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Abstracts - Thesis Abstracts - Jobs - Meetings

From the Editor

The Active Galaxies Newsletter is produced monthly. The deadline for contributions is the last friday 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. http://www.ast.man.ac.uk/~rb/agn

Rob Beswick

Abstracts of recently accepted papers

GMRT and VLA observations of HI and OH from the Seyfert galaxy Mrk 1

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We present Giant Meterwave Radio Telescope (GMRT) observations of the HI 21 cm line and Very Large Array (VLA) observations of the OH 18 cm line from the Seyfert 2 galaxy Mrk 1. HI emission is detected from both Mrk 1 and its companion NGC 451. The HI emission morphology and the velocity field of Mrk 1 are disturbed. The nuclear activities of Mrk 1 are most likely triggered by tidal interactions. We estimate the HI masses of Mrk 1 and NGC 451 to be $8.0(\pm0.6) \times 10^8$ $M_\odot$ and $1.3(\pm0.1) \times 10^9$ $M_\odot$ respectively. We have also detected HI and OH in absorption toward the nucleus of Mrk 1. Two OH lines, at 1665 and 1667 MHz, are detected. Each of the profiles of the HI and OH absorption is consist of two components that are separated by $\sim$ 125 km s^{-1}. Gaussian fitting gave dispersions of $\sim$ 44 km s^{-1} for both the components of the HI absorption. The profile of the OH absorption is qualitatively similar to that of the HI absorption. The peak optical depths of the two components of the HI absorption are $(7.3 \pm 0.4) \times 10^{-2}$ and $(3.2 \pm 0.4) \times 10^{-2}$. The corresponding peak optical depths of the 1667 MHz OH absorption are $(2.3 \pm 0.3) \times 10^{-2}$ and $(1.1 \pm 0.3) \times 10^{-2}$. The higher velocity components of the HI and OH (1667 MHz) absorption lines are blueshifted from the [OIII]λ5007, [OI]λ6300, and the systemic velocity by more than 100 km s^{-1}, but are consistent with the [OII]λ3727 velocity. This discrepancy is understandable if photo-ionized and shock-ionized gas co–exist in active galaxies. We speculate that the HI and OH absorption arise from a region which is pushed forward due to shocks, thereby giving an apparent blueshift to HI, OH, and [OII] lines. Both components of the OH absorption are thermally excited. The optical depth ratios $\tau_{\rm HI}/\tau^{1667}_{\rm OH}$ of both the components of the HI and OH absorption are $\sim$3, indicating their origin in dense molecular clouds. Using OH/A_v values for the Galactic molecular clouds, we obtain $9 < A_v < 90$ towards the line of sight of Mrk 1.

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preprint available at http://www.arxiv.org/abs/astro-ph/0208207

Observations of the neutral gas and dust in the radio galaxy 3C305

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We present MERLIN and Hubble Space Telescope (HST) observations of the central region of the nearby radio galaxy 3C 305 and use them to study the gas and dust in this object. The MERLIN observations are of neutral hydrogen (H I) absorption against the strong non-thermal 20cm continuum seen towards the central 4 kpc of 3C 305. Our $\sim$0.″2 (160 pc) resolution observations show that the H I absorption is highly localised against the south-western radio-emission with column densities $\sim 1.9\times10^{21}$ cm^{-2}. The absorption is broad (full width at half maximum, FWHM, of 145±26 km s^{-1}) and red-shifted by 130 km s^{-1} relative to the systemic velocity. The HST images in multiple optical and infrared filters (430 nm, 702 nm, [O III] 500.7 nm, [Fe II] 1.64μm and K-band polarization) are presented. Evidence is seen for coincidence of the [Fe II] emission with the knot at the end of the radio jet, which is evidence for the presence of shocks.

We compare the optical and radio images in order to investigate the relationship between the dust and neutral gas distributions. An unresolved (0.″07) nucleus is detected in H and K and its properties are consistent with a quasar reddened by $A_V > 4$. We propose that the absorption arises in a region of neutral gas and dust. Its structure is complex but is broadly consistent with an inclined disc of gas and dust encircling, but not covering, the active galactic nucleus. A comparison of the neutral gas observations and previous emission-line observations suggests that both the neutral and ionised gas are undergoing galactic rotation towards the observer in the north-east and away from the observer in the south-west. We propose that the outflow giving rise to the radio emission has a component towards the observer in the north-east and away from the observer in the south-west. Unfortunately as we do not detect radio emission from the compact nucleus we cannot set limits to neutral hydrogen absorption from a circumnuclear obscuring torus. write which journal which accepted your paper, for example:

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The Ionized Gas and Nuclear Environment in NGC 3783 II. Averaged HST/STIS and FUSE Spectra

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We present observations of the intrinsic absorption in the Seyfert 1 galaxy NGC 3783 obtained with the Space Telescope Imaging Spectrograph (STIS) on the *Hubble Space Telescope* (*HST*) and the *Far Ultraviolet Spectroscopic Explorer* (*FUSE*). We have combined 18 STIS and 5 *FUSE* observations to obtain a high signal-to-noise averaged spectrum spanning 905–1730 Å. The averaged spectrum reveals absorption in O VI, N V, C IV, N III, C III and the Lyman lines up to Lyϵ in the three blueshifted kinematic components previously detected in the STIS spectrum (at radial velocities of −1320, −724, and −548 km s^{-1}). The highest velocity component exhibits absorption in Si IV. We also detect metastable C III in this component, indicating a high density in this absorber. No lower ionization lines, i.e., C II and Si II, are detected. A weak, fourth absorption component is tentatively detected in the high ionization lines and Lyα and Lyβ at a radial velocity of -1027 km s^{-1}. The Lyman lines reveal a complex absorption geometry. The strength of the higher order lines indicates Lyα and Lyβ are saturated over much of the resolved profiles in the three strongest absorption components and, therefore, their observed profiles are determined by the covering factor. We separate the individual covering factors of the continuum and emission-line sources as a function of velocity in each kinematic component using the Lyα and Lyβ lines. The covering factor of the BLR is found to vary dramatically between the cores of the individual kinematic components, ranging from 0 to 0.84. Additionally, we find that the continuum covering factor varies with velocity within the individual kinematic components, decreasing smoothly in the wings of the absorption by at least 60%. Comparison of the effective covering factors derived from the H I results with those determined directly from the doublets reveals the covering factor of Si IV is less than half that of H I and N V in the high velocity component. Additionally, the FWHM of N III and Si IV are narrower than the higher ionization lines in this component. These results indicate there is substructure within this absorber. We also find evidence for structure in the column density profiles of the high ionization lines in this component. We derive a lower limit on the total column ($N_H \geq 10^{19}$ cm^{-2}) and ionization parameter ($U \geq 0.005$) in the low ionization subcomponent of this absorber. The metastable-to-total C III column density ratio implies $n_e \approx 10^9$ cm^{-3} and an upper limit on the distance of the absorber from the ionizing continuum of $R \leq 8 \times 10^{17}$ cm. The decreasing covering factor found in the wings of the absorption and the extreme compactness of the C III* absorber are suggestive of a clumpy absorption gas with low volume filling factor.

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Violence in the Hearts of Galaxies - Aberration or Adolescence?

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Violent activity in the nuclei of galaxies has long been considered a curiosity in its own right; manifestations of this phenomenon include distant quasars in the early Universe and comparatively nearby Seyfert galaxies, both thought to be powered by the release of gravitational potential energy as material from the host galaxy accretes onto a central supermassive black hole (SMBH). Traditionally, the broader study of the formation, structure and evolution of galaxies has largely excluded active galactic nuclei. Recently however, this situation has changed dramatically, both observationally and theoretically, with the realisation that the growth and influence of the SMBH, the origin and development of galaxies and nuclear activity at different epochs in the Universe may be intimately related. The most spectacular fireworks seen in distant quasars, may be relatively easy to explain since the era of greatest quasar activity seems to coincide with turbulent dynamics at the epoch of galaxy formation in the young, gas-rich Universe. Ubiquitous black holes are believed to be a legacy of this violent birth. Alternatively, black holes may be the seeds which drive galaxy formation in the first place. Closer to home, and hence more recently in the history of the Universe, a fraction of comparatively ordinary galaxies, similar to our own, have re-ignited their central engines, albeit at a lower level of activity. Since these galaxies are more established than their younger and more distant counterparts, the activity here is all the more puzzling. Whatever the mechanisms involved, they are likely to play an important role in galaxy evolution. I review the intriguing evidence for causal links between supermassive black holes, nuclear activity and the formation and evolution of galaxies, and describe opportunities for testing these relationships using the next generation of earth-bound and space-borne astronomical facilities.

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The Nuclear Regions of the Seyfert Galaxy NGC 4151 – Parsec-scale HI Absorption and a Remarkable Radio Jet

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Sensitive high angular and linear resolution radio images of the 240-pc radio jet in NGC 4151, imaged at linear resolutions of 0.3 to 2.6 pc using the VLBA and phased VLA at λ21 cm, are presented and reveal for the first time a faint, highly collimated jet (diameter $\lesssim$1.4 pc) underlying discrete components, seen in lower resolution MERLIN and VLA images, that appear to be shock-like features associated with changes in direction as the jet interacts with small gas clouds within the central $\sim$100 pc of the galaxy. In addition, λ21-cm spectral line imaging of the neutral hydrogen in the nuclear region reveals the spatial location, distribution and kinematics of the neutral gas detected previously in a lower resolution MERLIN study. Neutral hydrogen absorption is detected against component C4W (E+F) as predicted by Mundell et al, but the absorption, extending over 3 pc, is spatially and kinematically complex on sub-parsec scales, suggesting the presence of small, dense gas clouds with a wide range of velocities and column densities. The main absorption component matches that detected in the MERLIN study, close to the systemic velocity (998 km s^{-1}) of the galaxy, and is consistent with absorption through a clumpy neutral gas layer in the putative obscuring torus, with higher velocity blue- and red-shifted systems with narrow linewidths also detected across E+F. In this region, average column densities are high, lying in the range 2.7×10^{19} $T_{\rm S}$ < $N_{\rm H}$ < 1.7×10^{20} $T_{\rm S}$ cm^2 K^{-1} ($T_{\rm S}$ is the spin temperature), with average radial velocities in the range 920 < V$_{\rm r}$ < 1050 km s^{-1}. The spatial location and distribution of the absorbing gas across component E+F rules out component E as the location of the AGN (as suggested by Ulvestad et al.) and, in combination with the well-collimated continuum structures seen in component D, suggests that component D (possibly subcomponent D3) is the most likely location for the AGN. We suggest that components C and E are shocks produced in the jet as the plasma encounters, and is deviated by, dense clouds with diameters smaller than $\sim$1.4 pc.

Comparison of the radio jet structure and the distribution and kinematics of ionized gas in the narrow line region (NLR) suggests that shock-excitation by passage of the radio jet is not the dominant excitation mechanism for the NLR. We therefore favour nuclear photoionization to explain the structure of the NLR, although it is interesting to note that a small number of clouds with low velocity and high velocity dispersion are seen to bound the jet, particularly at positions of jet direction changes, suggesting that some NLR clouds are responsible for bending the jet. Alternatively, compression by a cocoon around the radio jet due to pressure stratification in the jet bow shock could explain the bright, compressed optical line-emitting clouds surrounding the cloud-free channel of the radio jet, as modelled by Steffen et al.

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A Search for "Dwarf" Seyfert Nuclei. VI. Properties of Emission-Line Nuclei in Nearby Galaxies

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We use the database from Paper III to quantify the global and nuclear properties of emission-line nuclei in the Palomar spectroscopic survey of nearby galaxies. We show that the host galaxies of Seyferts, LINERs, and transition objects share remarkably similar large-scale properties and local environments. The distinguishing traits emerge on nuclear scales. Compared with LINERs, Seyfert nuclei are an order of magnitude more luminous and exhibit higher electron densities and internal extinction. We suggest that Seyfert galaxies possess characteristically more gas-rich circumnuclear regions, and hence a more abundant fuel reservoir and plausibly higher accretion rates. The differences between the ionization state of the narrow emission-line regions of Seyferts and LINERs can be partly explained by the differences in their nebular properties. Transition-type objects are consistent with being composite (LINER/H II) systems. With very few exceptions, the stellar population within the central few hundred parsecs of the host galaxies is uniformly old, a finding that presents a serious challenge to starburst or post-starburst models for these objects. Seyferts and LINERs have virtually indistinguishable velocity fields as inferred from their line widths and line asymmetries. Transition nuclei tend to have narrower lines and more ambiguous evidence for line asymmetries. All

three classes of objects obey a strong correlation between line width and line luminosity. We argue that the angular momentum content of circumnuclear gas may be an important factor in determining whether a nucleus becomes active. Finally, we discuss some possible complications for the unification model of Seyfert galaxies posed by our observations.

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XMM-NEWTON Observation of the Seyfert 2 Galaxy NGC 4138

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The *XMM-Newton* data presented here are the first X-ray observations of the Seyfert 2 galaxy NGC 4138. Although the galaxy was observed by *ROSAT*/HRI, it was not detected, with a flux upper limit of about 1.1×10^{-13} erg cm^{-2} s^{-1} in the $0.2 - 2.4$ keV energy band. *XMM-Newton* performed the observation on 26 November 2001. The source is detected for the first time in X-rays with $F_{0.2-2.4} = 1.0 \times 10^{-13}$ erg cm^{-2} s^{-1}, in agreement with the upper limit of *ROSAT*. The source spectrum is typical of Seyfert 2 galaxies. We find heavy obscuration ($N_H \approx 8 \times 10^{22}$ cm^{-2}) and a flat photon index (≈ 1.6). The source intrinsic luminosity is about 5×10^{41} erg s^{-1} in the $0.5 - 10$ keV energy band.

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BL Lac Identification for the Ultraluminous X-ray Source Observed in the Direction of NGC 4698

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We report the identification of the optical and radio counterparts of the ultraluminous X-ray (ULX) source XMMU J124825.9+083020 (NGC4698-ULX1). The optical spectrum taken with the VLT yields a redshift of $z = 0.43$, which implies that the ULX is not associated with the nearby galaxy NGC 4698. The spectral energy distribution calculated from the available data indicates that the source is likely to be a BL Lac object. The possible synchrotron peak at X-ray energies suggests that this source may be a γ-ray emitter.

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The Accretion Rates and Spectral Energy Distributions of BL Lacertae Objects

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We investigate the relationship between accretion rates and the spectral energy distributions (SEDs) of BL Lac objects, using a sample of objects for which published information on the host galaxies, emission-line luminosities, and peakfrequencies and luminosities of their SEDs are available. The sample is composed of 43 BL Lac objects that have a relatively continuous distribution of peak frequencies. Using the emission-line luminosities to infer accretion rates, we find that low frequency-peaked BL Lac objects (LBLs) span a wide range of accretion rates, whereas high frequency-peaked BL Lac objects (HBLs) cover a more restricted range of lower values. There appears to be a continuous distribution of accretion rates between the two subclasses of BL Lac objects. We find that the peak frequency of the SED, $\nu_{\rm pk}$, correlates with the accretion rate, approximately with the form $\nu_{\rm pk} \propto \Lambda^{-3}$ in HBLs and $\nu_{\rm pk} \propto \Lambda^{-0.25}$ in LBLs, where $\Lambda \equiv L_{\rm lines}/c^2$. The peak luminosity of the SED is also strongly

correlated with Λ. These results strongly suggest that the accretion rate influences the shape of the SED in BL Lac objects. They also support models which couple the jet and the accretion disk. We present a physical scenario to account for the empirical trends.

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A Search for Active Galactic Nuclei in Sc Galaxies with H II Spectra

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We have searched for nuclear radio emission from a statistically complete sample of 40 Sc galaxies within 30 Mpc that are optically classified as star-forming objects, in order to determine whether weak active galactic nuclei might be present. Only three nuclear radio sources were detected, in NGC 864, NGC 4123, and NGC 4535. These galaxies have peak 6-cm radio powers of $\sim 10^{20}$ W Hz^{-1} at arcsecond resolution, while upper limits of the non-detected galaxies typically range from $10^{18.4}$ W Hz^{-1} to 10^{20} W Hz^{-1}. The three nuclear radio sources all are resolved and appear to have diffuse morphologies, with linear sizes of ~ 300 pc. This strongly indicates that circumnuclear star formation has been detected in these three H II galaxies. Comparison with previous 20-cm VLA results for the detected galaxies shows that the extended nuclear radio emission has a flat spectrum in two objects, and almost certainly is generated by thermal emission from gas ionized by young stars in the centers of those galaxies. The 6-cm radio powers are comparable to predictions for thermal emission that are based on the nuclear Hα luminosities, and imply nuclear star formation rates of $0.08 - 0.8\,M_{\odot}$ yr^{-1}, while the low-resolution NRAO VLA Sky Survey implies galaxy-wide star formation rates of $0.3 - 1.0\,M_{\odot}$ yr^{-1} in stars above $5M_{\odot}$. In a few of the undetected galaxies, the upper limits to the radio power are lower than predicted from the Hα luminosity, possibly due to over-resolution of central star-forming regions. Although the presence of active nuclei powered by massive black holes cannot be definitively ruled out, the present results suggest that they are likely to be rare in these late-type galaxies with H II spectra.

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A 20,000 $M_{\odot}$ Black Hole in the Stellar Cluster G1

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We present the detection of a $2.0(+1.4, -0.8) \times 10^4\ M_{\odot}$ black hole (BH) in the stellar cluster G1 (Mayall II), based on data taken with the Space Telescope Imaging Spectrograph onboard the *Hubble Space Telescope*. G1 is one of the most massive stellar clusters in M31. The central velocity dispersion (25 km s^{-1}) and the measured BH mass of G1 places it on a linear extrapolation of the correlation between BH mass and bulge velocity dispersion established for nearby galaxies. The detection of a BH in this low-mass stellar system suggests that (1) the most likely candidates for seed massive BHs come from stellar clusters, (2) there is a direct link between massive stellar clusters and normal galaxies, and (3) the formation process of both bulges and massive clusters is similar due to their concordance in the $M_{\bullet} - \sigma$ relation. Globular clusters in our Galaxy should be searched for central BHs.

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Axisymmetric Dynamical Models of the Central Regions of Galaxies

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We present axisymmetric, orbit superposition models for 12 galaxies using data taken with the *Hubble Space Telescope (HST)* and ground-based observatories. In each galaxy, we detect a central black hole (BH) and measure its mass to accuracies ranging from 10% to 70%. We demonstrate that in most cases the BH detection requires *both* the *HST* and ground-based data. Using the ground-based data alone does provide an unbiased measure of the BH mass (provided they are fit with fully general models), but at a greatly reduced significance. The most significant correlation with host galaxy properties is the relation between the BH mass and the velocity dispersion of the host galaxy; we find no other equally strong correlation, and no second parameter that improves the quality of the mass-dispersion relation. We are also able to measure the stellar orbital properties from these general models. The most massive galaxies are strongly biased to tangential orbits near the BH, consistent with binary BH models, while lower-mass galaxies have a range of anisotropies, consistent with an adiabatic growth of the BH.

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The Black Hole Masses and Host Galaxies of BL Lac Objects

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We have measured the central stellar velocity dispersion in the host galaxies of 11 BL Lac objects with redshifts $z \leq 0.125$. The range of velocity dispersions, $\sim 170 - 370$ km/s, is similar to that of nearby radio galaxies. Using the correlation between stellar velocity dispersion and black hole mass defined for nearby galaxies, we derive estimates of the black hole masses in the range $10^{7.9} - 10^{9.2} M_{\odot}$. We do not find any significant difference between the black hole masses in high-frequency-peaked and low-frequency-peaked BL Lac objects. Combining the velocity dispersions with previously measured host galaxy structural parameters, we find that the host galaxies lie on the fundamental plane of elliptical galaxies. This supports the conclusions of imaging studies that the majority of BL Lac hosts are normal giant ellipticals.

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Thesis Abstracts

Neutral Hydrogen Absorption studies of Active Galaxies

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Observations of neutral hydrogen (HI) absorption in the central regions of eight active galaxies are reported. These observations represent the most detailed studies of the neutral hydrogen component so far made of these sources, providing information on the HI gas distribution and kinematics on scales of $\sim 0\farcs2$, corresponding to linear scales of tens of parsecs in the nearest galaxies observed. The sample of active galaxies presented here consists of the radio galaxy 3C 293, two Seyfert galaxies NGC 7674 and NGC 7469, and five luminous infrared galaxies; NGC 6240, III Zw 35, UGC 2369, IR 0335+1523 and Zw 049.0. In each of these galaxies MERLIN has been used to provide the highest angular resolution observations of the neutral hydrogen content in these sources made to date. In addition to these high resolution HI studies the newly operational Giant Meterwavelength Radio Telescope has also been used to provide arcsecond resolution observations of the HI gas content in two of the MERLIN sources, 3C 293 and NGC 7674.

Against the central few kiloparsecs of the radio galaxy 3C 293 both the neutral hydrogen distribution and the radio continuum emission is imaged on linear scales of ~150 pc. The distribution and velocity structure of the HI gas against this radio galaxy is attributed to two gas structures. One of these gas structures is indicative of quiescent gas lying ~10 kpc from the galaxy centre and is physically associated with both ionised gas and dust lanes in the galaxy. The second HI velocity structure is situated within 600 pc of the active galactic nucleus (AGN) and is observed to form a circumnuclear disc with a velocity gradient of 179 km s^{-1} $arcsec^{-1}$. This circumnuclear disc of gas is shown to enclose a mass of $M_{dyn}(< 600\,pc) \leq 3.9 \times 10^9 (\sin^{-2} i)\, M_\odot$, where i represents the inclination of the disc.

Extremely localised HI absorption is observed against the unresolved nuclei of the Seyfert galaxies NGC 7674 and NGC 7469. In the case of the Seyfert-2 galaxy NGC 7674, it is shown that the HI is distributed within a 100 pc of the AGN. Against the unresolved Seyfert-1 nucleus of NGC 7469 the HI absorption is thought to either result from quiescent gas in the outer parts of this galaxy or from gas close to the nucleus. The HI absorption distribution in both of these sources is consistent with the absorption arising in circumnuclear dusty tori.

Of the five luminous infrared galaxies observed, HI absorption is detected in four cases. The observations of III Zw 35, IR 0335+015 and Zw 49.0 all revealed unresolved 1.4 GHz radio continuum structure against which HI absorption is detected. However, against the prototypical luminous infrared merger NGC 6240 extensive radio continuum is resolved and imaged. It is concluded that the radio continuum structure of NGC 6240 is consistent with the radio emission arising from both a starburst region and one or two AGN existing in the remnant nuclei of the merging galaxies. Extremely broad HI absorption is detected against the two dominant radio continuum components. The HI gas structure is consistent with a neutral gas disc forming between the two merging nuclei as they orbit around each other.