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Accepted Abstracts - Submitted Abstracts - Thesis Abstracts
Jobs Adverts - Meetings Adverts - Special Announcements

From the Editor

The Active Galaxies Newsletter is produced monthly. The deadline for contributions is the last day of the month. The Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter and are also available on the web page.

As always as editor of the newsletter I am very interested to hear any suggestions or feedback regarding the newsletter. So do not hesitate in emailing me your suggestions.

Many thanks for your continued subscription.

Melanie Gendre

Abstracts of recently accepted papers

Tracking Down the Source Population Responsible for the Unresolved Cosmic 6–8 keV Background

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Using the 4 Ms *Chandra* Deep Field-South (CDF-S) survey, we have identified a sample of 6845 X-ray undetected galaxies that dominates the unresolved $\approx$ 20–25% of the 6–8 keV cosmic X-ray background (XRB). This sample was constructed by applying mass and color cuts to sources from a parent catalog based on GOODS-South *HST* z-band imaging of the central $6'$-radius area of the 4 Ms CDF-S. The stacked 6–8 keV detection is significant at the 3.9σ level, but the stacked emission was not detected in the 4–6 keV band which indicates the existence of an underlying population of highly obscured active galactic nuclei (AGNs). Further examinations of these 6845 galaxies indicate that the galaxies on the top of the blue cloud and with redshifts of $1 < z < 3$, magnitudes of $25 < z_{850} < 28$, and stellar masses of $2 \times 10^8 < M_\star/M_\odot < 2 \times 10^9$ make the majority

contributions to the unresolved 6–8 keV XRB. Such a population is seemingly surprising given that the majority of the X-ray detected AGNs reside in massive ($M_\star > \sim 10^{10}\ M_\odot$) galaxies. We discuss constraints upon this underlying AGN population, supporting evidence for relatively low-mass galaxies hosting highly obscured AGNs, and prospects for further boosting the stacked signal.

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Are 3C 249.1 and 3C 334 restarted quasars?

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This *Research Note* follows up a Letter in which I posit that J1211+743 is a restarted radio source. This means that its structure, where the jet points to the relic lobe, is only apparently paradoxical. Here, I propose the same scenario and apply the same mathematical model to 3C 249.1 and 3C 334. The ultimate result of my investigation is that these two well-known radio-loud quasars can be understood best so far if it was assumed that they, too, had been restarted.

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The XMM deep survey in the CDF-S II. a 9-20 keV selection of heavily obscured active galaxies at z>1.7

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We present results on a search of heavily obscured active galaxies $z > 1.7$ using the rest-frame 9-20 keV excess for X-ray sources detected in the deep XMM-CDFS survey. Out of 176 sources selected with the conservative detection criteria ($> 8\sigma$) in the first source catalogue of Ranalli et al., 46 objects lie in the redshift range of interest with the median redshift $\tilde{z} \simeq 2.5$. Their typical rest-frame 10-20 keV luminosity is 10^{44} erg s^{-1}, as observed. Among optically faint objects that lack spectroscopic redshift, four were found to be strongly absorbed X-ray sources, and the enhanced Fe K emission or absorption features in their X-ray spectra were used to obtain X-ray spectroscopic redshifts. Using the X-ray colour-colour diagram based on the rest-frame 3-5 keV, 5-9 keV, and 9-20 keV bands, seven objects were selected for their 9-20 keV excess and were found to be strongly absorbed X-ray sources with column density of $N_{\rm H} \geq 0.6 \times 10^{24}$ cm^{-2}, including two possible Compton thick sources. While they are emitting at quasar luminosity, $\sim 3/4$ of the sample objects are found to be absorbed by $N_{\rm H} > 10^{22}$ cm^{-2}. A comparison with local AGN at the matched luminosity suggests an increasing trend of the absorbed source fraction for high-luminosity AGN towards high redshifts.

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The high-redshift ($z > 3$) AGN population in the 4 Ms *Chandra* Deep Field South

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We present results from a spectral analysis of a sample of high-redshift ($z > 3$) X-ray selected AGN in the 4 Ms *Chandra* Deep Field South (CDF-S), the deepest X-ray survey to date. The sample is selected using the most recent spectroscopic and photometric information available in this field. It consists of 34 sources with median redshift $z = 3.7$, 80 median net counts in the 0.5-7 keV band and median rest-frame absorption-corrected luminosity $L_{2-10\,keV} \approx 1.5 \times 10^{44} erg\,s^{-1}$. Spectral analysis for the full sample is presented and the intrinsic column density distribution, corrected for observational biases using spectral simulations, is compared with the expectations of X-ray background (XRB) synthesis models. We find that ≈ 57 per cent of the sources are highly obscured ($N_H > 10^{23} cm^{-2}$). Source number counts in the $0.5 - 2\,keV$ band down to flux $F_{0.5-2\,keV} \approx 4 \times 10^{-17} erg\,s^{-1} cm^{-2}$ are also presented. Our results are consistent with a decline of the AGN space density at $z > 3$ and suggest that, at those redshifts, the AGN obscured fraction is in agreement with the expectations of XRB synthesis models.

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The First Spectroscopically Resolved Sub-parsec Orbit of a Supermassive Binary Black Hole

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One of the most intriguing scenarios proposed to explain how active galactic nuclei are triggered involves the existence of a supermassive binary black hole system in their cores. Here we present an observational evidence for the first spectroscopically resolved sub-parsec orbit of a such system in the core of Seyfert galaxy NGC 4151. Using a method similar to those typically applied for spectroscopic binary stars we obtained radial velocity curves of the supermassive binary system, from which we calculated orbital elements and made estimates about the masses of components. Our analysis shows that periodic variations in the light and radial velocity curves can be accounted for an eccentric, sub-parsec Keplerian orbit of a 15.9-year period. The flux maximum in the lightcurve correspond to the approaching phase of a secondary component towards the observer. According to the obtained results we speculate that the periodic variations in the observed Hα line shape and flux are due to shock waves

generated by the supersonic motion of the components through the surrounding medium. Given the large observational effort needed to reveal this spectroscopically resolved binary orbital motion we suggest that many such systems may exist in similar objects even if they are hard to find. Detecting more of them will provide us with insight into black hole mass growth process.

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Black Hole Growth to $z = 2$ - I: Improved Virial Methods for Measuring $M_{\rm BH}$ & $L/L_{\rm Edd}$

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We analyze several large samples of Active Galactic Nuclei (AGN) in order to establish the best tools required to study the evolution of black hole mass ($M_{\rm BH}$) and normalized accretion rate ($L/L_{\rm Edd}$). The data include spectra from the SDSS, 2QZ and 2SLAQ public surveys at $z < 2$, and a compilation of smaller samples with $0 < z < 5$. We critically evaluate the usage of the Mg II λ2798 and C IV λ1549 lines, and adjacent continuum bands, as estimators of $M_{\rm BH}$ and $L/L_{\rm Edd}$, by focusing on sources where one of these lines is observed together with Hβ. We present a new, luminosity-dependent bolometric correction for the monochromatic luminosity at 3000Å, L_{3000}, which is lower by a factor of ~ 1.75 than those used in previous studies. We also re-calibrate the use of L_{3000} as an indicator for the size of the broad emission line region ($R_{\rm BLR}$) and find that $R_{\rm BLR} \propto L_{3000}^{0.62}$, in agreement with previous results. We find that FWHM (MgII) $\simeq$ FWHM (Hβ) for all sources with FWHM (MgII) $\lesssim 6000\,{\rm km\,s^{-1}}$. Beyond this FWHM, the Mg II line width seems to saturate. The spectral region of the Mg II line can thus be used to reproduce Hβ-based estimates of $M_{\rm BH}$ and $L/L_{\rm Edd}$, with negligible systematic differences and a scatter of $\sim$0.3 dex. The width of the C IV line, on the other hand, shows no correlation with either that of the Hβ or the Mg II lines and we could not identify the reason for this discrepancy. The scatter of $M_{\rm BH}$(C IV), relative to $M_{\rm BH}$(Hβ) is of almost 0.5 dex. Moreover, 46% of the sources have FWHM (C IV) $\lesssim$ FWHM (Hβ), in contrast with the basic premise of the virial method, which predicts FWHM (C IV) /FWHM (Hβ) $\simeq \sqrt{3.7}$, based on reverberation mapping experiments. This fundamental discrepancy cannot be corrected based on the continuum slope or any C IV-related observable. Thus, the C IV line cannot be used to obtain precise estimates of $M_{\rm BH}$. We conclude by presenting the observed evolution of $M_{\rm BH}$ and $L/L_{\rm Edd}$ with cosmic epoch. The steep rise of $L/L_{\rm Edd}$ with redshift up to $z \simeq 1$ flattens towards the expected maximal value of $L/L_{\rm Edd} \simeq 1$, with lower-$M_{\rm BH}$ sources showing higher values of $L/L_{\rm Edd}$ at all redshifts. These trends will be further analyzed in a forthcoming paper.

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A Three Parsec-Scale Jet-Driven Outflow from Sgr A*

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The compact radio source Sgr A* is coincident with a $4{\times}10^6\ M_\odot$ black hole at the dynamical center of the Galaxy and is surrounded by dense orbiting ionized and molecular gas. We present high resolution radio continuum images of the central $3'$ and report a faint continuous linear structure centered on Sgr A* with a PA$\sim 60^0$. The extension of this feature appears to be terminated symmetrically by two linearly polarized structures at 8.4 GHz, $\sim 75''$ from Sgr A*. A number of weak blobs of radio emission with X-ray counterparts are detected along the axis of the linear structure. The linear structure is best characterized by a mildly relativistic jet from Sgr A* with an outflow rate $10^{-6}\ M_\odot$ yr^{-1}. The near and far-sides of the jet are interacting

with orbiting ionized and molecular gas over the last 1–3 hundred years and are responsible for a $2''$ hole, the "minicavity", characterized by disturbed kinematics, enhanced FeII/III line emission, and diffuse X-ray gas. The estimated kinetic luminosity of the outflow is $\sim 1.2 \times 10^{41}$ erg s^{-1}, so the interaction with the bar may be responsible for the Galactic center X-ray flash inferred to be responsible for much of the fluorescent Fe Kα line emission from the inner 100pc of the Galaxy.

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Complete ionisation of the neutral gas: why there are so few detections of 21-cm hydrogen in high redshift radio galaxies and quasars

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From the first published $z \gtrsim 3$ survey of 21-cm absorption within the hosts of radio galaxies and quasars, Curran et al. (2008b) found an apparent dearth of cool neutral gas at high redshift. From a detailed analysis of the photometry, each object is found to have a $\lambda = 1216$ Å continuum luminosity in excess of $L_{1216} \sim 10^{23}$ W Hz^{-1}, a critical value above which 21-cm has never been detected at any redshift. At these wavelengths, and below, hydrogen is excited above the ground state so that it cannot absorb in 21-cm. In order to apply the equation of photoionsation equilibrium, we demonstrate that this critical value also applies to the ionising ($\lambda \leq 912$ Å) radiation. We use this to show, for a variety of gas density distributions, that upon placing a quasar within a galaxy of gas there is *always* an ultra-violet luminosity above which all of the large-scale atomic gas is ionised. While in this state the hydrogen cannot be detected nor engage in star formation. Applying the mean ionising photon rate of all of the sources searched, we find, using canonical values for the gas density and recombination rate coefficient, that the observed critical luminosity gives a scale-length (3 kpc) similar that of the neutral hydrogen (H I) in the Milky Way, a large spiral galaxy. Thus, this simple, yet physically motivated, model can explain the critical luminosity ($L_{912} \sim L_{1216} \sim 10^{23}$ W Hz^{-1}), above which neutral gas is not detected. This indicates that the non-detection of 21-cm absorption is not due to the sensitivity limits of current radio telescopes, but rather that the lines-of-sight to the quasars, and probably the bulk of the host galaxies, are devoid of neutral gas.

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Jet and Torus Orientations in High Redshift Radio Galaxies

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We examine the relative orientation of radio jets and dusty tori surrounding the AGN in powerful radio galaxies at $z > 1$. The radio core dominance $R = P_{\rm core}^{20\,{\rm GHz}}/P_{\rm extended}^{500\,{\rm MHz}}$ serves as an orientation indicator, measuring the ratio between the anisotropic Doppler-beamed core emission and the isotropic lobe emission. Assuming a fixed cylindrical geometry for the hot, dusty torus, we derive its inclination i by fitting optically-thick radiative transfer models to spectral energy distributions obtained with the Spitzer Space Telescope. We find a highly significant anti-correlation ($p < 0.0001$) between R and i in our sample of 35 type 2 AGN combined with a sample of 18 $z \sim 1$ 3CR sources containing both type 1 and 2 AGN. This analysis provides observational evidence both for the Unified scheme of AGN and for the common assumption that radio jets are in general perpendicular to

the plane of the torus. The use of inclinations derived from mid-infrared photometry breaks several degeneracies which have been problematic in earlier analyses. We illustrate this by deriving the core Lorentz factor Γ from the R-i anti-correlation, finding $\Gamma \geq 1.3$.

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Jet-induced star formation in gas-rich galaxies

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Feedback from active galactic nuclei (AGN) has become a major component in simulations of galaxy evolution, in particular for massive galaxies. AGN jets have been shown to provide a large amount of energy and are capable of quenching cooling flows. Their impact on the host galaxy, however, is still not understood. Subgrid models of AGN activity in a galaxy evolution context so far have been mostly focused on the quenching of star formation. To shed more light on the actual physics of the "radio mode" part of AGN activity, we have performed simulations of the interaction of a powerful AGN jet with the massive gaseous disc ($10^{11}\,M_\odot$) of a high-redshift galaxy. We spatially resolve both the jet and the clumpy, multi-phase interstellar medium (ISM) and include an explicit star formation model in the simulation. Following the system over more than 10^7 years, we find that the jet activity excavates the central region, but overall causes a significant change to the shape of the density probability distribution function and hence the star formation rate due to the formation of a blast wave with strong compression and cooling in the ISM. This results in a ring- or disc-shaped population of young stars. At later times, the increase in star formation rate also occurs in the disc regions further out since the jet cocoon pressurizes the ISM. The total mass of the additionally formed stars may be up to $10^{10}\,M_\odot$ for one duty cycle. We discuss the details of this jet-induced star formation (positive feedback) and its potential consequences for galaxy evolution and observable signatures.

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Jet interactions with a giant molecular cloud in the Galactic centre and ejection of hypervelocity stars

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The hypervelocity OB stars in the Milky Way Galaxy were ejected from the central regions some 10-100 million years ago. We argue that these stars, as well as many more abundant bound OB stars in the innermost few parsecs, were generated by the

interactions of an AGN jet from the central black hole with a dense molecular cloud. Considerations of the associated energy and momentum injection have broader implications for the possible origin of the Fermi bubbles and for the enrichment of the intergalactic medium.

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Major Galaxy Mergers Only Trigger the Most Luminous AGN

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Using multiwavelength surveys of active galactic nuclei across a wide range of bolometric luminosities ($10^{43}<L_{bol}(\mathrm{erg\,s^{-1}})<5\times10^{46}$) and redshifts ($0<z<3$), we find a strong, redshift-independent correlation between the AGN luminosity and the fraction of host galaxies undergoing a major merger. That is, only the most luminous AGN phases are connected to major mergers, while less luminous AGN appear to be driven by secular processes. Combining this trend with AGN luminosity functions to assess the overall cosmic growth of black holes, we find that ∼50% by mass is associated with major mergers, while only 10% of AGN by number, the most luminous, are connected to these violent events. Our results suggest that to reach the highest AGN luminosities -where the most massive black holes accreted the bulk of their mass - a major merger appears to be required. The luminosity dependence of the fraction of AGN triggered by major mergers can successfully explain why the observed scatter in the M-σ relation for elliptical galaxies is significantly lower than in spirals. The lack of a significant redshift dependence of the L_{bol}-f_{merger} relation suggests that downsizing, i.e., the general decline in AGN and star formation activity with decreasing redshift, is driven by a decline in the frequency of major mergers combined with a decrease in the availability of gas at lower redshifts.

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Are Outflows Biasing Single-Epoch C IV Black Hole Mass Estimates?

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We use a combination of reverberation mapping data and single-epoch spectra of the C IV emission line in a sample of both low and high-redshift active galactic nuclei (AGNs) to investigate sources of the discrepancies between C IV- and Hβ-based single-epoch black hole mass estimates. We find that for all reverberation mapped sources, there is a component of the line profile that does not reverberate, and the velocity characteristics of this component vary from object-to-object. The differing strength and properties of this non-variable component are responsible for much of the scatter in C IV-based black hole masses compared to Hβ masses. The C IV mass bias introduced by this non-variable component is correlated with the shape of the C IV line, allowing us to make an empirical correction to the black hole mass estimates. Using this correction and accounting for other sources of scatter such as poor data quality and data inhomogeneity reduces the scatter between the C IV and Hβ masses in our sample by a factor of ∼2, to only ∼0.2 dex. We discuss the possibility that this non-variable C IV component originates in an orientation-dependent outflow from either the proposed broad line region (BLR) disk-wind or the intermediate line region (ILR), a high-velocity inner extension of the narrow line region (NLR).

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Thesis Abstracts

Multiwavelength Studies of Radio-loud Active Galactic Nuclei in the *Fermi* Era

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Radio-loud active galactic nuclei where one of the jets is directed towards the observer at a small angle to the line of sight are known as blazars. Now is a particularly exciting time in blazar research, as the recently launched *Fermi* gamma-ray space telescope has detected hundreds of blazars at gamma-ray energies, allowing true multiwavelength studies of large samples of these objects for the first time. However, blazar research is plagued by selection effects, which has hindered progress in their understanding.

The majority of this Thesis involves the definition and exploitation of a new sample of nearby flat spectrum core-dominated radio sources, the Survey of Extragalactic Nuclear Spectral Energies (SENSE) sample, which contains 121 blazar-like objects. While the sample was designed to contain sources with similar core radio properties, no restrictions were placed on the optical properties, so the sample contains the expected BL Lacs, as well as passive elliptical galaxies, and some optical AGN. 25 SENSE sources are currently without redshifts. Work carried out using SDSS images to separate the host galaxy from the AGN core indicates that higher resolution images would allow the host galaxies to be detected and characterised so that the redshift could be estimated.

It was found that the SENSE sample shows no evidence for cosmological evolution using the $\langle V/V_{\mathrm{max}}\rangle$ test. This result is consistent with the SENSE sample being the beamed versions of FR-I galaxies. 78% of the SENSE sample show extended emission in available radio maps, and the extended luminosities of these sources are also consistent with a FR-I parent population. Cross-correlation of the SENSE sample with the second catalogue from the *Fermi* gamma-ray space telescope (2FGL) revealed that only 29 of the SENSE sources are gamma-ray loud. The properties of these gamma-ray detected sources were compared to the rest of the sample and no difference could be found in the available data.

The small number of SENSE sources detected by *Fermi* meant that the sample could not be used to investigate the relationship between synchrotron and inverse Compton emission in blazars. Instead, the CRATES radio catalogue was cross-correlated with 2FGL. The Compton efficiency parameter was defined as the ratio of (νS_ν) at the inverse Compton SED peak to (νS_ν) at radio frequencies. No difference was found between the Compton efficiencies of BL Lacs and FSRQs, indicating that the high energy emission in blazars is dominated by the synchrotron self-Compton process.

Meetings

THE MODERN RADIO UNIVERSE 2013

Bonn, Germany
22 - 26 April 2013

Webpage: `https://indico.mpifr-bonn.mpg.de/indico/conferenceDisplay.py?confId=21`
Email: `mru2013@lists.mpifr-bonn.mpg.de`

80 years ago, in spring 1933, Karl Jansky published his discovery of cosmic radio emission. This paved the way not only for a new discipline, radio astronomy, but also for an exploration of the universe that now encompasses almost the entire electromagnetic window.

Nowadays, radio astronomy is about to enter into yet another "golden era" with a number of new or upgraded radio facilities coming online and major new initiatives, like the SKA, are starting up. This conference will try to highlight the original and exciting science currently being produced by radio astronomical facilities, such as the Effelsberg telescope, the GBT, LOFAR, ALMA, the Karl Jansky VLA, eMERLIN, EVN, VLBA, as well as the pathfinder experiments of the Square Kilometre Array (SKA), and others.

The advanced science delivered by the radio astronomical community will improve our current knowledge of the universe, highlight new trends, and address key questions in modern astrophysics that may lead us to even more ambitious science goals to be targeted by future radio facilities like the SKA.

Science areas that will be discussed are among others: Cosmology, galaxy evolution, AGN and compact objects, star formation, interstellar medium, The Milky Way and Galactic science, radio transients, fundamental and astroparticle physics, extreme physics and associated theory. In particular:

- From the dark ages to cosmic large scale structure (EoR, dark energy, HI web)
- Galaxies and galaxy evolution (HI, radio continuum, magnetic fields)
- Stars and star formation (masers, radio stars, planetary radio emission, disks)
- Interstellar and Intergalactic Medium (physical processes in the ISM and IGM)
- Compact Objects (AGN, X-ray binaries, neutron stars, radio transients)
- Tests of fundamental physics (pulsars, fundamental constants)

The last Modern Radio Universe took place 2007 in Manchester commemorating 50 years of the Lovell telescope and looking forward towards the SKA. This issue of the conference commemorates the groundbreaking work of Karl Jansky 80 years ago and comes 40 years after the Effelsberg 100m telescope started operations.

The conference will consist of invited talks (approx. 20 min) and 15 min contributed talks (potentially a few 30 min review talks) plus posters. In short, combining past and future of radio astronomy, the main focus of the science presentations, will be to make an inventory of outstanding science results that are presently being obtained by the newly upgraded or constructed facilities.