HIstoryNU Abstracts

I. Gas Accretion and Removal: Theory and Observations

Tom Oosterloo: invited talk: *The observational perspective of HI in galaxies*

Roger Ianjamasimana: *Smooth HI Low Column Density Outskirts In Nearby Galaxies*
Abstract: The low column density gas at the outskirts of galaxies as traced by the 21 cm hydrogen line emission (HI) represents the interface between galaxies and the intergalactic medium, i.e., where galaxies are believed to get their supply of gas to fuel future episodes of star formation. Photoionization models predict a break in the radial profiles of HI at a column density of 5x10E+19 cm^-2 due to the lack of self-shielding against extragalactic ionizing photons. To investigate the prevalence of such breaks in galactic disks and to characterize what determines the potential "edge" of the HI disks, we study the azimuthally-averaged HI column density profiles of 17 nearby galaxies from The HI Nearby Galaxy Survey (THINGS) and supplemented in two cases with published Hydrogen Accretion in LOcal GAlaxieS (HALOGAS) data. To detect potential faint HI emission that would otherwise be undetected using conventional moment map analysis, we line up individual profiles to the same reference velocity and average them azimuthally to derive stacked radial profiles. To do so, we use model velocity fields created from a simple extrapolation of the rotation curves to align the profiles in velocity at radii beyond the extent probed with the sensitivity of traditional integrated HI maps. With this method, we improve our sensitivity to outer-disk HI emission by up to an order of magnitude. Except for a few disturbed galaxies, none show evidence for a sudden change in the slope of the HI radial profiles, the alleged signature of ionization by the extragalactic background.

Jing Wang: *The Bluedisk project: searching for footprints of gas accretion*
Abstract: We introduce the Bluedisk project, an HI and multi-wavelength mapping campaign to search for signs of gas accretion from 25 HI-rich galaxies by comparing to 25 control galaxies. We find that even the most extreme HI-rich galaxies exhibit regular HI morphologies similar to the control galaxies. On the other hand, we found an HI-rich environment around HI-rich galaxies, out to a projected distance of 1 Mpc and systematic velocity difference of 500 km/s. This result holds for both the HI in surrounding galaxies, and the HI in low-mass systems which can not be directly detected but cumulates to significant signals This result suggests a common underlying reservoir of cold gas for fueling both the central and satellite galaxies. Differences are also found on the gas phase metallicity and CO radial distributions between the HI-rich and control samples, indicating subsequent evolution of galaxy disks with gas accretion.

Sushma Kurapati: *Angular momentum of dwarf galaxies*
Abstract: We use high-resolution HI observations and broadband photometry to measure the baryonic mass (M) and baryonic specific angular momentum (j) for 11 dwarf galaxies that lie in the Lynx-Cancer void. We find that the locus of void dwarf galaxies in the j-M plane is the same as that of dwarf galaxies in average density

environments. However, all dwarf galaxies (i.e. regardless of environment) have significantly higher specific angular momentum than expected from the relation obtained for larger spiral galaxies. We find that this elevation in specific angular momentum occurs for dwarf galaxies with masses lower than 10^9.1 Msun. As the mass of the galaxy increases beyond 10^9.1 Msun, the baryonic specific angular momentum decreases and they tend to follow the relation obtained for the massive galaxies with zero bulge fraction. Interestingly, the mass threshold that we find, viz, 10^9.1 Msun is very similar to the mass threshold below which galaxy discs start to become systematically thicker. We examine the possibility that both these effects, viz. the thickening of disks and the increase in specific angular momentum are results of feedback from star formation. Such feedback would preferentially remove the low angular momentum gas from the central parts of dwarfs (thus increasing the specific angular momentum of the system) and also inject mechanical energy into the system, leading to thicker discs. We find, however, that the observed amount of observed star formation in our sample galaxies is insufficient to produce the observed increase in the specific angular momentum. It hence appears that other, as of yet not identified mechanisms, play a role in producing the observed enhancement in specific angular momentum. We speculate that cold accretion may be one possible mechanism.

Filippo Fraternali: invited talk: *The theoretical perspective of HI in galaxies*
Abstract: Understanding the flow of gas from the intergalactic medium to galaxies and viceversa is of key importance to trace the formation and the growth of galaxies. Gas accretion from the intergalactic medium is a natural consequence of the build-up of cosmic structures. However, unlike dark matter, gas is subject to a variety of complex physical processes that are only partially understood including radiative cooling, photoionisation, heat exchange and magnetic fields. Star-forming galaxies, throughout their history, transform gas into stars and this leads to a further pletora of phenomena, generically termed stellar feedback, that include kinetic energy injection, chemical enrichment, compression and various forms of heating. In this talk, I review some of the theoretical effort made in the recent years to understand gas flows in galaxies using both hydrodynamical simulations and analytic calculations.

Antonino Marasco: *Environmental HI stripping in the EAGLE simulations*
Abstract: It is widely recognised that environmental mechanisms can remove the cold gas from a galaxy, inhibiting star formation at later times.
However, given that the magnitude and timescales of these processes are poorly understood, their relevance for galaxy evolution is still debated. We use the EAGLE simulations to study how the HI content of present-day satellite galaxies depends on their environment. EAGLE shows that the environment acts mainly as an on-off switch to the build-up of the HI content of these systems, and predicts that the fraction of HI-depleted satellites systematically increases with increasing environment density and decreases with increasing stellar mass. We investigate the physics of the HI removal by focussing on three mechanisms: ram pressure stripping by the intra-group medium, tidal stripping by the host halo, and high-speed satellite-satellite encounters. By tracking back in time the evolution of the HI-depleted

satellites, we find that the most common cause of HI removal is satellite encounters, often combined with ram pressure stripping. HI removal generally occurs within the virial radius of the host halo, with timescales of just a few hundreds of Myr. Our results suggest that ram pressure stripping and high-speed encounters play a key role in shaping the evolution of present-day galaxies, with an unexpected dominance of the latter process.

John Dickey: *HI in the Magellanic Clouds: Excitation, Dynamics, History and Future*
Abstract: Studies of the 21-cm line from atomic hydrogen in the Magellanic Clouds have had several great advances, roughly one per generation, interspersed with a decade or two of analysis and planning. We are now in the middle of the fourth great advance, as the resolution and brightness sensitivity of the SKA pathfinders are improving by factors of three to ten over previous observations.
The 21-cm line shows both the dynamics of the gas and the shape and depth of the overall gravitational potential. With better resolution, more precise models of the rotation curves of both galaxies are becoming available. With faster survey speed, the large scale structure of the HI in the Magellanic Clouds, Bridge, and Stream is seen in much greater detail. In particular, HI clouds that were recently expelled from the galaxies are manifest. Combining stellar and gas dynamical modelling of the Magellanic System is still an important work in progress.
The excitation of the 21-cm line is an indicator of interstellar heating, cooling, and thermal stability. This can only be measured reliably by combining emission and absorption spectra, observed separately but for the same areas. In the lead-up to the GASKAP survey, very deep absorption spectra in many directions through the Magellanic Clouds have been observed. They show that the interstellar environment in the Clouds is in many ways similar to that of the Milky Way, but in other ways very different.
Looking back 60 years, and forward 10 to 20 years, HI studies of the Magellanic Clouds show how astrophysics makes progress driven by advances in technology and theoretical insight.

Shuiyao Huang: *PhEW: Physically Evolved Winds in Cosmological Simulations*
Abstract: QSO absorption line studies of the CGM using HST COS are the best direct way to study the accretion and galactic wind processes that are thought to dominate galaxy formation. Hydrodynamic simulations are crucial to interpret and understand these observations. Unfortunately, simulations are sensitive to wind implementations. Interactions at wind/halo gas interfaces in the CGM occur on scales that are much below the resolution of any current or near future galaxy formation simulation. We propose to implement a new wind algorithm that explicitly models the "subgrid physics" in the wind-halo gas interaction analytically within a simulation, using the simulation to provide the physical characteristics that will inform the interaction. Unavoidably, this introduces a few free parameters but we can restrict them by matching observed galaxy. Previous simulations using a more standard wind model approaches reproduced many observed properties of galaxies and metal-line absorption, but our new wind implementation will allow us to tie empirical successes, and failures, more securely to the underlying wind physics, both the ejection (mass-loading factors and ejection speeds) and the interaction between the

wind and gaseous halo, and allow us to identify absorption line features with specific physical processes.

II. Gas Accretion and Removal: Nature vs Nurture

Jacqueline van Gorkom: invited talk: *The environmental perspective of HI in galaxies*

Kyle Oman: *Quenching & stripping of cluster satellites via phase-space matching to simulated orbits*
Abstract: We use N-body simulations to infer the probability distribution of orbits of galaxies in clusters from their spatial and kinematic coordinates. We propose a simple model of environmental star formation suppression which we fit to a large sample of SDSS cluster member candidates to infer the quenching delay time, timescale, and efficiency in clusters. We find that cluster satellites are quenched rapidly, with ~100% efficiency, within approximately 1Gyr of their first pericentric passage. We repeat a similar exercise with a sample surveyed in 21cm emission in the Coma, A2192, A963, 3C 129 and UMa clusters to assess the orbital dependency of neutral hydrogen stripping; results are forthcoming.

Michelle Cluver: *Hidden Cool and Close Encounters*
Abstract: The 64-dish SKA Pathfinder, MeerKAT, will have unprecedented sensitivity to detect low column density neutral hydrogen. Although previously considered relatively unimportant in the baryon cycle due to its inability to survive in harsh environments, there is growing evidence that perhaps we have underestimated the utility of this tracer, particularly in group environments where neutral gas can act as a tracer of past interactions. I will show how using WISE mid-infrared tracers of stellar mass and star formation, in combination with the highly complete GAMA group catalogue, will pave the way for high and low column density HI observations to expose the details of how star formation proceeds in interacting environments.

Sheila Kannappan: *RESOLVE: The Critical Gas Accretion/Depletion Transition in the Nascent Group Regime*
Abstract: The REsolved Spectroscopy Of a Local VolumE (RESOLVE) Survey provides a census of HI in >1500 galaxies in >50,000 cubic Mpc of the nearby universe, complete down to galaxy masses in the large dwarf regime (~10^9 Msun). RESOLVE contains nearly 900 isolated galaxies and over 200 groups, ranging from pairs with group halo mass ~10^11.3 Msun up to clusters with halo mass ~10^14 Msun. In the transition from isolated galaxies to "nascent groups" (small 2-4 member groups with halo masses ~10^11.4-10^12.1 Msun), our data show an abrupt leveling off of the increase in "collapsed" baryonic mass, i.e. stars and cold gas in galaxies, relative to increasing halo mass (Eckert et al. 2017). Thus galaxy growth is "valved off" by the formation of nascent groups, through some combination of reduced gas accretion and increased gas depletion. In this talk I will show that it is in the nascent group regime, not the "hot halo" regime above 10^12.1 Msun, that group-integrated HI gas-to-stellar mass ratios G/S_group drop from >1, i.e. gas-dominated, to well below 0.3, becoming gas-poor. This drop occurs in tandem with first an increase, then a

decrease in the intra-group dispersion between individual galaxy HI gas-to-stellar mass ratios as G/S_group drops below 0.3, at which point average HI profile asymmetries increase. I will interpret these changes using a combination of case-study data -- ALMA CO and VLA HI maps for three nascent groups tracing the dispersion/asymmetry transition -- and star formation/metallicity/environment data for the full survey, probing interactions, accretion, and large-scale environmental influences. It will soon be possible to replicate this analysis with the higher-redshift 21cm LADUMA survey, to observe the evolution of the HI gas inventory in low-mass groups over cosmic time.

Raffaella Morganti: invited talk: *AGN feedback*
Abstract: Gas in the circumnuclear regions of galaxies can play multiple roles and trace multiple phenomena. HI observed in absorption against the radio AGN can be used to trace the gas in these central regions. These observations are telling us not only about the occurrence of HI in these AGN, but also the occurrence of fast and massive outflows driven by the interaction of the expanding radio jets with the surrounding medium.
I will discuss, based on the results from a pilot study using the \"old WSRT\", the prospectives for the upcoming \"blind\" HI absorption surveys planned with Apertif, ASKAP and MeerKat (and hopefully show some first results from commissioning).
I will also compare the properties of the HI with what found for other phases of the gas, in particular for warm ionised gas (using SDSS). Finally, absorption observations using the Very Long Baseline Interferometry (VLBI) can be used to trace the HI down to the pc scales and I will present the results of such a study for a small sample of young radio galaxies. Our results suggest different stages of evolution in jet-ISM interactions and I will discuss how these results provide important constraints for theoretical models.

Suma Murthy: *Feedback from low-luminosity AGNs: a case study of B2 0258+35*
Abstract: The interplay between the nuclear activity and the interstellar medium of galaxies plays an important role in their evolution: the gas accreting onto the dormant supermassive black hole turns it into an active galactic nucleus (AGN) and the ensuing activity is believed to starve the host galaxy of the fuel needed to form stars. The contribution of radio-loud AGNs to this feedback effect is yet to be well understood, more so that of low luminosity radio AGNs. These make up a significant fraction of the radio-loud AGN population, but are generally believed to be too weak to cause any significant impact. I will present the case of one such radio AGN B2 0258+35. Here, a combination of HI absorption, CO emission, continuum studies, and numerical simulations indicate that low power radio activity, under favourable circumstances, can not only disturb gas locally but also result in the formation of large scale radio structures. This thereby highlights the potential importance of low luminosity radio AGNs in the context of feedback.

Smriti Mahajan: *Blue spheroids: progenitors of spirals or ellipticals*
Abstract: We test if nearby blue spheroid (BSph) galaxies may become the progenitors of star-forming spiral galaxies or passively evolving elliptical galaxies by using panchromatic data from the Galaxy and Mass Assembly and ALFALFA surveys. We find that BSph galaxies are structurally very similar to their passively evolving red

counterparts, but their star formation and other properties are more like star-forming spirals. We show that BSph galaxies are statistically distinguishable from other spheroids as well as spirals in the multidimensional space mapped by luminosity-weighted age, metallicity, dust mass, and specific star formation rate. We use HI data to reveal that some of the BSphs are (further) developing their discs, hence their blue colours. They may eventually become spiral galaxies or fade into low-mass red galaxies depending upon their present environment.

Kelley Hess: *The HI Mass Function in Galaxy Groups*

Reynier Peletier: *Galaxy evolution in the Fornax cluster*
Abstract: I discuss the recent results of the Fornax Deep Survey, where we have defined a new sample of dwarf galaxies down to $M_g=-10$. The Fornax Cluster is ideal for studying the effects of the environment on the evolution of galaxies. I describe several features related to interactions: the infalling Fornax A group, the relation to the potential indicated by the X-ray contours, the properties of dwarf galaxies as a function of clustercentric distance as indicators of the morphology-density relation, distribution of star formation across the cluster, etc. I also discuss the detections of HI and CO in the cluster, and what they can tell us about the influence of the environment. To end, I will compare these results with some other nearby galaxy clusters.

Virginia Kilborn: *The global physical processes governing the HI content of galaxies*
Abstract: I will discuss the global HI content of galaxies as driven by major internal and external processes. This work will draw on both global scaling relations, along with detailed observations of nearby galaxies. The relative importance of galaxy environment, and initial formation conditions will also be discussed. Finally I will discuss how the upcoming pathfinder telescopes and the SKA will help us to understand the physics governing the HI content of galaxies.

Omkar Bait: *Discovery of a large HI ring-like structure near a massive quiescent galaxy*
Abstract: We present a resolved HI study of a quiescent galaxy (AGC 203001) with large amounts of HI gas in it ($M_{HI} \sim 3 \times 10^9$ Msun) using the Giant Metrewave Radio Telescope (GMRT). It is intriguing to find such large amounts of HI gas with no active star formation in the galaxy. This could be due to two possibilities, either the galaxy has a HI gas disc but it is stable under collapse (e.g, due to morphological quenching), and hence the galaxy is passive, or the galaxy has recently acquired gas from outside (e.g., gas rich mergers) or the gas has been tidally stripped. The HI image shows a large ring-like structure with no optical counterpart and is offset from the galaxy by ~23 kpc. The HI feature has a projected diameter of ~100 kpc. The host galaxy has an early type morphology and is in a group of 4 galaxies. We study the possibility whether tidal stripping can lead to such a large HI feature with no optical counterpart.

III. The Connection to Star Formation

Rob Kennicutt: invited talk: *Star formation in galaxies and its impact*
Abstract: The thermal radio continuum has long been recognized as a potentially powerful dust-free measure of the star formation rate (SFR). Most attempts to apply it to galaxies, however, have been plagued by the much brighter background synchrotron emission in the 1-10 GHz region. This talk will present results from the Star Formation in Radio survey (Eric Murphy PI), which targeted nuclear and extranuclear regions in 55 nearby galaxies, using matched-array VLA observations at 3, 15, and 33 GHz. These produce radio images with resolution and depth comparable to ground-based emission-line images, and robust spectral separation of the thermal and non-thermal emission components. Preliminary results and comparisons to other multi-wavelength SFR measurements will be presented.

Amelie Saintonge: invited talk: *Molecular gas in galaxies, now and in the past*
Abstract: Over the past 10 years, it has become possible to assemble measurements of molecular gas in large samples of normal star-forming galaxies up to z~2. These observations have been key in establishing the currently favoured model for galaxy evolution, which is centered around the cycling of gas in and out of galaxies and the efficiency of the star formation process. While star formation is a physical process taking place on very small scales, significant insights can be gained by systematic studies of the scaling relations between gas, star formation, and global galaxy properties. In this talk I will review some of these key observations at both low and high redshifts, and how they are shaping our understanding of how, when and where galaxies form their stars.

Danielle Lucero: *The HI-H2 transition in nearby CO-rich early-type galaxies*
Abstract: Steady star formation in a galaxy requires a continuous supply of H2. At the same time the steady formation of H2 requires a reservoir of HI. Clearly, a good grasp of the physical processes which determine the balance between these two cold gas phases is required in order to understand how star formation in galaxies is regulated. The question of molecule formation for disk galaxies has been thoroughly studied in the literature mostly through two different methods. The first is an empirical study using the CO and HI maps of nearby disk galaxies (e.g. Leroy etal. 2008). These studies infer that the molecular to atomic surface density ratio in disks is entirely a function of the hydrostatic midplane pressure which is in turn a function of the stellar and gas volume densities. The second method also utilizes gas maps and a first principles approach which models the chemical and physical processes that regulate the balance between the formation and dissociation of molecules (e.g. Krumholtz etal. 2008). Interestingly, both of these approaches predict values of the molecular fraction, which are roughly consistent with molecular and atomic observations in nearby disk galaxies. These empirical and theoretical models of molecule formation are already being used as input/constraints for theoretical models of star formation and galaxy evolution (e.g. Lagos et al. 2014; et al. 2016; Xie et al. 2016). However, it is unknown

whether these models of molecule formation derived for disk galaxies can be used for early-type galaxies. Early-type galaxies have very different gas contents, stellar populations and densities/distributions, UV field strengths, and evolutionary histories from that of spirals. In my talk, I will present ongoing work which for the first time extends the study of molecule formation to the case of early-type galaxies.

Basilio Solis: *Spatially resolved dust-to-gas mass ratio in nearby galaxies*
Abstract: The advent of ground-based and space observatories operating in the infrared (IR) to sub-millimeter and millimeter spectral regime resulted in a shift of our perception of dust, from simply disturbing observations by reddening and extinction towards playing a crucial role in the multi-phase interstellar medium (ISM) of galaxies. Dust emission provides powerful tools to trace some characteristics of the ISM, from the properties of cold dense material to the rate of star formation. Despite its importance, a comprehensive understanding of dust is still challenging, given the inner complexity of its evolution in the ISM.
The relation between the dust-to-gas ratio (DGR) and metallicity provides an important tool to study the evolutionary stage of a galaxy as it links the amount of metals bound in dust and in the gas phase. It allows to put constraints on dust evolution models which predict the balance between dust formation, growth and destruction and the total amount of metals. The dust evolution models depend strongly on a precise estimate of the dust mass and the mass of molecular gas.
I used a sample of 29 galaxies selected from the SINGS (Spitzer), KINGFISH (Herschel) and HERACLES (IRAM 30 m) and THINGS (VLA) surveys to study the relations between DGR and other ISM parameters, like the stellar mass, dust temperatures, star formation rate and metallicity.We implemented a hierarchical bayesian technique to derive the dust mass via fitting the far-IR spectral energy distribution. This method allows us to break the known degeneracy between the dust temperature and emissivity index and having a more accurate dust mass estimates. We found that the DGR-metallicity relation for kpc scale regions follow the same trend as for global values of galaxies. Additionally, we found a very strong influence of the DGR on the CO-to-H2 conversion factor (α_co), a high correlation between DGR and other ISM parameters, like stellar mass and star formation rate. Our total dust mass estimates are in agreement with published works but the bigger difference is for low-metallicity systems, where the normal methods overestimates the dust mass in lower signal-to-noise regions. The new DGR-metallicity relation for kpc regions we derived, fits better with a single power law and is steeper than what other previous studies found.

Evan Skillman: *Understanding Chemical Evolution without Gas Masses*
Abstract: Detailed star formation histories of individual galaxies are possible with a deep census of the current stellar population and these studies also provide a measure of the chemical evolution of the observed galaxy. There are also studies suggesting that comparably detailed studies may also be possible with integrated optical spectroscopy. From a chemical evolution point of view, the missing piece is the history of the gas content of the galaxy. I will speculate on how the large HI

surveys of the future may be able to provide some guidance in understanding the gas content component of chemical evolution.

Ralf Klessen: invited talk: *Theory of star formation*
Abstract: Stars and star clusters are the fundamental visible building blocks of galaxies at present days as well as in the early universe. They form by gravitational collapse in regions of high density in the complex multi-phase interstellar medium. The process of stellar birth is controlled by the intricate interplay between the self-gravity of the star-forming gas and various opposing agents, such as supersonic turbulence, magnetic fields, radiative feedback, gas pressure, and cosmic rays. Turbulence plays a dual role. On global scales it provides support, while at the same time it can promote local collapse. This process is modified by the thermodynamic response of the gas, which is determined by the balance between various heating and cooling processes, which in turn depend on the chemical composition of the material. I will review the current status of the field and discuss a few examples of the recent progress and controversies.

Cecilia Bacchini: *The Volumetric Star Formation laws: fundamental correlations between total gas, HI and SFR*
Abstract: Understanding the laws for the conversion of gas into stars is fundamental to investigate the formation and evolution of galaxies. Generally, the Kennicutt law is advocated to link the surface densities of star formation rate (SFR) and gas (HI+H2) with a break in the slope at low surface densities, but it is still unclear if a more fundamental correlation exists for the volume densities.
Converting surface densities to volume densities is problematic, as the thickness of gas discs strongly varies with galactocentric radius and between different galaxies. We present a treatment for the disc thickness based on the assumption of hydrostatic equilibrium that allows us to derive a new relation between gas and SFR volume densities.
We applied our method to twelve nearby star-forming galaxies from the THINGS sample with high quality rotation curves and mass decompositions, that are necessary to estimate the disc thickness radial growth. We find a superlinear volumetric relation with no break in slope over five orders of magnitude in density and smaller scatter with respect to the Kennicutt law. Moreover, a surprising and tight correlation between HI alone and SFR volume densities emerges, suggesting that atomic gas has a key role in the physics of star formation.
These relations may be universal for star-forming galaxies and they extends to spirals outskirts and dwarf galaxies, where the atomic phase fully dominates the gas density.

Moses Mogotsi: *The SUNBIRD Multi-wavelength Window into Starburst and LIRG Feedback*
Abstract: Intensely star forming galaxies provide us with ideal conditions to study star formation feedback in extreme conditions. In particular, multi-phase outflows due to star formation can be studied in great detail to determine how they affect star formation and galaxy evolution. SUNBIRD is a VLT adaptive optics infrared survey of nearby starbursts and U/LIRGs to study their interstellar medium, star formation and to detect supernovae. A systematic study of the properties and kinematics of 54 of these galaxies has been performed with SALT to identify and characterize outflows

and to study how they relate to star formation and star formation histories. H-alpha emission and NaD absorption lines were used to study the ionized and neutral gas kinematics. Follow-up of these galaxies has begun with ALMA and MUSE. Results from the analysis shows varied and complex gas dynamics across the sample and we find evidence of outflows (and inflows). I will present the latest results of the multi-wavelength kinematic study of the galaxies and their gas flows. HI is an important component of the star formation gas reservoir. I will also discuss the prospect HI studies of SUNBIRD galaxies with the SKA-precursor instruments and how they can be used in conjunction with other multi-wavelength observations to understand the gas cycle and its role in the evolution of intensely star forming galaxies such as U/LIRGs.

Maryam Arabsalmani: *HI emission studies of the closest Gamma Ray Burst host galaxy*
Abstract: The conditions required for GRB formation are still unknown. A likely hypothesis is that they form in regions with localized and intense star formation, such as massive super star clusters. Such regions are more common in post-merger galaxies where the absence of gravitational shear aids gravitational collapse of massive amounts of gas into dense super star clusters.
I present our study revealing the clear ongoing interaction between the closest known GRB (at z=0.0087) and its satellite galaxy through multi wavelength observations with Spitzer, VLT, and the GMRT array. Our HI 21 cm emission studies at first revealed evidence of interaction in the GRB host. Based on this evidence, we identified the interacting satellite galaxy in the vicinity of the GRB host using H-alpha, 4.5 micron, and optical observations. Our findings support the connection between GRB events and interacting systems. Such a connection being commonplace would put strong constrains on the likely channels of GRB formation.

Rob Crain: invited talk: *Cold gas in calibrated cosmological simulations of galaxy formation*
Abstract: I will discuss the advances made in producing the current generation of state-of-the-art cosmological simulations of the formation and assembly of the present-day galaxy population. Having been calibrated to reproduce the stellar properties of galaxies, these models have significant predictive power for the gas-phase Universe, positioning observations of the ISM and the CGM as particularly constraining for our understanding of galaxy evolution.

Ahmed Elagali: *Observations and theoretical study of colliding Galaxies and the effects on their star formation*
Abstract: Star formation in collisional ring galaxies are concentrated in spoke-like structures which terminate in a ring that result from a drop-through collision between two galaxies. While the formation of collisional ring galaxies are well-understood, observations have revealed the star-forming ISM to be surprisingly deficient of molecular gas even though ring galaxies are observed to be HI-rich and strongly star-forming. Current studies hypothesise that the compression-driven star formation found in the star-forming ring is likely to suffer from the immediate feedback effects of star formation which enhances the photodissociation rate of the molecular clouds that are confined within the ring. Using the EAGLE suite of

cosmological simulations, I find the global ISM of ring galaxies to have lower pressure and metallicities than normal star-forming disk galaxies. The collisional interaction is responsible for decreasing the ISM pressure internal to the ring as the ISM is swept up by the density wave towards the ring. On the other hand, at the radius of the ring, the star formation efficiency of ring galaxies is indistinguishable from that of normal star-forming disk galaxies, and thus the main reason for their integrated lower efficiency is the different gas surface density profiles.

Lorenzo Posti: *The angular momentum of galaxies and their haloes as a tracer of galaxy evolution*
Abstract: Angular momentum (AM) is one of the pivotal variables determining the different morphologies of galaxies. While tidal torques should supply baryons and dark matter with comparable amounts of AM, it is still unclear what determines which fraction of the available AM is eventually incorporated into the galaxies that we observe today.
I will show how analytic models in a LCDM framework and the observed properties of galaxies (including recent measurements in ~150 nearby galaxies, from dwarfs to massive spirals, with extended HI rotation curves and infrared photometry) can be folded together to unveil how much AM is present in the gas available to cool and form stars in the galaxy. If star formation proceeds inside-out, from the innermost and AM-poorer regions, we find that (Posti et al. 2018a,b) i) spirals need to accrete a significant portion of AM-rich gas from the outer regions (10-50%), while ellipticals must have lost ~40% of the AM initially in the gas due to mergers and dynamical friction; ii) the fraction of stellar-to-halo AM is a strong, non-linear function of galaxy mass for both spirals/ellipticals.
Comparing our estimate of the stellar-to-halo AM relation with the stellar-to-halo mass relation, we find that the efficiencies of star formation and AM retention closely follow each other, indicating that the AM distribution of dark matter and baryons are also very well correlated. I will speculate on the constraints on galaxy formation that this implies.

Sambit Roychowdhury: *The gas-to-dust cycle in star forming dwarf galaxies using resolved HI*
Abstract: Star forming dwarf galaxies are the most numerous galaxies in the nearby Universe, closely resembling the first galaxies that formed. They represent a goldmine in our own backyard for studying the baryon cycle in the smallest galaxies. Recent large multi-wavelength surveys of the Local Volume has made it possible to study these galaxies in considerable detail.
Atomic hydrogen (HI) remains the primary tracer of gas in these systems as CO, the tracer of molecular gas, become harder to detect due to a decrease in the CO-to-H2 ratio with decreasing metallicity. The atomic gas traces the total gas reservoir in dwarf irregulars - and consequently the whole ecosystem within which stars form.
I will present my efforts to model the full baryon cycle in the lowest (<20% solar) metallicity star forming dwarf galaxies from the well-defined DustPedia sample, which has multi-wavelength coverage in 42 bands ranging from the ultraviolet to submillimeter. Adding resolved HI maps, and using SFR and dust properties derived from SED fits using a hierarchical Bayesian approach, I study the relations between various properties tracing the evolution of gas, stars and dust in the galaxies. While

historically such studies have used single-dish HI fluxes, I compare the gas and dust properties within co-spatial regions using interferometric HI observations. The comparison is done either globally for the entire optical disks of the galaxies, or on a region-by-region basis within the galaxies. These observations are compared to the latest chemical evolution models to understand the gas-stars-dust cycle in star forming dwarf galaxies, and its similarities/dissimilarities to that in more massive star forming galaxies.

IV. Surveys and Analysis

Anne-Marie Weijmans: invited talk: *Lessons learned from MaNGA*

Tom Jarrett: *HICAT-WISE study of galaxy evolution*
Abstract: Consideration of the past star formation history, aggregated in the host stellar mass, and the current star formation (SF) activity underpins the study of galaxy evolution. SF is fuelled by hydrogen gas, and hence is equally important to the process of how galaxies build and evolve. Many studies are now combining the traditional galaxy mass-SF main sequence and the gas components, a multi-parameter approach that requires large and carefully selected host galaxy samples. Here we present a study of the Hi mass, stellar mass, and star formation rate using the Hi Parkes All Sky-Survey Catalogue (HICAT) and the Wide-field Infrared Survey Explorer (WISE). We construct various sub-samples based on the brightness, redshift range, and Hubble T-Type, and consider gas fractions, halo-spin dynamics, star burst and quenching phenomenon.

Unarine Tshiwawa: *The angular momentum content of early-type galaxies*
Abstract: We are currently investigating the relationship between specific baryonic angular momentum j_b and baryonic mass M_b (j_b - M_b relation) for a sample of 11 well-resolved WHISP galaxies. We have parameterized the WHISP cubes to produce new HI total intensity maps and velocity fields. ROTCUR has been used to generate a tilted-ring model for each galaxy. Our models have been compared directly to the HI data cubes in order to check their accuracy. In this talk, I will present some of the details of the methods we have used to process the HI data. I will also aim to present some preliminary measures of the
j_b - M_b relation for our galaxies. The importance of this study will be discussed in the context of the recent results from the literature.

Nissim Kanekar: *The gas mass of galaxies during the epoch of galaxy assembly*
Abstract: Optical imaging and spectroscopic surveys of the various deep fields have yielded detailed information on the properties of star-forming galaxies out to high redshifts. However, little is known about the atomic gas in these galaxies, due to the weakness of the HI 21cm line.
For large galaxy samples, stacking of the redshifted HI 21cm emission from the different galaxies allows us to achieve a far higher HI mass sensitivity than would be possible for individual objects. I will describe the first such HI 21cm stacking

experiment at z>1, using Giant Metrewave Radio Telescope (GMRT) HI 21cm spectroscopy of the
DEEP2 fields to probe the atomic gas mass and gas depletion time of star-forming galaxies, as well as the cosmological gas mass density, in the epoch of galaxy assembly.

Attila Popping: invited talk: *Data challenges of modern HI surveys*

Davide Punzo: *SlicerAstro: a versatile tool for linked 2D/3D visualization*
Abstract: Upcoming HI surveys will deliver large datasets, and automated processing using the full 3D information to find and characterize HI objects is imperative. In this context, visualization is an essential tool for enabling qualitative and quantitative human control on an automated source finding and analysis pipelines.
SlicerAstro, a multi-platform, open-source extension of 3DSlicer (www.slicer.org), is a linked 2D/3D (GPU accelerated) visualization tool for the inspection and analysis of complex 3D astronomical data such as HI spectral line emission data from galaxies.
In addition to interactive 3D navigation and widgets to interactively modify the color function used for the visual data representation, SlicerAstro offers the following capabilities: i) overlay capabilities fully supporting WCS; ii) fast and adaptive 3D filtering; iii) interactive 3D selection; iv) calculation of moment images; v) performance of statistics linked to selections in the 2D/3D displays; vi) construction of position-velocity slices along specified axes; vii) and comparative kinematic modeling. SlicerAstro is a C++ package and its modules can be accessed also by Python scripting allowing both fast performance and flexibility for implementing any user customized analysis. In this presentation I will demonstrate its capabilities using HI synthesis data of nearby galaxies.

Lourdes Verdes-Montenegro: *The HI needs for the SKA Regional Centres (SRCs)*
Abstract: The SKA Regional Centres (SRCs) are expected to provide access to the SKA community to data products, as well as the tools and processing power to generate and analyse advanced data products. Preparatory works are on-going in different regions, as AENEAS H2020 project (https://www.aeneas2020.eu) in Europe.
During the last AENEAS all-hands meeting I was asked, as both member of AENEAS and co-Chair of the SKA HI Science Working Group (HISWG), to summarize the needs of the community represented by the HISWG within the context of the SRCs. With this aim I did a survey within this WG, added my own experience, and presented a (for sure uncomplete) summary of processing considerations, data products and associated volumes, formats, and tools. I saw this talk just as a first step in the process, and I am convinced that further discussions and a better understanding of the Science Data Processor (SDP), SRCs and Data challenges is certainly required in the close future by the SKA scientific (and in our particular case, HI) community.
The HI/StoryNU workshop seems a right place to present an updated version of this talk, and hopefully motivate further discussions in order to improve its contents and hence make sure that the needs of the HI community are well integrated within the SKA Regional Centres early in the process.

Flash Talks

Pooja Bilimogga: *A comparative study of HI morphologies in Ursa Major and Perseus-Pisces galaxies*

Jamie Bok: *The role of HI mass and environment on the galaxy main-sequence turnover*
Abstract: The galaxy main sequence (MS) diagram (stellar mass (M^*) vs star formation rate (SFR)) shows a trend of increasing SFR with increasing M^* that begins to plateau for $M^* > 10^{10}$ solar masses. With neutral hydrogen (HI) serving as the fuel for star formation (SF), we investigate the possibility that the observed plateau in SFR on the galaxy main sequence corresponds to a depletion in HI mass, and thus transform the standard 2D galaxy MS into a 3D diagram, including integrated HI profile mass as the third axis. We conduct our analysis first on a sample of nearby gas-rich galaxy pairs drawn from the ALFALFA catalogue, which we compare with both our own sample of isolated ALFALFA galaxies, as well as the AMIGA sample of isolated galaxies. In this way we also investigate the role of environment in determining a galaxy its location on the MS. Quenching events can cause a galaxy to drop suddenly below the main sequence, while a starburst phase will cause a galaxy to migrate upwards off the main sequence. Galaxy-galaxy interactions have been associated with both phenomena mentioned above, and thus make for a particularly interesting sample to investigate on the MS. Our 3D MS makes use of stellar masses and SFRs measured in WISE, as well as integrated HI profile masses from the ALFALFA catalogue.

Ed Elson: *The relation between specific angular momentum and mass for a sample of late-type WHISP galaxies*
Abstract: I have investigated the relationship between specific baryon angular momentum, j_b, and baryon mass, M_b, for a sample of 37 nearby late-type galaxies observed as part of the WHISP survey. This work roughly doubles the number of galaxies with $M_b < 10^{10}$ Msun used to study the baryonic j-M relation. Measured HI surface density radial profiles together with optical and rotation curve data from the literature are used to calculate j_b and M_b for the galaxies. Treating the two quantities to be related via a power law, a best-fit index of 0.62 0.02 is obtained. This result is consistent with the theoretically-expected relation. This study, based on 30 arcsec HI imaging, suggests upcoming galaxy HI surveys such as LADUMA and WALLABY will play important roles in further understanding the evolution of galaxies in the local Universe via the baryonic j-M relation.

Avanti Gogate: *The HI Mass Function and ΩHI at z=0.2 from direct detections*

Anastasia Ponomareva: *Accretion in action? The mysterious case of NGC 5102*
Abstract: NGC 5102 is a low-luminosity (MB = 17.5) relatively unexplored galaxy within the nearby (3.5 Mpc) Cen A group, which also includes Cen A, M83 and NGC 5253. It is a classic S0 galaxy in appearance but has had a unusual star formation history. The mystery of this galaxy lies in its sustained star formation (uncharacteristic of an S0 galaxy) still ongoing now in its nuclear region, in the unusually compact nucleus (< 3 pc) made of young stars and in two counter-rotating stellar disks.

This continuing star formation is most likely being fuelled by the gas infall from its massive surrounding HI reservoir. In my talk I will present deep (4x12 h) ATCA observations of this HI reservoir together with the detailed study of its kinematics. I will discuss the possibilities of the gas infall into the centre of NGC 5102 which triggered the nuclear starburst, and thus, revitalised the former red sequence galaxy.

Tirna Deb: *Neutral Hydrogen in a striking Jellyfish galaxy*

Peter Kamphuis: *The HI to optical ratio of disk sizes*
Abstract: It has now been known for almost half a century that galaxies in over-dense regions are HI deficient. However, there are still many questions about how and especially when galaxies start to lose their gas as they fall into denser and denser environments. Are they pre-processed in their groups or do they lose their gas when falling into the clusters? Is the gas used up in star formation and no longer replenished or is the the gas actively stripped from the galaxies. In this talk I would like to introduce a novel way of investigating these effects. Traditionally, in larger samples these effects have been studied as the ratio between HI Mass and stellar Mass. Here instead I want to present the first attempts to use the ratio between the optical and HI radius of galaxies. This has the advantage that the measured quantities can be directly compared without the need for, often highly uncertain, conversions and distances.
For a first exploration we use the Westerbork HI Survey of Spiral and Irregular Galaxies (WHISP, van der Hulst 2002). We use this to establish the optical size indicator for which the ratio shows least variation with other galaxy parameters. We then use, as a first attempt to cover a larger range of densities than available from WHISP, the GALEX Arecibo SDSS Survey (Catinella et al. 2013) and the Arecibo Fast Legacy ALFA Survey (Haynes et al. 2011). These surveys are single dish and as such the HI radius is derived from the Mass-Size relation and as such the results should be confirmed in upcoming high resolution all sky HI surveys, such as WALLABY and with Apertif, supported by optical all sky surveys such as SDSS.

Vanessa Moss: *Uncovering the hidden iceberg structure of the Galactic halo*
Abstract: How the Milky Way gets its gas and keeps its measured star formation rate going are both long-standing mysteries in Galactic studies, with important implications for galaxy accretion and evolution across the Universe. I will present our discovery of two populations of neutral hydrogen (HI) in the halo of the Milky Way: 1) a narrow line-width dense population typical of the majority of bright high velocity cloud (HVC) components, and 2) a fainter, broad line-width diffuse population that aligns well with the population found in very sensitive pointings such as in Lockman et al. (2002). From the existing data, we concluded that the diffuse gas population may outweigh the dense HI by a factor of 3. This discovery of diffuse HI, which appears to be prevalent throughout the halo, takes us closer to solving the Galactic mystery of accretion and reveals a gaseous neutral halo hidden from the view of most large-scale surveys. We are currently carrying out deep Parkes observations as part of the Survey of Weak Intensity Southern HI (SWISH). Our goal is to investigate these results further, in order to truly uncover the nature of the diffuse HI and determine whether our 3:1 ratio (based on the limited existing data) is consistent with what is seen when Parkes and the 140 ft Green Bank telescope are employed at

comparable sensitivity. With these data, through a combination of both known and new sightline measurements, we aim to reveal the structure of the Galactic halo in more detail than ever before.

Peter Teuben: *ADMIT: automatically detecting HI in large data cubes*

Kijeong Yim: *The volumetric star formation law in nearby edge-on galaxies*
Abstract: We investigate radial variations of the scale heights and the vertical velocity dispersions of a sample of edge-on galaxies (NGC 891, 4013, 4157, 4565, and 5907) using OVRO/BIMA/CARMA 12CO (J=1-0), VLA/JVLA HI, and Spitzer data. We show that the disk thicknesses increase with radius and the velocity dispersions decrease with radius, which are contrary to the assumed constant values used in many literatures. The measured disk thicknesses are used to estimate the gas volume density, one that is directly related to star formation rate. Using the volume densities and the vertical velocity dispersions, we derive the turbulent interstellar gas pressure and show a strong correlation between the gas pressure and the star formation rate. In addition, we investigate a relationship between the CO disk thickness and the star formation rate.