only a fraction of our remnant sample, contrary to what classically suggested. This finding is also supported by the results that we have obtained from mock catalogues of radio galaxies. These were produced using Monte-Carlo simulations based on existing spectral and dynamical evolution models combined with observed source properties. We use these simulations to derive first order predictions of the fraction of remnants in radio flux limited samples, for comparison with our Lockman hole sample. We find that, using appropriate dynamical models for the radio galaxy evolution, our simulations produce fractions of remnant sources consistent with observations. In this talk I summarise the results of our empirical search and simulations as well as discuss our plan to expand this study to the entire LoTSS survey to enable a statistical investigation of the remnant properties over bigger samples.

Offset BCG-Xray Peak vs morphological parameters. JVLA observation of a high z MACS sample.

Morphological parameters are among the most powerful indicators of the dynamical state of galaxy clusters. Another simply but robust tool is represented by the BCG/Xray-Peak offset. Their comparison, lights the question “relaxed/non relaxed clusters” from another point of view. Is under JVLA investigation a wide sample of MACS high redshift galaxy clusters with the aim to improve the knowledge of diffuse radio emission at high z: first results of the imaging analysis.

Commensal Low Frequency Observing at the VLA: VLITE to LOBO

The VLA Low-band Ionosphere and Transient Experiment (VLITE) is a commensal low-frequency observing system that has been operational for the past two years on the NRAO VLA. The separate optical paths of the prime-focus sub-GHz dipole feeds and the Cassegrain-focus 1-50 GHz feeds allow both systems to operate simultaneously with separate correlators. The initial two years of VLITE operation provided real-time correlation of 10 antennas across the 320-384 MHz band with a total observing time approaching 12000 hours. We present an overview of the VLITE system, including highlights of the complexities of a commensal-observing program, space-array challenges, and scientific capabilities from our science-ready data pipeline. Looking forward in the near term, we are enhancing the VLITE correlator to allow data recording during the upcoming rapid-scanning VLA Sky Survey (VLASS) that will operate for 5400 hours in the VLA B configurations starting in 2017. In addition, we are expanding VLITE during the summer of 2017 to double the number of baselines to improve the stability and image fidelity. In the longer term, we seek a path to broadband expansion across all VLA antennas to develop a powerful new (Low-Band Observatory) LOBO.

Far Beyond Stacking in the Confusion Regime

Measuring radio source counts is critical for characterizing new extragalactic populations, brings a wealth of science within reach and will inform forecasts for SKA and its pathfinders. One way to push the counts to faint levels is via ‘stacking’, using the position information from another catalogue at higher resolution and (often) a different wavelength to extract the faint source flux. For the first time, we adopt the stacking method at the quasi-confusion limit. We test stacking in a fully Bayesian framework, applying it to the Square Kilometre Array Design Study (SKADS) simulation. The previous studies showed the counts is highly biased when confusion comes into play. With our method, the source counts is recovered correctly after considering the confusion effect in stacking method. This method is extremely useful for the upcoming radio surveys to undertake panchromatic joint analyses.
The impact of low frequency observations on the study of blazars and other gamma-ray sources

Low-frequency radio arrays are opening a new window for the study of the sky, both to study new phenomena and to better characterise known source classes. Being flat-spectrum sources, blazars are so far poorly studied at low radio frequencies. We study the spectral properties of the blazar population at low radio frequency and compare the radio and high-energy properties of the gamma-ray blazar population. We first present the results of a cross-correlation of the Murchison Widefield Array Commissioning Survey (MWACS) catalogue with the Roma blazar catalogue and the third catalogue of active galactic nuclei detected by Fermi-LAT. We find low-frequency counterparts for 186 out of 517 (36%) blazars, 79 out of 174 (45%) gamma-ray blazars, and 8 out of 73 (11%) gamma-ray blazar candidates. The mean low-frequency (120-180 MHz) blazar spectra are flatter than the rest of the population of low frequency sources, but are steeper than at GHz frequencies. Low-frequency radio flux density and gamma-ray energy flux display a mildly significant and broadly scattered correlation. We further show the preliminary results of a similar study performed on the wider and deeper Galactic and Extragalactic All-Sky MWA (GLEAM) survey and discuss how low frequency surveys can also be useful in the identification and characterisation of unassociated gamma-ray sources.
Abell 115 is a massive merging galaxy cluster. X-ray studies revealed a double peak in the surface brightness and a cold front associated with northern subcluster. The northern subcluster hosts a very luminous, disturbed radio galaxy, 3C28. Goveo et al. (2001) discovered a moderately bright and extended diffuse radio source with a complex and puzzling morphology. We confirm this peculiar morphology with both the GMR at 610MHz and the WSRF at 350MHz (Dumba et al., 2015). Unfortunately, the resolution in these observations does not permit to unambiguously disentangle 3C28 from a large part of the relic emission. Here, we present first results of the study of the diverse and fascinating radio sources in Abell 115 with LOFAR HBA. We will discuss, in particular, the morphology and spectral index of 3C28, a narrow angle tail galaxy close to the relic, J0056+26 and several other interesting, extended radio sources in the field. Furthermore, we present initial LOFAR results on the radio relic. The brightness of 3C28 and its proximity to the relic necessitates a very high dynamic range imaging in order to recover the extended diffuse emission. We therefore discuss our strategies employed in order to achieve the necessary dynamic range.

Radio relics are sources of synchrotron emission found in downstream regions of galaxy cluster merger shocks. Diffusive shock acceleration paired with subsequent cooling has been considered as a comprehensive explanation for the origin of radio relics. Recent observational evidence is pointing to a more complex scenario. We present predictions from two large cosmological simulations (MiSIC2 and Cosmic Web) on the radio relic findings of upcoming radio surveys. A novel approach is used to standardize and automate the extraction of the morphological features of radio relics. We first investigated how well these simulations agree with the NRAO VLA Sky Survey (NVSS). Our model reproduces the power, size, shape and alignment of radio relics with respect to their host clusters. Our analysis suggests a completeness of the NVSS relic sample of about 40% for fluxes above 10 mJy. In the simulations, we find a large number of marginally resolved radio gush objects at redshifts $z > 0.4$ that are not detected by current surveys. We predict that these objects with an extent of less than 1 arcmin can be identified with high resolution surveys like LOFAR-Tier I.
The low radio frequency view of the Perseus cluster

In this talk, I will review this mechanism, called mechanical AGN feedback, focusing on its radio signature. More specifically, I will present new results on multi-configuration observations of the Perseus cluster from the Karl G. Jansky Very Large Array (JVLA) at 230-470 MHz, probing the old particles population of the AGN outflows. These observations reveal a multitude of new structures associated with the "mini-halo" extending to hundreds of kpc in size, that seems to be influenced both by the AGN activity and by the sloshing motion of the cluster' gas. In addition, it has a filamentary structure similar to that seen in radio relics found in merging clusters. These results illustrate the high-quality images that can be obtained with the new JVLA at low radio frequencies.

Anomalous pulsar scattering at LOFAR frequencies

Scatter broadened pulsar signals carry information of their paths travelled through the ionized interstellar medium (ISM). These imprints are best studied at low frequencies where they are exaggerated. The LOFAR HBA band provides ideal datasets for such studies: offering broad bands at low frequencies. We introduce an improved forward-fitting technique to analyse highly scatter broadened profiles. We study the scattering imprints of 13 pulsars with simple profile shapes, and find anomalously low scattering spectral indices ($\alpha$ values). Such low indices are likely due to either anisotropic scattering mechanisms or finite scattering screens. We discuss whether our data contains evidence for these. We revisit the empirical scattering time (tau) vs DM relation introduced by Bhat et al. 2004, showing how our results support a frequency dependence of alpha. Lastly we discuss ways of improving detailed ISM analysis at low frequencies.

The mysterious giant radio source 0917+75

The radio source 0917+75 is an elongated diffuse emission located in a region away from rich clusters. It was studied in the past in the radio (VLA) and X-band. Despite of these data its origin and nature is not clear: it was suggested that this source could be a radio halo, a relic or a diffuse emission from a large scale filament. We present here new LOFAR radio data and unpublished VLA data in total intensity and polarization to discuss the origin and properties of this peculiar source.

Interstellar medium studies below 200 MHz: LOFAR single stations and NenuFAR

International LOFAR stations, equipped with powerful backends, can be used as individual telescopes, and provide data sets complementary to those obtained with the LOFAR Core. Such "local mode" observations are particularly adapted to monitoring observations, where the advantage of having a high observing cadence (one observation per week) outweighs the reduced sensitivity of a single station when compared to the full array. With such observations, it is possible to monitor the temporal evolution of the pulsars’ behaviour via its dispersion, scattering, intensity, and profile shape. We will present ongoing studies performed in the LOFAR high band (110-190 MHz), recent observations in the LOFAR low band (10-90 MHz), and plans for the upcoming NenuFAR telescope.

The low-frequency view of radio mini-halos

Diffuse radio emission has been observed in a number of cool-core clusters of galaxies in the form of a so-called ‘mini-halo’ (MH), which surrounds the radio-loud AGN on scales comparable to that of the cooling region. The MH emission is believed to be truly generated from the intra-cluster medium and can be explained in the framework of leptonic models, which envision in situ particle re-acceleration by turbulence in the cool-core region. However, several fundamental questions about the physics of these sources are still unresolved, including the connection between MHs and gas dynamics of the hosting clusters. Obviously, one problem is the limited statistics that prevent us from drawing firm conclusions on the link between thermal and non-thermal phenomena in cool cores. In a recent pilot study (Gitti et al. 2015, AASKA) we showed that future radio surveys with SKA1 at ~1.4 GHz have the potential to detect hundreds of new MHs. In this contribution, we aim at extending the previous exploratory study to investigate for the first time the low-frequency case. By considering the minimum flux detectable in radio surveys and exploiting the correlation between radio power and cooling flow power observed for known MH clusters, we estimate the detection limits achievable by future radio observational follow-up of X-ray cluster samples, such as HIFLUGCS, eROSITA and Athena. In particular, we show that future radio surveys with LOFAR and SKA1 at ~140 MHz have the potential to increase the number to >>1000 radio MHs, thus producing a breakthrough in the study of these sources. We further investigate the MH number distribution with redshift as a function of the cluster magnetic field, and discuss the essential role of the synchrotron radiation from radio surveys with future X-ray observations and theoretical studies in establishing the radio MH physical nature.

A HERA-19 view of the sky

The HI Epoch of Reionization Array is a 350 dish, low frequency array planned to measure the redshifted 21-cm signal from the cosmic dawn throughout the epoch of reionization. With the first 19 dishes (HERA-19) already built at the Karoo site, I present a look at early data aimed to characterize the instrumental response and the sky seen by HERA-19.
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<td>Guidetti Daria</td>
<td><a href="mailto:guidetti@ira.inaf.it">guidetti@ira.inaf.it</a></td>
<td>AGN populations in GOODS-N through eMERGE ultra-deep JVLA observations</td>
<td>Multi-wavelength studies of deep radio fields show a composite population of star-forming galaxies, radio-quiet and radio-loud AGNs, with the former dominating at the lowest flux densities (&lt; 100 microJy). However, the exact mixture between these types of radio sources is still matter of debate. Assessing the faint AGN component in deep radio fields, will provide an important tool to understand the role of nuclear activity in distant galaxies and its possible co-evolution with star-formation processes. The most direct way to identify faint AGN-radio emission is the detection of embedded radio cores in the host galaxies, through ultra-deep, high resolution extinction free radio observations. This would open the perspective of studying the whole AGN population in the radio band, including the radio-quiet component traditionally selected at other wavelengths (opt/IR/X-ray). In my talk I will report about the e-MERLIN Galaxy Evolution Survey (eMERGE, PI: Meeth), a legacy project which aims at undertaking a spatially-resolved study of AGN and star formation processes up to redshift in a 30 arcmin diameter field in GOODS-N, through sub-microJy smss and sub-arcsec (50-500 mas) imaging at 1.4 and 5 GHz, using combined JVLA and eMERLIN observations. I will focus on the 5 GHz JVLA mosaic observations and catalogue of GOODS-N (54 sources), in the framework of the eMERGE project, and on the study of a larger sample of GOODS-N galaxies (300 objects) selected at 1.4 GHz, both to constrain the presence of AGN cores in moderate-to-high redshift (1&lt;z&lt;5) galaxies, via radio spectra-morphological analysis with the additional help of multi-wavelength information. Such kind of studies will be extended to much larger areas and deeper sensitivities with SKA.</td>
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<td>Hajduk Marcin</td>
<td><a href="mailto:marcin.hajduk@uwm.edu.pl">marcin.hajduk@uwm.edu.pl</a></td>
<td>Planetary Nebulae in Low Frequency Radio Surveys</td>
<td>We identified 49 planetary nebulae in interferometric radio surveys in the frequency range of 150-330 MHz. Nebular fluxes do not exceed the 1.4 GHz flux in this range in almost all cases. This indicates that observations below 1 GHz trace optically thick emission. Radio emission is dominated by free-free thermal emission of electrons. Radio spectra of selected objects are analysed in the range from 150-330 MHz up to 43 GHz. Spectral fits constrain electron temperature and emission measure in planetary nebulae.</td>
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<td>Hake Catherine</td>
<td><a href="mailto:catherinewriter@physics.ox.ac.uk">catherinewriter@physics.ox.ac.uk</a></td>
<td>Early Science with LOFAR Observations of the XMM-UMSS field</td>
<td>Radio observations, especially at low frequencies, provide a unique window into the extragalactic universe. The lack of dust attenuation at these frequencies, as well as the ability to trace both Star Forming Galaxies and Active Galactic Nuclei out to high redshifts through their synchrotron emission, means we can use LOFAR observations to trace the evolution of galaxies. This allows greater understanding of the physical processes influencing their evolution. In this talk I shall present the imaging and early science from LOFAR observations of the XMM-UMSS field. This field is challenging due to being at low declination (-4.5 degrees), and thus at low elevation to the LOFAR antennae. This has been a difficult field to image, but due to the wealth of multi-wavelength information available, it is an important field to study. I shall present information on the observations and the difficulties faced when reducing these data, before showing the final image of the field. I will then discuss the catalogue extracted from these observations as well as the interesting emission and sources that can be seen in this field at these low frequencies. I will then present early science that can be done with this data (e.g. spectral indices, clustering and source properties), emphasising the importance of the complementary data at other wavelengths and the further uses of multi-wavelength observations for understanding galaxy evolution.</td>
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<td>Iacobelli Marco</td>
<td><a href="mailto:iacobelli@astron.nl">iacobelli@astron.nl</a></td>
<td>MSSS view of known diffuse emission from Clusters of Galaxies</td>
<td>Extended diffuse radio sources found in an increasing number of merging cluster of galaxies are not associated with any individual cluster galaxy but with the intracluster medium (ICM). The merger processes and the mass of the cluster seem to be relevant for their formation, evolution and energetic. These sources are the evidence of the presence on large scales in clusters, of magnetic fields. These objects, which signature is the low surface brightness, steep spectral index and large angular and linear scales, are ideal targets for LOFAR and low frequency studies in general. A sample of clusters known to host diffuse radio emission has been selected and analysed from re-reprocessed data of the Multi-frequency Snapshot Sky Survey (MSSS). In this poster we will present preliminary results of the spectral index characterisation of this sample with respect to their position in the X-ray vs radio power plot.</td>
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<td><a href="mailto:balt.indermuehle@csiro.au">balt.indermuehle@csiro.au</a></td>
<td>RFI prediction and avoidance</td>
<td>Low-frequency radio sites are susceptible to radio frequency interference (RFI) from a collection of man-made interferences. To minimise their impact, low frequency observatories are often located away from populated areas. Even for these sites however, anomalous propagation of the “ducting” kind can lead to signals from far away population centres impinging on these otherwise radio quiet sites. Using customised instrumentation consisting of bespoke software and receivers, we have characterised the site of the Murchison Radio Observatory (MRO) in remote Western Australia (WA) during times when “ducting” was active. We describe the setup of the RFI system used to track all known emitters providing location information, including terrestrial mobile communications, aviation, rail, marine, and space based transmitters. We cross correlate these data with meteorological models and observational data derived from near real-time observations from the Japanese Himawari 8 satellite and use them to provide short term ducting predictions. We expose these predictions as a RESTful interface to any interested clients. Current telescopes such as the Australian Square Kilometre Array Pathfinder (ASKAP), which has now entered early science operations, as well as future telescopes such as the Square Kilometre Array (SKA), are able to use this information to integrate adaptive scheduling and priorisation observations that are least affected by the predicted conditions.</td>
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<td>Kozarev Kamen</td>
<td><a href="mailto:a_kuzn@iszf.irk.ru">a_kuzn@iszf.irk.ru</a></td>
<td>Detailed Radio Imaging of a CME with the Murchison Widefield Array</td>
<td>Solar radio observations allow us to constrain the dynamics of high energy electron beams accelerated in both flares and coronal mass ejections (CME). In particular, the synchrotron emission from erupting flux ropes would give important information about the distributions of energetic electrons trapped in the core of CMEs. The Murchison Widefield Array is particularly well-suited to imaging the Sun and solar transients at multiple frequency channels between 80 and 300 MHz. This instrument holds great promise for improving the status of direct CME radio imaging. We present high-frequency and time-resolution imaging observations of a CME, which occurred on November 4, 2015. The observations allow us to obtain detailed frequency spectra of the plasma and synchrotron emission. In addition, such observations provide independent information about the thermal electron density, as well as the evolution of the CME flux rope in its initial stages. The new observations demonstrate the capability of the MWA to contribute to the monitoring and detailed analysis of solar eruptions through its high sensitivity, high dynamic range radio imaging.</td>
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<td>Krankowski Andrzej</td>
<td><a href="mailto:kand@uwm.edu.pl">kand@uwm.edu.pl</a></td>
<td>Implementation of LT dedicated regional ionosphere maps to the low frequency radio observations</td>
<td>The high spatial and temporal resolution ionospheric products dedicated to the International LOFAR Telescope (ILT) purposes are produced in a result of arrangements made during 2016 LOFAR Ionospheric Workshop in Warsaw. The main idea is to introduce product that would replace the currently used global maps with improvement of the accuracy. The proposed product is based on the total electron content map (TEC) adjusted to the operational area of the ILT (44N to 55N in latitude and 11W to 25E in longitude) with the resolution of 0.5 degree. As for temporal resolution, two types of products are introduced: ILTF, five minutes averaged map and ILTQ, fifteen minutes averaged map. Maps are generated using information about the total electron content from the GNSS observations performed by 126 EUREF Permanent Network (EPN) stations. Obtained TEC values are computed into corresponding vertical values and interpolated into target grid using natural neighbour interpolation technique. ILTF and ILTQ products’ validity performs well when compared to the other GNSS-based ionospheric products and the radar all-modes JASON measurements and show noticeable accuracy improvement of the Faraday rotation observation with the LOFAR telescope. ILT CONEX files since 2012 are available via the dedicated ftp server.</td>
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<td>Kuikk Mark</td>
<td><a href="mailto:m.j.kuikk@uva.nl">m.j.kuikk@uva.nl</a></td>
<td>Searching for low frequency radio transients with AARTFAAC</td>
<td>The Amsterdam ASTRON Radio Transit Facility And Analysis Centre (AARTFAAC) is an add-on to the central 6 LOFAR stations. Built to create a real-time monitor for low-frequency radio transients, with the aim of triggering other observatories upon reliable detections. It does so by snapshot imaging the entire visible sky every second with a few 10s of arcmin resolution, and detections sensitivities of a few 10s of nJy/beam. AARTFAAC aims to search for the type of bright, low frequency radio transients previously discovered in archived LBA data by Stewart et al. 2016. We estimate that at current capabilities our system should be able to observe on the order of 3 of these events per 24 hours of observing. Furthermore our near real-time analysis capabilities will allow us to generate triggers for follow up observations with the full LOFAR array, and further multi-wavelength observations, with the hope of collecting data with higher spatial and spectral resolution, and sensitivity, to associate a potential progenitor or afterglow. I will report on the recent commissioning progress, which now allow us to generate science quality data for offline processing. Currently ~150 hours of archived data is being processed offline, which will improved the current limits on 1 second timescale low frequency radio transients by an order of magnitude in sky area and sensitivity. I will also report on the preliminary results of this transient survey and lessons learned, which will be applied to design and implement analysis and classification algorithms allowing AARTFAAC to achieve it’s full automated real-time detect-and-trigger potential.</td>
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<td>Kumetsov Alexey</td>
<td><a href="mailto:a_kuzn@iszf.irk.ru">a_kuzn@iszf.irk.ru</a></td>
<td>Fine spectral structures in a solar type IV radio burst observed with LOFAR</td>
<td>We present the first observations of a moving type IV solar radio burst with the Low Frequency Array (LOFAR). The burst was observed for about 2 hours on 20 June 2015 in the frequency range of 30-80 MHz with high spectral, temporal and spatial resolution. The dynamic spectrum consisted of multiple sporadic short (~15 s) broadband pulses; the pulses had a distinctive “hockey-stick” shape with fast (and frequency-dependent) negative frequency drift. Radio imaging revealed a loop-like structure over the limb, with three dominant emission sources: two footpoints and the loop top. The brightness temperature was typically a few $10^8$ K, but sometimes exceeded $10^9$ K. This suggests a plasma emission mechanism. We discuss the formation mechanism of the observed fine spectral structures; the emission characteristics seem to be affected strongly by the propagation effects.</td>
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<td>Lal</td>
<td>Dharan</td>
<td><a href="mailto:dharam@nasa.tifr.res.in">dharam@nasa.tifr.res.in</a></td>
<td>Dissecting Coma using upgraded GMRT: The importance of low frequency data</td>
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<td>The upgraded GMRT serves as a testbed to demonstrate wide band, wide field-of-view imaging at these low frequencies; an SKA pathfinder instrument is nearing completion and has begun operations. We conducted several test studies using phase II release of the uGMRT, and focus on understanding data quality, fidelity of new GMRT wide-band backend and challenges in uGMRT data reduction and analysis. Among several of these test studies, we would also present the detailed understanding of low radio frequency imaging with the upgraded GMRT of the Coma cluster, an important laboratory to study the role of cluster environment on the properties of the radio sources in the cluster that can be determined via their flux densities or their spectra. We discuss the importance of low-frequency, multi-wavelength radio imaging and the improvements that will be possible due to upgraded GMRT and the roles of Lofar and SKA.</td>
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<td>Pulsar observations using the PL612 POLFAR station.</td>
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<td>We present the first results of pulsar observations that were performed using the PL612 LOFAR station located in Bailey, near Olkusz, Poland. This station, governed by the University of Warmia and Mazury, is one of the three telescopes build in Poland by the POLFAR consortium. For the purpose of pulsar observations we use a software-based system that was modelled after the one developed by the members of GLOW consortium for the use with German LOFAR stations. The PL612 station is observing pulsars regularly since the autumn of 2016. First pulsar observational tests were also made using PL611 station in Lazy near Krakow. Using these telescopes we intend to study the properties of individual pulsars from pulsars such as subpulsar drifting or nulling and the properties of the average pulse such as moding. Pulsar observations will be also used to investigate the properties of interstellar medium, by studying the effects of interstellar scintillation and scattering. In this presentation we will show preliminary results concerning almost all of the above mentioned research aspects.</td>
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<td>Linford</td>
<td>Justin</td>
<td><a href="mailto:linford@gwu.edu">linford@gwu.edu</a></td>
<td>Searching for Radio Transients with VLITE</td>
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<td>The VLA Low Band Ionosphere and Transient Experiment (VLITE) is a commensal low frequency system on the Karl G. Jansky Very Large Array (VLA). Because the VLA repeatedly observes certain areas for either calibration purposes (e.g., 3C286 &amp; 3C48) or as part of deep imaging campaigns (e.g., CHILES), there are many opportunities to search for transient sources. Thanks to the tagging along with VLITE observations, VLITE has access to a large swath of parameter space previously unavailable to transient searches, from minute to year timescales. We are utilizing the LOFAR Transient Pipeline to search for transient sources on multiple timescales with VLITE. We present early results from VLITE image plane transient searches.</td>
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<td>Londale</td>
<td>Colin</td>
<td><a href="mailto:l3@haystack.mit.edu">l3@haystack.mit.edu</a></td>
<td>Astronomy experiments enabled by the RAPID array</td>
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<td>The Radio Array of Portable Interferometric Detectors (RAPID) is a new imaging interferometer system developed at MIT Haystack Observatory in collaboration with the University of Cambridge in the UK, and JPL. It is unique in that each array element is fully self-contained, highly portable, solar powered, and requires no cabling. Essentially, each element is a miniaturized low-frequency VLBI station with an independent clock and recording system, that can be shipped to any desired location, then picked up and moved by hand; correlation is performed offline, allowing processing elements to be fine-tuned in response to the observed behavior of target sources. The unparalleled flexibility of a RAPID array facilitates a wide variety of radio studies including a number of strong-signal astronomical applications. In this presentation, we focus on three such applications, specifically high-time, spectral and angular resolution imaging of the quiet and active Sun, astrometric measurements of jovian decimetric radiation, and wideband high-precision mapping of the galactic background synchrotron radiation. The extraordinary scientific potential of the RAPID system for these experiments, driven by customized, detailed sampling of the relevant radiation field, is highlighted.</td>
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<td>Mandal</td>
<td>Soumyajit</td>
<td><a href="mailto:mandal@strw.leidenuniv.nl">mandal@strw.leidenuniv.nl</a></td>
<td>LOFAR observations of the Lockman Hole field and the merging galaxy cluster ABELL 1914</td>
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<td>The Low Frequency Array (LOFAR) is a powerful survey instrument and particularly sensitive to steep spectrum diffuse objects. LOFAR data processing is challenging due to the data volume and the ionosphere, which, at low frequencies, needs to be calibrated as a function of time and location. In this talk, I will present our ongoing work on the <del>48 hours of LOFAR observation of the “Lockman hole” which is a well studied extra-galactic field with extensive multi-band ancillary data covering a wide range in frequency, essential for characterizing the physical and evolutionary properties of the various source populations detected in deep radio fields (mainly star-forming galaxies and AGNs). I will also present our work on the merging galaxy cluster Abell 1914 where we have analysed LOFAR (150MHz), GMRT (325MHz and 610MHz), VLA (1.4GHz), CFHT and Chandra observations allowing us to 1) Discover an ultra steep spectrum source (4C38.39; spectral index</del>2) that is probably not part of the previously claimed radio halo, 2) Discover a new candidate radio relic, 3) Study the structure of the previously claimed radio halo, which appears unique as it does not trace the distorted k-ray map. Using the deep, multi-frequency data available in the Lockman Hole, we will also be able detect ultra steep spectrum sources related with galaxy cluster mergers. One of our aims is to study the detailed astrophysical mechanisms that are responsible for creating extended ultra steep spectrum sources in galaxy clusters. We also aim to study the properties of the cluster’s non-thermal particles and magnetic fields.</td>
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<td>Machev</td>
<td>Alexandar</td>
<td><a href="mailto:apmachev@strw.leidenuniv.nl">apmachev@strw.leidenuniv.nl</a></td>
<td>Distributed Processing of LOFAR Data</td>
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<td>One of the goals of the LOFAR telescope is to conduct deep wide-field surveys. The LoTSS survey will observe 3100 fields, each of which needs to undergo several processing steps. In the span of five years, the total data produced will be close to 50 PB. These data rates require processing at locations with high-speed access to the archived data. To complete the LoTSS project, the processing software needs to be made portable and moved to high throughput clusters with a high bandwidth connection to the LTA. This work presents a framework that makes the LOFAR software portable, used to scale out LoTSS data reduction. Discussed are the high level details, implementation, data flow and results.</td>
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Performance test of QI-fitting in cosmic magnetism study

Cosmic magnetic field is ubiquitous in the universe and plays an important role in the understanding of the evolution and structure formation of astronomical objects. Also cosmic magnetism is one of the key sciences of the Square Kilometre Array and its precursors. In order to understand about the origin and evolution of the cosmic magnetic field, it is necessary to accurately draw the information of the cosmic magnetic field from the polarimetry such as the observation of synchrotron radio waves, and we use a method called Faraday tomography. Faraday tomography is a promising technique that constructs a Faraday spectrum representing a distribution of the polarized intensity and the cosmic magnetic field along the line of sight from the observed polarized intensity. According to this method, we can get the information about three-dimensional structure of not only the magnetic field strength but also thermal electrons and cosmic rays. Since all of the information is stored in the Faraday spectrum, we are studying to estimate the Faraday spectrum accurately from observed polarized intensity. One method for estimating the Faraday spectrum is called QI-fitting which is model fitting method. QI-fitting is performed in three steps as follows, the assumption of a model of the Faraday spectrum, comparing the model with the observation and the estimation of the best model parameters using Markov Chain Monte Carlo(MCMC) method, and an objective evaluation of the results using the information criterion called Akaike's Information Criterion(AIC) or Bayesian Information Criterion(BIC). In this study, we test a performance of the QI-fitting in the simple simulations and research how these criteria work as indicators of evaluation of QI-fitting.

The nature of the faint low-frequency radio source population

We present a multifrequency study into the nature of faint radio sources in a deep radio image with the Giant Metrewave Radio Telescope at 612 MHz covering 1.2 deg$^2$ of the ELAIS N1 region. We detect 2800 sources above 50 μJy beam$^{-1}$. By matching to multifrequency data, we obtain a redshift estimate for 63 per cent, with 29 per cent based on spectroscopy. For 35% of the sources with redshifts, we use radio and X-ray luminosity, optical spectroscopy, mid-infrared colours and 24 μm and IR to radio flux ratios to search for the presence of an active galactic nucleus (AGN). The analysis reveals a rapid change in the population as flux density decreases from >500 μJy to ~100 μJy. We find that 80.3 per cent of the objects show no evidence of AGN and have multiwavelength properties consistent with radio emission from star-forming galaxies (SFG). We classify 11.4 per cent as radio-quiet (RQ) AGN and the remaining 8.3 per cent as radio-loud (RL) AGN. The redshift of all populations extends to z > 3 with a median of ~2. The median radio and far-IR luminosity increases systematically from SFG, to RQ AGN and RL AGN. The median 24μm for SFG, 0.89 ± 0.01, is slightly below that for RQ AGN, 1.05 ± 0.03, and both differ substantially from the value for RL AGN of ~1.06 ± 0.07. However, SFG and RQ AGN show no significant difference in far-IR/radio ratios and have statistically indistinguishable star formation rates inferred from radio and far-IR luminosities. We conclude that radio emission from host galaxies of RL AGN in this flux density regime primarily from star formation activity.

Low-frequency observations of a hybrid blazar

Blazars constitute intriguing subclass of the active galactic nucleus. Their family includes BL Lacertae objects as well as flat-spectrum radio-loud quasars. These sources are characterized by rapid variation of the continuum and polarized flux, superluminal motions in their radio core and high-emergent GHz and even TeV gamma-ray emission. High dynamic range radio imaging of BL Lac objects sometimes reveals the presence of a diffuse, extended radio emission with the integrated luminosity exceeding, in several cases, the FRI/FRII division. Among them, there is quite unique source - "mini blazar" which merges the properties of BL Lac and FSRQ. With the help of the MWA VLA Sky Server and dedicated Giant Metrewave Radio Telescope observations, we have disclosed and investigated an extended structure of this hybrid object, which could be caused by a multiple jet activity of the central AGN.
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<tr>
<td>Polderman</td>
<td><a href="mailto:i.polderman@astro.ru.nl">i.polderman@astro.ru.nl</a></td>
<td>Lithium: Cosmic Ray Tomography with LOFAR LBA</td>
<td>In the low frequency radio regime, the Milky way emission is dominated by synchrotron radiation from low energy cosmic rays. By mapping this emission we will gain further knowledge of these cosmic rays. In this same low frequency regime, HI regions can be seen as absorption regions against the Galactic background radiation. By observing these regions with an interferometer we will be able to quantify the synchrotron emission being emitted behind the HI regions. Effectively, these HI regions divide the line of sight into multiple parts helping us gain dimensional information. Using dedicated LOFAR LBA observations we plan to significantly expand on the list of existing of lines of sight from literature and get better coverage of our galaxy. Combining all lines of sight gives us a map with the synchrotron emissivity in a large part of the Milky Way. From this map we can draw conclusions about the cosmic ray density by comparing it to different cosmic ray models.</td>
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<td>Pommeran</td>
<td><a href="mailto:mamtapan@gmail.com">mamtapan@gmail.com</a></td>
<td>Bright Cluster Galaxy and feedback in cool core clusters</td>
<td>Brightest Cluster Galaxies (BCGs) are the most luminous population of massive galaxies known within the cluster environment. Nearly all BCGs tend to show radio emission with radio jets varying in size from a few kpc to Mpc scale with various morphological and spectral details. At optical wavelengths many BCGs show ionised emission line (H-alpha) nebula with a range of different morphological structures and inner disc region with rotational velocities ranging from ~100 to several hundred km/s. In this paper we present a correlation between the disc and jet properties (alignment, radio power, rotational velocity, etc.) using the MSSS, GMRT, VLA and optical data on BCGs and discuss the impact of feedback and mergers in the cluster environment, in order understand the duty cycle (birth, evolution and death) of AGNs in cool core clusters.</td>
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<td>Pupillo</td>
<td><a href="mailto:g.pupillo@ira.inaf.it">g.pupillo@ira.inaf.it</a></td>
<td>Experimental characterisation and modelling of the antenna patterns of LOFAR</td>
<td>In April 2016, a joined Italian-Dutch team performed an experimental campaign at Esos (The Netherlands) to characterize the electromagnetic responses of the Low Band Antennas (LBAs) and High Band Antennas (HBAs) of a LOFAR station. The main aim of the measurement campaign was to validate/improve the beam models for the LOFAR stations including mutual coupling, i.e. without assuming that all element beams are equal. The measurement was carried out by using a radio-frequency transmitter installed on an Unmanned Aerial Vehicle (UAV) flying over the LOFAR station. Specifically, for the LBAs and HBAs, several crosstalks and more advanced flight strategies have been made through multiple element beam patterns at different frequencies. Data analysis is still in progress, however these measurements already demonstrated that we can reliably measure individual elements and tiles in a station, for which the far field condition is satisfied, despite the fact that this condition is not satisfied for the full station. By means of properly verified and &quot;tuned&quot; simulations, we can infer an improved description of the station beam pattern. Finally, we will point out the very interesting behaviour in the LBA response at the dipole resonance frequency, around 57 MHz.</td>
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<td>Roskowski</td>
<td><a href="mailto:jaro@astro.uni-hamburg.de">jaro@astro.uni-hamburg.de</a></td>
<td>Radio galaxies with LOFAR: relic emission from opposites scales</td>
<td>Divers in their age, scale and distance, the radio galaxies (RGs) are one of the imprints of the AGNs. One of the open questions regarding these objects is the phase of their activity. Because of their characteristic synchrotron emission, it is necessary to go to low frequencies in order to detect possible diffuse and extended emission. Indeed this emission would be the remaining of a previous activity, and, hence, show a steeper spectrum. New generation of radio telescopes such as LOFAR are thus extraordinary tools, which enable us to achieve our main goal and analyse different steps of RGs' evolution. Here we present our current work, which is focusing on the study of individual objects belonging to the two extremes of the RGs, with the principal use of this European radio interferometer. On one end, 4C33.33 is a member of the family of the oldest and biggest objects, the Giant RGs. Because of this expected very extended and faint emission, its mapping is still a challenge not only for the science case but also for the automated processing and imaging of the data. It is also demonstrating the possibility for users to contribute in the development of the reduction tools, as simultaneously learning to master them. On the other end, the most compact and youngest of RGs (CSS/GPS - such as 1159+6465 shown here) require the use of LOFAR European baselines to resolve them and to observe the older emission. Thus this work is a part of the current exhilarating difficulty to solve within the frame of an international collaboration; the extension of the LOFAR pipelines to all its stations.</td>
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<td>Savin</td>
<td><a href="mailto:federica.savin@hs.uni-hamburg.de">federica.savin@hs.uni-hamburg.de</a></td>
<td>Discovery of AGN radio remnants in galaxy groups with LOFAR</td>
<td>Radio remnant sources present steep spectra that make them ideal targets for low-frequency observations. Our aim is to search for radio remnant sources with the Low Frequency Array (LOFAR). We carried out an observation within the Tier-1 deep imaging LOFAR survey of the northern sky and used the facet calibration scheme to obtain an image with a sensitivity of 135 mJy/beam at 10.5”×6” resolution in the frequency range (120 - 168 MHz). We discovered an extended radio source located at center of the poor galaxy cluster MaxBCG 1099.31832+53.72503. We reveal the presence of a central radio galaxy embedded in radio diffuse emission with a projected linear size of 630 kpc at z = 0.18095. We studied the spectral properties of different regions of the source deriving a low-frequency spectral index map between LOFAR and GMRT images. GMRT images reach a sensitivity of 5.5 µJy/beam at 4.8”×4.8” resolution. The morphology of the central AGN in MaxBCG 1099.31832+53.72503 and the derived spectral index map allow us to classify the source as a Fanaroff-Riley type II (FR-II) radio remnant, fading away after the ceasing of its activity phase.</td>
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<td>Skrzypczak</td>
<td>Sebastian</td>
<td>Do we understand the cosmic dipole?</td>
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<td>Biny</td>
<td><a href="mailto:biny@ncra.tifr.res.in">biny@ncra.tifr.res.in</a></td>
<td>GMRT study of candidate X-shaped radio galaxies</td>
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<td>Shulevski</td>
<td>Aleksandar</td>
<td>AGN radio relics hosted by multi-core galaxies</td>
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<td>Siewert</td>
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<td>Estimation of the cosmic radio dipole</td>
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<td>Skrzypczak</td>
<td>Anna</td>
<td>Meterwavelength Single-pulse Polarimetric Emission Survey: Component Widths &amp; Profile Classification</td>
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<td>Tier Veen</td>
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<td>Localising Fast Radio Bursts with LOFAR</td>
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<td>Radio Recombination Lines from MB2 with LOFAR</td>
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The dipole of the cosmic microwave background defines a reference frame for cosmology. It is assumed since its discovery that the CMB dipole is caused by the proper motion of the Solar system. This hypothesis leads to the prediction that the corresponding Doppler shifts and aberration effects are universal to all frequencies. Thus the CMB frame is assumed to be the comoving frame of freely falling Friedmann observers, which is essential in the analysis of many cosmological observables such as the Hubble diagram. As any fundamental hypothesis, also the proper motion hypothesis must be tested. We present results from a suite of cosmic radio dipole measurements based on public continuum catalogues across frequencies. We find that the cosmic radio dipole agrees with the direction of the CMB dipole within errors but has an excess in amplitude which increases with wavelength (at between 2 and 3 sigma). The limitations and consequences of our finding are discussed. (T. Siewert submitted a poster which will cover the more technical aspects of parameter estimation, cleaning and masking of catalogs etc.)

The nature of X-shaped radio galaxies is a matter of considerable debate in the literature: Lal & Rao 2005 showed that the low-surface-brightness wings have flatter radio spectral slopes than the active lobes in 3C223.1, an X-shaped source, which is not compatible with any of the currently accepted models for their formation. The statistical understanding of nature of these sources is a must in order to investigate in detail the mechanism of the formation of X-shaped sources and hence we undertook a study of a large sample of (candidate) X-shaped sources gleaned from the VLA FIRST survey images using GMRT. Here, we present our preliminary results including GMRT images, spectral structure, etc.

Low frequency images of the radio sky are an ideal data set to search for remnants of AGN activity. I will describe the initial results of a search performed in the vicinity of massive multi core cluster galaxies using the LoTSS survey and discuss why these systems provide an ideal case for timing AGN duty cycles.

A detailed study of the structure of the pulsar profile as well as the individual profile components was conducted for the 123 pulsars observed in the Meterwavelength Single-pulse Polarimetric Emission Survey. Using the schemes developed by Rankin (1990, 1993a) we classified the profile morphology for all the pulsars in our sample. This resulted in 53 new classifications as well as 38 corrections. The different profile classes were associated with different physical parameters like, characteristic age, spin-down energy loss, etc. The availability of high quality single pulse data enabled us to separate the individual components of the profile in a large number of pulsars. We measured the 50% width of the components ($W_{50}$) and found the presence of a lower boundary line (LBL) for the distribution of $W_{50}$ with the pulser period ($P$). We constrained the boundary line performing quantile regression which served as a more robust estimate, independent of any geometrical assumptions. We corroborated a $P^{-0.5}$-dependence of the LBL for the individual components which was earlier reported for the overall profile width. In addition, we also established that the boundary was similar for both the core and conal components. However, our values for the boundary differed from previous studies, where the expected boundary was $2.45P^{−0.5} \pm 0.5$ at 1 GHz, while our corresponding value was $2.01P^{−0.5} \pm 0.5$. We also measured the separation between the adjacent components but these were not as well constrained as the component widths. The individual components are associated with the spinning process in the Inner Acceleration Region (IAR) of the pulsar magnetosphere. Our analysis demonstrates the specks in the IAR to be more densely packed than previously assumed. Performing the same analysis in LOFAR frequencies will help us to further the LBL because of the frequency to radius mapping.

Fast Radio Bursts (FRBs) are highly dispersed pulses, and therefore likely of extra-galactic origin, that have been discovered in recent years. For only one source an accurate position and redshift has been determined, proving this extra-galactic origin. This redshift is required for good energy estimates and to use the FRB as a probe to study intergalactic matter. Typically, FRBs are discovered by a single dish telescope offering poor resolution and thus not enabling us to find an association with a host galaxy. In this contribution I will explain how the Low Frequency Array (LOFAR) can be used to localise sources, even for one-off events, by immediate follow-up of self-triggered events or by events found by Effelsberg and APERTIF. I will also present results from a real-time Fast Radio Transient Search (FRATS) with LOFAR and discuss the expectations for low frequency detectability of FRBs.

Radio Recombination Lines (RRLs) have been detected in LOFAR observations of MB2. The first detection in the LBA frequency range (Morabito et al. 2014) complemented with our results using the High Band Antennae provide us with constraints on the physical properties of the cold gas component of the interstellar medium of this nearby galaxy.
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<td>Varenius</td>
<td><a href="mailto:eskil.varenius@shalmers.se">eskil.varenius@shalmers.se</a></td>
<td>Subsecond International LOFAR observations of nearby starburst galaxies at 150 MHz</td>
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<td>Vocks</td>
<td><a href="mailto:cvocks@aip.de">cvocks@aip.de</a></td>
<td>Interpretation of low-frequency images of the solar corona</td>
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<tr>
<td>West</td>
<td><a href="mailto:jennifer.west@dunlap.utoronto.ca">jennifer.west@dunlap.utoronto.ca</a></td>
<td>Cygnus loop: probing the two remnant scenario</td>
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<tr>
<td>Zucca</td>
<td><a href="mailto:pietro.zucca83@gmail.com">pietro.zucca83@gmail.com</a></td>
<td>Kinematics and shock locations of a spatial resolved solar type II radio burst with LOFAR.</td>
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We present new subarcsecond images of the galaxies Arp 299 and NGC4194 made with the International LOFAR telescope at 150 MHz. The main aim is to study in detail the structure of the low frequency radio emission from both AGN and star forming regions in these galaxies. The high spatial resolution allows us to separate compact emission from e.g AGN core and SNe from extended halos and outflows, and to study the structure of free-free absorption in the galaxy nuclei. We compare these new preliminary images with previously published subarcsecond LOFAR images of the nearby star forming galaxies M82 and Arp 220.

The solar corona is the hot, tenuous outer atmosphere of the Sun. It is highly structured due to coronal magnetic fields, but generally shows a barometric density profile along magnetic fields, for altitudes well below the sonic critical point that marks the transition towards the supersonic solar wind. If the Sun is observed at a given radio frequency, then the corona becomes opaque below the density level where that frequency corresponds to the local plasma frequency, that is a function of electron density only. LOFAR’s frequency range corresponds to the middle (high band) and upper (low band) corona. Since the refractive index of a plasma approaches zero for radio waves near the local plasma frequency, refraction effects become important. A ray path through the solar corona shows total reflectance and cannot connect a source that is located near the solar limb and at such a coronal height, where the wave frequency equals the local plasma frequency, with an observer on Earth. This has important consequences on the appearance of the low-frequency radio Sun under quiet conditions. The diameter of the radio Sun increases with decreasing frequency, as expected from the relationship between electron density and plasma frequency. But it does not appear as a disk with constant brightness temperature, even for an isothermal corona. So deriving the radius of the radio Sun requires fitting of observed intensity profiles to ray-tracing simulations, based on free-free radio wave emission and absorption, as well as refraction. These simulations also depend on the plasma conditions above that radius. LOFAR’s capability of simultaneously observing a broad frequency range enables the derivation of a consistent coronal density model. We’ll present results for solar coronal density and temperature profiles based on LOFAR low band images.

The Cygnus Loop is a well-studied supernova remnant (SNR) that has been observed across the electromagnetic spectrum, however existing low frequency observations are very low resolution. Although widely believed to be an SNR itself with a blow-out region in the south, we are considering the possibility that this object is two distinct but interacting SNRs. This interpretation is motivated by large differences in observed polarization properties across the SNR. We believe that these differences imply differences in age and/or explosion environment. LOFAR data will provide a critical information that can help disentangle the thermal and synchrotron radiation components. In addition the possibility of detecting LOFAR polarization is very exciting.

Type II radio bursts are evidence of shocks in the solar atmosphere emitting radio waves ranging from metric to kilometric lengths. These shocks may be associated with coronal mass ejections (CMEs) reaching super-Alfvénic speeds. Radio imaging of the decimeter wavelengths is now possible with the Low Frequency Array (LOFAR), opening a new radio window to study coronal radio shocks leaving the inner solar corona and entering the interplanetary medium and understand their association with CMEs. Here, we study a coronal shock associated with a CME and type II radio burst to determine the location where the shock is triggered in relation to the propagating CME, the ambient medium Alfvén speed and the orientation of the coronal magnetic field. The type II shock imaging and spectra were obtained using 95 simultaneous tied-array beams of LOFAR while the CME was observed by the Large Angle and Spectrometric Coronagraph (LASCO) on board the Solar and Heliospheric Observatory (SOHO). Using the tied array beam observing mode of LOFAR we were able to locate the type II radio shock position between 45 and 75 MHz and relate it to the expanding flank of a CME leaving the inner corona. The radio emission associated with the type II shock was found to be located at the flank of the CME in a region where the mach number is between 1.5 to 2.0 and the shock geometry is quasi-perpendicular.