# Interstellar Medium in the Nearby Universe

## A workshop on interstellar matter, light, and magnetic fields in our Milky Way and nearby galaxies.

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ABSTRACT BOOKLET

http://www.sternwarte.uni-erlangen.de/ism2018

# Supernova remnants with the LOw Frequency ARay (LOFAR)

Maria Arias

Supernova explosions are the events that most significantly affect the ISM at parsec scales, injecting it with kinetic energy and freshly synthesised elements. Supernova remnants (SNRs) actively carry out these processes as blast wave of the explosion and the ejected material interact with the circumstellar and later interstellar media around them.

The steep radio power law indices of SNRs make them brighter at lower radio frequencies. Low-frequency, broad band instruments like the LOw Frequency ARay (LOFAR) in The Netherlands (covering the 30−190 MHz range) are ideally suited for the study of galactic SNRs. LOFAR's broad field of view and sensitivity allow us to map the larger, older remnants that might otherwise be too faint; its multi-frequency abilities allow us to note variations in their brightness at different frequencies, both due to intrinsic spectral index variations (which are related to the underlying shock conditions) or due to intervening, free-free absorbing material.

In my talk I will discuss several recent LOFAR results on the Galactic Plane that probe SNRs, their environments, and their line-of-sight ISM. I will emphasise our recent LOFAR study of low-frequency free-free absorption to trace the cold ionised material internal to Cassiopeia A's reverse shock, and our current work on mixed-morphology supernova remnants, in particular on the field of VRO 42.05.01.

# The dynamics of the magnetised ISM

Robi Banerjee

Magnetic fields are an elemental part of the interstellar medium (ISM) that have a large impact on the dynamics of the ISM on various spatial scales. Here, I'll talk about the long-standing issue of how to generate magnetically supercritical cloud cores, which are essential to understanding star formation in our own Galaxy. Furthermore on a related issue, I'll discuss how to circumvent the "magnetic braking catastrophe", which was thought to be a major problem for the formation of protostellar discs.

# First self-consistent study of feedback from ultraluminous X-ray sources

Tobias Beuchert

Compact objects such as black holes (BHs) and neutron stars (NSs) are known as effective engines that convert rest mass energy into immense radiated and mechanical feedback via the process of accretion. Besides strong wide-angle winds, jets are the most powerful outflows and focus matter at relativistic speeds into narrow solid angles. Although these processes are ubiquitous on all mass scales, from stellar-mass BHs/NSs to supermassive BHs, their direct observation has been largely prevented by limitations in the instrumental sensitivity and angular resolution. In particular, the launching mechanism of jets remains one of the key questions in modern astrophysics. Recently, a special class of "ultraluminous X-ray sources" (ULXs) has been identified. ULXs are supposed to be super-Eddington accreting stellar-mass BHs/NSs. Their low mass and high brightness permits the first study of accreting compact objects and their evolution on human time-scales and in distant galaxies. The feedback that is evidently emerging from ULXs is, moreover, strong enough to blow cavities into and excite the surrounding gas. Still, very little is known on the feedback mechanisms that may be at play in ULXs. I am presenting a novel method using multiwavelength spectroscopy to extract information on these driving forces as they are stored inside inflated nebulae. We will explore physical models able to describe the radiated and mechanical energy from super-Eddington winds and collimated jets. Understanding how jets can be launched in extreme accretion environments in particular is fundamental to our understanding of the bigger picture and how jets are launched from all kinds of accretion flows. Studying accretion-feedback self-consistently will allow me to tackle these questions for the first time.

# The neutral atomic interstellar medium in the nearby universe

Elias Brinks

I will present an overview of what we know about the Neutral Atomic Interstellar Medium in nearby galaxies. This constituent of the ISM is most abundant in late-type, i.e, spiral and (dwarf) irregular galaxies. It not only extends throughout a typical spiral galaxy at an almost constant column density, but continues out to considerable distance beyond the optically visible part, although at gradually decreasing column density. Frozen into this medium is the all pervasive magnetic field.

The atomic gas provides the reservoir from which, after having turned molecular, stars form. Supernova explosions from massive (young) stars can expel coronal gas into the halo where in due course it will cool, recombine, and eventually fall back onto the disk; this process is known as the galactic fountain. Primordial gas still accreting onto the large-scale structures described by LambdaCDM cosmology is thought to provide a constant supply of pristine material, at a rate roughly equal to the observed star formation rate of a typical galaxy.

I will review some of the highlights of the many recent surveys and studies that have focused on the atomic gas content in late-type galaxies, and will hint at what we can expect from some of the major surveys that are being planned with precursor instruments for the Square Kilometre Array (SKA), and what we hope to achieve with the SKA proper.

# A New Method to Derive Star Formation Histories in Dwarf Galaxies (poster)

Marius Čeponis

A new method to determine star formation histories of stellar systems, like dwarf galaxies, is presented. The method uses multicolour stellar photometry data of resolved stellar populations. Star formation histories are determined by comparing observed populations with artificially generated ones based on star counts in binned colour-magnitude diagrams. Parameters of synthetic populations are adjusted iteratively to match observations. The method has been extensively tested with synthetic galaxies and stellar populations of the dwarf irregular galaxy Leo A.

## Dynamical evolution and non-equilibrium ionisation of the interstellar plasma

Miguel de Avillez

Since the seminal works of Bania & Lyon (1980) there has been a large effort in modeling the interstellar plasma by assuming that each fluid element has the same atomic history and a constant adiabatic parameter. The former assumption implies that the ionic and emission histories of the plasma are the same for all the fluid elements. And thus, a cooling function (calculated assuming collisional ionization equilibrium; CIE) is included as a sink term in the energy equation. However, due to the competition between recombination and cooling processes the interstellar plasma is far from CIE. Progress was made a few years ago with the first to date time-dependent joint dynamical and thermal simulations of the interstellar plasma. Further developments included: (i) a variable adiabatic parameter, whose value depends on the atomic history of the plasma and is only constant in a specific range of temperatures, and (ii) non-thermal electron distribution functions. In this talk I'll review the current state in the field.

# CPIPES - A collisional + photoionization plasma emission software for interstellar medium simulations (poster)

Miguel de Avillez

We have developed the Collision + Photoionization Plasma Emission Software (CPIPES) to trace the time-dependent evolution of the ionization structure of the plasma and its emission processes. CPIPES can be used coupled to any (magneto)hydrodynamical software or work as a standalone software. It features steady state and time-dependent calculations of the ionization structure, cooling and emission spectra of optically thin plasmas in a Lagrangean fashion. The physical processes included in CPIPES are electron impact ionization, inner-shell excitation auto-ionization, radiative and dielectronic recombination to excited levels (followed by cascades), charge-exchange reactions (recombination with H I and He I and ionization with H II and He II), continuum (bremsstrahlung, free-bound, and two-photon) and line (permitted, semi-forbidden, and forbidden) emission. The radiative model further comprises detailed calculations of the relative populations due to electron impact excitation and de-excitation, and spontaneous emission using up to a 70-levels model. The code further includes photoionization due to an external radiation field, and inner-shell photoionization due to cascades. In addition, Auger and Coster-Kronig photo-ejection of deep shell electrons is taken into account. CPIPES includes thermal and non-thermal distributions of electrons and protons and is used to determine the ionization structure and emission of ionized plasmas with cosmic rays.

# A fresh look on cosmic rays and magnetic fields in halos of disc galaxies

Ralf-Jürgen Dettmar

Recent numerical models of the multiphase ISM underline the importance of cosmic rays and magnetic fields for the physics of the ISM in disc galaxies. Observations of properties of the ISM in galactic halos constrain models of the expected exchange of matter between the star-forming disc and the environment (circumgalactic medium, CGM). We will present new observational evidence from radio-continuum polarization studies of edge-on galaxies on magnetic field strength and structure as well as cosmic ray propagation in galactic halos. The new findings result from the CHANG-ES (Continuum HAlos in Nearby Galaxies - an EVLA Survey; PI J. Irwin) project which has observed 35 edge-on galaxies with the Karl G. Jansky Very Large Array (JVLA) in two frequency bands (L- and C-band) and in three array configurations (D, C, B). This survey benefits significantly from the new multi-channel capability of the upgraded facility. From the total power maps, a "mean" radio-continuum halo has been derived and the polarization information provides information on the magnetic field structure in the halos. The findings will be discussed in the context of CR driven galactic winds. In addition, we will also briefly discuss most recent results from LOFAR observations of edge-on galaxies.

# The young stellar objects inside SNR CTB 109

Baha Dinçel

We present the results of optical and NIR photometry of two young stellar objects (YSOs) J230230.53+585807.9 and J230229.64+585755.5 embedded inside a warm dust cloud projected on the shell-type supernova remnant (SNR) CTB 109. We had previously shown that the host cloud might have been hit by SN shock waves. Based on the MIR flux values from ALLWISE catalog, these sources are Class II YSOs. Through our NIR photometry performed at the Calar Alto Observatory using the PANIC instrument of the 2.2 meter telescope, we measured the extinction and the stellar parameters, which suggest that the YSOs are very young and rather massive. The more massive YSO has almost reached the main sequence, while the other is still at the pre-main sequence stage. We detected H$\alpha$ emission in the less evolved YSO spectrum with the TFOSC instrument of the RTT-150 telescope at TUG. The optical photometry performed at TUG with the T-100 telescope covering a three month interval revealed that neither show any flux variation. The mass accretion rates derived from the H$\alpha$ flux are lower than the values which are typically measured for YSOs. This can be explained by the fact that the circumstellar material has been influenced by the SN shock.

# G53.41+0.03 - a newly discovered Galactic supernova remnant

Vladimír Domček

We present the serendipitous discovery of a new supernova remnant, G53.41 + 0.03, in deep targeted LOw Frequency ARray (LOFAR) High Band Antenna (HBA) observations of the pulsar wind nebula G54.1+0.3. We use LOFAR HBA, archival WSRT and VLA observations to find that G53.41+0.03 has a radio spectral index of $\alpha = -0.6 \pm 0.2$, which is consistent with the expected range for supernova remnants. Our analysis of the coincident archival it XMM-Newton observations shows that G53.41+0.03 has the spectral characteristics of a 1000−8000 year old supernova remnant: it has strong emission lines and is best characterized by a non-equilibrium ionization model. We also discuss other supernova remnants and supernova remnant candidates in the LOFAR field of view.

# Massive cluster/O star formation triggered by cloud-cloud collision in the Milky Way

Yasuo Fukui

A recent systematic study of molecular clouds in Galactic high mass star forming regions lead to the discovery of more than 30 clusters/isolate O stars which were likely formed by cloud-cloud collision. They include the major star forming regions like the Orion Nebula, M17, NGC 6334, M20, RCW 120 etc. and many of the results will be published in a special issue on cloud-cloud collision of PASJ in 2018 April. The collision is often supersonic and strong compression by collision provides an ideal condition to form high mass stars in a short time scale of $\sim 10^5$ yrs. Theoretical works of such collision offers a basis to understand the physical processes and the outcomes including the top heavy core mass function (Takahira et al. 2014; Inoue and Fukui, 2013). In this contribution, we summarize the observational evidence for collisional interaction and the typical cloud properties based on cloud statistics. We discuss that details of O star formation is better understood by the collisional interaction and that there is a threshold gas column density for O star formation. The high frequency of the collision implied suggests that cloud-cloud is one of the major mechanism of high mass star formation in the Milky Way.

# The far-infrared and HCN correlations from molecular cloud cores to global galaxies

Yu Gao

The dense molecular gas mass, traced by HCN $J = 1 - 0$, linearly correlates with the far-infrared (FIR) luminosity ($\sim$star formation rate, SFR) for essential all star-forming systems near and far. The spatially resolved FIR-HCN correlation in the disks of spiral galaxies, a local star formation law in terms of dense molecular gas across the disks, is also established, essentially same as that established from the Galactic cloud cores and that of global galaxies. Such tight linear SFR-dense molecular gas correlations suggest that the SFR depends linearly upon the mass of dense molecular gas. This is drastically different from the traditionally established Kennicutt-Schmidt (K-S) laws that relate the total gas and SFR in galaxies as there are no unique correlations in these K-S laws. Finally, we introduce the MALATANG large program on the JCMT to map the HCN and HCO+ $J = 4 - 3$ line emission in over 20 nearest IR-brightest galaxies. MALATANG bridges the gap, in terms of physical scale and luminosity, between extragalactic (i.e., galaxy-integrated) and Galactic (i.e., giant molecular clouds) observations, showing again such linear correlation with FIR in high-J HCN emission.

# X-raying the local ISM

Efrain Gatuzz

In this talk I will review our recent results in the analysis of X-ray spectra to study the physical conditions of the local interstellar medium (ISM). In recent year we have performed a detailed benchmarking of the atomic data comparing theoretical modeling with experimental measurements and astrophysical observations (Gatuzz et al. 2013, Gorczyca et al. 2013, Gatuzz et al. 2014, Hasoglu et al. 2014, Gatuzz et al. 2015, Gatuzz et al. 2018). Although the main components of the ISM are neutral species, the undoubted presence of charged ions prompted us to develop a new ISM X-ray absorption model called ISMabs , used to determine the absorbing material distribution as a function of source distances and galactic latitude-longitude (Gatuzz et al. 2015, Gatuzz et al. 2016). Also, we revised the detectability of the CO X-ray molecular absorption in the ISM using our ISMabs model, and performing a Monte Carlo (MC) simulation analysis of the goodness of fit. Our results reinforce the conclusion that molecules have a minor contribution to the absorption features in the O K-edge spectral region (Joachimi et al. 2016). We have developed an X-ray absorption model called IONeq which includes ionization equilibrium condition in order to study the structure of the Milky Way gas. With this model we have found that the high-ionization absorption features observed in X-ray spectra are not intrinsic to the X-ray sources but imprints from the galactic ISM. We have estimated the density distribution for the neutral, warm and hot ionized (Gatuzz et al. 2018a). Also, we have analyzed absorption lines due to Carbon in the local ISM by modeling X-ray nova high-resolution spectral features (Gatuzz et al. 2018b). Finally, by using the accurate distance measurements obtained by the Gaia observatory in combination with the hydrogen equivalent column density measurements obtained from the XMM-Newton spectral-fit database, we performed a 3D mapping of the cold absorption component in the local galactic ISM (Gatuzz et al. 2018c).

# Temperature-dependent laboratory measurements of the far-infrared to millimeter opacity of carbonaceous dust-analogues (poster)

Jonas Greif

We are measuring and analysing the FIR- and THz- Spectra of pyrolysed microcrystalline cellulose as an analogue of carbonaceous interstellar dust. We are using cellulose-powder with crystal sizes of about 20 $\mu$m and are heating it up to 1000°C. First results of the mass normalised extinction are presented and compared to Jäger et al. (1998). The temperature dependent measurements took place in a dry environment at room temperature (RT) down to the environmental temperature of $T_{env} = 10$ K.

Our aim is to assess carbonaceous dust analogues in terms of structure, nature and morphology. For theoretical and observational investigation we are going to determine their optical constants. Furthermore, we are going to calculate the emission cross section of particles with different geometries to compare them with the measured results.

# Characterising cloud-scale star formation physics, feedback and ISM structure beyond the Milky Way - results of a comprehensive local universe survey

Alex Hygate

I will present a statistical method, validated with high-resolution disc galaxy simulations, that harnesses the breakdown of the star formation law at small scales to measure a great variety of key quantities characterising the cloud-scale physics of star formation and feedback. This method allows us to directly measure the molecular cloud lifetime, the timescale for feedback to disperse molecular clouds, feedback outflow velocity, star formation efficiency, ISM instability length scale, and feedback-to-ISM coupling efficiency. Previous constraints on these quantities have been restricted to the Milky Way and a few very nearby galaxies. I will present systematic measurements of these quantities across more than a dozen galaxies in the Local Universe, including the LMC, M33, NGC 300, and the wide range of systems covered by the PHANGS survey of nearby galaxies. In concert with modern high-resolution instruments such as ALMA and MUSE, we can now do "Milky Way science" in a large number of galaxies in differing environments from the local Universe out to tens of Mpc. Furthermore, I will discuss the expanded range of science that upcoming observatories such as JWST, the E-ELT and the SKA will enable us to undertake with this method. I will show how these measurements probe the underlying physical processes driving star formation, such as by using measured values of the feedback timescale to discriminate between different feedback mechanisms. These results reveal how star formation and feedback vary with the galactic environment. By comparing these results to studies of the Milky Way, I will demonstrate that this (or any other single) galaxy provides only a limited (and possibly biased) view of the underlying physical complexity. Finally, I will highlight how we can measure diffuse emission fractions across our galaxy sample by using the ISM instability length scale as a physically motivated basis to decompose gas mass and star formation tracer maps into their diffuse and concentrated components, an example of how we can use the quantities we constrain with the method to drive further science.

# The interstellar dust composition: new insights using X-rays and new laboratory measurements (poster)

Psaradaki Ioanna

The content of the interstellar medium (ISM) is very important for the evolution of galaxy and for star formation processes. Today it is known that the structure of the ISM mainly consists by gas, dust and molecules. However, the composition of dust in the ISM is not yet fully understood. Insights can be gained from the X-ray band. High-resolution X-ray spectroscopy is a powerful method to investigate the interstellar dust composition. With X-ray spectra of bright background sources, it is possible to determine the silicate content and the physical properties of the diffuse regions in the ISM. It is a powerful way to probe the different phases of the interstellar medium and the chemical composition of dust at different lines of sight. In this work we analyse XMM-Newton and Chandra observations of the LMXB GX9+9 which is proposed as a good candidate to study the ISM. We also use new laboratory measurements of the chemical composition of dust gained from the Electron Microscope Spectrometer in Cadiz, Spain. In particular, we focus on the Fe L and O K edges, two powerful elements to study the chemical composition of dust grains along this line of sight.

# [C II] as a SFR tracer in M31 and M51: A constant photoelectric heating efficiency links [C II] 158 $\mu$m with young stars

Maria Kapala

The energy balance sets the structure of the interstellar medium (ISM) phases, which in turn control the processes of star-formation (SF). We investigate the balance between the heating by stellar radiation, and neutral gas cooling dominated by [C II] emission line. [C II] is typically the brightest far-IR emission line from star-forming galaxies, and it has been proven to be a useful SFR tracer, both locally and at high redshifts, however, with some vital caveats. Specifically, we are interested wheather there are any changes in the efficiency of the photoelectric heating (PEeff), the dominant heating mechanism of the neutral gas, that might affect reliability of the [C II] as a SFR tracer.

To address these issues, we have assembled a unique set of observations in two nearby galaxies, M31 and M51. Multi wavelength FUV-FIR photometric coverage enables a well constrained SED modelling. Key observations of [CII] emission at high, 50 pc, resolution in five SF regions in M31 (Herschel), and the first fully mapped galaxy at $\sim 650$ pc resolution in M51 (SOFIA), enable a local and a global studies. Finally, we model individually resolved stars with 6 band HST photometry down to spectral type F0 with PHAT survey in M31 using BEAST (Bayesian Extinction and Stellar Tool) for an independent measurement of the heating at smallest scales.

A commonly used ratio [C II]/TIR (total IR emission), fails as a proxy for PE-eff, because the TIR measures all dust heating, not just the FUV photons capable of ejecting electrons from dust grains (Kapala et al. 2017). We find [C II]/TIR to be strongly correlated with UVatt/TOTatt (inferred from MAGPHYS SED fitting), indicating that, in M31 at least, one of the dominant drivers for [C II]/TIR variation is the relative hardness of the absorbed stellar radiation field. We define PEeff(UV), [C II]/UVatt which should be more closely related to the true PE efficiency, which we find to be essentially constant ($1.85 \pm 0.8\%$) in all explored 700$\times$700 pc fields in M31, regardless of the value of [C II]/TIR (varying by a factor of 3).

I will present the above findings and the preliminary results of the PEeff(UV) on 650 pc scales in M51, and explore environmental dependencies between the arm, interarm, and nuclei regions.

# Magnetic field estimates in the 30 Dor C superbubble with Chandra

Patrick Kavanagh

Superbubbles are powered by the stellar winds and subsequent supernova explosions of a massive stellar population. The detection of TeV gamma-rays from the 30 Dor C superbubble in the Large Magellanic Cloud by the High Energy Stereoscopic System (H.E.S.S.) has shown that superbubbles can and do accelerate particles up to cosmic-ray energies, though the dominant production mechanism (i.e., hadronic or leptonic) is still unclear. The answer to this question is locked in the unique synchrotron X-ray shell of 30 Dor C. The widths of the synchrotron emission regions are directly related to the downstream magnetic field, which is a crucial parameter assessing dominant TeV gamma-ray emission mechanism. In this talk I will present the results of a high spatial resolution Chandra observation of the synchrotron shell, which has allowed us to estimate the downstream magnetic field and infer the dominant cosmic ray production mechanism in this new and important source class in TeV astronomy.

# Galactic fountains persistently fuel the Milky Way galaxy star formation

Juergen Kerp

Since Gyrs the Milky Way Galaxy forms persistently stars. To maintain this star formation the gaseous reservoir needs to be replenished. Major or minor mergers are disfavored observationally because of the smooth and continuous transition of the alpha element abundance from the disk to the halo stars. Many theoretical models underline the importance of Galactic-winds and -fountains for this replenishment. However, the accretion mode is observationally hard to constrain.

Here, we present a detailed correlation study of Planck far-infrared and HI4PI H I 21-cm line data, studying the distribution of molecular gas towards the high galactic latitude sky. We find compelling evidence for a neutral gas accretion flow descending trans-sonically from the disk-halo interface towards the galactic disk. During that descent the atomic gaseous phase performs a phase transition to the molecular one. At sub-pc scales instabilities occur and form a "Galactic molecular rain".

# "Infrared diagnostics of the ISM: from dark globule in our Galaxy to the circumnuclear environment of young radio sources" (poster)

Emily Kosmaczewski

We present an analysis of infrared features in interstellar medium in the dark globule DC 314.8−5.1. Specifically, we present a breakdown of the polycyclic aromatic hydrocarbon (PAH) infrared emission features in the dark globule. We show that these features can be used to determine conditions of the system. The dark globule is shown to have a high ionization rate, but an average molecular size not proportional to this result. We therefore conclude that the dark globule is at the onset or just prior to low-mass star formation and that many interesting results can be derived from the study of this system. We also present a set of 16 compact, symmetric, young radio sources which also have interesting infrared characteristics. The relation between the 12 $\mu$m infrared luminosity and the 2−10 keV X-Ray luminosity is compared and analyzed in relation to other galactic systems. A comprehensive multi-wavelength database is compiled from the literature for these young radio sources, and interesting cases are highlighted for future analysis.

# Interstellar Magnetic Fields

Roland Kothes

The interstellar medium of our Galaxy is threaded by magnetic fields. Magnetic fields contribute significantly to the total pressure of the interstellar gas, are essential for the onset of star formation, and control the density and distribution of Cosmic Rays in the ISM. Magnetic fields can be found everywhere and affect almost everything. Magnetism is one of Nature's fundamental forces, but its origin and evolution are still poorly understood. In this presentation I will review observational approaches for the detection of magnetic fields, our current knowledge of interstellar magnetic fields and the large-scale magnetic field in our Galaxy and briefly discuss what we can learn from observations of magnetic fields in nearby Galaxies.

# Bright-Red Star Populations in the Leo A Galaxy (poster)

Alina Lescinskaite

We have studied a bright-red star population (stars in the colour-magnitude diagram $I$ vs. $V-I$ being brighter and redder than the red giant branch (RGB) tip) in the dwarf irregular galaxy Leo A using multicolour photometry data obtained with the Subaru, HST ACS, and Spitzer telescopes. We developed a reliable method to clean out contaminating foreground Milky Way stars. This allowed us to study the spatial distribution of the bright-red stars within the Leo A galaxy and compare it with the distribution of RGB stars.

# H$\alpha$ observations of supernova remnants

Oliver Lux

We use H$\alpha$ observations to investigate the geometry of supernova remnants (SNRs). The observations were done with the Schmidt telescope camera (STK) at the university observatory Jena. We present H$\alpha$ images of the SNRs CTB 1 and HB 21, as well as two different approaches to determine the geometrical centre of the SNRs. We want to use the results to constrain the areas in which we want to search for potential runaway candidates as former binary companions of the corresponding supernova progenitor.

## X-raying the Large Magellanic Cloud ISM

Pierre Maggi

The hot component of the multi-phase ISM is a tenuous plasma at a temperature of several million degrees, shining brightly in soft X-rays. Studying this phase at large scale in our own Galaxy is hampered by strong absorption and distance uncertainties. In galaxies beyond the Local Group, observational challenges such as low flux and unresolved point source emission pose serious limitations. An ideal middle ground is found in the LMC, the nearest star-forming galaxy, seen almost face-on. We used hundreds of XMM-Newton observations, combining archival data with our own Very Large Programme survey, to cover the central region ($5^\circ \times 5^\circ$) of the LMC. In this talk, I will present the early results of this large scale study. I will show the resulting spectral properties (in terms of temperature, luminosity, and chemical composition) of the hot LMC ISM at scales from $3'$ to $30'$. Then, I will discuss the relation between the various phases of the LMC ISM, and the connection between the X-ray diffuse emission and the star formation in the LMC.

# Searching for molecular gas bombarded by cosmic rays near supernova remnants

Nigel Maxted

Gamma-ray astronomy may offer answers to a long-standing question of high energy astrophysics: Where do cosmic rays come from? The gamma-ray emission seen from some middle-aged supernova remnants is now known to be from distant populations of cosmic-rays (probably accelerated locally) interacting with gas, but there is still much work to be done in accounting for the Galactic cosmic-ray flux. Dense gas tracers such as CS and $NH_3$ have proven to be useful probes of gamma-bright regions, while SiO emission can directly highlight shock-disrupted gas in middle-aged W28 supernova remnant, helping to reveal it as a TeV cosmic ray accelerator. Young PeV gamma-ray supernova remnants require different techniques to address the question of cosmic-ray acceleration. The CTA telescope will allow us to do this. I will present mulit-wavelength studies of the young supernova remnants RX J1713.7−3946, HESS J1731−347, Vela Jr, HESS J1534−571 and others. I will describe how Mopra CO data will put future gamma-ray maps into context.

# The Mopra Galactic plane CO survey

Nigel Maxted

Catherine Braiding, Graeme Wong, Nigel Maxted, Michael Burton, Gavin Rowell, Miroslav Filipovic, on behalf of the Mopra Team

The release of 50 square degrees of $^{12}$CO, $^{13}$CO and C$^{18}$O data taken with the Mopra radio telescope, Australia, is a key step towards creating a molecular map of the Southern Galactic Plane. With 0.5 arcminute spatial resolution and 0.1 $\mathrm{km\,s^{-1}}$ velocity resolution, Mopra CO data cubes will complement future multi-wavelength studies, and add to our understanding of star formation, dynamics, and chemistry within the Milky Way. A major science goal driving this Galactic mapping project is the investigation of gamma-rays originating from cosmic-ray interactions with gas. The next-generation gamma-ray observatory, Cherenkov Telescope Array, will give us arcminute resolution that will resolve features on the scale of molecular cores. It is important that we have matching gas data to pinpoint potential cosmic-ray sources. We give an overview of the Mopra Galactic Plane CO Survey data, and progress.

# CTB 109: a supernova remnant interacting with a molecular cloud

Minja Mäkelä

CTB 109 (G109.1−1.0) is a Galactic supernova remnant (SNR) with a diameter of 30′. The SNR appears semicircular in the x-ray and radio wavelengths where it expands as a circular shell to the east. On its western side the shell is distorted and the expansion of the shell seems to have stopped. Infrared observations show a large molecular cloud (MC) on the west side and the SNR is likely interacting with the MC there. The shock wave from the supernova is driving into the MC and heating the material.

We have used several infrared bands to study the SNR and the region where the SNR-MC interaction takes place. We focus on examining the dust and gas properties at several locations in and around the SNR and estimate the shock wave effects.

# Cloud collision triggered high-mass star formation in the Sagittarius Arm

Atsushi Nishimura

Recently, cloud-cloud collision (CCC) is getting much attentions as a promising model of high-mass star formation (HMSF). The strength of the model is that it is explainable whole SF process from the cloud scale (10 pc, $n_{H_2} \sim 10^3$ cm$^{-3}$) to the dense core scale (0.1 pc, $n_{H_2} > 10^6$ cm$^{-3}$); once clouds collided with supersonic velocity, gas is compressed into the shocked interface (Habe & Ohta 1992) and magnetic field is enhanced in there (Inoue & Fukui 2013). Then magnetically supported massive filaments are formed in the interface plane, and gravitational fragmentation along the massive filaments provide high-mass accretion rate ($> 10^{-4}$ $M_\odot$) to the gas flows toward the dense cores (Inoue et al. 2018). Series of CO observations toward super star clusters (e.g., Westerlund2: Furukawa et al. 2009; RCW 38: Fukui et al. 2016) and famous high-mass star formation regions (see PASJ special issue published in Apr. 2018) show that such colliding events occur almost universally. In this talk, we summarize the observation results of the famous HMSF region in the Sagittarius Arm including NGC 6334 (Fukui et al. 2018), M17 (Nishimura et al. 2018), M16 (Nishimura et al submitted) and M8, and discuss variety of collision parameters (e.g., cloud mass, velocity difference) which might bring diversity of SF activity in HMSF regions.

# On the energy density ratio between protons and electrons in supernova remnants

Dusan Onic

We used 3D hydrodynamic supercomputer simulations, coupled with a non-linear diffusive shock acceleration model (NLDSA), to obtain the energy density ratio between cosmic ray (CR) protons and electrons accelerated at blast waves of supernova remnants (SNRs) during free expansion and Sedov phases of evolution. The evolutions of two SNRs G1.9+0.3 (expansion in low density environment of a young SNR) and HB 3 (evolution in dense environment of an evolved SNR) were simulated. As a significant result we obtained that proton to electron energy density ratios gradually decrease in both SNRs when proton to electron number density ratios stay constant during evolution. It indicates that diffusive shock acceleration for electrons gives higher energy increments than for protons at blast waves of SNRs.

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# X-ray luminosity and size relationship of supernova remnants

Po-Sheng Ou

The Large Magellanic Cloud (LMC) has ∼60 confirmed supernova remnants (SNRs). Because of the known distance, 50 kpc, the SNRs' angular sizes can be converted to linear sizes, and their X-ray observations can be used to assess X-ray luminosities ($L_X$). We have critically examined the LMC SNRs' sizes reported in the literature to determine the most plausible sizes. These sizes and the $L_X$ determined from *XMM-Newton* observations are used to investigate their relationship in order to explore the environmental and evolutionary effects on the X-ray properties of SNRs. We find: (1) Small LMC SNRs, a few to 10 pc in size, are all of Type Ia with $L_X > 10^{36}$ ergs s$^{-1}$. The scarcity of small core-collapse (CC) SNRs is a result of CCSNe exploding in the low-density interiors of interstellar bubbles blown by their massive progenitors during their main sequence phase. (2) Medium-sized (10−30 pc) CC SNRs show bifurcation in $L_X$, with the X-ray-bright SNRs either in an environment associated with molecular clouds or containing pulsars and pulsar wind nebulae and the X-ray-faint SNRs being located in low-density interstellar environments. (3) Large (size>30 pc) SNRs show a trend of $L_X$ fading with size, although the scatter is large. The observed relationship between $L_X$ and sizes can help constrain models of SNR evolution.

# Radio evolution of supernova remnants including cosmic ray acceleration

Marko Pavlovic

We present a model for the radio evolution of supernova remnants (SNRs) obtained by using three-dimensional hydrodynamic simulations coupled with nonlinear kinetic theory of cosmic-ray (CR) acceleration in SNRs. We model the radio evolution of SNRs on a global level by performing simulations for a wide range of the relevant physical parameters in the interstellar medium. In terms of MFA, we include both resonant and nonresonant modes in our large-scale simulations by implementing models obtained from first-principles simulations. This type of modeling is expected to be a useful apparatus for future observers working on powerful radio telescopes such as ALMA, MWA, ASKAP, SKA, and FAST.

# LVM & SDSS-V: An optical IFU survey of the nearby universe

Eric Pellegrini

In the last few decades we have constructed a comprehensive description of how populations of galaxies evolve through time, and of the broad correlations seen among galaxies' internal properties. We know on kiloparsec scales that the formation of stars scales with the density of gas, and that the phase and motions of the gas are affected by the subsequent evolution of the stars. However, these correlations remain merely descriptive in almost all extragalactic contexts. SDSS-V will probe down to the physical scales from which the global correlations arise, to witness "astrophysics in action" on sub-kiloparsec scales.

The Local Volume Mapper (LVM) in SDSS-V will take the first step towards the "spectral panopticon", a full spectroscopic image of the sky, providing optical IFU data-cubes to resolve, e.g.,SF structures, GMCs, H II regions and young stellar clusters. The LVM will cover the bulk of the MW disk at 0.1-1 pc resolution,the Magellanic Clouds at 10 pc resolution, M31 & M33 at 20 pc resolution, and Local Volume galaxies out to a distance of $\sim$3 Mpc at $< 50$ pc resolution, in total about 1 steradian of sky.

# Maps of diffuse interstellar bands (poster)

Martin Piecka

The correlation between the extinction and the strength of the diffuse interstellar bands (DIBs) has been known for a long time. However, we still do not understand the origin of the DIBs and know only little about their properties. Studying DIBs may help with the research of the interstellar dust which seems to be related to their carriers via the mentioned correlation. To this date, detailed maps of the DIBs are not available. Simple maps have been created thanks to the large amount of data available in the VizieR database. From those, it can be implied that the carriers seem to be concentrated near the Galactic plane, as predicted. A very interesting behaviour can be seen in the plots against the Galactic longitude. The strength of the DIBs seems to increase towards the centre of the Galaxy while no correlation can be found in the direction of the movement of the Sun.

## Feedback of massive-star groups on the surrounding ISM

Moritz Pleintinger

Massive-star groups strongly affect the surrounding ISM through stellar winds and supernova explosions. As freshly formed nucleosynthesis products, such as $^{26}$Al or $^{60}$Fe, are carried by those phenomena, they shape the Galaxy dynamically and chemically. The 1.8 MeV emission line from $^{26}$Al decay is a key tracer of ongoing nucleosynthesis and chemical enrichment in our Galaxy. Because the half-life of $^{26}$Al nuclei of $\sim$0.7 Myr is comparable to the crossing time of massive-star ejecta inside superbubbles, the emisssion is closely connected to the dynamical properties of massive star groups and their surroundings. We investigate these circumstances by comparing population synthesis models to gamma-ray observations performed with INTEGRAL/SPI. This approach provides access to the nexus between stellar physics and ISM properties. $^{26}$Al sources in the Milky Way are expected to be located mainly on the leading edges of the spiral arms, associatied with frequently merging superbubbles. Thus, we focus on simulating the $^{26}$Al emission by modeling the Galactic distribution of OB associations, as they are obtained through population synthesis calculations. An overview over the impact of different model parameters, such as stellar rotation, metallicity, explodability, and binary fraction onto population synthesis calculations will be given. Comparing simulations of different morphological models to gamma-ray measurements finally opens the possibility to test the underlying assumptions of stellar feedback and to validate 3D spatial distributions of the lage-scale $^{26}$Al emission.

# The Expansion of the Forward Shock of 1E 0102.2–7219 in X-rays

Paul Plucinsky

We measure the expansion of the forward shock of the Small Magellanic Cloud supernova remnant 1E 0102.2–7219 in X-rays based on em Chandra X-Ray Observatory on-axis ACIS (em Advanced CCD Imaging Spectrometer) observations from 1999 through 2017. We estimate a blast wave global expansion rate of $0.0253 \pm 0.0044\ \mathrm{yr}^{-1}$ ($\sim 1/4$ of the previous X-ray measurement). We combine the expansion rate with the blast wave and reverse shock radii to generate a grid of one dimensional shock models for a range of ejecta masses and swept-up masses to constrain the progenitor mass, explosion energy, age, circumstellar density and unshocked ejecta mass. We find a constant density ambient medium does not reproduce the observed values. Models with a power-law density profile $\sim \mathrm{r}^{-2}$ (appropriate for a uniform steady progenitor stellar wind) better reproduce the observed values of forward/reverse shock radii and forward shock velocity. For ejecta masses $6-12\ \mathrm{M}_\odot$ and swept-up masses $10-30\ \mathrm{M}_\odot$, we find a range of progenitor masses $16-42\ \mathrm{M}_\odot$ with explosion energies $0.22-0.58\times10^{51}$ erg, ages $\sim$ 2700-3300 yr, ambient interstellar densities $0.13-0.40\ \mathrm{cm}^{-3}$, and unshocked ejecta masses of $0.40-3.9\ \mathrm{M}_\odot$. The explosion energies are consistently below $1.0 \times 10^{51}$ erg for the range of assumed values indicating a relatively low explosion energy for this supernova. Our blast wave velocity implies a lower limit on the post shock electron temperature of 0.7 keV, assuming Coulomb heating, which is consistent with the estimate from X-ray spectral analysis. This indicates a significantly smaller amount of energy going into accelerating cosmic rays than previously estimated.

# Paucity of bow shocks around High-mass X-ray binaries (poster)

Michal Prišegen

High-mass X-ray binaries (HMXBs) are systems consisting of a massive, early-type star (spectral class O or B) in a process of stellar evolution and a compact object, a neutron star or a black hole, revolving around their common center of mass. Owing to the past supernova explosion of one of its components, possibly combined with close dynamical encounters of the system with other stars in its parent cluster as well, a significant portion of HMXBs possess high (runaway) space velocities. A possible method of searching for runaway star candidates is through the detection of bow shocks associated with them. The presence of a bow shock provides a unique insight into the physics of the system and the surrounding interstellar medium. However, only a handful of HMXBs have been investigated for the presence of a bow shock. The only known HMXBs driving a bow shock are Vela X-1 and 4U 1907+09. Here, we present the results of a complete survey of HMXBs and HMXB candidates listed in Liu et al. (2008) and Walter et al. (2015), using the data obtained by the Spitzer Space Telescope and Wide-field Infrared Survey Explorer. The presence of extended emission was revealed in the vicinity of several objects, however, no unambiguous bow shocks were detected. The absence of bow shocks around HMXBs could be understood if the majority of these objects still reside within the hot, low-density bubbles around their parent star clusters. Also, the dynamical ejection of massive binaries is apparently less efficient than the ejections caused by binary supernova explosions.

# News on TeV supernova remnant shells

Gerd Pühlhofer

TeV observations of supernova remnants are crucial to probe particle acceleration at the highest accessible energies. The H.E.S.S. experiment continues to improve the data of the small class of known (southern-hemisphere) TeV supernova remnant shells. Broadband studies and simulations are used to probe the nature of the relativistic particles. Also, it has now been possible to identify previously unknown supernova remnant candidates, from the H.E.S.S. TeV data alone. I will discuss how these sources may fit into the spectrum of known gamma-ray emitting supernova remnants.

# Molecular gas outflow in the starburst galaxy NGC 1808 imaged by ALMA

Dragan Salak

Dynamics of molecular gas in barred starburst galaxies is related to two important phenomena: (1) large-scale gas inflow that accumulates fuel for star formation in the galactic central region, and (2) gas outflow (feedback in terms of supernova explosions and stellar winds) that regulates star formation activity. We present our recent high-resolution ($\sim 1''$) ALMA observations of molecular gas traced by CO ($\mathrm{J} = 1 - 0$ and $\mathrm{J} = 3 - 2$) in the nearby barred starburst galaxy NGC 1808 (Salak et al. 2016, 2017 ApJ). The observations reveal an evolutionary sequence of molecular clouds from bar-driven inflow to a 500-pc ring, enhanced star formation activity, and molecular winds from the galactic nucleus (inner 200 pc) and from the 500-pc ring with velocities of $50-180$ $\mathrm{km\,s^{-1}}$ and a velocity gradient of $+0.4$ $\mathrm{km\,s^{-1}\,pc^{-1}}$ in the outflow direction. The mass outflow rate is estimated to be (0.1−1)x SFR in the starburst nucleus, suggesting modest star formation quenching by the winds.

# Shock-cloud interaction in the Galactic/Magellanic supernova remnants: Evidence for cosmic-ray acceleration

Hidetoshi Sano

In young supernova remnants (SNRs; $\sim$ 2000 yrs old), interaction between the shockwaves and interstellar neutral gas is a key element in understanding the origin of cosmic rays and their high-energy radiation. Fukui et al. (2012) demonstrated a good spatial correspondence between the TeV gamma-rays and total interstellar gas in the young SNR RX J1713.7−3946. This gives one of the essential conditions producing the hadronic gamma-rays, and evidence for cosmic ray acceleration. Subsequent studies presented similar results for young SNRs HESS J1731−347 (Fukuda et al. 2014), Vela Jr. (Fukui et al. 2017), and RCW 86 (Sano et al. 2018 in prep.). As regards cosmic ray electrons, Sano et al. (2010, 2013) revealed that the gas clumps associated with the SNR RX J1713.7−3946 are rim-brightened in synchrotron X-rays, suggesting that the shock-cloud interaction induces the turbulence and magnetic field amplification. Moreover, the strong turbulence also produces cosmic ray electrons with large roll-off energies (Sano et al. 2015). Similar trend is also seen in the Magellanic superbubble 30 Doradus C (Babazaki et al. 2018; Yamane et al. 2018 in prep.). In this talk, we introduce the recent results of shock-cloud interaction toward the Galactic/ Magellanic SNRs bright in the TeV gamma-rays and synchrotron X-rays.

# Positrons in the interstellar medium

Thomas Siegert

The positron annihilation signal from the centre of our Galaxy appears puzzling for now more than four decades. Unlike at any other wavelength, the 511 keV signal is dominated by a bright bulge and shows only a low surface-bright but thick disk. There is a large variety of sources which can produce the amounts of positrons that are seen to annihilate. However, which sources contribute to what extent and where in the Milky Way is hard to constrain theoretically and observationally. Among the different sources are radioactive nucleosynthesis ejecta from massive star winds, core-collapse supernovae or thermonuclear supernovae, highly magnetised neutron stars, and black hole binary systems. Even exotic explanations, such as dark matter particle interactions, have been proposed to approach this problem. As most of the plausible sources are mainly distributed along the thin disk of the Galaxy, but the annihilation sites are strongly concentrated towards the centre, the propagation of positrons through the interstellar medium is an important ingredient to be studied. Initially, the positrons are produced at MeV energies or higher, and thus act as relativistic cosmic-ray anti-particles. Using data from the INTEGRAL/SPI gamma-ray telescope, these positrons are caught in their final moment, when annihilating with electrons - but at rest, not at these relativistic energies. The cosmic-ray propagation inside the different phases of the interstellar medium must hence be governed by energy losses, for example from plasma interactions, bremsstrahlung or synchrotron radiation, and guided by the galactic magnetic field lines on small and large scales. In this talk, I will present positron annihilation spectroscopy as an alternative and complementing approach to understand cosmic-ray propagation in the interstellar medium - from relativistic energies to thermalisation.

# Identifying the AGN contribution to [C II] ionization in luminous local AGN

Irina Smirnova-Pinchukova

It is considered that Active Galactic Nuclei (AGN) play a substantial role in galaxy evolution affecting the conditions of the interstellar medium and star formation. However, measurements of the star formation rate for AGN host galaxies is tricky, because star formation tracers are contaminated by the AGN radiation. The galaxy evolution questions are especially acute for high-redshift astronomy where the [C II] 158$\mu$m fine structure transition is commonly used as a star formation tracer. A detailed examination of the [C II] luminosity-star formation rate relation for AGN hosts can only be done with nearby galaxies for which the observations in far-infrared wavelengths are more difficult.

I present the results of an observing campaign for [C II] line mapping for 6 nearby ($0.01 < z < 0.06$) galaxies with luminous AGN via the Far Infrared Field-Imaging Line Spectrometer (FIFI-LS) aboard SOFIA. With SOFIA we resolve galactic structure well beyond a point source in [C II] line for more than half observed galaxies, but the obtained resolution is, of course, lower than in optical wavelengths. To disentangle the contribution of AGN and to compensate the lack of spatial resolution we use a novel method of combining the [C II] data with an extinction corrected H$\alpha$ line maps (from VLT/MUSE) which is a reliable star formation tracer and can be used as a prior. The goal of this new technique is to calibrate the AGN contribution to the [C II] luminosity as a function of AGN luminosity which is crucial for the interpretation of the [C II] emission for high-redshift QSOs.

# Stellar feedback in giant H II regions: a case study of M101

Wei Sun

A key process in galaxy evolution is galactic feedback in form of fast winds of massive stars and their eventual supernova explosions. But its mechanical coupling with surrounding interstellar medium is still under debate. We performed a study of multi-phase gas in two giant H II regions (GHRs) in M101, NGC 5461 and NGC 5471, by analyzing echelle spectra of H$\alpha$ line emission, data cube of H I gas, and the X-ray observation of hot plasma. The multi-Gaussian fitting to the H$\alpha$ line profiles shows the presence of both "bright narrow" and "faint broad" components across much of the GHRs. In particular, the H$\alpha$ velocity mapping shows a blueshift feature of $\sim 20$ km s$^{-1}$ at the location of modestly evolved stellar contents; and the H$\alpha$ line from NGC 5471B shows a "shell-like" decomposition result, which represents an expanding ionized gas shell of $\sim 100$ km s$^{-1}$. The neutral gas is depleted in the brightest knots of these two GHRs, and aggregates at the periphery region. A comparison between the mechanical energy observed in multi-phase gas and input by the young stars indicates a feedback efficiency of$\sim$ 10%, lower than the prediction by the superbubble model. A comprehensive study requires the ultraviolet absorption line investigation of tenuous ionized gas.

# Massive star formation triggered by galactic tidal interaction in the LMC

Kisetsu Tsuge

Revealing the mechanism of massive cluster formation is one of the most important issues of astronomy. We have decomposed the H I gas into the two H I velocity components (L- and D-components), which are colliding toward the H I Ridge, in the southeastern end of the Large Magellanic Cloud (LMC) hosting the young massive cluster R136 and ∼400 O/WR stars (Doran et al. 2013). The collision is possibly evidenced by bridge features connecting the two H I components in the velocity space, and complementary spatial distributions between them. We also investigate the correlation between the Planck/IRAS data of dust optical depth and the H I intensity, and found that the low-metallicity gas of the Small Magellanic Cloud (SMC) flowed into the LMC by the tidal interaction. We propose a hypothesis that the inflow of low-metallicity gas from the SMC and the collision with the LMC gas triggered the formation of R136 and the surrounding high-mass stars. Fujimoto & Noguchi (1990) advocated that the last tidal interaction between the LMC and the SMC about 0.2 Gyr ago induced collision of the L- and D-components. This model was later confirmed by numerical simulations (Bekki & Chiba 2007). We suggest that the molecular cloud of $10^6$ $M_\odot$ embedded in the dense H I gas was formed at the shock-compressed interface between the colliding L- and D-components, leading to the formation of R136. In addition to R136, we investigate the clouds around LHA 120-N 44 (N44), which is the second most active massive star forming regions, and conclude the same scenario about the formation. With the comparisons of the cloud properties between R136 and N44, we discuss massive star formation scenario of the whole LMC.

# Evolution of supernova remnants and particle acceleration

Dejan Urošević

The brief introduction on hydrodynamic and radio evolution of supernova remnants (SNRs) is given. Additionally the fundamentals of particle acceleration to the cosmic ray (CR) energies are presented, especially for the so-called diffuse shock acceleration (DSA) mechanism at the SNR shocks. As an SNR evolves, the associate blast wave loses energy, and the efficiency of particle acceleration decreases. It results in change of emission intensities at frequencies at which we expect radiation from CR electrons (in radio, X and gamma domains) and protons (in gamma domain). Furthermore, I present some new results related to: radio evolution of SNRs, changing of the radio spectra through SNR evolution, and the justification of equipartition assumption in SNRs - every of them mainly based on non-linear DSA model.

# Fueling the Milky Way Star Formation: On the formation of high altitude molecular gas (poster)

Charitarth Vyas

For billions of years the Milky Way Galaxy has formed stars. An efficient refueling process is necessary to maintain this persistent star formation. Several gas accretion modes are under investigation. H I line from Effelsberg-Bonn H I Survey (EBHIS, Winkel et al. 2016, A&A, 585, A41) and far-infrared intensity from Planck full-sky data (Planck intermediate results XLVIII, 2016, A&A, 596, A109) allow to identify the location of molecular high altitude clouds. Matching these regions of interest with the Planck Catalogue of Galactic Cold Clumps (PGCC, Planck 2015 results. XXVIII, 2016, A&A, 594, A28) discloses the presence of cold molecular gas. Here, we cross-correlate multi-frequency data from EBHIS, Planck, and DRAO H I Intermediate Galactic Latitude Survey (DHIGLS, Blagrave et al. 2017, ApJ, 834, 2) to investigate the formation of molecular gas high above the Galactic disk, in the disk-halo interface. However, we identified that the PGCC reveals a residual contamination with extragalactic sources. It also appears to be biased towards warmer gas components. Moreover, the Planck thermal dust temperature map (Planck intermediate results XLVIII, 2016, A&A596, A109) reveals significantly more locations of cold gas than comprised in the PGCC.

Hence, we apply an independent approach to identify Galactic compact cold clumps by cross-correlating dust and gas using Planck dust temperature map and EBHIS, respectively. We focus here on two high altitude molecular clouds, Draco and Spider, with the firm distance limits, for a quantitative comparison with the PGCC. We also calculate the physical properties of identified cold gas cores, disclosing, eventually, the locations of cold gas accretion flows of the Milky Way Galaxy.

# Molecular cloud formation and dispersal by stellar feedback

Stefanie Walch

Star formation takes place in the densest and coldest parts of the interstellar medium (ISM), in dark molecular clouds. These are swept up by multiple supernova explosions on scales of several hundred parsec. While condensing out of the warm ISM, the clouds are continuously fed with fresh gas. Thus, the turbulent substructure and magnetic field properties are imprinted during cloud formation. We study the formation of dense clouds, the onset of star formation, and the evolution of the molecular clouds under the impact of stellar feedback from newly born massive stars in high-resolution "galactic zoom-in simulations". In these zoom-ins, we resolve the clouds down to their filamentary structures on scales of less than 0.1 parsec. In MHD runs we see striations, which are not present without magnetic fields. Furthermore, magnetic fields slow down the cloud evolution and prolong the cloud lifetime. Star formation is modelled using sink particles, which contain small-N star clusters. The hosted massive stars emit ionizing radiation and stellar winds. We show that the particular column density distribution of a forming cloud determines the impact of ionizing radiation that leads to the dispersal of the cloud.