Radio 2017

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Würzburg, Festung Marienberg

Book of Abstracts

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Welcome

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Science symposium / 2

Imaging the spatial, spectral, and temporal sky via information field theory

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Information field theory (IFT), the information theory for fields, permits the derivation of imaging algorithms, which are optimized for specific measurement situations. I will present the current state of the IFT algorithms RESOLVE and D3PO for radio synthesis and γ/X-ray imaging, respectively, highlight scientific results obtained with them, and discuss their future evolution.

Science symposium / 5

High Frequency Cluster Radio Galaxies: Luminosity Functions and Implications for SZE Selected Cluster Samples

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We study the overdensity of point sources in the direction of X-ray-selected galaxy clusters from the Meta-Catalog of X-ray detected Clusters of galaxies (MCXC; $\langle z \rangle = 0.14$) at South Pole Telescope (SPT) and Sydney University Molonglo Sky Survey (SUMSS) frequencies. Flux densities at 95, 150 and 220~GHz are extracted from the 2500~deg^2 SPT-SZ survey maps at the locations of SUMSS sources, producing a multi-frequency catalog of radio galaxies.
In the direction of massive galaxy clusters, the radio galaxy flux densities at 95 and 150~GHz are biased low by the cluster Sunyaev-Zel'dovich Effect (SZE) signal, which is negative at these frequencies. We employ a cluster SZE model to remove the expected flux bias and then study these corrected source catalogs. We find that the high frequency radio galaxies are centrally concentrated within the clusters and that their luminosity functions (LFs) exhibit amplitudes that are characteristically an order of magnitude lower than the cluster LF at 843~MHz. We use the 150~GHz LF to estimate the impact of cluster radio galaxies on an SPT-SZ like survey. The radio galaxy flux typically produces a small bias on the SZE signal and has negligible impact on the observed scatter in the SZE mass-observable relation. If we assume there is no redshift evolution in the radio galaxy LF then 1.8 ± 0.7~percent of the clusters with detection significance $\xi \geq 4.5$ would be lost from the sample. Allowing for redshift evolution of the form $(1+z)^{2.5}$ increases the incompleteness to 5.6 ± 1.0~percent. Improved constraints on the evolution of the cluster radio galaxy LF require a larger cluster sample extending to higher redshift.

Summary:

We use the MCXC catalog of galaxy clusters, the SUMSS catalog of radio galaxies, and the SPT-SZ survey maps to measure the overdensity of radio galaxies associated with clusters. We construct radio galaxy LFs and radial profiles at 843~MHz, 95~GHz, 150~GHz and 220~GHz. The MCXC systems in the SPT-SZ and SUMSS regions have a median redshift $z \sim 0.1$, and the highest redshift system is at $z = 0.686$. There are 139 MCXC objects in the SPT-SZ region and 333 in the SUMSS region; they span the mass range from groups to clusters with a median mass $M_{500} = 1.5 \times 10^{14}\mathrm{M}_{\odot}$ and $M_{500} = 1.7 \times 10^{14}\mathrm{M}_{\odot}$ in the SPT-SZ and SUMSS regions, respectively.

To construct LFs at high frequencies, we examine SPT maps at the locations of SUMSS sources, extracting the high frequency fluxes and correcting for the cluster SZE flux at 95 and 150~GHz. We compare this sample with the 150~GHz sample with uncorrected fluxes to examine the impact of SZE flux biases, showing that they are significant – especially for high redshift clusters that are more compact on the sky and for higher mass clusters that have stronger SZE signatures. In essence, it is more challenging to find cluster radio galaxies at high frequency in high redshift and high mass clusters, because the SZE signature is biasing their fluxes low.

We use the SUMSS selected sources with fluxes measured at SPT frequencies and correct for SZE flux bias (at 95 and 150~GHz) to construct the cluster radio galaxy sample for further analysis. We find that the radial profile is centrally concentrated, consistent with an NFW model with concentration $c = 108^{+107}_{-48}$. We examine the spectral indices of the radio galaxy population, finding that the spectral index α measured between 95 and 150~GHz is steeper than that measured between 843~MHz and these high frequencies. We construct the LFs and find best fit parametrizations within the context of \citet{condon02} models. In doing so, we assume the overdensity of radio galaxies toward a cluster is at the redshift of the cluster, and we apply a k-correction using the spectral indices extracted from the sample. The amplitude of the 843~MHz LF is approximately one order of magnitude higher than the amplitude of the high frequency LFs. Our high frequency radio galaxy sample is not large enough to constrain redshift or mass trends in the radio galaxy LF.

We use the measured high frequency cluster radio galaxy LFs to examine the effect of the contaminating flux on the SZE signatures of galaxy clusters. To do that, we use the LF for a given cluster mass and redshift to obtain the number and flux of cluster radio galaxies, sampling 10^6 times to recover the full range of behavior of the cluster radio galaxies within the clusters. We define a quantity called the contamination s, which is the absolute value of the ratio of the total cluster radio galaxy flux from all the radio galaxies with power $> 10^{21}$~W~Hz^{-1} to the total SZE flux of that cluster within r_{200}. With this information we calculate the fraction of clusters with $s \simeq 1$, where the total cluster radio galaxy flux in a cluster is equivalent to the negative SZE flux. We find that 0.5 and 1.4~percent of clusters meet this criterion for cluster mass $M_{500} = 3 \times 10^{14}\mathrm{M}_{\odot}$ and redshift $z = 0.25$ at 150 and 95~GHz, respectively.

To estimate the impact of cluster radio galaxies on the cluster sample from the SPT-SZ 2500~deg^2 survey at 150~GHz, we use the theoretically predicted mass function to produce 100 mock cluster samples. We then compare the $\xi > 4.5$ cluster samples with and without cluster radio galaxies. We find that around 1.8 ± 0.7~percent of clusters would be lost from the sample in a redshift range of 0.25 to 1.55 in the 2500~deg^2 SPT-SZ survey.

We evaluate the bias in the parameters of the $\zeta-$mass relation caused by radio galaxy contamination and find a small shift in the mean parameter values which is well within the current 1-σ parameter constraints. We also calculate the contribution of the cluster radio galaxy contamination to the intrinsic scatter in the $\zeta-$mass relation for the observed clusters, finding that cluster radio galaxies contribute a scatter of 2.8 ± 0.4~percent out of a total empirically calibrated $\sim$22~percent scatter.

Finally, we note that with the MCXC sample we cannot place strong constraints on the redshift evolution of the high frequency radio galaxy LF. We review previous findings at 1.4~GHz, none of which provide evidence for strong redshift evolution of the cluster radio galaxy LF. We attempt to bracket the impact of possible redshift evolution by adopting a radio galaxy LF evolution in the number of point sources of the form $(1+z)^{2.5}$, showing that at 150~GHz there could be a 5.6 ± 1~percent incompleteness in a $\xi > 4.5$ SPT-SZ like SZE selected cluster sample.

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Broadband Polarization Sky Survey with the MPIfR-MT-SKA prototype dish

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I will discuss about the future prospects of the MeerKAT prototype single-dish for performing broadband all sky polarization survey.

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The low-frequency radio continuum—star formation rate relation in nearby galaxies with LOFAR

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We present first results of our survey of nearby galaxies with 140-MHz data from pointed observations and from the LOFAR 2-m Sky Survey (LoTSS). With the facet calibration technique we are now able to reach an rms noise level close to the thermal noise of ~150 μJy/beam at 7—10 arcsec spatial resolution. These maps are sensitivity matched with medium-deep (1 hr) observations of other state-of-the-art radio interferometers such as the Jansky VLA. We have selected our galaxies from the SINGS and KINGFISH infrared surveys, which provide us with ample of ancillary data. The infrared maps from HERSCHEL and Spitzer can be combined with GALEX far-ultraviolet maps in order to construct reliable star-formation rate surface density maps, corrected for internal absorption by dust. Balmer Halpha maps can be used to separate the thermal radio continuum emission, although at 140 MHz we expect the thermal fraction to be small (< 10 per cent). We also have ancillary radio maps, both 1.4-GHz continuum maps from the WSRT SINGS survey, as well as HI line emission maps from the VLA THINGS survey. We also have selected some highly inclined (>80 degree) galaxies from the CHANG-ES survey with complementary Jansky VLA data at 1.5 and 6 GHz. These data can be used to study the spatially resolved radio continuum—star formation rate (RC—SFR) relation on a 1-kpc scale in a statically meaningful sample. As part of this study, we will explore the effects of cosmic-ray transport by diffusion in galactic discs, the relation between the magnetic field and gas density as well as gas kinematics and the vertical cosmic ray transport by advection in galactic winds.

Science symposium / 8

Pulsar science with the German LOFAR stations

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The International LOFAR stations in Germany are mainly dedicated to pulsar observations. An unprecedented pulsar monitoring campaign has been carried out since 2013, thus enabling a variety

of research topics. Such topics are mainly focused on interstellar medium (ISM) studies, and range from variations in the ISM electron content to Solar wind probing. I will describe this unique and cutting-edge data set, revise the works done by now and report the latest results from Bielefeld University and MPIfR.

Science symposium / **9**

LOFAR observations of the quiet solar corona

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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 are 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 polar coronal density and temperature profiles based on LOFAR low band images.

Science symposium / **10**

Faraday rotation at low frequencies

Author: Shane O'Sullivan[1]

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I will present a low-frequency, broadband polarisation study of the FRII radio galaxy PKS J0636−2034 (z = 0.0551), using data from the Murchison Widefield Array (MWA) from 70 to 230 MHz. The large, continuous wavelength-squared coverage across the MWA band allows the polarisation and Faraday rotation properties to be determined with a precision approximately two orders of magnitude better than traditional cm-wavelength radio interferometers. A combination of rotation measure synthesis and broadband polarisation model-fitting are used to constrain the Faraday depolarisation properties of the source to very high accuracy.

Science symposium / **11**

Radio and CTA: Synergies and Transients

Author: Stefan Wagner[1]

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CTA will be the first Cerenkov Facility designed for observatory operation.
This will facilitate multifrequency studies of stationary, variable, and transient sources.
The radio- and VHE gamma-ray sky are dominated by non-thermal sources and joint studies in both bands will provide matching constraints on source properties and radiation mechanisms.
Properties and construction time-scales of the two stations operating 120 telescopes as well as modes of operation and access will be described.

Science symposium / **12**

Enabling S-Band Capability for MeerKAT

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This talk will be on the MPIfR's efforts to equip the MeerKAT array with receivers and signal processing infrastructure that allows access to the skies in the 1750-3500 MHz range. We are building a 400-beam GPU-based beam-former and a processing cluster to serve as the pulsar and transient hunting machine. The plans on this machine and results from the initial tests with two telescopes will be discussed.

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Update MeerKAT

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I will provide an update on the current status of the MeerKAT array.

Science symposium / **14**

Progress Report: LOFAR observation of NGC 4631

Author: Stefan Blex[1]

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I will present the current status of the main part of my PhD project, the LOFAR observation of NGC 4631.
NGC 4631 is a large edge-on spiral galaxy with high star formation rate and strongly interacts with NGC 4627 and NGC 4656/7. NGC 4631 also exhibits a large, prominent halo of warm and hot ionized gas.
NGC 4631 has been observed as part of the LOFAR Survey of nearby galaxies with the LOFAR HBA for 6.4 hours during Cycle 0 (2013-04-18/19), using the Core and Remote Stations.
This talk covers improvements of direction-dependent over direction-independent calibration, experimentation with Factor parameters and facet setups and first glance analysis of the current processing stage image.
The LOFAR image of NGC 4631 shows lots of diffuse emission outside the disk, correlating nicely with previous X-ray and radio observations. Furthermore, due to the huge improvement in resolution over previous measurements, fine structures are discernible in the halo, e.g. filaments can be traced up to 10 kpc out of the disk.
The talk may also include a quick look at NGC 4656, one of NGC 4631's interaction partners which is also in the field of view of another facet of the observation.

Science symposium / **15**

Merging galaxy clusters in radio surveys

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The intra-cluster medium accounts for most of the baryon mass in galaxy clusters. However, its dynamical processes, magnetic fields properties, and cosmic ray content are still poorly constrained. Diffuse synchrotron emission in galaxy clusters provides a probe for all of these three components.

Radio relics are synchrotron emission sites found in downstream regions of galaxy cluster merger shocks.
While they are often confirmed through targeted X-ray and radio observations their signature is also present in large surveys. Several models for the origin of radio relics have been proposed.

Through Bayesian statistics one can infer the posterior likelihood of competing models given the data and prior information. Approximate Bayesian Computation (ABC) is an approach to estimate the posterior likelihood if the complexity of the data is high.

We use ABC to investigate diffusive shock acceleration models with and without pre-existing relativistic electrons based on the NVSS survey and cosmological simulations. I present what we can infer from our current data pool and which surveys we need to strengthen the model inference capabilities of our ABC approach.

Science symposium / **16**

Deep L-band VLA observations of the Toothbrush cluster

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We present the results of deep L-band VLA observations of the merging galaxy cluster 1RXS J0603.3+4214, which host one of the brightest relics, known as Toothbrush, and an elongated giant radio halo. Our new VLA images provide an unprecedented detailed view of the Toothbrush, revealing enigmatic filamentary structures. These VLA observations in combination with GMRT and LOFAR data, allowed us to study the spectral index distribution at very high resolution. A simple toy model suggest that there are significant variations of the magnetic field strength along the line of sight. The downstream spectral profile, between 150 MHz to 1.5 GHz, can be explained by an inhomogeneous magnetic field and high Mach number shock. The radio halo shows an average spectral index of about $\alpha = -1.16 \pm 0.05$ and a slight gradient from north to south. Excluding the southernmost part, the halo morphology agrees very well with the X-ray morphology. A power-law correlation is found between the radio and X-ray surface brightness. We will also present our preliminary polarization results.

Science symposium / **17**

Properties of Main Sequence star-forming galaxies before and after MIGHTEE

Author: Maurilio Pannella[1]

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I will describe what we've learned in the last decade about star-forming galaxies by using the deepest available HST, Spitzer, Herschel, ALMA and JVLA data and how this is going to be boosted and refined in the coming years thanks to the new upcoming radio continuum facilities like MeerKAT and eventually SKA. I'll focus in particular on the MIGHTEE/LADUMA surveys and the still closed windows they are going to open on galaxy evolution studies.

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Multi-frequency estimation of the cosmic radio dipole from continuum radio surveys

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Continuum surveys of the radio sky provide a rich resource of information. Besides the analysis of individual galaxies and other astrophysical sources, they also allow us to probe cosmological models. We analyse the data provided by several surveys across radio frequencies to estimate the Cosmic Radio Dipole in the radio source counts. This dipole is a deviation from the statistically isotropic Universe caused by the proper motion of the Solar system and the large

scale structure. The kinetic effect is also hold responsible for the
temperature dipole of the Cosmic Microwave Background.
In this talk I will describe the quality cuts required to make radio continuum catalogues suitable for cosmological analysis. In particular I will show results from the analysis of NVSS, SUMSS, WENSS, TGSS ADR1 and GLEAM, which together cover a decade in frequency and the full sky.

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Active Galactic Nuclei Jets Probed by Very-Long-Baseline Interferometry

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Very-long-baseline interferometry (VLBI) probes compact regions at the hearts of active galactic nuclei at a submilliarcsecond resolution. This technique enables detailed studies to be made of the non-thermal emission in the innermost regions of relativistic plasma jets. The scope of VLBI studies becomes ever broader, reaching higher resolution with longer baselines (space VLBI) and at higher frequencies (millimetre wavelength VLBI), opening new horizons with high fidelity polarization imaging to study the magnetic field structure and Faraday rotation, and exploring ample synergies in astrometric studies provided by the first results coming from the GAIA mission. Over the past decade, the combination of VLBI observations and the multi-messenger approach have proven exceptionally successful, helping to understand the nature of non-thermal gamma-ray emission observed with the Fermi/LAT, providing valuable insight on the physics of relativistic X-ray iron lines in AGN, searching for the astrophysical sources of neutrinos detected by IceCube, and potentially expanding this type of studies to the search of electromagnetic counterparts of gravitational waves. I will summarize recent results from some of these topics.

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Deciphering the 3D Morphology of Blazars with GMRT observations

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TU Dortmund Group Report

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This is the group report for the TU Dortmund group at the GLOW consortium meeting.

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Multi-Wavelength Source Identification using Machine Learning Methods

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Driven by a wealth of upcoming missions and observatories across a wide frequency range, astronomy is entering a new era of survey science. As data volumes grow rapidly and data structures become more heterogeneous, progress regarding source populations will still crucially depend from efficient identification of sources across these multi-frequency and multi-messenger datasets. In recent years, machine learning approaches have matured into a powerful research tool for automatic source classification. In this talk, chances and challenges of machine learning methods as used already for gamma-ray observations will be discussed in the context of upcoming large radio surveys.

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VLBI and gamma-ray studies of radio galaxies

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The γ-ray sky is strongly dominated by blazars, i.e. AGN with relativistic jets oriented closely with our line of sight. Radio galaxies are their misaligned counterparts, and make up about ~ 1-2% of all AGN observed by Fermi-LAT. At TeV energies, only 5 radio galaxies have currently been detected, but recent work has shown that the CTA has good potential for detecting more of these elusive Very-High-Energy sources. In spite of their small numbers in γ-ray catalogs, radio galaxies provide us with a view of AGN jets which is less biased by Doppler boosting effects, and allow us to test jet production and emission models in light of the unified scheme of radio-loud AGN. The combination of γ-ray data and high-resolution Very Long Baseline Interferometry (VLBI) studies is a powerful

tool in order to investigate these objects. We present selected results of an ongoing study focused on the radio galaxies in the southern-hemisphere VLBI (and multi-wavelength) monitoring program TANAMI.