ISM-SPP
Period II
Kick-off School/Workshop

April 27th-30th, 2015

Kardinal-Döpfner-Haus
Freising

MONDAY, APRIL 27th

12:30 Lunch

13:30 Lecture: Properties of the ISM
by Andreas Burkert (USM/LMU) (90')

15:00 Coffee

15:30 Lecture: Dust properties and dust evolution from observations/modeling
by Svitlana Zhukovska (MPIA) (90')

17:00 Student Meet and Greet
by Alessandro Ballone (USM/MPE) (60')

18:00 Dinner

TUESDAY, APRIL 28th

09:00 Lecture: Molecules in Space
by Thomas Giesen (Universität Kassel) (90')

10:30 Coffee

11:00 Lecture: Chemistry in the ISM
by Simon Glover (Universität Heidelberg) (90')

12:30 Lunch

14:30 Lecture: The multiphase ISM
by Stefanie Walch (Universität zu Köln) (90')

16:00 Coffee

16:30 Lecture: Star Formation out of the Magnetised ISM
by Robi Banerjee (Universität Hamburg) (90')

18:00 Welcome Banquet (Kardinal Döpfner Haus)

WEDNESDAY, APRIL 29th

09:00 Structure analysis from line observations
by Volker Ossenkopf (Universität zu Köln) (12'+3')

Unfortunately, it is impossible to resolve the full three-dimensional distribution of densities, velocities and magnetic fields in molecular clouds through astronomical observations as we are bound to celestial positions and a frequency scale. The frequency scale, allows to address the velocity distribution through molecular line observations. The relation between underlying ppp-structures and observed ppv-cubes is, however, far from trivial. Chemical differentiation, excitation and radiative transfer effects systematically distort the characteristics of the observed structures.
We will show how statistical properties of interstellar turbulence measured in terms of scaling relations, probability distribution functions, and correlation functions change when measured through molecular line observations.

09:15 Wind bubbles within HII regions around O stars
by Jonathan Mackey (Universität Bonn & Universität zu Köln) (12'+3')

Mass loss from massive stars is very important for determining their evolution and death, but their wind properties can be difficult to measure and are often very uncertain. Main sequence massive stars have fast and highly ionized winds, driving bubbles in their surroundings that have proven surprisingly difficult to detect. We have run simulations showing that wind bubbles are typically very asymmetric and do not fill their HII regions. X-ray emission from the shocked wind is very weak, about 0.1% of the input energy, with the rest being dissipated by mixing with cooler photoionized gas. It appears likely that arcs of infrared emission (often seen within HII regions) can be explained as the outer edges of asymmetric wind bubbles, and this can potentially be used to constrain stellar wind strength.

09:30 SILCC: SImulating the Life-Cycle of molecular Clouds
by Stefanie Walch (Universität zu Köln) (12'+3')

Molecular clouds are cold, dense, and turbulent filamentary structures that condense out of the multi-phase interstellar medium. They are also the sites of star formation. The minority of new-born stars is massive, but these stars are particularly important for the fate of their parental molecular clouds as their feedback drives turbulence and regulates star formation.
I will present results from the SILCC project (SImulating the Life Cycle of molecular Clouds), in which we study the formation and dispersal of molecular clouds within the multi-phase ISM using high-performance, three-dimensional simulations of representative pieces of disk galaxies. Apart from stellar feedback, self-gravity, an external stellar potential, and magnetic fields, we employ an accurate description of gas heating and cooling as well as a small chemical network including molecule formation and (self-)shielding from the interstellar radiation field. We study the impact of the supernova rate and the positioning of the supernova explosions with respect to the molecular gas in a well defined set of simulations. This allows us to draw conclusions on structure of the multi-phase ISM, the amount of molecular gas formed, and the onset of galactic outflows. Furthermore, we show how important stellar wind feedback is for regulating star formation in these disks.

09:45 Ever-changing dust: unveiling dust properties across galactic environments
by Svitlana Zhukovska (MPIA) (12'+3')

Interstellar dust is an ubiquitous component of the ISM playing an active role in shaping its physical and chemical structure from the earliest evolution of galaxies. In order to improve the understanding of dust properties as a function of environment we employ models of dust evolution, including main sources and sinks of dust and constraints from observations. Local dwarf galaxies allow to study interstellar dust sources and probe their roles during galactic history. Recently, we tested theoretical models of dust production from low- and intermediate-mass stars using observationally derived dust production rates in the Large Magellanic Cloud. To constrain the controversial efficiencies of dust condensation in type II SNe, we combine generic models of dust evolution in dwarf galaxies with recent Herschel observations of a large sample of dwarf galaxies. I will show that the observed dust-to-gas ratio vs. metallicity relation corroborates relatively low condensation efficiency in SNe and additional growth of dust mass by accretion in the ISM, in contrast to previous studies. The latter process is the dominant dust source in our Galaxy, and is subject of our ongoing modelling, aiming at interpretation of the small-scale variations of dust properties observed in the local Milky Way. I will introduce this more detail model of interstellar dust evolution based on hydrodynamical simulations of the lifecycle of molecular clouds.

10:00 The evolution of blast waves in turbulent media
by Sebastian Haid (Universität zu Köln) (8'+2')

Supernovae inject a large amount of energy and momentum into the interstellar medium. This is important to set phase structures, regulate star formation or drive outflows. An immediate result of this interaction is turbulence, also in the surroundings of supernovae. The density profile of the ambient medium crucially influences the evolution of the remnant.
We provide a semi-analytic framework, extending published, to simulate and understand the evolution of a supernova blast wave. It is able to recover the 3-dimensional momentum input of a single SN in structured media and the velocity distribution of the shock-accelerated material.
We perform single supernova explosions into ambient media with simple radial profiles and extend the scheme to turbulent three dimensional structures. We confirm the trend of recent numerical simulations of increasing momentum in less dense surroundings but with negligible numerical costs. Moreover we show an additional increase by isothermal turbulent motion.

10:10 Atomic and molecular intermediate-velocity clouds
by Tobias Röhser (Universität Bonn) (8'+2')

Intermediate-Velocity Clouds (IVCs) are HI clouds in the lower galactic halo that are thought to be related to a galactic fountain process. Most IVCs are predominantly atomic with a negligible fraction of molecular hydrogen (H_2) while molecular IVCs (MIVCs) are extremely rare. With respect to the galactic fountain hypothesis, IVCs and in particular MIVCs might be an important ingredient for the accretion of cold gas onto the Milky Way in order to sustain the ongoing star formation. For two particular IVCs, an atomic and a molecular cloud, we obtained high-resolution HI data with the Westerbork-Synthesis Radio Telescope and ^{12}CO$(1 \rightarrow 0)$ and ^{13}CO$(1 \rightarrow 0)$ emission maps with the IRAM 30m telescope. These observations allow us to study the important physical parameters to investigate the formation of molecular clouds at the disk-halo interface. We find that the differences in the small-scale structure of the atomic and molecular IVCs reflect their different chemical state. By comparing the measured ^{12}CO$(1 \rightarrow 0)$ emission to the inferred H_2 distribution, extracted from the FIR data of the Planck satellite, we find strong variations of the X_{CO} factor with low conversion factors at the CO emission peaks. We discuss the prerequisites for the formation of MIVCs by analysing the conditions in other high-latitude atomic and molecular clouds.

10:20 [CII] synthetic emission maps of simulated galactic discs
by Annika Franeck (Universität zu Köln) (8'+2')

C^+ fine structure emission has recently been studied with Herschel and Sofia. The results promote C^+ as a tracer for star formation in galactic discs or CO-dark molecular gas. Furthermore, the scale height of the C^+ emission in the Milky Way and in distant galaxies is not well understood. Does it trace the disc dynamics? Using RADMC-3D, we post-process three-dimensional, magneto-hydrodynamical simulations of pieces of stratified, galactic discs with a solar-neighborhood gas surface density of 10 $M_\odot$/pc^2 to compute synthetic C^+ emission maps. Excluding the emission from photon-dominated regions, we find that most of the C^+ emission in our model originates from the surfaces of cold molecular clouds. These contribute a narrow but prominent component to the C^+ maps. Moreover, we see a broad component distributed around the midplane, which stems from warmer gas. We compare simulations including different physics (with/without gas self-gravity, or with/without magnetic fields) and different supernova rates, and study the influence on the C^+ scale height. We find that the C^+ scale height is highly variable, as the emission traces the onset of galactic outflows.

10:30 Coffee

11:00 Probing the interstellar PAH hypothesis in electrodynamic traps
by Sandra Brünken (Universität zu Köln) (12'+3')

Co-author: Stephan Schlemmer, I. Physikalisches Institut, Universität zu Köln, Germany

The PAH hypothesis associates the unidentified infrared (UIR) emission bands observed in many astronomical environments to the fluorescence of large polycyclic aromatic hydrocarbons (PAHs) that are excited by the interstellar radiation field. Whereas the presence of PAHs in space is now widely accepted, there are still many open questions related to the details of the PAH hypothesis. One of the key issues regards the composition of the interstellar PAH family, since no single carrier of the observed IR bands could be identified so far. In this project we want to perform highly sensitive IR and far-IR action spectroscopic laboratory studies of PAH ions in different hydrogenation and charge states to be compared to astronomical observations. Experiments will be carried out on mass-selected, cold PAH ions in temperature variable ion traps. Here we will present our instrumentation and method development during the past funding period towards this goal, and outline the proposed studies.
Another question concerns the formation and destruction of PAHs. We will study directly, by mass spectroscopic means, the dissociation processes of PAH ions irradiated by visible and UV light. Related to this, we want to obtain high-resolution ro-vibrational and ultimately rotational spectra of small ionic fragments and building blocks of PAHs, which will support searches for these species with sensitive radio-telescopes like ALMA. First results on the linear C3H+ ion obtained with a newly developed scheme for rotational action spectroscopy will be shown [1].
[1] Brünken et al., ApJ 783 (2014) L4

11:15 Chirped-pulse broadband rotational spectroscopy for laboratory astrophysics
by Melanie Schnell (Universität Hamburg) (12'+3')

The observed variations in molecular abundances in interstellar space originate from both physical and chemical reasons. We will use a combination of chirped-pulse Fourier transform rotational spectroscopy in different frequency ranges with telescope observations to analyse the molecular composition of the universe. By exploring the interstellar molecular complexity and by discovering new molecule classes and key chemical processes in space, the present understanding of interstellar chemistry can be significantly advanced.
Array telescopes provide new observations of rotational molecular emission, leading to an urgent need for microwave and millimeter wave spectroscopic data of exotic molecules. We will use broadband rotational spectroscopy with the cold conditions of a molecular jet and the higher temperatures of a waveguide to mimic different interstellar temperature conditions. Its key advantages are accurate transition intensities, tremendously reduced measurement times, and unique mixture compatibility, as will be discussed in this talk. Furthermore, I will introduce a new chirped-pulse Fourier transform millimeter-wave spectrometer in the 75-110 GHz frequency range that we are currently constructing.

11:30 Dust formation and processing in the ISM
by Cornelia Jäger (Friedrich-Schiller-Universität Jena) (12'+3')

The condensation of carbonaceous and siliceous dust under conditions prevailing in molecular clouds has been experimentally studied. For this purpose, molecular species including refractory elements were deposited on cold substrates. The gaseous precursors of such condensation processes in the ISM are formed by erosion of dust grains in supernova shocks. In the laboratory, we have produced the atomic and molecular precursors by laser evaporation of solid dust analoga. The substrates represent the cold surfaces of surviving cold, circumstellar grains. The precursors were isolated in a cryogenic matrix. Diffusion processes were triggered by a gentle annealing of the icy matrix. The efficient formation of amorphous silicates and carbon at temperatures of about 12 K has been monitored by IR spectroscopy. On the other hand, molecule formation can be triggered by ion bombardment at the interface between ice and solid carbon grains leading to strong grain erosion. Laboratory experiments on the erosion of carbonaceous grains by 200 keV protons showed the formation of CO and CO2 molecules at the expense of solid carbon. The observed erosion restricts the lifetime of the solid carbon material and may influence the formation of more complex molecules in astrophysical environments.

11:45 Laboratory measurements of the far-infrared to millimeter wave dust opacity
by Pierre Mohr (Friedrich-Schiller-Universität Jena) (8'+2')

Co-authors: F. Lewen, H. Mutschke

In this project, we have synthesized glassy Mg-Fe silicates as interstellar-dust analog materials and have determined their absorption/emission coefficients at low temperatures in the wavelength range from 50 micrometers to 4 millimeters. We have found a strong dependence of the dust opacity on the temperature and a moderate depencence on the chemical composition, i.e. the content of divalent and trivalent iron. A dependence on the grain size is also detected, which could point to an influence of additional defects created by milling. In the new project phase, we will continue with similar measurements on carbonaceous materials.

11:55 A global view on the correlation of dust and gas
by Daniel Lenz (Universität Bonn) (8'+2')

The correlation between neutral hydrogen and dust has been extensively studied since the IRAS mission. This led to important insights into gas and dust physics, the accretion history of the Milky Way and eventually the distribution of the CO-dark molecular gas. For a full-sky analysis, the spatial resolution of these studies was limited by the angular resolution of the HI data of about one degree. The recently finished Effelsberg-Bonn HI Survey (EBHIS) has improved this by a factor of more than five.
We aim to consistently relate the latest, most modern data of different dust and gas tracers for the entire Galaxy. This allows us to generate all-sky maps of e.g. the $\mathrm{X_{CO}}$ conversion factor, dust emissivity and the (CO-dark) molecular gas.
Among the data sets used for this study are EBHIS and the Galactic All Sky Survey (GASS) for the atomic neutral hydrogen, Planck and IRIS data for all the dust-related information and the diffuse Fermi LAT data which act as a tracer of the total hydrogen column density. The relation between this data is evaluated using a Bayesian model, utilising modern methods of inference and image analysis. We present the first results of this work and compare our inferred values to other studies of smaller regions and individual objects in the Galaxy.

12:05 Radiative transfer of dust in star-forming filaments
by Roxana Chira (ESO) (8'+2')

Dust emission surveys at sub-mm and far-infrared wavelengths, e.g. by Herschel, provide new possibilities to study star formation in filamentary molecular clouds. The column density and temperature profiles that are derived with these observations rely on models that describe dust particles in a time-constant environment. Thereby, it is assumed that all the dust is visible for the observer. However, up to today, it is not established how the ability of observing dust depends on the surrounding radiation fields. We apply our three-dimensional dust radiative transfer code to model externally heated clumpy filaments. We predict the intensity and temperature distributions by varying the strengths of the external heating field and the dust composition. The model results are confronted with observations.

12:15 Lunch

14:30 The Bending Vibration of the C_3-Molecule and its Isotopologues in the Terahertz Region
by Thomas Giesen (Universität Kassel) (12'+3')

Co-authors: Thomas Büchling, Alexander Breier and Guido Fuchs

Short carbon chains are fundamental for the chemistry of stellar and interstellar ambiances: They are omnipresent throughout the interstellar medium, they likely participate in the formation of long carbon chains and they are products in photo-fragmentation processes of larger species. Triatomic carbon C_3 exhibits a mid-infrared $_3$ antisymmetric stretching mode and a $_2$ bending vibration at 1.9 THz. The detection of $_2$ is experimentally challenging as radiation sources in the terahertz frequency region were missing for a long time as they are in the transition area between optical and microwave techniques. In our experiment carbon is vaporized by laser-ablation and diluted in a supersonic jet of helium. Through absorption spectroscopy the molecular constants of the main isotopologue $^{12}C^{12}C^{12}C$ and of singly ^{13}C substituted species are derived. These laboratory measurements are taken as a basis for further astrophysical observations of different C_3-isotopologues. This will lead to a better understanding of the chemistry of the stellar and interstellar medium.

14:45 Striations, Arcs and Whisps in Numerical Simulations
by Matthias Gritschneder (USM/LMU) (12'+3')

We investigate the fate of B44, a giant trunk in the Ophiuchus region. Employing the AMR-code RAMSES, we are able to show that the wisps and striations visible in the recent Planck Observations can be explained by the hydrodynamical interaction of the trunk with the wind caused by the massive stars in this region.

15:00 Deciphering the ISM around the Scorpius-Centaurus OB Association
by Martin Krause (MPE) (12'+3')

The Scorpius Centaurus OB association (parallactic distances 118-145 pc) is the closest massive star group to the Sun. Its extent of more than 50 degrees on the sky ensures spatially resolved information from radio up to gamma ray frequencies. We analyse multiwavelength data for the different gaseous component: hot X-ray emitting bubbles, swept-up HI and molecular shells, dusty filaments and star-forming clumps. Gamma ray lines from radioactivities constrain recent supernova events. We connect the different gas phases by hydrodynamical modelling and simulations. I will present an overview of the observations on the Scorpius-Centaurus region and the discuss the physical processes we might witness.

15:15 The Pillars of Creation Revisited with MUSE
by Anna Faye Mc Leod (ESO) (8'+2')

The results of the first publication from our FuSIOn (Feedback in massive star forming regions: from SImulations to Observations) project, in which we seek to validate the predictions of numerical simulations of star forming clouds that include feedback in the form of stellar winds and photo-ionisation by comparing them with observations, are presented. We observed the iconic Pillars of Creation in M16 with the integral field spectrograph MUSE at the VLT: for the first time in the long and rich research history of this region, it was possible to study the ionisation structure of the Pillars (which suffer from the feedback from massive O and B type stars in their vicinity) in great detail over the entire visible wavelength range and map the gas kinematics and the relevant physical parameters (e.g. line of sight velocity, extinction, electron density, electron temperature, as well as integrated intensity and line ratios). We report the presen ce of a previously undetected protostellar bipolar outflow at the tip of one of the Pillars and estimate the expected life-time of these structures. Finally, we discuss the comparison with our simulations and radiative transfer calculations.

15:25 Lyman-Werner Radiation from Primordial Stars and its Influence on the ISM
by Anna Schauer (Universität Heidelberg) (8'+2')

Population III (or Pop III) stars can influence their surroundings in several ways and by so doing regulate subsequent star formation. Their radiation may ionize or photodissociate H_2 in the surrounding interstellar medium and break out to affect other halos. Even if ionizing photons are trapped, Lyman-Werner (LW) photons may still escape the halo and photodissociate H_2 in nearby halos, preventing them from cooling and forming stars. The LW escape fraction therefore is a key parameter in cosmological simulations of early reionization and star formation. Its value for realistic high-redshift halos has not yet been parametrized as function of halo mass or stellar mass. To do so, we have performed radiation hydrodynamical simulations of LW UV escape from 10^5 to $10^7\ M_\odot$ halos with $9-120\ M_\odot$ Pop III stars with the ZEUS-MP code. We find that escape fractions vary from 0% to 95%, depending on halo and stellar mass, and that LW photons cannot escape the most massive halo locally in our sample even from the most massive Pop III star. We also find that shielding of H_2 by neutral hydrogen, which has been neglected in simulations to date, produces escape fractions that are considerably lower, up to factors of three for the least massive stars in our sample, than those predicted by H_2 self-shielding alone.

15:35 Second Generation Star Formation in Primordial Supernova Remnants
by Katharina Wollenberg (Universität Heidelberg) (8'+2')

J031300 is now the most metal-poor star discovered to date, with a maximum Fe abundance of $10^{-7.1}$ solar. Two possible Pop III supernova candidates have been identified, with progenitor masses of 12.4 and 60 Msun, whose nucleosynthetic yields that are a good match to the chemical abundances found in J031300. However, explaining the actual metallicity of J031300 also requires an understanding of how the metals produced by the first supernovae are diluted in the early IGM and later taken up into second-generation stars. We study this process, by modeling mixing in a primordial supernova remnant and its fragmentation into new stars using high-resolution numerical simulations. We employ the Kepler stellar evolution code to obtain models of the two low energy Pop III supernovae which match the chemical abundances of J031300, and we combine these results with 2D simulations of mixing and fragmentation in the supernova remnants at later times using the ZEUS-MP magnetohydrodynamics code.

15:45 Coffee

16:15 Future Funding

17:05 Density Distribution Functions in Molecular Clouds and their Prognostic Power
by Philipp Schneider (USM/LMU) (8'+2')

17:15 The evolution and fate of G2: a compact source scenario
by Alessandro Ballone (USM/MPE) (8'+2')

The evolution of the dust cloud G2, discovered by Gillessen et al. (2012), has been continuously monitored from 2004 to now. The most recent position-velocity diagrams, obtained from the integral field spectrograph SINFONI at VLT, clearly show that G2 has experienced the pericenter passage. Thus, G2 is now subject to the maximum tidal field of the supermassive black hole and hydrodynamical effects will dominate the further evolution. Despite of this wealth of observations, the nature of the cloud is still unclear and a dichotomy between two most popular models still remains, namely the "diffuse cloud" and the "compact source" scenarios. The present contribution focuses on the investigation - by means of new 3D AMR simulations - of the second scenario, with G2 being the outflow from a low-mass central source. A direct and detailed comparison with the available observations allows us to draw the attention to the effect of the many different involved parameters and to the differences arising in the near future, enabling us to shed light on the nature of G2.

17:25 Three-dimensional Modeling of Dust in the Milky Way using Gaia
by Sara Rezaei Khosbakht (MPIA Heidelberg) (8'+2')

Co-authors: C. A. L. Bailer-Jones, R. J. Hanson
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We present a non-parametric model to mode probabilistically the three-dimensional distribution of dust in the Milky Way. Knowledge of dust distribution in the Galaxy is required when estimating intrinsic stellar properties which are in turn necessary to estimate fundamental quantities like age, origin and structure of the Galaxy. Our model uses line-of-sight extinctions towards stars at different, known positions in the Galaxy. However, unlike many earlier studies which considered each line-of-sight separately, it addresses the correlation structure of dust. Since individual interstellar extinctions are not independent, we use a Gaussian process model to connect these individual lines-ofsight, according to distances between the stars, which gives us the possibility to infer dust densities for any point in 3D space for which no previous extinction information has been presented. Gaia will provide parallaxes to hundreds of millions of stars across the Galaxy to remarkably high accuracy from which stellar distances can be estimated. Interstellar extinctions of these stars will also be estimated using the low resolution spectrophotometry from Gaia. Having the 3D positions of stars as well as their extinctions, we can infer dust densities for areas with no or poor data. It, therefore, reveals the importance of accurate parallax estimation from Gaia on the precision of inferred dust densities.

17:35 Connecting Hydrogen Shells to Massive-Star Groups
by Daniel Kröll (Universität Bonn) (8'+2')

Superbubbles and bubbles in the interstellar medium are formed by winds of massive stars and their supernova explosions. Knowing the properties of these bubbles is key to determine the energy input by stellar groups and its history.
We study the hydrogen structures in the vicinity of the closest OB Association, the Scorpius-Centaurus association at 140 pc distance. We investigate if our model based on the stars of the subgroups and their expected outputs can consistently explain the observed structures. With the HI Galactic All Sky Survey a total coverage of the region with a resolution of 14.4' is available.
We use methods from image processing to find candidate structures in the HI data. Then we use our model of massive-star created structure in the interstellar medium in the 3D position-position-velocity space, and fit our homogeneous spherical shell model to the data.
We describe a first appliecation to the Upper Scorpius subgroup of the OB Association, and indicate how we plan to find similar bubbles along the entire plane of the galaxy and determine their properties.

18:00 Dinner

09:00 Squeezed between shells: The fate of the Lupus I molecular cloud
by Benjamin Gaczkowski (USM/LMU) (12'+3')

Today molecular cloud formation is attributed to collisions of large-scale flows in the ISM. Such flows can be driven by stellar feedback processes and supernovae. The numerous massive stars in the three sub-groups of the Sco-Cen OB-association created a huge system of expanding loop-like H I structures around each of the sub-groups. The Lupus I molecular cloud is situated in the middle between the Upper-Scorpius (USco) and the Upper-Centaurus-Lupus (UCL) sub-groups. At this location the expanding USco H I shell interacts with a bubble driven by the winds of the remaining B-stars of UCL. With a distance of 150 pc Lupus I represents the nearest example where we can study how such a collision process forms and influences new dense clouds in the ISM. We present LABOCA continuum sub-mm observations of Lupus I, complemented by Herschel and Planck data from which we constructed column density and temperature maps to characterize the cloud in a multi-wavelength approach. All maps revealed that the cloud can be divided into two distinct regions. The northern part that has on average lower densities and higher temperatures as well as no active star formation and the center-south part with dozens of pre-stellar and protostellar cores where density and temperature reach their maximum and minimum, respectively. The column density PDFs from the Herschel data show double-peaked profiles for all parts of the cloud. In those parts with active star formation also a power-law tail is found. With LABOCA the PDFs follow the denser parts of the cloud showing good agreement with those from Herschel for the second lognormal component and the power-law tail. The distribution of the 15 cores we found with LABOCA confirms that only the center-south part of Lupus I is actively forming stars whereas the north is quiescent. We argue that the main driving agents in the formation process of Lupus I are the advancing USco H I shell in whose edge the cloud is most likely embedded colliding with the UCL wind bubble compressing Lupus I in-between. This might be the reason for the elongated shape, the double peak PDFs and the co-aged population of pre-stellar and protostellar cores.

09:15 Studying cloud structure with G-virial method
by Guang-Xing Li (USM/LMU) (12'+3')

In this talk I will present the G-virial method, which allows to quantify (1) the importance of gravity in molecular clouds in the position-position-velocity (PPV) space, and (2) properties of the gas condensations in molecular clouds. After introducing the method, I will discuss how to study the importance of gravity in star formation, and how we can link different models and simulations with the method.

09:30 Characterizing the Ionized Gas around Massive Protostars
by Alberto Sanna (MPIfR Bonn) (12'+3')

At an early stage of stellar evolution, massive young stellar objects (YSOs) inject large amounts of mechanical energy into the ISM by powerful outflow phenomena, which are a main outcome of mass accretion onto the protostar. In turn, this outflow activity provides a major source of turbulent energy for the cluster gas. In this context, it is fundamental to properly characterize the dynamical interaction between massive YSOs and their surrounding envelopes over a wide range of spatial scales and physical phenomena.
This project aims at systematically quantify the energetics injected by massive forming stars into the ISM at their early stages of evolution, focusing on spatial scales on the order of 1000 AU. We propose to achieve this goal by means of high-resolution and high-sensitivity Jansky Very Large Array (JVLA) observations, in 3 spectral bands (from 6 to 22 GHz) and with an angular resolution of about 0.1 arcsec, of the hyper-compact radio continuum emission of a robust sample (40) of massive YSOs.

09:45 Multi-wavelength synthetic observations of the ISM
by Simon Glover (Universität Heidelberg) (12'+3')

Numerical simulations of star formation and stellar feedback have now advanced to the point where they routinely include relatively sophisticated treatments of the microphysics of the ISM. However, much of the predictive power of these simulations can only be harnessed if we can convert their results into synthetic observables that can be compared with observations of the real ISM. In this talk, I will discuss our ongoing efforts to produce and analyze synthetic observations of the ISM on a variety of scales and will give some examples of what we can learn from these studies.

10:00 The Interstellar medium and Star Formation in Nearby Galaxies
by María Jesús Jiménez (Universität Heidelberg) (8'+2')

Co-authors: Frank Bigiel (Institut für Theoretische Astrophysik, Zentrum für Astronomie der Universität Heidelberg, Germany), Karin Sandstrom (Steward Observatory, University of Arizona, USA), Eva Schinnerer (Max Planck Institute für Astronomie, Heidelberg, Germany), Annie Hughes (Max-Planck-Institut für Astronomie, Heidelberg, Germany), Amanda Kepley (National Radio Astronomy Observatory, Green Bank Observatory, USA), Alberto D. Bolatto (Department of Astronomy, University of Maryland, USA), Andreas Schruba (Max Planck Institut für extraterrestrische Physik, Garching, Germany), Gaelle Dumas (IRAM, 300 Rue de la Pisicne, St. Martin dHères, France), Laura Zschaechner (Max Planck Institute für Astronomie, Heidelberg, Germany), Adam K. Leroy (National Radio Astronomy Observatory, Charlottesville, USA), Antonio Usero (Observatorio Astronómico Nacional, Madrid), Fabian Walter (Max Planck Institut für Astronomie, Heidelberg, Germany), Diane Cormier (Institut für theoretische Astrophysik, Zentrum für Astronomie der Universität Heidelberg, Germany), Karl-Friedrich Schuster (IRAM, 300 Rue de la Piscine, St. Martin dHères, France), Santiago García-Burillo (Observatorio Astronómico Nacional, Madrid), Carsten Kramer (IRAM, Avenida Divina Pastora 7, Granada, España) ans Jeróme Pety (IRAM, 300 Rue de la Piscine, St. Martin d'Hères, France)

The efficiency of star formation in other galaxies is often studied only focusing on molecular gas traced by CO emission due to the faintness of other lines. However the emission coming from lines such as HCN or HCO+ is an essential tool to probe the actual dense gas.
Therefore one of the key ways to probe the physics conditions in the star forming gas and as importantly, study if and how they vary across galactic disks and galaxy-to-galaxy, is assembling observations of molecular lines with different critical densities and compare these observations to tracers of star formation. For this purpose we initiated a large program (EMPIRE) using EMIR at the IRAM 30m telescope to map emission from dense gas tracers (HCN, HCO+, HCN, etc.) along with the CO isotope 13CO and C180 across 9 nearby disk galaxies.
Combined with existing ancillary data at virtually all wavelengths from the radio to the UV, we will be able to assess the physical properties of the gaseous ISM and and how they vary across entire galaxy disks systematically for the first time.

10:10 The impact of protostellar outflows on the interstellar matter:
complementary NIR spectra to CO maps
by Volker Weiss (TLS Tautenburg) (8'+2')

Proto-stellar outflows are a signpost of stellar birth. Despite many investigations of such flows, their impact on the parental molecular cloud is still highly disputed. Simulations suggest that proto-stellar outflows are too weak to replenish turbulent energy globally, and thus have little influence on stabilizing the cloud. On the other hand, observations show that outflows can generate highly stirred local velocity fields. Within the framework of the DFG Priority Program ”Interstellar Matter” our study aims at clarifying the role of proto-stellar outflows for their environment. To this end, we derive parameters of a statistically complete sample of outflows in a star-forming (SF) region. To preclude additional sources of energy and momentum input, we chose a near-by, low-mass, outflow-dominated SF region, namely NGC 1333. Here we conduct a thorough exploration of all accessible outflows over a broad spectral interval, ranging from shock-excited H_2 in the near-IR to the millimeter radiation of entrained CO. By means of this ”bolometric approach more precise information on the flow properties can be gathered. Dynamical parameters as mass and velocity are derived from spectral and spatial CO line fluxes, respectively. Morphological properties like opening angle and inclination are derived from the CO line maps. Complementary information are obtained from multi-epoch H_2 imaging as well as IR-spectra of the driving jets. With the progress of the work in mind, this year I will focus on the observations and preliminary results of CO-maps and the complementary NIR-spectra of NGC 1333.

10:20 Nuclear Star Cluster: an illustration of scale coupling in dwarfs galaxies
by Nicolas Guillard (ESO) (5')

Observations of dwarfs galaxies suggest that Black Holes (BHs) and Nuclear Clusters (NCs) are co-evolving with their hosts. However, their formation and how they are fueled is still unclear. NCs, unlike BHs, may provide a visible record of the accretion of stars and gas. Therefore, they can be used as probes for the gas and star fueling of the nuclei of dwarfs galaxies.
Whether NCs form via accretion of multiple clusters or in-situ star formation, the mass build-up in such regions ultimately depends on both pc-scale (e.g. turbulence, physics of the ISM) and kpc-scale (e.g. spirals, bars). Thus, one needs to understand these scaling coupling in order to properly address the physical processes involved in NCs formation. The associated physical processes have so far been studied numerically at resolution from 100 to 50pc, mostly focusing on the role of bars. The main nuclear structures (e.g., the nuclear disks at the 10-50 pc scale) thus remain unresolved and the fueling processes unclear.
From the analysis of simulations of a dwarf galaxy at parsec resolution, the aim of my project is to study the coupling effects between large scale (30kpc) and small scale (pc). I will focus on the fueling mechanisms and the formation of nuclear star clusters and emphasise the impact of star formation and stellar driven feedback.

10:25 Monte Carlo simulations of galaxy protoclusters in COSMOS sky survey
by Neven Tomicic (MPIA) (5')

Galaxy clusters are large virialized collections of galaxies. Galaxies contribute about 5% to the mass of the cluster, the intracluster medium about 10% and the dark matter up to 85%. These structures are formed from galaxy protoclusters. A protocluster is an early type of clusters with fewer galaxies and an observed higher number densities of galaxies, compared to other parts of the observed sky. The goal of this paper is to simulate galaxy protoclusters at different redshifts (z=2,3,4,5). using Monte Carlo simulations, following the predefined surface profiles of the protoclusters and taking into account the errors of photometric redshift (versus spectroscopic redshifts) specifically for the COSMOS survey. By simualting 1000 different types of protoclusters (Virgo, Coma and Fornax), we quantified the characteristics of the search methods of protoclusters in the COSMOS, such as completeness (a number that defines the share of galaxies derived after search methods , compared to the total numbers of galaxies in the protoclusters), contamination (a number that defines the share of galaxies in the sky that does not belong to the protocluster), number density and effective radius (radius within which there is 68% of the mass of protocluster) and their behaviour for different types and redshifts. The results show that completeness of the protoclusters does not change compared to the redshift, while contamination increases with the distance from the centre of PC. The calculated effective radii of our simulated PCs agree within the factor 2 with the initial radii calculated by Chiang et al. (2013). Despite the discrepancy within our effective radii, 55-65% of galaxies are in protoclusters, which is consistent with the results of Chiang et al. (2013). We believe that the differences between the radii are caused by the fact that our simulations do not take into account the distribution of the mass in the protoclusters. We assumed that all galaxies have the same mass, which can significantly affect the calculations of effective radius. In the end we applied the search methods of protoclusters and the method of calculating the effective radius to existing protoclusters in COSMOS field, at different redshifts.

10:30 Coffee

11:00 The first Galaxy scale hunt for high-mass protostars
by Timea Csengeri (MPIfR Bonn) (12'+3')

The ATLASGAL survey is one of the most sensitive and extensive ground-based survey of the inner Galaxy at sub-millimeter wavelengths, and provides an unprecedented view on all stages of massive star formation. Over 10 000 compact sources have been identified (Csengeri et al. 2014), and we have made substantial progress in characterising various evolutionary stages of the evolution of massive clumps by using ancillary radio and mid-infrared data, and assigned distances to a large number of sources.
Selected from ATLASGAL, we identified a complete sample of 45 objects which are massive ($> 650 M_{\rm sol}$), dense (surface density $> 1\,{\rm g\,cm^{-2}}$) and lack bright mid-infrared objects. Our selection of these mid-infrared quiet massive clumps is complete within 4.5 kpc, and to date represents the best potential sites to host the next generation of the most massive stars currently forming in our Galaxy. We used ALMA to perform the first systematic survey at high angular-resolution to look for high-mass protostars in this sample of massive clumps. As a first step by achieving a 0.1 pc physical scale we confirm massive ($> 500 M_{\rm sol}$) compact embedded sources and also reveal intensive outflows associated with these potentially young, Class 0 like high-mass protostars. Such a Galactic scale sample complemented with spectroscopic follow-up observations is the first step to characterize the initial conditions of high-mass star and cluster formation.

11:15 Stellar feedback in GMCs: Winds or SNe?
by Katharina Fierlinger (USM/TUM) (12'+3')

Giant molecular clouds (GMCs) are reshuffled by stellar winds and supernova explosions of massive stars. These processes – which we call stellar feedback – create bubbles in the interstellar medium (ISM) and insert newly produced heavy elements and kinetic energy into their surroundings, possibly driving turbulence in GMCs. Most of this energy is thermalized and immediately removed from the GMC by radiative cooling. In this work we estimate the amount of feedback energy that is retained as kinetic energy when the bubble walls have decelerated to the sound speed of the ambient medium and the kinetic energy will be dissipated. We argue that the feedback of the most massive still existing star outweighs the feedback from less massive stars.

11:30 Chemical evolution of the SN-driven ISM: the impact of SN positioning
by Andrea Gatto (MPA) (8'+2')

Supernova (SN) explosions are an important component for shaping the interstellar medium (ISM). They produce its hottest phase while driving turbulent motions in the warm and cold gas. Globally, these random motions could provide a net turbulent support and help to regulate star formation. The impact of SNe on the ISM is, however, strongly dependent on the thermodynamic properties of the ambient medium with which they interact.
We use 3D hydrodynamical simulations both in a (256 pc)^3 periodic box and in a $(500pc)^2 \times \pm 5$ kpc region of a galactic disc to model the impact of SN explosions on the multi-phase ISM using different initial densities and SN rates. We include radiative cooling, diffuse heating, and the formation of molecular gas using a chemical network. The SNe explode at a fixed rate either at random positions, at density peaks, or both, or clustered in space and time.
We show that SN positioning has a dramatic impact on the recovered ISM properties. SNe located at random positions are able to efficiently heat up and, at the same time, compress the ambient medium. Explosions positioned in density peaks, on the other hand, result in huge radiative losses and they strongly suppress the formation of molecular hydrogen.

11:40 Modelling the Magnetic Field and the Chemistry Evolution of the ISM
by Anabele-Linda Pardi (MPA) (8'+2')

Co-authors: Philipp Girichidis (MPA), Thomas Peters (Universität Zürich),Stefanie Walch (Universität zu Köln), Thorsten Naab (MPA), Andrea Gatto (MPA), Richard Wünsch (Academy of Sciences of the Czech Republic),Simon C.O. Glover (Universität Heidelberg), Ralf S. Klessen (Universität Heidelberg), Paul C. Clark (Cardiff University) and Christian Baczynski (Universität Heidelberg)

We carry out three-dimensional MHD simulations of the magnetised multiphase interstellar medium (ISM) focusing on the connection between chemical and magnetic evolution. The simulations of periodic boxes include a complex chemical network tracking molecule formation and destruction. We also include supernova (SN) feedback.
Magnetic field saturation occurs when the field dissipation and amplification are balancing out each other. Our results show that the magnetic field saturates at a constant value regardless of the initial field configuration. However, the saturation limit and the time needed to reach saturation are highly sensitive to the initial parameters like density, SN rate and numerical resolution. We also find that an initial homogeneous magnetic field of the order of 0.5 G leads to formation of 20% less molecular hydrogen due to the additional magnetic pressure in the dense ISM phase. The magnetised medium being harder to mix by SN stirring maintains a lower temperature, decreasing the volume filling fraction of the hot ionised gas to 50% .
We conclude that magnetic fields significantly change the chemistry and the multi-phase structure of the ISM and should be considered in all future simulations. Details, however, are subject to further investigation.

11:50 The influence of AGN feedback on the ISM in early-type galaxies
by Maximilian Eisenreich (MPA) (8'+2')

We use hydrodynamical simulations to study the influence of AGN accretion and feedback on the late morphological and kinematic evolution of the hot and cold interstellar medium and young stars in isolated early-type galaxies (ETGs). The complex interplay of gas cooling from a hot halo, feedback from star formation (metal and energy return from supernova Ia and II, AGB winds) and gas accretion onto and feedback (kinetic and radiative) from the central AGN is investigated. We present the most prominent signatures of AGN feedback on the kinematics and phase distribution of the gas, it's metal distribution, and the stellar population.

12:00 Latest results from FIFI-LS on small Irregular Galaxies
by Aaron Bryant (Universität Stuttgart) (8'+2')

12:15 Lunch

14:30 The submillimeter emissivity of crystalline water ice
by Harald Mutschke (Friedrich-Schiller-Univ. Jena) (12'+3')

Co-author: Caroline Reinert

Surprisingly little data are available on the absorption/emission index of water ice for submillimeter wavelengths. We present new spectroscopic measurements for crystalline water ice cooled to low temperatures and derive a simple T-dependent model for the opacity based on power laws

14:45 Toward Gas-phase Spectroscopy of C_{60}^+
by Sunil Kumar Sudhakaran (MPI für Kernphysik) (12'+3')

Co-authors: Bastian Kern (Karlsruher Institut für Technologie), Christian Meyer (Max-Planck-Institut für Kernphysik), Gael Rouille (Max-Planck-Institut für Astronomie), Dmitry Strelnikov (Karlsruher Institut für Technologie), Wolf Andreas (Max-Planck-Institut für Kernphysik), Peter Bizenberger (Max-Planck-Institut für Astronomie), Klaus Blaum (Max-Planck-Institut für Kernphysik), Christian Breitenfeldt (Ernst-Moritz-Arndt-Universität Greifswald), Jürgen Göck (Max-Planck-Institut für Kernphysik), Ulrich Grözinger (Max-Planck-Institut für Astronomie), Thomas Henning (Max-Planck-Institut für Astronomie) and Jonas Karthein (Max-Planck-Institut für Kernphysik)

One of the long-standing mysteries in astronomy is the origin of the interstellar absorption features that are observed in the visible to near infrared range and dubbed as the diffuse interstellar bands (DIBs). Despite the observation of several hundred lines, none of them has been unambiguously attributed to a chemical species. A potential candidate believed to be responsible for some of these absorption features is C_{60}^+ [1,2] for which no laboratory gas-phase spectra exist. Our objective is to carry out the first gas-phase spectroscopy of C_{60}^+ using a cryogenic ion-beam trap [3]. The stored molecular ions will be subject to excitation by near-infrared laser light spanning the range of the suggested absorption features of C_{60}^+. At resonance, the absorbed energy is expected to be re-distributed among the vibrational modes of the molecule followed by the delayed emission of mid-infrared radiation [4]. A significant fraction of the emitted light will be guided onto highly sensitive blocked impurity band (BIB) detectors which feature extremely low dark current and high sensitivity. After the proof-of-principle experiments with C_{60}^+, this novel spectroscopy scheme should also be applicable to a wide range of other complex organic molecular ions like, e.g., polycyclic aromatic hydrocarbons. The measurement scheme, preparatory work toward its implementation, and the current state of the experimental setup will be presented.

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15:00 Large scale filaments associated with Milky Way spiral arms
by Ke Wang (ESO) (12'+3')

Co-authors: Leonardo Testi[1], Adam Ginsburg[1], Malcolm Walmsley[2,3],Sergio Molinari[4], Eugenio Schisano[4]
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The ubiquity of filamentary structure at various scales through out the Galaxy has triggered a renewed interest in their formation, evolution, and role in star formation. The largest filaments can reach up to Galactic scale as part of the spiral arm structure. However, such large scale filaments are hard to identify systematically due to limitations in identifying methodology (i.e., as extinction features). We present a new approach to directly search for the largest, coldest, and densest filaments in the Galaxy, making use of sensitive Herschel Hi-GAL data complemented by spectral line cubes. We present a sample of the 9 most prominent Herschel filaments from a pilot search field. These filaments measure 37-99 pc long and 0.6-3.0 pc wide with masses $(0.5-8.3)\times10^4$ $M_\odot$, and beam-averaged (28", or 0.4-0.7 pc) peak H_2 column densities of $(1.7-9.3)\times10^{22}$ cm^{-2}. The bulk of the filaments are relatively cold (17-21 K), while some local clumps have a dust temperature up to 25-47 K due to local star formation activities. All the filaments are located within $<$ 60 pc from the Galactic mid-plane. Comparing the filaments to a recent spiral arm model incorporating the latest parallax measurements, we find that 7/9 of them reside within arms, but most are close to arm edges. These filaments are comparable in length to the Galactic scale height and therefore are not simply part of a grander turbulent cascade. These giant filaments, which often contain regularly spaced pc-scale clumps, are much larger than the filaments found in the Herschel Gould's Belt Survey, and they form the upper ends in the filamentary hierarchy. Full operational ALMA and NOEMA will be able to resolve and characterize similar filaments in nearby spiral galaxies, allowing us to compare the star formation in a uniform context of spiral arms.

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