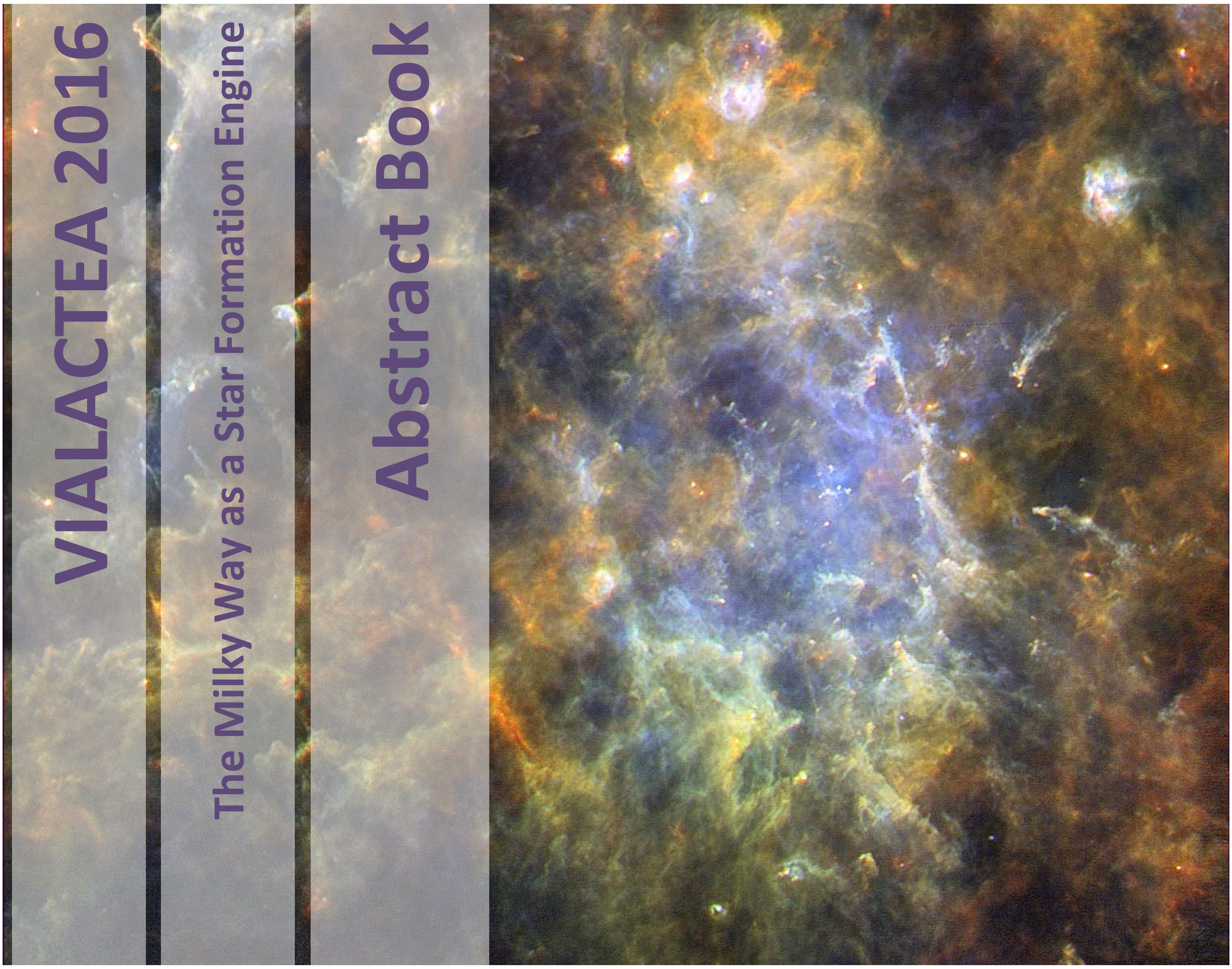
VIALACTEA 2016

The Milky Way as a Star Formation Engine

Abstract Book



Angelicum Congress Center
Pontifical University of Saint Thomas Aquinas
Rome, September 26th-30th 2016

A Conference organised by INAF IAPS
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Abstract Book and Final Programme

VIALACTEA 2016

The Milky Way as a Star Formation Engine

Towards a predictive Galaxy-scale model of the

Star Formation Life-Cycle

Angelicum Congress Center

Pontifical University of Saint Thomas Aquinas

Rome, September 26th-30th 2016

Sponsored by

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Scientific Programme

Monday 26th September 2016

Session 1: InterStellar Medium, Molecular clouds and Filaments: from the diffuse texture of the ISM to the backbone skeleton of the Milky Way

09:00	09:30	00:30	Institutional welcome talks			
09:30	10:00	00:30	Molecular cloud dynamics and star formation in galaxies	Andi Burkert	LMU, Munich	**I**
10:00	10:20	00:20	SEDIGISM: A molecular line survey of the Galactic Plane with APEX	Frederic Schuller	MPIfR, Bonn	C
10:20	10:40	00:20	THOR - The HI, OH, Recombination Line survey of the Milky Way	Michael Rugel	MPIA, Heidelberg	C
10:40	11:10	00:30	**Coffee Break**			
11:10	11:30	00:20	Building a (fully resolved) molecular cloud catalog of the Galaxy	Dario Colombo	MPIfR, Bonn	C
11:30	11:50	00:20	FOREST Ultra-wide Galactic Plane Survey In Nobeyama (FUGIN): Project Overview and Global Distribution and Kinematics of Molecular Gas	Tomofumi Umemoto	NAO, Tokyo	C
11:50	12:10	00:20	The MopraCO survey of the Southern Galactic Plane	Domenico Romano	University of New South Wales	C
12:10	12:30	00:20	Using CO line ratios to trace the physical properties of molecular clouds	Camilo Peñaloza	Cardiff University	C
12:30	12:40	00:10	Posters Snapshot Preview			
12:40	14:10	01:30	**Lunch**			
14:10	14:20	00:10	Posters Snapshot Preview			
14:20	14:50	00:30	The Physics of Molecular Clouds Formation	Paul Clark	Cardiff University	**I**
14:50	15:10	00:20	Analytical tools to characterize the density structure of molecular clouds	Nicola Schneider	University of Cologne	C
15:10	15:30	00:20	The Origin of Molecular Cloud Turbulence	Paolo Padoan	ICC-University of Barcelona	C
15:30	15:50	00:20	Investigating the interactions between cosmic rays and interstellar medium	Nicola Marchili	INAF-IAPS, Rome	C
15:50	16:10	00:20	The line-of-sight dust temperature distribution as a probe of Galactic star formation	Ken Marsh	Cardiff University	C
16:10	16:40	00:30	**Coffee Break**			
16:40	17:00	00:20	VIALACTEA e-Infrastructure and Science Gateway: Milky Way Analysis Workflows	Ugo Becciani	INAF-Osservatorio di Catania	C
17:00	17:20	00:20	Evolutionary Picture of Giant Molecular Cloud Mass Functions on Galactic Scales	Masato Kobayashi	Nagoya University	C
17:20	17:40	00:20	Mutiwavelength study to reveal dust properties and cloud 3D structure	Laurent Pagani	LERMA-Obser. de Paris	C
17:40	18:00	00:30	VIALACTEA Knowledge Base: a resource to analyse the Milky Way data.	Robert Butora	INAF-Osservatorio di Trieste	C

Tuesday 27th September 2016

8:45	9:15	00:30	The Wispy Milky Way in Hi-GAL and molecular gas: a global view of filamentary structures in the Galactic Plane	Eugenio Schisano	INAF-IAPS, Rome	**I**
09:15	09:35	00:20	Quiescent fibers in the NGC1333 proto-cluster	Alvaro Hacar	University of Vienna	C
09:35	09:55	00:20	Probing the filamentary nature of massive star-forming regions with ArTéMiS	Philippe Andre	CEA/SAp, Saclay	C
09:55	10:15	00:20	Filaments and compact sources distribution in the Lupus star forming region	Milena Benedettini	INAF-IAPS, Rome	C
10:15	10:45	00:30	Toward True Topology	Alyssa Goodman	CfA-Harvard	**I**
10:45	11:15	00:30	**Coffee Break**			
11:15	11:35	00:20	Magnetic fields and filaments in the ISM: their relative orientation observed with Planck	Andrea Bracco	CEA/SAp, Saclay	C
11:35	11:55	00:20	Simulations of magnetized molecular cloud filaments	Gilberto Gomez	UNAM, Morelia	C
11:55	12:15	00:20	What can filament dynamics tell us about core formation?	Gwenllian Williams	Cardiff University	C

Session 2: Demographics of Galactic Clumps and Cluster Progenitors: conditions, timelines, rates and efficiencies of cluster and massive star formation as a function of mass and environment

12:15	12:45	00:30	Statistical properties of the early stages of star formation in the inner Galaxy: the Hi-GAL Clump Catalogue	Davide Elia	INAF-IAPS, Rome	**I**
12:45	12:55	00:10	Posters Snapshot Preview			
12:55	14:25	01:30	**Lunch**			
14:25	14:35	00:10	Posters Snapshot Preview			
14:35	14:55	00:20	Light from the Dark: Using Hi-GAL to Study the The Formation and Evolution of Massive Clumps in Infrared Dark Clouds	Gary Fuller	University of Manchester	C
14:55	15:15	00:20	The JCMT Plane Survey: Compact Source Catalogue and First Results	David Eden	John Moores Univ., Liverpool	C
15:15	15:35	00:20	Discussing the distance bias on the estimation of Hi-GAL compact source physical properties	Adriano Baldeschi	INAF-IAPS, Rome	C
15:35	16:15	00:20	Testing theories of triggered star formation in the outer Galactic disk	Kazi Rygl	INAF-IRA, Bologna	C
			Evolutionary indicators on Galactic clumps: examination of dust properties of sources from the Hi-GAL survey.	Manuel Merello	INAF-IAPS, Rome	C
16:15	16:45	00:30	**Coffee Break**			
16:45	18:00	01:15	**DEBATE 1**			

Wednesday 28th September 2016

08:45	09:15	00:30	Filaments, Shells, and Bubbles: Toward Galactic View of Star Formation	Shu-Ichiro Inutsuka	Nagoya University	**I**
09:15	09:35	00:20	Regulation of Galactic Star Formation Rates by Turbulence, Magnetic Fields and Stellar Feedback	Jonathan Tan	University of Florida	C
09:35	10:05	00:30	ATLASGAL - dense gas structure of the inner Galaxy	James Urquhart	University of Kent	**I**
10:05	10:25	00:20	The ATLASGAL Survey: Evolution of high-mass star-forming regions	Andrea Giannetti	MPIfR, Bonn	C
10:25	10:45	00:20	Non-thermal motions in massive star forming regions: turbulence vs. self-gravity	Alessio Traficante	INAF-IAPS, Rome	C
10:45	11:15	00:30	**Coffee Break**			
11:15	11:35	00:20	The star-forming content of CHIMPS	Andrew Rigby	Cardiff University	
11:35	11:55	00:20	An Overview of Physical Properties of Clumps in the Bolocam Galactic Plane Survey	Yancey Shirley	Steward Obs. - University of Arizona	C
11:55	12:15	00:20	Q+: a new method for quantifying structure in young clusters	Sarah Jaffa	Cardiff University	C
12:15	12:35	00:20	Synthetic modelling of Spectral Energy Distributions of young embedded clusters	Sergio Molinari	INAF-IAPS, Rome	C
12:35	14:05	01:30	**Lunch**			
14:05	14:35	00:30	Chemistry of star-forming regions in the Galaxy and beyond	Floris van der Tak	SRON/University of Groningen	**I**
14:35	14:55	00:20	The Herschel-HIFI view of massive protostellar objects	Fabrice Herpin	Lab. Astrophysique Bordeaux	C
14:55	16:25	01:30	**VIALACTEA Tools Live Demos/Hands-on Sessions/Poster Session**			
16:25	16:55	00:30	**Coffee Break**			
16:55	17:25	00:30	New challenges in Astrophysics and the new ICT frontiers	Fabio Pasian	INAF-Osservatorio di Trieste	**I**

Session 3: the Milky Way in the context of environment and other galaxies

17:25	17:35	00:10	Posters Snapshot Preview			C
17:35	18:05	00:30	Star formation and the ISM lifecycle in the centre of galaxies	Steve Longmore	John Moores University, Liverpool	**I**

Thursday 29th September 2016

08:45	09:00	00:15	Strengthening in Europe the foundations of Space Science and Technology: the success story of VIALACTEA	Giuseppe D'Aquino	REA-FP7, Bruxelles	**I**
09:00	09:20	00:20	Gas Flows and Star Formation in the Galactic Center	Cara Battersby	CfA-Harvard	C
09:20	09:40	00:20	Large-scale latitude oscillations of the Galactic Plane: disk instability or extraplanar gas accretion?	Alberto Noriega-Crespo	STScI, Baltimore	C
09:40	10:10	00:30	Cloud-scale studies of gas and star formation in nearby galaxies	Annie Hughes	IRAP, Toulouse	**I**
10:10	10:30	00:20	Giant molecular clouds properties in nearby galaxies	Rosita Paladino	INAF-IRA, Bologna	C
10:30	11:00	00:30	**Coffee Break**			
11:00	11:30	00:30	The formation and evolution of molecular clouds	Steffi Walch	University of Cologne	**I**
11:30	11:50	00:20	The High-Resolution View on the Gas-Star Formation Cycle in Nearby Galaxies	Andreas Schruba	MPE, Garching	C
11:50	12:10	00:20	The formation of Milky Way under chemical and radiative feedback	Luca Graziani	INAF-Osservatorio di Roma	C

Session 4: Triggering, Spiral Arms, Turbulence and Gravitation: sifting the ingredients of a Galactic Star Formation Recipe

12:10	12:40	00:30	Star formation and ionized regions in the Inner Galactic Plane	Pedro Palmeirim	LAM, Marseille	**I**
12:40	14:10	01:30	**Lunch**			
14:10	14:30	00:20	Classification of Galactic Bubbles from a Morphological Multiwavelength Study	Milena Bufano	INAF-Osservatorio di Catania	C
14:30	14:50	00:20	Adaptive Active Contour Segmentation for automatic bubble detection	Duane Carey	University of Leeds	C
14:50	15:20	00:30	Star formation as a function of Galactic environmen	Sarah Ragan	Cardiff University	**I**
15:20	15:40	00:20	The role of cloud-cloud collision in triggering O star formation	Yasuo Fukui	Nagoya University	C
15:40	16:00	00:20	Star formation and feedback in spiral shock formation of molecular clouds	Ian Bonnell	University of St. Andrews	C
16:00	16:20	00:20	A Cautionary Note about Composite Galactic Star Formation Relations	Genevieve Parmentier	University of Heidelberg	C
16:20	16:50	00:30	**Coffee Break**			
16:50	18:20	01:30	**DEBATE 2**			

Friday 30th September 2016

08:45	09:15	00:30	Observing simulations: The effect of spiral arms and galactic shear on molecular clouds	Ana Duarte-Cabral	University of Exeter	**I**
09:15	09:35	00:20	Star Formation laws from molecular cloud evolution	Enrique Vazquez	UNAM, Morelia	C
09:35	09:55	00:20	The influence of supernovae explosions and HII ionising feedback on star formation	Patrick Hennebelle	CEA/SAp, Saclay	C
09:55	10:15	00:20	Cloud/cloud collisions, cluster formation, and bipolar HII regions	Ant Whitworth	Cardiff University	C
10:15	10:35	00:20	Simulating radiative feedback in the interstellar medium: ISM properties, star formation regulation, and observational diagnostics	Thomas Peters	MPA, Garching	C
10:35	11:05	00:30	Coffee Break			

Session 5: The 3D Galaxy

11:05	11:35	00:30	The Bar and Spiral Structure Legacy (BeSSeL)	Andreas Brunthaler	MPIfR, Bonn	**I**
11:35	12:05	00:30	The large-scale structure of the Galaxy from radio to NIR tracers	Roberta Paladini	IPAC-Caltech	**I**
12:05	12:35	00:30	The Gaia revolution	Sofia Randich	INAF-Osservatorio di Arcetri	**I**
12:35	12:55	00:20	Three dimensional maps of dust extinction along the Milky Way plane	Heddi Arab	CDS, Strasbourg	C
12:55	13:15	00:20	Distance estimates for Galactic Plane Surveys	Delphine Russeil	LAM-OAMP, Marseille	C
13:15	13:35	00:20	The Vertical Structure of the Spiral Arms of the Milky Way Galaxy	Bob Benjamin	University of Wisconsin	C
13:35	14:35	01:00	**Lunch/Posters**			
14:13	16:05	01:30	**VIALACTEA Knowledge-base, Visualization and Data analysis Tools: Demos, Hands-on Sessions and Users-driven Use-Cases**			

End of Conference

Oral Sessions

Session 1

Interstellar Medium, Molecular clouds and Filaments: from the diffuse texture of the ISM to the backbone skeleton of the Milky Way

Molecular cloud dynamics and star formation in galaxies

Andreas Burkert

Invited Talk

I will review current ideas of the various complex, non-linear dynamical processes that regulate the structure and evolution of the molecular component in galaxies and its condensation into stars.

Observations indicate that the physics of the molecular web and star formation is self-regulated by an intimate coupling of processes that connect gas infall from the cosmic web on Mpc scales with the formation of molecular cores and their gravitational collapse on sub-parsec scales. Connecting these multi-scale processes self-consistently is one of the biggest challenges for future models of galaxy evolution.

SEDIGISM: A molecular line survey of the Galactic Plane with APEX

Frederic Schuller, for the SEDIGISM consortium

In order to complement the many continuum Galactic surveys available with crucial distance and gas-kinematic information, we carried out a systematic, homogeneous, spectroscopic survey of the inner Galactic Plane.

The SEDIGISM survey (Structure, excitation, and dynamics of the inner Galactic Interstellar Medium) covers 78 sq. deg. of the inner Galaxy (-60 deg < ℓ < 18 deg, |b| < 0.5 deg) in the J=2-1 rotational transition of 13CO. The emission from this rare istopologue of CO is usually optically thin, making it an ideal tracer of the cold dense interstellar medium.

I will present the first result derived from the analysis of a small science demonstration field, where we detect hundreds of clumps, clouds and filamentary structures. Finally, I will highlight the perspectives of exploiting the full survey data.

THOR - The HI, OH, Recombination Line survey of the Milky Way

Michael Rugel, Henrik Beuther and the THOR team

How does cloud formation proceed from atomic to molecular gas? Is there small scale structure in the atomic hydrogen component of the ISM? How do the ionized, atomic and molecular phases of the interstellar medium interact, e.g. in photodissociation regions or in feedback processes around high mass star forming clusters or supernovae remnants? To address these questions, the THOR (THOR - The HI,OH, Recombination Line survey of the Milky Way) maps the HI 21 cm line, the continuum from 1-2 GHz, the four OH ground stat transitions and 19 Radio Recombination lines in the northern part of the Milky Way (l = 15° - 67°, |b| <1.25°) at a ~20" spatial resolution. The OH absorption against Galactic HII regions as well as extragalactic sources allow us to investigate phase transitions of the ISM in more diffuse gas and around photon-dominated regions. Furthermore, for thousands of continuum sources, their physical properties can be characterized by means of their spectral index between 1 and 2 GHz. In addition to this, the radio recombination line data enables investigations of the kinematics of ionized gas and feedback processes back into the ISM.

Building a (fully resolved) molecular cloud catalog of the Galaxy

Dario Colombo, Erik Rosolowsky, Ana Duarte-Cabral, Adam Ginsburg, Annie Hughes, Jessica Dempsey, Malcolm Currie

Modern high resolution, molecular gas surveys of the Galactic Plane are unveiling an astonishing picture of the three-dimensional gas organization of the Milky Way. This provides the opportunity to investigate the building blocks of the molecular medium, the Giant Molecular Clouds (GMCs), in an unprecedented level of detail. So far, however, such kind of study has been restricted to a handful of targets, since common automatic segmentation methods, being severely affected by survey designs, are unable to decompose GMC-sized objects out from the diffuse medium in high resolution data. The algorithm we designed, SCIMES (Spectral Clustering for Interstellar Molecular Emission Segmentation), overcomes these limitations by considering the cloud segmentation problem in the broad framework of the graph theory. To prove this, we will present the SCIMES cloud catalog from the CO(3-2) High-Resolution Survey second data release. The clustering approach allows to automatically identify a variety of gas morphologies including coherent filamentary structures and holes within the molecular interstellar medium. Together, we will propose new methods to investigate shapes and inner structure of the molecular clouds in a statistical fashion. We will relate those properties to the classic integrated ones (as effective radius, velocity dispersion, luminosity) and the star formation capabilities of the clouds. This pioneer study will guide a future, systematic cataloging of all discrete molecular gas features of our own Galaxy.

FOREST Ultra-wide Galactic Plane Survey In Nobeyama (FUGIN): Project Overview and Global Distribution and Kinematics of Molecular Gas

Tomofumi Umemoto, Tetsuhiro Minamidani, Kazufumi Torii, Atsushi Nishimura, Mikito Kohno, Shinji Fujita, Mika Kuriki, Nario Kuno, Mitsuhiro Matsuo, Yuya Tsuda, Satoshi Ohashi, Tomoka Tosaki, and the FUGIN team

Recent improvement of surface accuracy of the Nobeyama 45-m Telescope and the new multi-beam receiver "FOREST" realized large-scale mapping observations with high sensitivity within a short time. FOREST Ultra-wide Galactic plane survey In Nobeyama (FUGIN) project is one of the legacy projects using the Nobeyama 45-m Telescope and FOREST. This project aims to investigate the distribution, kinematics, and physical properties of the both diffuse and dense molecular gas in the Galaxy from large-scale to small-scale at once. We are conducting a simultaneous On-The-Fly mapping of 12CO, 13CO, and C18O J=1-0 line emission toward a part of inner (10d ≤ l ≤ 50d, -1d ≤ b ≤ +1d) and outer (198d ≤ l ≤ 236d, -1d ≤ b ≤ +1d) Galaxy, where spiral arms, bar structure, and molecular gas ring are included. This survey achieves the highest angular resolution to date (~18") and sensitivity, and therefore, we can find clumps located at three times further distant than previous surveys. Our survey will provide us invaluable data set for investigating the physics of galactic ISM, particularly the evolution of neutral gas from galactic scale to small filament/clump/core scales, even inside of giant molecular clouds, and will link ISM studies of nearby galaxies with ALMA to studies of star formation in the Galaxy. We will present an overview of FUGIN project, observation plan, and results to date.

Large-scale and detailed structures of molecular clouds such as entangled filaments are revealed. Although some of them are well corresponding to infrared filaments and dark clouds seen in the Spitzer GLIMPS images, most of them seen in the 13CO and C18O maps are newly identified. It is also unveiled that not only large-scale kinematics of molecular gas such as spiral arms but also new signs of cloud-cloud collision and interaction between supernova remnants and molecular clouds.

The MopraCO survey of the Southern Galactic Plane

Domenico Romano, Michael G. Burton, Catherine Braiding

The MopraCO project (see also Burton et al., 2013, Braiding et al., 2015) is a CO J=1-0 line survey across the 4th Quadrant of the Milky Way, performed using the 22 m diameter single dish Mopra telescope in Australia. It includes the three main CO molecule isotopologues (^{12}CO, ^{13}CO and $C^{18}O$) and more than 100 square degree have been surveyed, spanning from l=265º to +10º and b=±0.5º, covering also the Carina complex and the Central Molecular Zone, and extending beyond b=±0.5º in several regions. The final plan is to cover l=265º to +10º b=±1º. The use of the 8 GHz-wide UNSW-MOPS spectrometer and the fast mode of on-the-fly mapping, developed for the Mopra telescope, permits us to reduce the cycle time to 1/4 of a second.

Compared with the previous Dame et al. 2001 CO survey of the Southern Galactic plane the MopraCO spectral and spatial resolution of 0.1 km/s and 0.6' respectively are an order of magnitude better. This permits us to improve the model of our Galaxy, showing the spirals structures with unprecedented details, in particular in the inner regions where the tracers of spiral arm tangents show an offset from the mid-arms that is matched by maser data, while the real structure of the innermost region remains difficult to define. Furthermore, the $^{12}CO/^{13}CO$ line ratios are found to be higher in the diffuse gas outside the GMC complexes than inside them, opening new hypothesis on the X_{co} factor used to estimate the masses of the molecular clouds.

Providing a detailed large scale third dimension across the Southern Galaxy in the wide range of velocity (-500 to 450 km/s), this survey in combination with the other ones will help also to better characterise the GMC complexes and the dense cores inside them, giving more insights on the early stages of massive star formation activity.

Analytical tools to characterize the density structure of molecular clouds

N. Schneider (I. Physik. Institut, University of Cologne, Germany) et al.

The main physical processes that govern the formation of molecular clouds and stars are turbulence, gravity, magnetic fields, and radiative feedback. I will review analytic tools that help to trace and disentangle these various processes in observations and numerical simulations. Applying dedicated tools to the large survey data sets of the Milky way that are available now is an essential step to make progress in understanding the molecular cloud and star-formation process in our galaxy.

I will focuss on N-PDFs (probability distribution functions of (column)-density), power-spectra, Delta-variance and a new method, the wavelet-based cross-correlation function. A comprehensive summary of the results applying these tools on Herschel imaging data and molecular line maps will be presented, together with some comparison to cloud simulations. Special emphasis will be given to observational signatures of turbulence and radiative feedback.

Molecular Clouds Formation

Paul Clark

Invited Talk

The timescale over which molecular clouds form sets the basis for the entire star formation process. In this talk, we will review the current work on molecular cloud formation. First, we look at the physics behind the associated chemical and thermodynamical transitions that mark ‘cloud formation’, and discuss the ’observational’ picture that is emerging from the numerical simulations, and the implications for the cloud formation timescales and the onset of star formation. In addition, we will examine the best ways of observationally probing the phase transition, with a discussion of the current and up-coming observational surveys. Finally, to help envisage where our research will be going in the coming years, we will discuss some of the open-ended questions that lie at the heart of cloud formation.

The Origin of Molecular Cloud Turbulence

Paolo Padoan, Troels Haugbølle, Luibin Pan, Mika Juvela, Åke Nordlund

Turbulence is ubiquitous in molecular clouds (MCs), but its origin is still unclear because MCs are usually assumed to live longer than the turbulence dissipation time. Interstellar medium (ISM) turbulence is driven by large-scale sources such as galactic infall, spiral arm shocks and supernova (SN) explosions, but it has never been demonstrated that such sources are also capable of driving a turbulent cascade inside MCs consistent with the observations.

We have carried out a simulation of SN-driven turbulence in a volume of $(250\ \mathrm{pc})^3$, specifically designed to test if SN driving alone can be responsible for the observed turbulence inside MCs, and for their formation and evolution. In a series of recent papers we have characterized the statistical properties of SN-driven turbulence and of the clouds it produces.

Using both synthetic CO observations and the raw simulation data we have shown that SN driving establishes a velocity scaling consistent with the usual scaling laws of supersonic turbulence, that the same scaling laws extend to the interiors of MCs, and that the velocity-size relation of the MCs selected from our simulation is consistent with that of MCs from the Outer-Galaxy Survey, the largest MC sample available. The mass-size relation and the mass and size probability distributions also compare successfully with those of the Outer Galaxy Survey.

We have also found that the compressive ratio (the power in compressive modes divided by the power in solenoidal modes) in MC turbulence driven by SNe has a broad distribution, with a maximum probability at a value of 0.3, much lower than expected for turbulence driven by a purely compressive random acceleration. Overall, the realistic properties of the simulated clouds confirm that SN-driven turbulence can explain the origin, structure and dynamics of MCs as a result of predominantly external driving.

Related papers:

http://adsabs.harvard.edu/abs/2016ApJ...822...11P (Apj 822, 11, 2016)

http://adsabs.harvard.edu/abs/2015arXiv151004742P (Accepted by ApJ)

http://adsabs.harvard.edu/abs/2016arXiv160503917P (Accepted by ApJ)

figura?

Investigating the interactions between cosmic rays and interstellar medium

Nicola Marchili; Sergio Molinari; Giovanni Piano; Andrea Giuliani; Marco Tavani; Anna Maria Di Giorgio

Large part of the diffuse gamma-ray emission at low galactic latitudes originates from the propagation of cosmic rays through interstellar medium.

Gamma-ray observations have been essential for the development and constant improvement of theoretical models that aim at describing how cosmic rays interact with the interstellar gas and radiation fields of the Milky Way.

The comparison with observations demonstrates that it is possible to model the diffuse gamma-ray emission within the Galaxy starting from an approximate three-dimensional distribution of the galactic medium. However, an exhaustive knowledge of all the mechanisms that influence the interactions between cosmic rays and medium is yet to come.

We present the result of a study that investigates the relationship between cosmic-ray propagation and star formation. For this purpose, gamma-ray data from the AGILE satellite have been analysed and compared with distributions of atomic and molecular hydrogen in the Milky Way to check whether there is a link between the properties of different galactic regions and the production of gamma-rays within them.

The line-of-sight dust temperature distribution as a probe of Galactic star formation

Kenneth A. Marsh & Anthony P. Whitworth

Image cubes of differential column density as a function of dust temperature for diffuse dusty structures have been constructed for the entire Galactic Plane using continuum observations from the Hi-GAL survey in the wavelength range 70-500 microns.

The estimation technique, PPMAP, takes full account of the instrumental point spread functions, thus providing enhanced spatial resolution with no necessity to smooth the observations to a common resolution.

The key assumption is that the dust emission is optically thin at all observational wavelengths. The temperature decomposition has the potential to distinguish physically different components along the line of sight. In particular it can provide more accurate estimates of the mass of cold material in dense cores than is possible via more conventional techniques which yield only the mean line-of sight dust temperature. It can also aid in the decomposition of column density PDFs into the contributions from distinctly different physical components involved in the star formation process.

We will present examples of the detailed temperature variations within structures such as bubbles, filamentary complexes, and cores and, with the aid of simulation results, examine the statistical behaviour on a Galactic scale with particular emphasis on possible environmental effects on the star formation process.

VIALACTEA e-Infrastructure and Science Gateway: Milky Way Analysis Workflows

U. Becciani, E. Sciacca, F. Vitello, A. Costa, A. Hajnal, P. Kacsuk

This talk presents the developments related to the implementation of an e-Infrastructure and a science gateway in the context of the FP7 VIALACTEA project.

The science gateway operates as a central workbench for the VIALACTEA community in order to allow astronomers to process the new-generation (from Infrared to Radio) surveys of the Galactic Plane to build and deliver a quantitative 3D model of our Milky Way Galaxy. The final model will be used as a template for external galaxies to study star formation across the cosmic time.

The adopted AGILE software development process allowed to fulfill the community needs in terms of required workflows and underlying resources monitoring. The scientific requirements arose during the process highlighted the needs for easy parameter setting, fully embarrassingly parallel computations and large-scale input dataset processing. Therefore the science gateway based on the WS-PGRADE/gUSE framework [Kacsuk, 2012] has been able to fulfill the requirements exploiting the parameter sweep paradigm and parallel jobs execution of the workflow management system.

We describe the main features of the science gateway technologies based on the WS-PGRADE/gUSE portal framework which provides several ready-to-use functionalities off-the-shelf. It allows development of scientific workflows composed of nodes corresponding to almost any kind of application in a convenient graphical user interface. The workflows can be executed in parallel on a wide set of Distributed Computing Infrastructures such as grids, clusters, supercomputers and clouds. The portal enables sharing, importing and exporting workflows and managing credentials (and robot certificates), or gathering workflow execution statistics. Beyond these features, the portal is extensible, in fact WS-PGRADE/gUSE offers a number of interfaces to add new applications and portlets to its base capabilities.

Finally, we show the workflows implemented for performing intensive computations towards the Milky Way analysis: map making, i.e. the formation of sky images from the instruments data; data mining to obtain band-merged catalogues relating sources with associated counterparts at different wavelengths; filamentary structure detection and extraction from images. As an example we focus on the porting of two recent map making applications into workflow technologies (i.e. UniMap [Piazzo, 2015] and PPMAP [Marsh, 2015]). This allowed to easily perform the automatic importing of the needed input catalogue images from the Hi-GAL survey [Molinari, 2010], to parallelize the processing of the tiles into the underlying computing infrastructure and to calculate the final mosaic. The gateway users are then enabled to process the aforementioned applications without knowing the technical details of the underlying infrastructure (e.g. storage and data access or the software configuration details).

Evolutionary Picture of Giant Molecular Cloud Mass Functions on Galactic Scales

Masato Kobayashi, Shu-Ichiro Inutsuka, Hiroshi Kobayashi, Kenji Hasegawa

We formulate and compute the time evolution of giant molecular cloud mass functions on galactic disks. In our model, a network of expanding supernovae and HII regions drives the giant molecular cloud formation and evolution. Such a network provides (i) giant molecular cloud formation and self-growth through multiple episodes of warm neutral medium compression, (ii) giant molecular cloud self-dispersal by radiation from massive stars that are born within those clouds, and (iii) cloud-cloud collisions.

We successfully reproduce the observed variation of giant molecular cloud mass functions between arm and inter-arm regions (e.g., M51 by Schinnerer et al. 2013; Colombo et al. 2014a). Our results suggest that the mass function slope is well characterized by a single power-law exponent, which is controlled by the ratio of giant molecular cloud formation timescale over its dispersal timescale, whereas the massive end is controlled by cloud-cloud collisions. Future large radio observations with finer spatial resolution and higher sensitivity may put unique constraints on the giant molecular cloud formation/dispersal timescales in different environment on galactic scale.

In addition, we also evaluate the amount of dispersed gas that regenerates giant molecular clouds and find the relation between this regeneration amount and the mass function slope. With this result, we insist that obtaining a complete picture of gas recycling processes in interstellar medium requires the understanding of the fate of dispersed gas such as CO-dark clouds and optically thick HI gas. In this contribution, we would like to present our results and discuss this new unified picture of giant molecular cloud mass function evolution throughout galactic disks.

Multiwavelength study to reveal dust properties and cloud 3D structure

Laurent Pagani & Charlène Lefèvre

Dust represents 1% in mass of molecular clouds, second only to H2 and He, both invisible, and is therefore the most abundant tracer to study these clouds. Three different techniques are commonly used to measure the dust column density: reddening in the near infrared, scattering from visible to mid-infrared and emission in the far-infrared and submillimeter wavelengths. None of these techniques can cover the full range of column densities alone and all have their own caveats.

We recently demonstrated the inability of emission measurements alone, with Herschel and submillimeter telescopes, to reveal the large quantities of extremely cold dust (5-7K, Pagani 2015) buried in the clouds. On the other hand, efficient scattering revealed by Spitzer has proven to extend up to mid-infrared tracing the cold large grain component (the coreshine effect at 3-5 µm, Pagani et al. 2010, Steinacker et al. 2010, Lefèvre et al. 2014) but also indirectly in extinction at 8 µm by drastically reducing the observed background absorption (Lefèvre et al. 2016).

Due to the inherent asymmetric behaviour of scattering (asymmetric radiation field impinging on the cloud, asymmetric scattering direction of grains), 3D modeling of the clouds becomes compulsory. Grain properties, grain density, and temperature vary inside the clouds making the modeling degenerate. However the necessity to fit the observations on a large number of wavelengths (> 15) from 1 to 1000 µm will allow us to suppress the degeneracy, reveal the 3D structure of the clouds and pinpoint the dust properties which work at all wavelengths.

The present work is a first step toward a secure model of dark clouds that will open up a wealth of developments, such as 3D dynamics, 3D chemistry and magnetic field interplay.

VIALACTEA Knowledge Base: a resource to analyse the Milky Way data.

Molinaro, Butora & al.

The VIALACTEA project used a combination of images, data cubes and catalogues of point-like, compact or diffuse objects. To store and access all of these a storage and database system, as well as a set of services on top of them, as been set up and named the VIALACTEA Knowledge Base (VLKB).

Here we present this archiving system focusing on three main topics: the use cases the VLKB fulfills, the content and architecture of the VLKB and its heterogeneity, and the reasons that led to an architecture that is both Virtual Observatory inspired but custom requirement driven.

The Wispy Milky Way: a global view of filamentary structures in the Galactic Plane

Eugenio Schisano

Invited Talk

Everywhere in the Galaxy the interstellar medium is found to be arranged in filamentary patterns: from tenuous and bright features of the diffuse medium to dense, near infrared-dark, substructures of molecular clouds filaments are a recurrent morphology.

Arranged as single and isolated objects or as a multiple systems of nesting structures converging into a dense hub, showing a wide range of scales from tens of pc down to sub-pc, these filamentary morphologies are induced by the combined effect of large-scale flows, turbulence, magnetic field and gravity. Moreover, Herschel observations have shown the existence of a relation between dense filaments and the earliest stages of star formation. Nevertheless, the effective connection between these structures and the hosted star-forming seeds is currently a fundamental open question.

The answer is not unique and seems to range from their own gravitational fragmentation into star-forming clumps to favorable modes to quickly accumulate material into massive clumps, ultimately forming massive stars or stellar protoclusters.

In this talk I present the catalogue, provided in the framework of the VIALACTEA project, of about 30000 candidate filaments traced in the Herschel data by their dust emission. These filaments, being located everywhere in the Milky Way from its outskirts to the inner edge of the Central Molecular Zone, are representative of different galactic environments. This large dataset has been classified with the help of several ancillary data (e.g. molecular lines and mid infrared data). The catalogue sets up a significant initial point to determine the link between the large-scale interstellar medium and star formation.

Quiescent fibers in the NGC1333 proto-cluster

A. Hacar, M. Tafalla, & J. Alves

Whether the star formation mechanism within clusters is a distinct process or simply a scaled up version of the one observed in isolated environments has generated an intense and recurrent debate during the last decades.

Aiming to investigate the gas properties within young stellar clusters, we have surveyed the intermediate-mass NGC1333 proto-cluster in Perseus using high sensitivity millimeter line single-dish observations. These data reveal the presence of multiple dense and independent structures superposed along the line-of-sight detected in dense tracers like N2H+ and NH3.

Using our Friends-In-Velocity analysis algorithm, we have identified a complex network of 14 velocity-coherent filaments (fibers) tangled within the NGC 1333 cluster. These fibers are characterized by presenting transonic internal velocity dispersions along their typical ~0.4pc of length and contain most of the cores identified in these region by previous surveys.

Our results indicate that, even in dense environments like NGC1333, the YSOs are formed from the gravitational fragmentation of a sonic medium, that is, from the fragmentation of these velocity-coherent and quiescent fibers. Similar networks or bundles of small-scale fibers, with analogous characteristics than those found in NGC1333, have been observed within the low-mass B213 star-forming filament in Taurus (Hacar et al 2013). These findings then suggest a common star formation mechanism within both clustered (e.g. NGC1333) and isolated environments (e.g. B213) where their differences naturally arise from the level of complexity of these networks.

Probing the filamentary nature of massive star-forming regions with ArTéMiS

Ph. André (Lab. AIM - CEA Saclay)

Herschel observations of nearby molecular clouds suggest that interstellar filaments and prestellar cores represent two fundamental steps in the star formation process.

They support a picture of low-mass star formation according to which filaments form first in the diffuse ISM, probably as a result of large-scale compressive flows, and then prestellar cores arise from gravitational fragmentation of the densest filaments.

Whether this picture also applies to regions of high-mass star formation is an open question, in large part because the resolution of Herschel is insufficient to resolve the inner width of filaments in the nearest regions of massive star formation.

The ArTéMiS bolometer camera recently installed on the APEX telescope provides more than a factor of 3 better resolution than Herschel/SPIRE at 350 & 450 microns and is a powerful tool to address this question.

I will summarize initial results obtained with ArTéMiS for the NGC 6334 complex (A&A in press, cf. astro-ph/1605.07434), as well more recent results on the central molecular zone from our June 2016 observing campaign at APEX, and will discuss possible future prospects.

Filaments and compact sources distribution in the Lupus star forming region

Milena Benedettini

The Lupus complex is one of the nearest molecular clouds where the formation of low mass stars can be studied. Within the Herschel Gould Belt Key Program the three main clouds of the complex, Lupus 1, 3 and 4, were mapped in the far infrared with unprecedented sensitivity, allowing for the first time the complete census of the dense cores and the clear identification of the filamentary structures.

The Lupus clouds are characterized by low column densities both of the diffuse medium and of the denser material assembled in filaments. In particular, most of the filaments have mass per unit length smaller than the critical value for radial gravitational collapse. Nevertheless, some of the filaments that on average are thermally subcritical contain dense cores that may eventually form stars. This is an indication that in the low column density regime, the critical condition for the formation of stars may be reached only locally and this condition is not a global property of the filament.

Finally, in Lupus we find multiple observational evidences of the key role that the magnetic field plays both in forming filaments and in determining their confinement and dynamical evolution.

Toward True Topology

Alyssa Goodman

Invited Talk

A century ago, E.E. Barnard made a remarkable series of wide-field optical images of so-called "Dark Nebulae," showing them to be highly filamentary structures, associated with very young stars.

When radio astronomy came of age, about half a century ago, Barnard's dark dusty clouds were among the first targets, and searches showed radio continuum associated with the brightest star-forming (HII) regions, and plenty of dense (primarily molecular) gas associated with the dark extended structures seen in the optical images. But, the *resolution* of radio images was very low, and led to blurry views of the true topology of the ISM spawning the idea of "molecular clouds" as blobs of gas that hosted regions of active star formation.

Over the past three decades, higher-and-higher resolution wide-field surveys of CO, NIR extinction, and infrared/sub-mm dust maps have been bringing us back to the view Barnard had a century ago of a very filamentary topology for the ISM. As simulation techniques have also improved, resolved structures appear filamentary at smaller and smaller scales.

In this talk I will discuss the nature, possible origins, and possible significance, of observed and simulated filamentary structures from Galactic (kpc) to star-forming (100 AU) scales. In particular, I will demonstrate that some - but critically not all - large filaments may help trace out the structure of galaxies, and that the influence of filamentary structure may even persist to sub-core (<0.1 pc) scales. I will suggest quantitative classification criteria for filaments, and show that applying such criteria can help separate the various filaments' diverse origins and futures. I will end by suggesting that our community work together to use the many relevant online surveys to piece together our best estimates for the "true topology" of the ISM, using and adding to the data Harvard graduate student Catherine Zucker has compiled at the new web site http://milkyway3d.org.

Magnetic fields and filaments in the ISM: their relative orientation observed with Planck

Andrea Bracco

Investigating the dynamics of the interstellar medium (ISM) is key to gaining insight into the formation of the filamentary density structure that pervades both the diffuse medium and dense molecular clouds (MCs), where star formation takes place.

A plethora of numerical and analytical models associates the origin of this filamentary structure to the interplay between self-gravity and magnetohydrodynamical (MHD) turbulence in the ISM.

However, only few observational constraints exist to favour one specific scenario. Despite the great effort of observers during the last decades, interstellar magnetic fields (MFs) still represent a main unknown of filament formation. Polarized thermal emission at sub-millimeter and far-infrared wavelengths from interstellar dust grains is the most suitable technique to investigate the density-weighted MF-structure in the ISM.

The Planck satellite has recently completed the first all-sky maps of dust polarization at 850 microns, allowing us to probe the correlation between the MF geometry and the filamentary density structure with unprecedented statistics.

In this talk I will focus on the study of the relative orientation between the MF and the density structures from the diffuse medium to MCs. The filamentary structure seen in total intensity is observed statistically aligned with the MF orientation in the diffuse ISM, while it becomes statistically perpendicular in denser filaments in MCs. I will discuss the implications of this result in the context of filament formation.

Simulations of magnetized molecular cloud filaments

Gilberto C. Gómez, Enrique Vázquez-Semadeni, Manuel Zamora-Avilés

We explore the structure of filaments formed in simulations of magnetized molecular clouds undergoing global gravitational collapse.

In this context, the filaments are not equilibrium structures, but the locus of the accretion from their surrounding to the cores embedded in them or at the intersection with other filaments. So, in this context, filaments are long-lived flow structures.

In this talk we will discus the magnetic field structure of filaments formed in this scenario.

What can filament dynamics tell us about core formation?

Gwenllian Williams, Nicolas Peretto

Interstellar filaments represent a key stage in star formation. As they become gravitationally unstable, the densest filaments fragment into cores. The link between filament, core and star formation is one of the main issues of modern astronomy.

Infrared dark clouds (IRDCs) help shed light on the subject as they contain the fingerprints of the initial conditions of star formation. SDC13 in particular is an IRDC system of 4 parsec-long filaments, lies 3.6kpc away in the galactic plane, and contains $1000M_{sun}$ of material.

From N2H+(1,0) IRAM 30m data at 27" resolution, global longitudinal velocity gradients were observed, corresponding to an increase in velocity width at the centre, which we interpret as gas flows along the filaments fuelling star formation. However, with 0.5pc resolution, our single-dish data is not enough to study the finer scale link between filament fragmentation and core formation.

Here we present new JVLA 5'x5' NH3(1,1) and NH3(2,2) mosaics of SDC13 at 4" resolution, probing 0.07pc scales. The ammonia column density map reveal different fragmentation properties for each filament, evidenced by varying collapse timescales and spacings of the cores.

By performing hyperfine structure fitting, we resolve stark differences in the velocity field as well, with longitudinal velocity gradients along one filament, and radial gradients across the other. Put together, we interpret these differences as two distinct modes of fragmentation, possibly stimulated by differences in the filaments' local environment. Also, 2/3 of the starless JVLA cores show peaked velocity dispersion at their centres, contrary to that seen in nearby star forming regions.

We believe these are signatures of the filament fragmentation process itself, indicating the accumulation of gas being accreted into cores. We have shown this cannot be attributed to opacity effects. This local increase of dynamic pressure could prevent further fragmentation, and contribute to the formation of super-Jeans cores and intermediate mass stars.

Session 2

Demographics of Galactic Clumps and Cluster Progenitors: conditions, timelines, rates and efficiencies of cluster and massive star formation as a function of mass and environment

Statistical properties of the early stages of star formation in the inner Galaxy: the Hi-GAL Clump Catalogue

Davide Elia

Invited Talk

Hi-GAL is a large-scale survey of the Galactic plane, performed with the Herschel Space Observatory in five infrared continuum bands between 70 and 500 μm.

We present a band-merged catalogue of spatially matched sources and their properties derived from fits to the spectral energy distributions and heliocentric distances, based on the photometric catalogues presented in Molinari et al. (2016a), covering the portion of Galactic plane -71°< ℓ <+67°.

The band-merged catalogue contains 100922 sources with a regular spectral energy distribution, 24584 of which show a 70 μm counterpart and are thus considered proto-stellar, while the remainder are considered starless.

Thanks to this huge number of sources, we are able to carry out a preliminary analysis of early stages of star formation, identifying the conditions that characterise different evolutionary phases on a statistically significant basis. We calculate surface densities to investigate the gravitational stability of clumps and their potential to form massive stars. We also explore evolutionary status metrics such as the dust temperature, luminosity and bolometric temperature, finding that these are higher in proto-stellar sources compared to pre-stellar ones. The surface density of sources follows an increasing trend as they evolve from pre-stellar to proto-stellar, but then it is found to decrease again in the majority of the most evolved clumps.

Finally, we study the physical parameters of sources with respect to Galactic longitude and the association with spiral arms, finding only minor or no differences between the average evolutionary status of sources in the fourth and first Galactic quadrants, or between "on-arm" and "inter-arm" positions.

Light from the Dark: Using Hi-GAL to Study the The Formation and Evolution of Massive Clumps in Infrared Dark Clouds

G. Fuller, A. Traficante, N. Peretto, A. Duarte-Cabral, J.E. Pineda, N. Billot, M. Thompson, D. Ward-Thompson, S. Molinari

The origin and evolution of the massive clumps which eventually form massive stars and their associated clusters is one of the most poorly understood aspects of massive star formation. To study such clumps we have exploited the Hi-GAL survey to provide a complementary view of the dense, quiescent regions identified in the Spitzer Dark Cloud (SDC) catalogue.

Hi-GAL has allowed the construction of a clean sample of sources, removing from the SDC catalogue artefacts due to IR background fluctuations. This has confirmed that 76+/-19 % of the SDCs correspond to true column density enhancements, 'real' clouds.

Using a new, elliptical aperture photometry algorithm, the compact Hi-GAL counterparts of the SDCs have been identified. providing mass and luminosity estimates for each source. For the galactic longitude range from 15 degrees to 55 degrees, this analysis has identified a sample of 1723 clumps ranging in mass up to greater than 10^4 M_{sun} in 764 SDCs.

Using the Hi-GAL 70 micron observations to identify those clumps which have already formed protostars has allowed us to identify a sample of massive starless clumps. The most extreme of these clumps have properties similar to SDC335 which is currently forming 3 OB stars and is likely to go on to form an OB association. Observations of a sample of these massive starless clumps shows that they are dynamically active, with non-gaussian line profiles. The majority of the sources show infall which allows us to constrain the growth and evolution of these clumps.

In this presentation I will discuss these and other recent results on the massive starless cores and their implications for the formation of massive stars. In addition, I will describe recent work looking at clumps which seen in absorption at 70 microns but not detected at 160 microns.

The JCMT Plane Survey: Compact Source Catalogue and First Results

David Eden, Toby Moore, Rene Plume, James Urquhart, and the JPS Consortium

The JCMT Plane Survey (JPS) has surveyed the northern Inner Galactic Plane in the 850 µm continuum with SCUBA-2 with more than 20,000 sources in ~ 72 square degrees detected over the full survey region between Galactic longitudes of ℓ=7 and ℓ=63. We present the final compact source catalogue, and it's production, and a series of early science results from the JPS. In combination with other Galactic Plane surveys, it becomes a valuable asset to solving the major questions in Galactic star formation.

Discussing the distance bias on the estimation of Hi-GAL compact source physical properties

Adriano Baldeschi

The degradation of spatial resolution in star-forming regions observed at large distances (d>1 kpc) with Herschel, and the consequent confusion affecting the smallest condensations (cores) in molecular clouds, can lead to estimates of the global physical parameters (as radius, mass, temperature and luminosity) of the detected compact sources (clumps) which not necessarily mirror the properties of the original population of contained cores. In turn, this can lead to inaccurate conclusions about the classification of a cloud as high- or low-mass star forming region, and about its evolutionary status.

The aim of this study is to quantify the bias introduced in the estimation of these parameters by the distance effect.

To do so, we consider Herschel maps of well-known nearby star forming regions taken from the Herschel-Gould belt survey (Orion A, Perseus, Lupus III, Lupus IV and Serpens), and simulate their "moving away" to understand what amount of information is lost and what survives when a distant star forming region is observed with Herschel resolution.

In the maps "moved away" to different heliocentric distances we detect compact sources and extract their photometry, from which we derive their physical parameters as if they were "original" Hi-GAL maps, i.e. treating them with no reminiscence either to the "original map" or to those "moved" at other distances.

In this way, we are able to discuss how the starless/protostellar source fraction, the mean temperature and the size of the sources, as derived from observations, change with distance. Moreover, we discuss in detail the ability of clumps to form massive stars, based on the mass vs radius plot and we discuss the distance bias in the luminosity vs mass plot and the distance bias in the star formation rate.

In conclusion, we provide to the astronomer dealing with Herschel maps of distant star forming regions a set of caveats and prescriptions to partially recover the original character of the core population in unresolved clumps not known a priori.

Evolutionary indicators on Galactic clumps: examination of dust properties of sources from the Hi-GAL survey.

Manuel Merello

Results are presented on the association between physical properties derived for Hi-GAL clumps across the inner and outer Galaxy, and independent signposts of evolution of Galactic sources.

Dust derived parameters such as L/M ratio between the bolometric luminosity and the mass of the clump, bolometric temperatures and surface densities, are tested against sources gas properties (kinetic temperatues, dynamics, fractional abundance) obtained from line observations.

Association with available large datasets of Ammonia low excitation inversion transitions give cold gas features for a sample of ~1500 Hi-GAL clumps in different stages of evolution (IRDCs, protostellar sources, UCHII candidates, sources associated with water masers), while new observations of CH3CCH with APEX telescope probe inner-gas temperatures.

The comparison between dust and gas environments shows evidence of distinctive regions of evolution from prestellar candidates, protostellar clumps and UCHII regions in the L-M diagram. In addition, we present a preliminary study on the spatial associations between NIR/MIR sources with typical colors of Young Stellar Objects, and their hosting clumps.

These studies allow us to build and test evolutionary schemes potentially applied to a statistical significant sample of Galactic sources.

ATLASGAL — dense gas structure of the inner Galaxy

James Urquhart

Invited Talk

Massive stars have a profound impact on their environment. They shape the interstellar medium (ISM) with their strong stellar winds and ionizing radiation, and play a role in regulating star (and planet) formation, and ultimately driving the chemical and physical evolution of their host galaxies. However, despite their importance, our understanding of the initial conditions required for massive star formation and the processes involved in the early evolution are still poorly understood.

Our ability to make significant progress in this field has been dramatically enhanced in recent years with the completion of a large number of Galactic plane surveys that cover the whole wavelength range from the near-infrared to the radio (e.g., UKIDSS, GLIMPSE, HIGAL, CORNISH). One such survey is the APEX Telescope Large Area Survey of the Galaxy (ATLASGAL), which provides a large and systematic inventory of massive, dense clumps and includes representative samples of all of the earliest embedded stages of high-mass star formation. Here we give an overview of this survey and our efforts to map the distribution of massive star forming regions across the Galaxy.

We use these results to investigate the influence of different environments and Galactic location on the star-formation efficient and the role of the spiral arms.

The ATLASGAL Survey: Evolution of high-mass star-forming regions

Giannetti, A., Leurini, S., Wyrowski, F., Urquhart, J., Koenig, C., K.M. Menten

The ATLASGAL project delivered the most comprehensive inventory of objects at 870 µm in the inner Galaxy, and is a powerful tool to select sources in all evolutionary stages. A great wealth of molecular-line data (IRAM 30m, APEX, Mopra) are available for ATLASGAL-selected clumps, allowing us to obtain fundamental information on the initial conditions for massive star formation, and how these evolve after its onset.

In this contribution I will use this vast dataset to investigate the effects of cluster formation on the physics and chemistry of the surrounding environment. The analysis is focused on the process of warm-up, its relation with an evolutionary sequence and with changes in molecular abundances. I will discuss the modeling of commonly-used tracers for which we have a large number of transitions between 80 and 360 GHz (CO isotopologues, methyl acetylene, acetonitrile, ammonia and methanol), and follow the gas warm-up both in time, until the formation of hot-cores and HII regions, and radially, from the outer to the inner layers of the clumps.

In this context I will discuss the biases in the estimates of temperatures associated with the most common thermometers, address CO depletion as a function of evolution, and compare the abundances of the more complex species to the predictions of recent models of chemical evolution in star-forming regions.

Filaments, Shells, and Bubbles: Toward Galactic View of Star Formation

Shu-ichiro Inutsuka

Invited Talk

We propose a unified picture of star formation in the Galaxy. Recent high-resolution magneto-hydrodynamical simulations of two-fluid dynamics with cooling/heating and thermal conduction have shown that the formation of molecular clouds requires multiple episodes of supersonic compression.

This finding enables us to create a new scenario of molecular cloud formation as the interacting shells or bubbles in galactic scale, which explains various observational properties such as cloud-to-cloud velocity dispersions, emergence of filamentary structure, accelerating star formation, and very low star formation efficiencies.

We estimate the ensemble-averaged growth rate of individual molecular clouds, and predict the associated cloud mass function. The recent claim of cloud-cloud collisions as a mechanism for forming massive stars and star clusters can be naturally accommodated in this scenario. This explains why massive stars formed in cloud-cloud collisions follows the power-law slope of the mass function of molecular cloud cores repeatedly found in low-mass star forming regions.

Non-thermal motions in massive star forming regions: turbulence vs. self-gravity

A. Traficante; G.A. Fuller; N. Peretto; N. Billot; R. Smith; S. Molinari

In this talk I will discuss the results obtained combining data from massive clouds, clumps and cores to investigate the observed non-thermal motions in massive star formation.

It is still unclear if the formation of massive stars occurs in pressure-confined regions, supported against a quick collapse by the highly turbulent medium and possibly magnetic fields, or if the gravity is the driver of the observed non-thermal motions,leading to a much faster, gravo-turbulent collapse.

There is an increasing evidence that the Larson line-width size relationship, often interpreted as a consequence of the turbulence that drives the non-thermal motions in massive regions, is violated. Instead, a significant contribution to the observed supersonic motions may be driven by the gravity itself, modifying the relation in a dependence of the line-width with both the size and the mass surface density of the regions.

I will show the results obtained combining Hi-GAL dust continuum with MALT90 line emission data to obtain the gravo-turbulent properties of a large sample of hundreds of clumps. I will show how these data do not follow the Larson relationship but, combined with ancillary data of giant molecular clouds and massive clumps and cores, including a sample of massive starless clumps, follow a line-width-size-surface density relation. These results favour a scenario in which the observed non-thermal motions in massive str forming regions are mostly driven by self-gravity.

Cloud/cloud collisions, cluster formation, and bipolar HII regions

Anthony Whitworth, Scott Balfour, David Hubber

We present SPH simulations of clusters formed by cloud/cloud collisions. We demonstrate how the initial morphology of the resulting cluster, its Initial Mass Function, and the speed of mass segregation within the cluster, all depend critically on the speed of the collision. Lower-velocity collisions produce monolithic star clusters, in which competitive accretion can quickly build massive stars, and most of these massive stars are located near the centre of the cluster; feedback from the massive stars is effective in terminating star formation, and often produces bipolar HII regions; the IMF is broad, i.e. there are significant numbers of both high-mass and very low-mass stars and brown dwarfs. In contrast, higher-velocity collisions produce more distributed, fractal star clusters, with a narrower Initial Mass Function, i.e. both fewer high-mass stars and fewer lower-mass stars. Feedback is less effective, and star formation is more prolonged.

The star-forming content of CHIMPS

Andrew J. Rigby, Toby J. T. Moore and David J. Eden

CHIMPS, the CO Heterodyne Inner Milky Way Plane Survey, is a high-resolution survey of a section of the northern inner Galactic plane in 13CO and C18O (J=3-2) that has been carried out at the 15m James Clerk Maxwell Telescope (JCMT). The survey area covers approximately 18 square degrees between longitudes of 28 and 46 degrees and latitudes of |b| ution Survey (COHRS), and as such ought to be more closely linked to star formation.

By combining the CHIMPS data with additional CO data from COHRS and the GRS, the excitation temperatures, optical depths and column densities of the 13CO emission have been determined on a voxel-by-voxel basis. Dense clumps of emission have been extracted, and we explore their physical properties and their significance for our understanding of molecular clouds and their interiors. The CHIMPS data are also combined with 70 micron data from Hi-GAL to identify the star-forming content of the CHIMPS clumps, and we present results from a study of the star-formation efficiency across this section of the Galaxy.

An Overview of Physical Properties of Clumps in the Bolocam Galactic Plane Survey

Yancy Shirley, Brian Svoboda, Timothy Ellsworth-Bowers, Erik Rosolwosky, & Jason Glenn

I shall present an overview of the physical properties of clumps in the Bolocam Galactic Plane Survey (BGPS). The BGPS surveyed dust continuum emission from over 200 square degrees of the Galactic plane at 1.1mm. Followup observations using spectral lines of HCO+, NH3, 13CO, and C18O constrain the line of sight velocity of BGPS clumps.

Using a Bayesian technique, the probability that a source lies at a given heliocentric distance has been derived for nearly 2000 BGPS clumps. I shall review the method from which distances are constrained as well as the Monte Carlo technique used to derive physical properties, in particular the mass probability density function for clumps. These techniques are applicable to both the ATLASGAL and HiGAL submillimeter continuum surveys.

Physical properties such as size, mass, temperature (derived from NH3 observations), linewidth, etc. show systematic increases when BGPS clumps are sorted by protostellar indicators with increasing luminosity (from starless candidate, 70 micron only, H2O maser detected, CH3OH maser detected, to UCHII). I shall also compare the physical properties derived from a seeded-watershed algorithm vs. the more traditional Gaussian FWHM definition as well as compare clump properties between the BGPS and ATLASGAL surveys.

Q+: a new method for quantifying structure in young clusters

S. E Jaffa & A. Whitworth

Simulations of star formation must be informed and validated by comparison with observation. However, since star-forming clouds and the star clusters they spawn are chaotic systems, this comparison can only be made using statistical measures. Young star clusters often exhibit sub-structured distributions, which give them a fractal appearance, and this has been exploited with the Q parameter.

However, computed values of Q do not always return the correct fractal dimension for synthetic star clusters, as other parameters used to generate the fractal structure are ignored. In the box-fractal method of generating artificial star clusters, the structure is specified by: D - the fractal dimension, C - the density scaling exponent, and G - the number of generations.

We present a new algorithm that is able to robustly estimate these parameters from a two-dimensional image of a cluster. We anticipate that this algorithm will be useful, not only for characterising observed star clusters and quantifying their evolution, but also for comparing different observed star clusters with each other and with the results of simulations.

Synthetic modelling of Spectral Energy Distributions of young embedded clusters

Sergio Molinari, Thomas Robitaille

We will present a new grid of 20 millions models for the integrated Spectral Energy Distributions of young embedded clusters. The systems are modelled as a collection of Young Stellar Objects and protostars embedded in clumps of dust and gas. For clumps with total masses going from 100 to 10^5 solar masses, we assume a fraction of ISM locked in dense cores bound to form stars from 5 to 50% of the total clump mass.

The protostars models grid of Robitaille (2006) is MC sampled using Kroupa (2001) IMF as a weight function until the required total mass in protostars+disks+envelopes is reached. With assumptions of uniform star formation history we randomly sample the age of each protostar in a range between 10^4 years to a maximum limit that varies between 5x10^4 and 5x10^5 years. The emission of the intra-cluster dust not locked in cores is modelled as a modified greybody with temperatures between 10 and 40K. Each parameters combination is sampled 10 times to explore the effects of models variances and degeneracies.

Chemistry of star-forming regions in the Galaxy and beyond

Floris van der Tak

Invited Talk

The chemical composition of interstellar clouds and star-forming regions is a great tool to diagnose their physical conditions, including parameters that are otherwise hard to determine such as their ionization rates and ages.

This talk discusses recent results on the gas, dust, and ice composition of Galactic and nearby extragalactic regions where stars are forming. These include photon-dominated regions, hot molecular cores, and low- and high-mass protostellar envelopes. The talk concludes with a review of outstanding questions and the role of upcoming facilities such as JWST and SPICA.

The Herschel-HIFI view of massive protostellar objects

Fabrice Herpin, Luis Chavarria, Thierry Jacq, Jonathan Braine, Floris van der Tak, Friedrich Wyrowski, Ewine van Dishoeck

We present Herschel-HIFI observations acquired as part of the WISH key-project of 14 far-IR water lines, and several other species, in a sample of galactic massive protostellar objects: five mid-IR-quiet and five mid-IR-bright HMPOs, two hot molecular cores, and one UCHII.

Using water as a tracer of the structure and kinematics, we individually study each of these objects, estimate the amount of water around them, but also shed light on the high-mass star formation process.

We analyze the gas dynamics from the line profiles. Then through modeling of the observations using the RATRAN radiative transfer code, we estimate outflow, infall, turbulent velocities, molecular abundances, and investigate any correlation with the evolutionary status of each source. For the mid-IR quiet objects, the molecular line profiles exhibit a broad component coming from the shocks along the cavity walls associated with the protostars, and an infalling (or expansion for IRAS05358+3543) and passively heated envelope component, with highly supersonic turbulence likely increasing with the distance from the center.

Accretion rates between 6.3 x 10^{-5} and 5.6 x10^{-4} Msol/yr are derived from the infall observed in three of our sources. For the more evolved objects of our sample, no infall is observed. Expansion velocities from 2.0 to 2.5 km/s and 1-1.5 km/s turbulent velocities are derived. For the whole sample, the outer water abundance is estimated to be at the typical value of a few 10^{-8}, while the inner abundance varies from 1.7x10^{-6} to 1.4x10^{-4} with respect to H2 depending on the source.

We confirm that regions of massive star formation are highly turbulent and that the turbulence likely increases in the envelope with the distance to the star as predicted by the turbulent core model for high-mass star formation. The inner abundances are lower than the expected 10^{-4} perhaps because our observed lines do not probe deep enough into the inner envelope, or because photodissociation through protostellar UV photons is more efficient than expected. For the mid-IR-quiet HMPOs, we show that the higher the infall/expansion velocity in the protostellar envelope, the higher is the inner abundance, maybe indicating that larger infall/expansion velocities generate shocks that will sputter water from the ice mantles of dust grains in the inner region. High-velocity water must be formed in the gas-phase from shocked material.

New challenges in astrophysical data management: ICT approaches and EU policies

Fabio Pasian

Invited Talk

The current large surveys have already introduced important changes in the approach to astrophysical data management, i.e. data acquisition, reduction, analysis, archiving and retrieval. The future projects (e.g. Euclid, LSST, CTA, SKA, etc.) will increase size and complexity of data by orders of magnitude. This implies the need of finding new ICT approaches, new hardware and software techniques, better integration between data and computing infrastructures, improved standards, and especially a whole new attitude to searching and finding solutions adequate to the magnitude of the problems.

Relying only on ICT progress is not the solution: improved relationships between ICT engineers and scientists are also necessary, together with strong support to a proper culture of computing and data management in the astrophysics community. The policies defined by the EU and the projects funded up to now within the H2020 framework confirm that this is a proper path to follow and encourage pursuing these perspectives.

Session 3

The Milky Way in the context of environment and other galaxies

Star formation and the ISM lifecycle in the centre of galaxies.

Steve Longmore

Invited Talk

I will describe recent progress trying to understand the interlinked, multi-scale processes that shape star formation and the ISM lifecycle in the centre of galaxies.

I will focus on the observed global and cloud-scale properties of gas in the centre of our own Galaxy, and how these are being used to directly confront theoretical predictions of star formation models seeking to explain how the SFR and SFE may vary as a function of environment.

I will conclude by putting these results in the context of other regions of the Galaxy and extragalactic systems.

Gas Flows and Star Formation in the Galactic Center

Cara Battersby

Star formation occurs in remarkably diverse environments throughout the universe, yet our understanding of this fundamental process is dominated by observations of nearby clouds, which show very little environmental variation.

Observations of the early universe reveal prolific star formation in regions with gas densities and pressures orders of magnitude higher than in our solar neighborhood. The inner few hundred parsecs of the Milky Way, known as the Central Molecular Zone (CMZ), is the closest laboratory for testing star formation in the extreme environments (hot, dense, turbulent gas) that once dominated the universe.

I will present a large-scale perspective on gas flows and star formation in the Galactic Center through a comparison of Herschel observations with recent simulations. Additionally, I will introduce preliminary results from CMZoom, a Submillimeter Array legacy survey to expose and characterize sites of star formation across the CMZ. These measurements allow us to address fundamental questions regarding the nature of star formation in extreme environments.

Large-scale latitude oscillations of the Galactic Plane: disk instability or extraplanar gas accretion ?

Alberto Noriega-Crespo, S. Molinari, J. Bally, T. Moore, D. Elia, et al.

We use the Herschel Hi-GAL survey data to assemble a complete mosaic of the inner Galaxy between l = -70° and +68° in the far-infrared continuum to study the large-scale spatial distribution in Galactic longitude and latitude of the interstellar medium and of dense, star-forming clumps in the inner Galaxy.

The width of the diffuse dust column density traced by the Hi-GAL 500μm emission varies across the inner Galaxy with a mean value of 1.2°-1.3°, similar to the distribution of MIPSGAL 24μm sources and of Hi-GAL sources with a 250-μm counterpart. Hi-GAL sources with a 70-μm counterpart define a much thinner disk with a mean FWHM~0.75°, which is in excess of the result obtained by the ATLASGAL submillimetre survey.

The detailed latitude distribution as a function of longitude shows clear modulations both for the diffuse emission and for the compact sources. The displacements are mostly towards negative latitudes with excursions of ~0.2° below the midplane at GLON~ +40°, +12°, -25°, and -40°. The only positive bend peaks at GLON ~ -5°. No such modulations can be found in the MIPSGAL 24μm or WISE 22μm data when the entire source samples are considered. Modulations that are in part similar to the ones exhibited by the Herschel sources appear when the mid-infrared catalogues are filtered according to criteria that primarily select Young Stellar Objects.

The lack of these distortions in tracers of more evolved YSOs or stars, would seem to rule out gravitational instabilities or satellite-induced perturbations, because they should act on both the diffuse and stellar disk components. We propose that the observed bends are caused by incoming flows of extra-planar gas from the Galactic fountain or the Galactic halo interacting with the gaseous disk. With a much lower cross-section, stars decouple from the gaseous ISM and relax into the stellar disk potential. The timescale required for the disappearance of the distortions from the diffuse ISM to the relatively evolved YSO stages are compatible with star formation timescales

Cloud-scale studies of gas and star formation in nearby galaxies

Annie Hughes

Invited Talk

Cloud-scale models of star formation predict that the transformation of gas into stars depends on the local density, turbulent velocity dispersion, and gravitational boundedness of the interstellar gas. A new generation of nearby galaxy surveys with facilities like ALMA and NOEMA will systematically access these conditions in nearby galaxies at the scale of individual star-forming clouds. This is a major opportunity for linking the cloud-scale physics of star formation to galactic-scale processes, and reconciling the Galactic and extragalactic views of star formation.

In this contribution, I will highlight new results from our comparative analysis of the cloud-scale molecular gas properties -- surface density, velocity dispersion, gravitational boundedness, mass distribution -- and star formation activity across a small yet diverse sample of nearby galaxies. Both within and among galaxies, we observe variations in molecular gas properties that support a context-dependent (i.e. non-universal) relationship between gas density and star formation, and the role of galactic environment in regulating the small-scale density distribution of the ISM.

Finally, I will discuss how the combination of high angular resolution mapping and sensitive multi-line spectroscopic surveys offers a promising way to make progress in understanding the origin of extragalactic star formation laws.

Giant molecular clouds properties in nearby galaxies

Rosita Paladino

One of the challenges in galaxy evolution is to link the intra-cloud understanding of star formation processes, developed in the Milky Way, to the picture of kpc-scaling relations, usually studied in external galaxies. Nearby galaxies are the ideal laboratory for this investigation since they allow the study of star formation processes on large scale, while still being close enough to reveal the local details, if high resolution and sensitivity are achieved.

Detailed images of the molecular distribution in nearby galaxies, which were so far few exceptions, thanks to ALMA unprecedented capabilities will become the rule. It will be possible to address important questions, such as what is the importance of local and global effects in triggering star formation, which is the role of magnetic fields, or how do environmental conditions or galaxy properties influence star formation.

I will review some of the recent results in this field obtained with ALMA, and show the potential steps forward that this new facility will allow. I will present also some preliminary results from recently obtained ALMA observations of the spectacular barred galaxy NGC3627. The resolution achieved allows the study of giant molecular clouds properties in different environments inside this galaxy (the nucleus, the inner ring, the bar) revealing the details of gas motion.

The formation and evolution of molecular clouds

Stefanie Walch

Invited Talk

Star formation takes place in the densest and coldest parts of the interstellar medium (ISM), in dark molecular clouds. These condense out of the warm interstellar medium, which continuously feeds the star forming cloud with fresh gas, and which imprints the cloud sub-structure, magnetic fields, and supersonic turbulent motions. However, supersonic turbulence is expected to decay on a crossing time unless it can be sustained by some physical process, e.g. stellar feedback. Since the turbulent dynamical state has been observed, the idea of short-lived, dynamically evolving molecular clouds is widely accepted. It is thus likely that the turbulent, internal sub-structure of molecular clouds is imprinted already during their formation process.

Furthermore, molecular clouds consist of molecular hydrogen, which can only be traced indirectly in observations, mostly by means of CO line and dust extinction measurements. Therefore, simulations of molecular cloud formation and evolution start to treat the gas dynamics and molecule formation at the same time. By means of synthetic observations, a sophisticated comparison of simulations and observations is becoming feasible.

In this talk I will show recent numerical results on molecular cloud formation and evolution carried out by different groups as well as by our own project called SILCC (www.astro.uni-koeln.de/silcc). In particular, our simulations show that Supernova feedback can cause a hot volume filling ISM phase and drive galactic fountains and outflows, while early stellar feedback limits the gas accretion onto young, star-forming molecular clouds and thus regulates the star formation efficiency on scales of several hundred parsec.

The High-Resolution View on the Gas-Star Formation Cycle in Nearby Galaxies

Andreas Schruba

State-of-the-art instrumentation like ALMA, NOEMA, JVLA, and VLT/MUSE is revolutionizing our view on the gas-star formation cycle in nearby galaxies. I will highlight recent results from several concerted legacy-type surveys targeting galaxies inside and outside the Local Group.

These observations resolve the interstellar medium and young stellar population down to individual molecular clouds and young stars and provide a detailed view so far was only known from within the Milky Way but over entire galaxies.

This includes (a) the structure of the atomic and molecular gas and the separation of the atomic gas into a cold and warm neutral medium, the finding of significant diffuse molecular gas, and observational evidence what drives the atomic-molecular phase balance. (b) A characterization of the gas properties at cloud-scale reveals many similarities but also systematic variations that depend on galactic environment. (c) The large-scale gas-star formation (Schmidt-Kennicutt) relation relates to the (varying) cloud-scale gas properties and changes become apparent between massive disk, low mass, and interacting/starbursting galaxies. (d) The resolved observations allow us to extract the evolutionary timescales of the gas-star cycle.

In summary, new high-resolution observations of nearby galaxies transform our understanding on how the gas properties and star formation process depend on galactic environment and regulate each other.

The formation of Milky Way under chemical and radiative feedback

Luca Graziani

Models of Milky Way formation aim at self-consistently reproduce the observed properties of our galaxy (e.g. gas/dust mass, gas/stellar metallicity, star formation rate,..) by following their redshift evolution in the context of the Local Group assembly. Although feedback processes (mechanical/chemical/radiative) have been recognized as key ingredient for any successful galaxy formation model, their consistent inclusion still lacks many important details and it is often incomplete.

In this talk, after introducing the numerical model of galaxy formation GAMESH (Graziani et al., MNRAS, 2015), I will discuss the results of a new high-resolution, zoom-in Galaxy formation focusing on the impact of feedback on the star formation history and on the final properties of stellar metallicity in the Milky Way. Many key questions will be addressed, as the role of mini-halos in the star formation at high redshift, the transition between POPIII and POPII as regulated by chemical feedback, and the impact of reionisation in suppressing star formation.

Finally, the chemical evolution of the local group and its role in setting up the current stellar population observed in our Galaxy will be discussed in detail.

Session 4

Triggering, Spiral Arms, Turbulence and Gravitation: sifting the ingredients of a Galactic Star Formation Recipe

Star formation and ionized regions in the Inner Galactic Plane

Pedro Palmeirim

Invited Talk

I will present a comprehensive statistical analysis of star-forming objects located in the vicinity of 1360 bubble structures throughout the Inner Galactic Plane and their local environments. The compilation of nearly 125 000 star-forming sources, detected in both Hi-GAL and GLIMPSE surveys, provided a broad overview of the different evolutionary stages of star-formation in bubbles, from prestellar objects to more evolved Young Stellar Objects (YSOs).

Surface density maps reveal a clear evolutionary gradient, where more evolved star-forming sources are found close to the center of the bubbles, with ~80% more sources per unit area in the direction of the bubbles compared with the surrounding outer fields. We find Clump Formation Efficiency to be approximately two times higher at the shell of the bubbles than in fields not affect by feedback. Furthermore, we derive dynamic ages for the bubbles and find that bubbles are more efficient in forming massive YSOs (MYSOs) at the early stages of the HII expansion (< 2 Myr).

Finally, we advocate for the pre-existence of clumps in the medium prior to the bubble expansion in order to explain the formation of MYSOs in the youngest HII regions (< 1 Myr), and present some supporting numerical simulations results.

Testing theories of triggered star formation in the outer Galactic disk

K.L.J. Rygl, E. Schisano, S. Molinari, T. Prusti, T. Antoja, D. Elia, J. de Bruijne, C. Manara

The interstellar medium in the outer Galactic disk contains less molecular material and fewer star formation than the inner disk, allowing to study the effect of different environmental properties as well as a lower level of confusion.

Despite the lower molecular densities, high-mass star formation and OB stars are found in the outer Galaxy, up to Galactocentric distances of 13 kpc, though their numbers are quite limited awaiting more maser parallaxes and the Gaia all sky astrometric survey. Due to their strong stellar winds, O stars can blow shells and bubbles in the ISM. Whether star formation will be triggered in these shells, depends on the density, the ISM dispersion and the energy output of the star. For example, material swept up by a luminous O star in the quiescent outer Galaxy requires a lower density threshold for gravitational collapse, than it would have in a more turbulent ISM.

We investigate shell-like structures around currently known O stars in the outer Galactic plane, using the Herschel infrared Galactic plane survey maps for obtaining the column densities and active star-formation indications. We compare these observational quantities to theoretical thresholds of gravitational collapse in expanding shells and discuss the possibility of observing the influence of the Galactic shear on triggered star formation.

Classification of Galactic Bubbles from a Morphological Multiwavelength Study.

Filomena Bufano - INAF Osservatorio Astrofisico di Catania

We present the latest results obtained from the study of Galactic Bubbles as possible physical agents responsible of the triggering and regulation of the star formation in our galaxy and, in general, in spiral galaxies.

This work, born within the wide framework of the 'Via Lactea' European project, is based on the analysis of Galactic Plane images from the major new-generation surveys, performed from 1μm to the radio wavelength range.

Firstly, we present the first extended (1814 objects) catalogue of bubble infrared fluxes, obtained starting from the Simpson et al. (2012) bubble catalogue. Then, we show the results on bubble classification: inspecting the radio, Herschel and WISE images, we developed a method that can be used to discriminate automatically between bubbles related to HII regions and circumstellar envelopes surrounding evolved stars, such as SNRs, PNe and LBVs. This has been done taking advantage of the data mining potentialities in highlighting similarities and common patterns based on a variety of indicators and parameters derived from the analysis of data.

Adaptive Active Contour Segmentation

Duane Carey, Andrew Bulpitt, Melvin Hoare

Active contours are a family of unsupervised image segmentation techniques that use textural properties of an image to delineate structures of interest. However, most contouring methods come with substantial parameterisation and this research has developed a novel technique that limits the subjectivity of local active contours. Local contouring involves the use of kernels to calculate summary statistics along the evolving front of a contour and the choice over which kernel size to select can be ambiguous.

In this approach, the Bhattacharyyan distance between the pixel intensities of a contours inside and outside areas, which are contained within the bounds of a small initial kernel size, is used to select appropriate kernels. In addition to regional statistics, this technique also makes use of gradients and this is achieved by using the sign of Magnetostatic forces. This further limits subjectivity as it negates the need to define coefficients that control this information's influence.

This methodology is generic and can be used with any statistical active contour. Although active contours are extremely flexible and robust to most image artefacts, they still can't demarcate specific structures directly. Therefore, a small expert annotated training dataset has been used with hand selected features and a grid optimised two class support vector machine to segment 5118 bubble structures within the 70μm images of the Herschel dataset. Experiments show, the presented approach is as accurate as other kernel selection methodologies but substantially reduces processing time.

Star formation as a function of Galactic environment

Sarah Ragan

Invited Talk

Galactic plane surveys of the Milky Way in a variety of gas or dust tracers give us different perspectives of how the physical conditions of the interstellar medium vary throughout the Galaxy.

The Herschel Infrared Galactic Plane Survey (Hi-GAL) covers the peak of the spectral energy distribution of dense, cold dust and thus supplies an essential part of the observational description of the conditions necessary for star formation in the Milky Way.

With a catalogue of over 100000 compact Hi-GAL sources, I will discuss how star formation varies as a function of Galactocentric radius and proximity to spiral arms. This allows us to revisit several long-standing questions about the effect large-scale Galactic properties have on star formation on parsec scales.

Moreover, with a comprehensive profile of the Milky Way over kiloparsec scales, these results provide a new detailed context in which to understand star formation in external galaxies.

The role of cloud-cloud collision in triggering O star formation

Yasuo Fukui

I present most recent observational pieces of evidence which indicate cloud-cloud collision in triggering O star formation in super star clusters and isolated O stars in the Milky Way.

Outstanding examples include NGC3603, Westerlund2, and RCW38. MHD numerical simulations show that the shock-compressed layer between the colliding clouds creates highly turbulent and dense gas state where the high mass accretion rate 10^{-3} M_o/yr is attained. This rate is required to overcome the stellar feedback in high mass star formation.

I will discuss how common such collisions are in the Milky Way and in the Magellanic Clouds.

Star formation and feedback in spiral shock rormation of mlcular clouds

Ian Bonnell

I will present ongoing work on how galactic scale flows due to spiral arms can lead to the formation of dense molecular clouds and star formation.

Star formation occurs due to a combination of the large scale convergent flows coupled with thermal instabilities and self-gravity once the gas reaches higher densities.

Internal turbulence arises primarily due to the large scale motions coupled with smaller scale structures and instabilities. Resulting star formation rates scale with the surface density of gas to the 3/2 power and linearly with the surface density of dense molecular gas. Stellar feedback often appears to have a minimal affect on halting star formation but could have greater impact in removing any external boundary layer and thus unbinding the molecular clouds.

These simulations provide a means of understanding global star formation laws and of providing self-consistent initial conditions to study star formation

A Cautionary Note about Composite Galactic Star Formation Relations

Genevieve Parmentier

We explore the pitfalls which affect the comparison of the star-formation (SF) relation for nearby molecular clouds with that for distant compact molecular clumps. We show that both relations behave differently in the star vs. gas surface densities space, even when the physics of star formation is the same. This is because the SF relation of nearby clouds relates gas and star surface densities measured locally, that is, within a given interval of gas surface density, or at a given protostar location (local measurements). In contrast, when the stellar content of a distant molecular clump remains unresolved, only its total SF rate can be obtained from e.g. the clump infrared luminosity (global measurements).

We show that, although the local and global relations have different slopes, this per se cannot be taken as evidence for a change in the physics of SF with gas surface density. Great caution should thus be taken when physically interpreting a composite SF relation, that is, a relation combining local and global measurements.

SF laws from molecular cloud evolution

Enrique Vazquez-Semadeni, Manuel Zamora-Aviles

After making a brief reminder of the evidence suggesting that molecular clouds (MCs) may be in global, hierarchical gravitational collapse, I will discuss a model for the evolution of MCs and their star formation rate (SFR) based only on diffuse gas accretion, gravitational contraction, instantaneous SFR given by the mass at high densities divided by its free-fall time, and cloud evaporation by ionizing feedback from massive stars.

This model gives the evolution of the SFR in the clouds, with the only free parameter being the total mass accreted onto the cloud. In particular, it predicts that the SFR of moderate-mass clouds (10^{-3} - 10^{-4} M_{sun}) generally increases over time, and that in their final evolutionary stages they will have contracted to become dense massive-SF clumps, at which time they undergo a SF burst that destroys them, and places them in the locus occupied by such clumps in the Kennicutt-Schmidt diagram. It also predicts that ensembles of clouds of various masses, weighted by a realistic cloud mass spectrum reproduces the galaxy-scale trend observed by Gao & Solomon for SFR versus dense gas mass.

Finally, the model allows the dating of MCs by simultaneous measurement of any pair of cloud physical properties, such as total mass and dense gas mass fraction, where one of the properties functions as a proxy for the cloud's age. Upon doing this, the model correctly reproduces the scatter in SF efficiency (SFE) observed for clouds with such values of their physical properties.

Observing simulations: The effect of spiral arms and galactic shear on molecular clouds

Ana Duarte Cabral

Invited Talk

To fully understand the global processes that lead to star formation, it is crucial to start by understanding the hierarchical organisation of the molecular component of the interstellar medium.

However, defining and extracting molecular clouds is not an easy task: they are not a discrete well-defined entity - instead, they are formed as a result of the interchange and evolution of gas through the galaxy, and are thus often part of a continuum of gas with a mix of different fractions of atomic and molecular components, and different abundances of molecular species such as CO. Moreover, Milky Way studies suffer from yet another issue: a severe line of sight confusion that complicates the identification of “real” individual GMCs.

Here I will present our recent work trying to grasp some of these issues, by studying the population of GMCs from a simulation of a portion of a spiral galaxy. We have used a new algorithm (SCIMES) to extract GMCs from both the physical 3-dimensional space, and from an observer’s perspective on CO emission datacubes.

I will present the results from comparing the properties of clouds retrieved from the different extractions, as a means to understand the biases inherited from the perspective, resolution and tracer used. I will also explore how different galactic environments can affect GMC properties, namely by following the clouds as they travel from the shear-dominated inter-arm regions into and through spiral arms.

The Gaia Revolution

Ronald Drimmel

Invited Talk

ESA and the Gaia Data Processing and Analysis Consortium has just recently announced the first data release from the Gaia mission, containing a first harvest of parallaxes and proper motions.

I will describe some of the properties of this first data release, as well as the promise that Gaia holds for future Milky Way studies with special focus on mapping the interstellar medium and star formation.

The influence of supernovae explosions and HII ionising feedback on star formation

Patrick Hennebelle, Olivier Iffrig, Sam Geen

One of the most fundamental question in the field of star formation and interstellar medium is how star formation is regulated and one of the most promising physical process is stellar feedback. In the talk I will present a series of numerical experiment which include supernovae explosions and HII ionising radiation computed through a radiation transfer code.

I will show that supernovae could in principle regulate star formation and reproduce the galactic scale height but when a delay is introduced to take into account the life time of the massive stars, the star formation rate becomes significantly higher pointing toward the need for other sources of feedback such as HII radiation and I will then discuss the role it is playing.

Regulation of Galactic Star Formation Rates by Turbulence, Magnetic Fields and Stellar Feedback

Jonathan C. Tan, Michael J. Butler, Sven Van Loo, Romain Teyssier, Joakim Rosdahl

Star formation from the interstellar medium of galactic disks is a basic process controlling the evolution of galaxies. Most stellar populations are built in this way. Understanding the star formation rate in a local patch of a disk with a given gas mass is thus an important challenge for theoretical models.

Here we simulate a kiloparsec region of a disk, following the evolution of self-gravitating molecular clouds down to subparsec scales, as they form stars with a subgrid model based on regulation by turbulence. The stars then inject feedback by dissociating and ionizing UV photons and supernova explosions. We assess the relative importance of each feedback mechanism.

Our fiducial models that combine all three types of feedback yield, without fine-tuning, rates that are in excellent agreement with observations, with dissociating photons playing a dominant role. Comparison with simulations that include magnetic fields indicate that they can also play an important role in reducing star formation rates.

Simulating radiative feedback in the interstellar medium: ISM properties, star formation regulation, and observational diagnostics

Thomas Peters

A full understanding of the multi-phase structure of the turbulent interstellar medium (ISM) is one of the most important challenges in modern astrophysics. It is pivotal for the interpretation of observations and the planning of observational strategies, and for developing numerical models of star and galaxy formation. The complex interplay of gravitational collapse, radiative cooling, magnetic fields, the formation and destruction of molecules, and stellar feedback by ionizing and non-ionizing radiation, winds, and supernova explosions is still poorly understood.

In my talk, I will present kpc-scale stratified box ISM simulations that include a time-dependent chemical network to follow the abundances of H^+, H, H2, C^+ and CO, a tree-based radiation transfer method to model self-shielding by gas and dust, an external galactic potential, self-gravity and stellar feedback by ionizing and dissociating radiation from star clusters, stellar winds, and supernova explosions.

I will discuss the properties of the ISM in these simulations and how stellar feedback regulates star formation to produce realistic star formation rates. Finally, I will derive observables from the simulations with synthetic observations, in particular Hα maps and BPT diagrams, and explain how they can be related to the star formation rate and ISM properties in the simulations.

Session 5

The 3D galaxy

The Bar and Spiral Structure Legacy (BeSSeL) Survey

Andreas Brunthaler

Invited Talk

The goal of the *BeSSeL* Survey (*B*ar and *S*piral *S*tructure *L*egacy Survey) is to study the spiral structure and kinematics of the Milky Way. We will accomplish this by determining distances, via trigonometric parallax, and proper motions of star forming regions in the Milky Way.

The target sources are methanol and water masers that are associated with young massive stars and compact HII regions that trace spiral structure. With accurate distance measurements we will locate spiral arms, and with absolute proper motions we can determine the 3-dimensional motions of these massive young stars.

The goal of BeSSeL is to measure accurate distances and proper motions of a few hundred high mass star forming regions in the Milky Way until 2017. This will result in a catalogue of accurate distances to most Galactic high mass star forming regions visible from the northern hemisphere and very accurate measurements of fundamental parameters such as the distance to the Galactic center (R_0), the rotation velocity of the Milky Way (Θ_0), and the rotation curve of the Milky Way.

The large-scale structure of the Galaxy from radio to NIR tracers

Roberta Paladini

Invited Talk

Our knowledge of the large-scale structure of the Galaxy is derived from a multitude of tracers, from sources such as HII regions, to gas, e.g. HI and CO, and dust. Therefore, only performing observations at different wavelengths, from the radio to the NIR, we can collect the information required by Galactic tomography. However, modeling tools are crucial for the full exploitation of the collected data.

As an example, I will discuss the case of the so-called "3-D ISM inversion analysis", i.e. its current advantages and limitations.

Galactic Bar/Spiral Interaction in the Milky Way and Beyond

Henrik Beuther, Sharon Meidt

To understand the gas dynamics at the interface of the Galactic bar and spiral arms in our own Milky Way galaxy, we examine as an extragalactic counterpart the evidence for multiple distinct velocity components in the cold, dense molecular gas populating a comparable region at the end of the bar in the nearby galaxy NGC 3627.

Using combined IRAM Plateau de Bure and 30m data, we analyze the different gas components at the bar/spiral interface. The high velocity dispersions arise with often double-peaked or multiple line-profiles. Comparing the centroids of the different velocity components to expectations based on orbital dynamics in the presence of bar and spiral potential perturbations, a model of the region as the interface of two gas-populated orbits families supporting the bar and the independently rotating spiral arms provides an overall good match to the data. An extent of the bar to the corotation radius of the galaxy is favored. We expect situations like this to favor strong star formation events such as observed in our own Milky Way since gas can pile up at the crossings between the orbit families.

Three dimensional maps of dust extinction along the Milky Way plane

Heddy Arab, Laurent Cambrésy, Doug Marshall, David Eden

We present new three-dimensional maps of the Milky Way interstellar extinction following the Hi-GAL survey coverage. These 5 and 10 arcmin spatial resolution and 100 pc distance resolution maps are based on 2MASS and GLIMPSE photometry of giant stars and reveal the dust 3-D distribution in our galaxy out to a distance of 15 kpc.

The wealthy structure exhibited by the maps at all scales makes them great tools to study the morphology of the Milky Way. In particular, they are used in the distance determination workflow of the VIALACTEA project.

Moreover, we also compare our new map to other Milky Way interstellar medium content indicators such as dust column density and CO maps and interpret the results in terms of temperature and dust property variations.

The Vialactea distance tool

Delphine Russeil et al.

Knowing the distance of the sources is essential to derive their physical parameters.

In the frame-work of the Vialactea project we developed an automatic method to determine such distances allowing to manage the large source sample.

Using the molecular and HI line cubes collected in the database I will present how we extract the velocity and then the distance for the sources.

The Vertical Structure of the Spiral Arms of the Milky Way Galaxy

Robert Benjamin, Peter Barnes, Audra Hernandez, L. Matthew Haffner, Alex Hill, Dhanesh Krishnarao

One of the surprises of "Extended Nessie" (Goodman et al 2014) – a long infrared dark cloud associated with the Scutum-Centaurus spiral arm of the Galaxy– is the fact that it lies within a few parsecs of the Galactic plane.

Using (1) recent CO observations from the Three-millimeter Ultimate Mopra Milky Way Survey (ThrUMMS), (2) HI observations from the Southern Galactic Plane Survey (SGPS), and the Parkes Galactic All-Sky Survey (GASS), and (3) velocity-resolved H-alpha and [S II] emission line data from the Wisconsin H-alpha Mapper (WHAM Hill et al 2014), I present an analysis of the full three dimensional vertical density and velocity structure of this spiral arm from the midplane to ~2 kiloparsecs above the disk, with a focus on the mid-plane variation of this arm and the factors regulating its full vertical extent.

I contrast the vertical structure of this arm to selected segments of other spiral arms in the Galaxy, principally the Perseus and Carina spiral arms.

Poster Contributions

1

Multi-scale Planck corrections to Herschel dust continuum emission maps

J. Abreu-Vicente, A. Stutz

We present a Fourier-space method to combine the publicly available Herschel PACS and SPIRE data with the Planck thermal dust emission model. The method effectively combines the Planck large angular scale emission with the small scale Herschel emission, similar to the “feathering” method used in interferometry and recently implemented by Csengeri et al. to correct the ground-based ATLASGAL data.

This method eliminates the pervasive negative fluxes present in the PACS 160 micron archive data while preserving the structure in the background of both the PACS and SPIRE data. We generate column density and temperature maps from data calibrated with this method. We analyze the validity of our new method using star–forming regions in a range of environments: low-mass Bok Globules (B68), nearby star–forming regions (Perseus), and high-mass star forming regions in the Galactic plane (including IRDC G11 and W31). We accurately recover low column density material, comparing well to previous near-infrared extinction methods at intermediate column densities, and providing a more accurate temperature assumption for interpretation of single frequency continuum data such as those obtained by ATLASGAL.

The Herschel data, combined with our method, allow studies of the column density and temperature distributions of molecular clouds across a wide range of Galactic environments: a key step to study the physics of star- and cluster-formation.

2

All-sky polarization properties of Planck Galactic Cold Clumps

D. Alina, I. Ristorcelli, L. Montier et al.

All-sky polarization properties of Planck Galactic Cold Clumps Magnetic fields are considered one of the key physical agents that regulate star formation, but their actual role in the formation and evolution of dense cores remains an open question. Polarimetric studies in the infrared and sub-millimeter wavelengths are particularly well-suited to probe the magnetic field structure at different stages of star formation and confront them to theories and numerical simulations.

The Planck satellite polarized data allow us to study not only the magnetic field structure, as traced by the interstellar dust polarized emission, but also the dust properties and the dust alignment mechanisms at the clump formation stage.

We perform a statistical analysis of the Galactic Cold Clumps in order to derive their polarization properties. We also study the polarization properties of the filaments in which the Cold Clumps are embedded. We confirm a statistical decrease of polarization fraction in the center of the clumps, as well as in the filaments. We quantify this decrease at the resolution of the Planck data (5') and discuss its possible origins in terms of the magnetic field structure and dust alignment mechanisms.

3

The Demographic Revolution from CHaMP: Physics of Clump Evolution and Star Formation

Peter Barnes, Rebecca Pitts, Audra Hernandez, Erik Muller

We report new results on the physics and evolution of massive molecular clumps, the birthplaces of star clusters in the Milky Way. From an analysis of the J=1-0 emission from the 3 main CO isotopologues, we show that ~75% of the mass of all molecular clouds, from small star-forming clumps to large GMCs, is contained within the parsec-scale clumps, and only ~25% of the mass is distributed in a diffuse molecular component, suggesting that parsec-scale clumps may be the true building blocks of the molecular ISM.

We show that in half of these clumps, their dense interiors are pressure-confined by a massive envelope, confirming theoretical expectations; the remainder may be dynamically evolving. We also see evidence of slow, large-scale mass accretion in these clumps, with mass-doubling timescales of ~10s of Myr, consistent with recent theoretical simulations. This also supports earlier CHaMP results suggesting that ~95% of clumps are quiescent, slowly evolving to a vigorous star-formation phase, which only then disperses the clump. We present detailed maps of physical parameters in these clumps, derived from both continuum and spectral-line data, and including the spatially-resolved CO-bright mass fraction. The inferred CO-dark mass fraction is seen to vary widely with location, consistent with recent GOTC+ results and numerical models.

We extend the new CO-to-H_2 conversion law from ThrUMMS (Barnes et al 2015), which has strong dependencies on both I_{co} and T_{ex}, and gives a much tighter correlation with other measures of mass than does the standard X-factor. The new law is easily applicable to a wide range of observational data.

4

Spectroscopy of Shocks in Outflows: the case of BHR71

Milena Benedettini

Outflows from protostars are the main feedback of the star formation activity on the ISM. In particular, the shocks generated by the interaction of the accelerated jet with the ambient medium are one of the main processes through which the gas phase of the interstellar medium is enriched of molecular species. We present the first far infrared Herschel images of the entire BHR71 outflows system. The images reveal the presence of several knots of warm, shocked gas along the fast moving jet. The intensity lines ratios in the knots are quite similar showing that the excitation conditions of the fast moving gas do not change significantly along the outflow, apart at the extremity of the Southern blue lobe that is expanding outside the parental cloud. In one of the knots where a large set of data are available we combined our Herschel observations with previous data from Spitzer, SOFIA and APEX to derive the physical and the shock conditions. Rotational diagram, spectral profile shape and LVG analysis of the CO lines from the (3-2) to the (22-21) showed the presence of two gas components: one extended, cold (T ~80 K) and dense ($n(H_2)$ = $3\times10^5 - 10^6$ cm^{-3}) and another compact (18"), warm (T = 1700 – 2200 K) and less dense ($n(H_2)$ = $4\times10^4 - 6\times10^6$ cm^{-3}). Two shocks are required to model the overall set of data: a CJ type shock able to fit the CO, SiO and H_2 observations and a dissociative J type shock necessary to reproduce the atomic [OI] emission.

5

Carbon monoxide as a tracer of the molecular ISM

Chris Brunt

The principal tracers of the molecular ISM on Galactic scales are the 1-0 spectral lines of carbon monoxide. I will describe and discuss the results from extensive analysis of panoramic surveys of the Galactic Plane in the 1-0 lines of ^{12}CO and ^{13}CO, with particular attention paid to the global relations between the ^{12}CO and ^{13}CO line intensities, and the relation of each separately as a tracer of molecular hydrogen (i.e. the ^{12}CO X-factor, and the use of the optically thinner ^{13}CO as an alternative). I will also describe the empirical effects of observed abundance variations, excitation, saturation, and fractionation on the line intensities. I argue in particular that abundance variations are centrally important for understanding the calibration of each line to each other and to molecular hydrogen.

6

Fragmenting Filaments

Roxana-Adela Chira, J. Kainulainen, J. C. Ibanez Mejia, M. Mac Low

Dust surveys, for example by Herschel, have shown the complexity of molecular clouds and how important their filamentary structure is for the process of star formation. One of the key questions in this context is how filaments fragment and condensate into pre-stellar cores. We address this question by investigating the evolution in time of filaments that formed within FLASH AMR simulations of a self-gravitating, magnetized, supernova-driven, ISM, and the criteria that lead to their fragmentation. Furthermore, we use synthetic observations to explore how those fragmentation processes can be observed. We discuss the results in context of the underlying physics of the simulations, and typical observational capabilities

7

Fragmentation in accreting filaments

S. D. Clarke, A. P. Whitworth & D. A. Hubber

We use smoothed particle hydrodynamic simulations to investigate the growth of perturbations in infinitely long, initially sub-critical but accreting filaments. The growth of these perturbations leads to filament fragmentation and the formation of cores. Most previous work on this subject has been confined to the growth and fragmentation of equilibrium filaments and has found that there exists a preferential fragmentation length scale which is roughly 4 times the filament's diameter. Our results show a more complicated dispersion relation with a series of peaks linking perturbation wavelength and growth rate. These are due to gravo-acoustic oscillations along the longitudinal axis during the sub-critical phase of growth, when the filament is far from equilibrium. The positions of the peaks in growth rate have a strong dependence on both the mass accretion rate onto the filament and the temperature of the gas. When seeded with a multi-wavelength density power spectrum there exists a clear preferred core separation equal to the largest peak in the dispersion relation. Our results allow observers to estimate a minimum age for a filament which is breaking up into regularly spaced fragments, as well as a maximum accretion rate. We apply the model to recent observations by Tafalla & Hacar (2015) of fragmenting sub-filaments in Taurus and find accretion rates consistent with those estimated by Palmeirim et al. (2013)

8

Multiwavelength studies on galactic HII regions

Somnath Dutta, Soumen Mondal, Jessy Jose.

The massive stars within HII regions have profound influence on its neighborhood in the form of their strong stellar winds, radiation and eventually supernova explosion. They act as a good energy source to the overall interstellar medium of the galaxy. The studies of galactic HII regions containing massive stars provide a platform to understand both high- and low-mass star formations. Multiwavelength studies of such regions provide census of YSOs, their fundamental parameters e.g. masses, ages, effective temperatures, circumstellar disks around them (if any exists) etc. From such parameter space, broad pictures emerge on the young star-forming regions (SFRs) like star-formation history, star-formation efficiency, star formation timescales etc. We studied the stellar contents and star formation activities of a few, isolated, distant Galactic HII regions using deep optical, near-infrared and mid-infrared data sets. The stellar surface density analysis using nearest neighborhood method have been performed to understand the spatial structure of the clusters in each HII regions. Optical spectroscopic analysis of bright sources have been used to identify the massive members and to derive the fundamental parameters such as age and distance of the regions.

The K-band extinction map and cloud density structure are derived using nearest neighborhood technique. Using IR colour-colour criteria and H_2-emission properties, we identified and classified the candidate young stellar objects (YSOs) in the regions. The age estimates from circumstellar disc fraction of each region are in agreement with that of the colour-magnitude diagram based analyses. We also carried out the CCD optical I-band time series photometry of the young cluster NGC 2282.

The deep I-band analysis enables us to probe the study of variability towards low-mass end of pre-main sequence stars. Using differential photometry, large rms deviation of magnitudes, and significant periods in a Lomb-Scargle analysis we identified a total of 65 stars as photometric variable. Majority of them are variable T-Tauri stars having periods less than 15 days. Such periodic variability are proposed to be the results of rotational modulation by hot or cool spots on the stellar surface. Aperiodic variable stars originates from flare-like activity, dispersal of disks, and variations in circumstellar extinction etc.

9

Turbulence and magnetic fields in star forming regions

D. Falceta-Goncalves

Star formation occurs in turbulent and magnetized molecular clouds. The role of each of these processes in regulating star formation rates and efficiency is still a matter of debate. Moreover, the origin and evolution of turbulence in quiescent clouds is also unknown. In this work we provide a numerical study that provides solid evidences for a Galactic scale origin for the ISM turbulence. Also, zoomed in models reveal the mechanisms that drive density enhancements and further clump/core collapse in magnetized clouds. We run models to cover a wide range of turbulent and magnetization degrees. We show that magnetic fields are not dominant on the evolution of core mass functions, and star formation rates, but turbulence is.

10

Molecular cloud formation in high-shear, magnetized colliding flows

Erica Fogerty, Adam Frank, Fabian Heitsch, Jonathan Carroll-Nellenback, Christina Haig, Marissa Adams

The colliding flows (CF) model is a well-supported mechanism for generating molecular clouds. However, to-date most CF simulations have focused on the formation of clouds in the normal-shock layer between head-on colliding flows. I will discuss the effects of allowing weakly magnetized colliding flows to instead meet at an oblique shock layer. Oblique shocks generate shear in the post-shock environment, and this shear creates inhospitable environments for star formation. As the degree of shear increases (i.e. the obliquity of the shock increases), we find that it takes longer for sink particles to form, they form in lower numbers, and they tend to be less massive. With regard to magnetic fields, we find that even a weak field stalls gravitational collapse within forming clouds. Additionally, we find that oblique shocks tend to reorient over time in the presence of a magnetic field, so that they become normal to the oncoming flows and the background magnetic field. This leads to post-shock molecular clouds and filaments also becoming normal to the flows and background magnetic field. As this reorientation is simply a consequence of MHD shock processes, our results may have far-reaching implications for reorientation in astrophysical environments. Most importantly, this process could explain recent measurements of pre-stellar filaments being aligned normal to their background magnetic fields.

11

Synthetic observations of large-scale molecular cloud simulations: Bringing theory and observations together

Søren Frimann, Jes Jørgensen, Troels Haugbølle

Numerical simulations are a powerful tool to study how star formation proceeds in molecular clouds. However, to properly understand whether numerical simulations give an accurate representation of the star formation process, it is important to create synthetic observables from the simulation that can then be compared directly to real observations.

Here, and in Frimann et al. (2016), we present synthetic observations of a large number of protostellar systems obtained from a large-scale adaptive-mesh-refinement (AMR) magnetohydrodynamics simulation of a molecular cloud (volume = $5pc^3$) that simultaneously resolves the environment around individual protostellar systems on scales down to 8AU. The large number of protostars that form in the simulation enables us to do the analysis in a truly statistical manner and to understand how star formation proceeds in a large-scale molecular cloud as a whole by comparing directly with observational surveys of molecular clouds.

For example, we calculate the distribution of evolutionary signatures of the protostars in the simulation and compare to observed distributions from surveys by the Spitzer Space Telescope and Herschel Space Observatory (Evans et al. 2009; Dunham et al. 2014) and find that the distributions are well-matched. We also investigate the distribution of distances between protostars and their parental core, and find that, on average, protostars do not migrate far away from their place of birth. A result that is also supported by observational results (e.g. Jørgensen et al. 2007; 2008).

Overall, we establish the direct comparison between numerical simulations and real observations is a powerful tool for understanding star formation, and find that numerical simulations of molecular clouds give a fair representation of reality.

12

Assessing the environmental dependence of observational tracers of H_2

Troels Frostholm, Tommaso Grassi, Troels Haugbølle, Paolo Padoan

When estimating column densities of H_2, it is necessary to observe a proxy molecule, notably C, CO or OH, and assume a conversion factor to H_2. Such conversion factors are obtained in different ways, including one-dimensional models of PDRs in virial equilibrium. Their validity has recently been assessed by comparing to direct 3D numerical simulations of molecular clouds including chemistry and a prescribed external UV-radiation field (e.g. Clark & Glover, 2015).

We present a new multi-frequency ray tracing radiative transfer module coupled to non-equilibrium chemistry modelled with the KROME package (Grassi+2014) for performing molecular cloud simulations using the RAMSES code. Using this code with a molecular cloud chemistry including H-C-O and an improved prescription of the UV-field that avoids the asymmetry caused by an imposed field on the boundary, we are able to directly gauge the ratio of H_2 to the most important tracer molecules. We do this in a realistic interstellar medium model explored in Padoan et al 2016, but now with radiative transfer and non-equilibrium chemistry included. The environmental robustness of different tracers is evaluated by considering clouds of different size and morphology inside the model.

Furthermore, the use of synthetic observations allows determining the relationship between observed line fluxes in proxy molecules and H_2 column density. The possibility of using several tracers in unison to find H_2 abundances with greater accuracy is explored.

13

ELVIS on FIRE: Hydrodynamical Simulations of the Local Group

Shea Garrison-Kimmel

The FIRE (Feedback In Realistic Environments) simulations include realistic physical prescriptions for star formation and the resultant stellar feedback, including radiation pressure from massive stars, stellar winds, photoionization and photoelectric heating, and both core-collapse and Ia supernovae. When applied to cosmological zoom-in simulations, the FIRE physics reproduce the observed halo-stellar mass scaling, satellite counts around Milky Way (MW)-size hosts, and internal galaxy properties such as the mass-metallicity relation, among other observables. Here I present the results of applying FIRE to Local Group-like environments, extending the predictive power of these simulations beyond the virial radius of the Milky Way (~300 kpc). In particular, I will both explore how the dwarf galaxies that fill the Local Volume are affected by the proximity of the Milky Way and Andromeda galaxies throughout their evolution, beginning with the pollution of their interstellar medium at high redshift, and investigate how those same dwarf galaxies affect the Milky May and M31 themselves, including potentially spurring star formation through close passages with the central galaxies. Overall, I will highlight how high-resolution simulations, combined with wide-field surveys and targeted observations, can inform our understanding of the Local Group both today and in the past.

14

The Regulation of the Cold Neutral Gas Mass Fraction by Turbulent Motions

Adriana Gazol, Marco A. Villagran

We present results from hydrodynamic simulations with forced turbulence at a scale of 50 pc and cooling functions adapted to describe the thermal conditions at four different galactocentric distances: 8.5, 11, 15, and 18 kpc. These experiments are aimed to study the effects of varying the turbulent velocity v_{rms} on the atomic cold gas mass fraction. With realistic v_{rms} we obtain average one dimensional cold gas mass fractions which are comparable with the observed values.

Our simulations can also lead to an approximately constant cold gas mass fraction for distances > 11 kpc when considering subsonic perturbations for 15 and 18 kpc. We also find that the average one dimensional cold gas mass fraction and that the average one dimensional cold gas mass fraction and the volumetric cold gas mass fraction do not follow the same radial trends. We also present preliminary results on the effects of magnetic fields on the atomic cold mass fraction.

15

Accurate chemistry and microphysics in star-forming regions

Tommaso Grassi

One of the most challenging problems related to observations of star-forming regions is to determine the mass of the observed objects. There are several methods to achieve this for molecular clouds, for example line strengths of CO can be converted to a H_2 column depth (e.g. Shetty+2016). However, this could be extremely variable depending on the specific physical parameters (see e.g. Szücs+2014). These discrepancies emerge because CO is involved in a complicated chemical network in the gas phase (e.g. carbon chains and PAHs), as well as active on grain surfaces where it can freeze out and where the formation can be catalyzed (e.g. Hocuk+2014). Other tracers are less chemistry dependent, such as HF (Phillips+2010, Indriolo+2013) or OH (Tassis+2012b, 2014), but they require state of the art magnetohydrodynamical (MHD) models with on-the-fly chemistry to properly understand their behaviour.

We use the KROME package for microphysics (Grassi+2014, 2016) to model the chemical and thermal evolution of a molecular cloud coupling using MHD simulations with multifrequency radiative transfer, simplified chemistry (~300 reactions), thermal processes, dust microphysics (Grassi+2016), and lagrangian tracer particles. This is followed up with more complicated chemistry (~5000 reactions) that doesn't affect the thermal evolution on top of the tracer particles in a post-processing step. This technique allows to track e.g. fluorine chemistry to determine realistic HF abundances, on top of e.g. OH that is already available from the simplified network. These results can be processed by synthetic observations (Frimann+2016) to provide an effective tool capable of constraining the mass of the star-forming regions.

16

The Three-mm Ultimate Mopra Milky Way Survey. III. A Catalog of the Southern Molecular Cloud Physical Properties

Audra K. Hernandez, Peter J. Barnes, Ana Duarte-Cabral, and Erik Muller

The Three-mm Ultimate Mopra Milky Way Survey (ThrUMMS) provides a uniform and unbiased mapping of a 60^0 X 2^0 region of our Galaxy's southern plane (fourth-quadrant) in three CO isotopologues and CN. We present a new catalog of southern molecular clouds identified from the 13CO (J=1-0) data. By applying the dendrogram based algorithm SCIMES (Spectral Clustering for Interstellar Molecular Emission Segmentation; Colombo et al. 2015) on the ThrUMMS data we have found nearly ~12.700 structures of which ~900 are estimated to be of molecular clouds mass, with nearly ~200 estimated to be giant molecular clouds (GMCs) with masses above 10^4 solar masses. We present our initial estimates of the cloud physical properties, including their temperatures, column densities, velocity dispersions, elongation, and mass surface densities, as well as their distribution thought the Galactic plane. Since ThrUMMS provides simultaneous mapping for all three CO isotopologues, excitation temperatures on the (l,b,v) pixel scale are measured directly from the ^{12}CO for the ^{13}CO based column density measurements. We derive the kinematic distances for all molecular structures using the Galactic rotation model of Reid et al. (2009). Additionally, we will demonstrate how cloud boundary definitions can change, as well as the derived physical properties of the cloud, when a dendrogram based algorithm is applied to (l,b,v) cubes of CO-derived H_2 column density instead of the original 3D molecular line intensity data. We anticipate finding that the $N(H_2)$ (l,b,v) approach leads to smaller and higher-column density structures than the common molecular line intensity (l,b,v) approach based on the optical depth corrections.

17

Birth of molecular clouds: early evolution

G. Joncas, J. Scholtys, F. Blais

Studying the processes related to the formation and early evolution of molecular clouds is essential to our understanding of the interstellar medium (ISM) at large and of star formation. Four high galactic latitude clouds have been observed in HI, CO and far-infrared. They are ideal laboratories for grasping the physics at work as only turbulence, magnetic fields and the interstellar radiation field come into play. These clouds were discovered using clues from UV H_2 absorption lines and by comparing IRAS dust emission to HI column density from aperture synthesis observations obtained using the DRAO interferometer. Since the varying degrees of HI velocity shears and varying dust characteristics from cloud to cloud implied evolutionary effects, the clouds were mapped in CO and ^{13}CO using the Onsala 20m telescope. The clouds show different degrees of clumpyness and a large fraction of the narrow CO lines have multiple components (2-3). High resolution simulations of turbulent colliding HI flows have been calculated and are being compared to our observations to determine a timeline. A scenario of the early evolution of molecular clouds will be presented.

18

Properties of the CORNISH-North UCHII sample

Ivayla Kalcheva

The CORNISH VLA survey provides a complete and unbiased high-resolution sample of 240 ultra-compact HII (UCHII) regions at 5GHz. Counterparts were identified in the latest data of the Galactic plane - from infrared to X-ray wavelengths. The aim of studying this sample is to shed more light on questions such as the feedback process in high mass star formation regions and the Milky Way structure traced by them, the evolution of HII regions and their effect on their environment. The poster will report results on properties such as the physical sizes, Lyman fluxes, spread of Galactic latitudes relative to the mid-plane and spectral indices to confirm the UCHII region identity. Early results from fitting X-ray spectral data are consistent with massive star forming regions associated with hard diffuse emission and hint at changes in the X-ray emission with evolution when compared to earlier and later phases. Another important aspect that is explored is the morphology of UCHII regions. This is achieved by implementing new 'active contours' software on the infrared counterparts to the UCHII regions. The aim is to conduct systematic classification according to shape and to explore the UCHII sample morphologies in the context of triggered star formation.

19

Millimeter Hydrogen Recombination Lines toward a New Sample of Galactic Massive Star-forming Clumps

Won-Ju Kim

We carried out millimeter radio recombination lines (mm-RRLs, $39 \leq n \leq 65$ and $\Delta n = 1, 2, 3$, and 4) surveys using the IRAM 30-m and MOPRA 22-m telescopes toward 976 compact dust clumps of the APEX Telescope Large Area Survey of the Galaxy (ATLASGAL) survey. These mm-RRLs surveys aim at searching for embedded HII regions in the dust clumps and studying the characteristics of the HII regions toward an unbiased sample without any specific criteria. Half of sample have been also selected to be 8 μm dark to cover very young clumps. By means of our observations, we found 178 HII regions in which 178 Hnα, 65 Hnβ, 23 Hnγ, and 22 Hnδ mm-RRLs were detected. It is the largest sample of mm-RRLs to date.

All sources were searched subsequently for radio counterparts. There are three sources confirmed as HII regions only based on mm-RRL detections. In addition, 37 % (63 sources) of the mm-RRLs sources could possibly trace new dense HII regions since radio counterparts are found only offset but within 2 of the dust clump positions. Six sources have broad RRL features (FWHM > 40 km/s). Such BRLOs imply the existence of significant turbulent motions. Although the mm-RRLs could be stimulated by maser emission, the ratios of the observed mm-RRLs are consistent with LTE conditions. We present evidence that the dynamics of the mm-RRLs are related to turbulent motions in the parental molecular clouds through comparison of their $H^{13}CO^{+}$(1-0) FWHM line widths with detection and non-detection of mm-RRLs. We also present a significant correlation (correlation coefficient 0.72) between integrated fluxes of mm-RRL and 6 cm continuum emission. It implies that the mm-RRLs are associated with UCHIIs. Through comparison with other cm- and mm-RRLs surveys, HII regions found by our observations are considered to be in moderate turbulent conditions because their mean mm-RRLs widths (28.5 km/s) are between extended HIIs (WISE HIIs, mean width of 22.3 km/s) and UCHIIs (mean width of 33.4 km/s).

20

FUGIN : Molecular cloud associated with the high-mass star forming region W33

Mikito Kohno, Kengo Tachihara, Atsushi Nishimura, Akio Ohama, Hidetoshi Sano, Hiroaki Yamamoto, Yasuo Fukui, Tomofumi Umemoto, Tetsuhiro Minamidani, Kazufumi Torii, Mitsuhiro Matsuo, Shinji Fujita, Mitsuyoshi Yamagishi, and the FUGIN team

High-mass stars have significant influence through interstellar medium, on galactic evolution via supernova explosion and ultraviolet radiation. Theoretical studies have proposed models of "Core Accretion" and "Competitive Accretion" as their formation mechanism (e.g. Tan et al. 2014). However, these ideas are still under dispute. Recently, it has been suggested that formations of super star clusters and Spitzer bubbles are triggered by cloud-cloud collision (CCC) (Fukui et al 2014, Torii et al. 2015). In this study, we aim to search for the early stage of the CCC process observing the molecular clouds surrounding compact HII regions. W33 is a high-mass star forming region whose distance is estimated to be 2.4 kpc (Immer et al. 2013). W33 contains six components (W33 Main (compact HII region), W33A, W33B, W33A1, W33B1, and W33 Main1). We observed the W33 region by the Nobeyama 45-m Telescope in ^{12}CO, ^{13}CO, and C^{18}O (J=1-0) as a part of the FUGIN project (FOREST Ultra-wide Galactic plane survey In Nobeyama), and analyzed together with the JCMT archive data ^{12}CO (J=3-2) (Dempsey et al. 2013). We detected three velocity components (35 km/s, 48 km/s, and 55 km/s) and a molecular outflow in the W33 Main region from the FUGIN and JCMT data. The dynamical age of the outflow is about 105 yr indicating the young age of the region. We found that the distribution of the blue-shifted cloud (35 km/s) and red-shifted cloud (55 km/s) are spatially anti-correlated. The multi-J level CO intensity ratio of R(3-2)/(1-0) of both clouds are enhanced as R(3-2)/(1-0) > 0.8 around W33 Main. These results imply W33 region is likely to be formed by recent CCC.

21

The spatial and ionization structure of the warm ionized medium throughout the Carina arm

Dhanesh Krishnarao, L. Matthew Haffner, Robert A. Benjamin

We present spectroscopic maps and analysis of the warm ionized medium (WIM) around the Carina arm at Galactic longitudes 280° with a combination of the HI and CO longitude-velocity tracks corresponding to the near, far, and tangency portions of the Carina arm. We measure exponential scale heights of electron density squared using Hα emission along the spiral arm and analyze the relationship of the scale height with Galactic longitude, known star forming regions, etc. On-going Hβ observations along the same sight lines offer a direct method for extinction corrections. Using available [S II] λ6716 emission data, we statistically quantify the strength of the relationship of the [S II] / Hα line ratio as a function of both scale height and emission measure. We additionally use preliminary [N II] λ6584 emission line observations to study the behavior of the [N II] / Hα and [S II] / [N II] line ratios. This multi-wavelength, optical emission line analysis provides insight towards the complex ionization structure and electron temperature distribution of the WIM around this spiral arm structure.

22

Turbulence and Gravity: Friends of Foes?

Alexei Kritsuk, Supratik Banerjee, David Collins

Our understanding of interaction of turbulence, gravity, and magnetic fields across scales in star-forming environments still remains elusive. One fundamental underlying difficulty for quite some time has been the lack of phenomenology for the energy cascade in supersonic turbulence. As this lingering hole recently got patched, the next natural step is to quantify the effects of self-gravity on the turbulence. We analyzed self-gravitating isothermal supersonic turbulence in the asymptotic limit of large Reynolds numbers.

Based on the inviscid invariance of total energy, an exact relation is derived for the homogeneous and statistically stationary case. Gravitational effects enter the relation in a form of mixed second-order structure functions, describing the exchange of kinetic and gravitational energies at different spatial scales. A set of new elementary spectral energy diagnostics is introduced to verify the relation with data from observations and numerical experiments. We show that for the isotropic case, the correlation between density and gravitational acceleration may play an important role in modifying the scale-to-scale energy transfer in self-gravitating turbulence. I will show examples from AMR-MHD simulations with self-gravity to illustrate the dynamics of gravitational phase transitions and structure formation in turbulent molecular clouds.

23

A Galaxy-wide sample of dense filamentary structures

Silvia Leurini, Friedrich Wyrowski, Karl Menten

Filamentary structures are ubiquitous in the interstellar medium and they likely play a major role in star formation. However, the mechanisms leading to their formation and their link to the star formation process are not well understood. Until now, our knowledge on the properties of filaments is based on a relatively limited number of examples.

To fill this gap, we carried out the first systematic search for filamentary structures across the inner Galactic plane making use of the APEX Telescope Large Area Survey of the Galaxy (ATLASGAL), the largest and most sensitive ground based survey of the inner Galactic plane in the submillimetre wavelength regime. For the vast majority of the filament candidates, we have kinematic distances based on spectroscopic data and their main physical properties can be derived. In this contribution, I will present the main results of our analysis also in light of the recent completion of the SEDIGISM (Structure, Excitation, and Dynamics of the Inner Galactic ISM) survey, which allows a detailed velocity structure analysis of the filaments identified in continuum data.

Our sample covers an important range of the mass-size parameter space that is currently not well explored. The alignment of the filaments with the galactic plane indicates that the dynamics of the Galactic disk have significant impact on the dynamics of the dense molecular gas. Comparing the velocities of the filaments with the loci of the spiral arms we show that for ~80% of the filaments their velocities are found within 10 km/s of those of the general spiral arm they reside in. The luminosities of massive YSOs and HII regions associated with filaments have similar distributions as the rest of the Galactic population of these objects implying that a significant fraction of all massive stars form in filaments. I will conclude with detailed analysis of a few filaments for which we already collected large scale spectroscopic data.

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Hi-fidelity Multi-Scale Local Processing for visually optimized far infrared Herschel images

Gianluca Li Causi

In this poster we present the Local-Multi-Scale Histogram-Stretching, Color-Balancing, and Sharpening processes that we developed to produce the high-fidelity stunning panorama of the far-infrared Galactic Plane, acquired with the Herschel satellite within the Hi-GAL survey at 70, 160, 250, 350 and 500 µm. We project the map tiles of three selected bands onto a 3-channel panorama, which spans the full 360 degrees of galactic longitude on a ~2.5 degrees wide stripe, at the pixel scale of 3.2", in cartesian galactic coordinates. Then we process this image, altering the image photometry with the aim to improve the visual perception of morphological features, by applying a custom multi-scale local stretching algorithm, enforced by a local multi scale color balance, and applying an edge-preserving contrast enhancement to perform an artifact-free details sharpening. The central region of the resulting panorama is shown hereafter, and some beautiful regions are enlarged at bottom.

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Physical and Chemical Probes of the Evolution of Star Cluster Formation

Wanggi Lim, Jonathan C. Tan, Sean J. Carey, Bo Ma, Jouni Kainulainen, Eugenio Schisano, Julieanna Bacon, Mengyao Liu and Emily M. Moser

The formation of star clusters remains an important unsolved problem of contemporary astrophysics. Open questions abound, including: What are the initial conditions? What processes regulate the fragmentation of gas clumps into populations of stars? What is the timescale of cluster formation? What processes regulate the final star formation efficiency, boundedness and initial cluster mass function? To help address these questions I will present results from my Ph.D. thesis research, which is focussing on studies of gas and dust in two populations of dense, molecular gas clumps.

First, I present results from an analysis of ten well-studied Infrared Dark Clouds (IRDCs), which are thought to represent some of the earliest evolutionary stages of star cluster formation. We derive masses from both mid- and far-infrared extinction mapping (from Spitzer & Herschel imaging data) and sub-mm dust emission mapping (from Herschel imaging). We also present results of spectroscopic infrared extinction mapping with Spitzer IRS for several IRDCs.

These multi-wavelength studies allow us to assess systematic uncertainties in the methods and thus obtain more reliable mass surface density (Sigma) maps of cloud structures and total masses. For example, such studies have allowed us for the first time to measure reliably the peak of the Sigma-probability distribution function (PDF) in a massive IRDC and assess the mass fraction in a high-Sigma power law tail, which constrains models of self-gravitating turbulence in the cloud.

These studies also test models of grain growth in the clouds and begin a census of the embedded stellar population at these earliest stages. Second, we study a large (~300) sample of HCO^+ selected clumps that are thought to be a complete census of dense gas in a large volume of the local Galactic disk and which thus probe the entire evolutionary sequence of star cluster formation. We assess masses, luminosities and temperatures (again with Herschel data) and compare with dynamical and chemical properties of the clumps derived from ^{13}CO and $C^{18}O$ maps of the clumps. The luminosity (L) to mass (M) ratio is the key evolutionary indicator that we use for star cluster formation, i.e., as the internal luminosity from the embedded stellar population builds up and the gas mass is dispersed. We examine how various physical and chemical properties of the clumps evolve as L/M increases in the population and discuss the implications of these results for the open questions posed above.

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Cloud Structure OF Galactic OB Cluster Forming Regions From Combining Ground and Space Based Bolometric Observations

Yuxin Lin, Hauyu Baobab Liu, Di Li, Zhiyu Zhang, Adam Ginsburg, Jaime E. Pineda, Lei Qian, Roberto Galvan-Madrid, Anna F. Macleod, Eric Rosolowsky, James E. Dale, Katharine Immer, Eric Koch, Steve Longmore, Daniel Walker, Leonardo Testi

We have developed an iterative procedure to systematically combine the millimeter and submillimeter images of OB cluster-forming molecular clouds, which were taken by ground based (CSO, JCMT, APEX, IRAM-30m) and space telescopes (Herschel, Planck), to yield images which have high angular resolution but with little or no loss of extended structures. Based on the combined images, we have derived the ~10" resolution dust column density and temperature maps for the seven extremely luminous ($L > 10^6$ $L_{sun)}$ Galactic OB cluster-forming molecular clouds, namely W49A, W43-Main, W43-South, W33, G10.6-0.4, G10.2-0.3, G10.3-0.1.

These images reveal dramatically different cloud morphologies. For example, molecular clouds W49A and G10.6-0.4 show the highly centrally concentrated geometry, where the central parsec scale dense molecular clumps occupy 10%-20% of the overall cloud mass. They are connected with radially aligned gas filaments.

The W43 molecular clouds, which are known to be relatively turbulent, show larger numbers of widely distributed localized gas cores/clumps. G10.3-0.1 and G10.2-0.3 are interacting with HII regions, and show large-scale clumpy ring-like morphology, or clumpy shells that are closely following the outer rim of the HII regions. Their different cloud morphology may indicate the very different modes of OB cluster-formation, or may indicate parent molecular cloud structures at very different evolutionary stages. We hypothesize that the massive molecular gas clumps located at the centre of G10.6-0.4 and W49A may be direct consequence of the global collapse of the parent molecular clouds. Such kind of massive clumps may be rare, which may eventually form gravitationally bound massive stellar clusters. They can be analogous to the young massive clusters or globular clouds found in the extragalactic surveys.

Finally, we found that with the high angular resolution we achieved, our visual classification of cloud morphology can be linked to the systematically derived statistical quantities (i.e. the enclosed mass profile, the column density probability distribution function, the two-point correlation function of column density, and the probability distribution function of clump/core separations). These results may represent a very fundamental step forward in the studies of starbursts and star-formation laws in a systematic and statistical sense.

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The collapse and fragmentation of molecular cloud cores

Oliver Lomax

We use an ensemble of SPH simulations to follow the evolution of molecular cloud cores as they collapse and fragment into protostars. The initial conditions of these simulations are constructed to match the statistical properties of cores in the Ophiuchus molecular cloud complex. The protostars spawned by these cores match the mass function and multiplicity statistics of observed young protostars (including quadruples, quintuples and sextuples), but only if protostellar radiative feedback is episodic. We also present synthetic images and spectra of the fragmentation process. These are calculated using a new Smoothed Particle Monte Carlo Radiative Transfer algorithm. This is a particle-based adaptation of the Lucy (1999) algorithm. The method is able to model external, embedded and diffuse radiation sources, with density fields spanning a large dynamic range. We show how the external appearance of a protostellar core changes due to the changing luminosities and positions of the embedded stars, and evaluate the extent to which lower-mass stars can hide in the glare from their more massive siblings.

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Comparing Herschel dust emission structures, magnetic fields observed by Planck, and dynamics: high-latitude star forming cloud L1642

J. Malinen, L. Montier, J. Montillaud, M. Juvela, I. Ristorcelli, S. E. Clark, O. Berné, J.-Ph. Bernard, V.-M. Pelkonen, D. C. Collins

The nearby high-latitude cloud L1642 is one of only two known very high latitude ($|b| > 30^0$) clouds actively forming stars. This cloud is a rare example of star formation in isolated conditions, and can reveal important details of star formation in general, e.g., of the effect of magnetic fields. This cloud has been mapped as part of our Herschel Key Programme 'Galactic Cold Cores' where we made Herschel observations of over 100 cold objects detected with Planck and scattered over the whole sky. We compare Herschel dust emission structures and magnetic field orientation revealed by Planck polarization maps in L1642, and also combine these with dynamic information from molecular line observations. The high-resolution Herschel data reveal a complex structure including a dense, compressed central clump, and low density striations. The Planck polarization data reveal an ordered magnetic field that pervades the cloud and is aligned with the surrounding low density striations. We show that there is a complex interplay between the cloud structure and large scale magnetic fields revealed by Planck polarization data at 10' resolution. This suggests that the magnetic field is closely linked to the formation and evolution of the cloud. We see a clear transition from aligned to perpendicular structures approximately at a column density of N(H) = $2x10^{21}$ cm^{-2}. We conclude that Planck polarization data revealing the large scale magnetic field orientation can be very useful even when comparing to the finest structures in higher resolution data, e.g. Herschel at ~18" resolution.

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The Herschel Point Source Catalogue

Gabor Marton, Bernhard Schulz and the HPSC working group

The Herschel Space Observatory was the fourth cornerstone mission in the European Space Agency (ESA) science programme, with excellent broad band imaging capabilities in the sub-mm and far-infrared part of the spectrum and with a goal to answer a key question: How do stars form and evolve, what is their relationship with the interstellar medium? Although the spacecraft finished its observations in 2013, it left a large legacy dataset that is far from having been fully scrutinised and still has a large potential for new scientific discoveries. This is specifically true for the photometric observations of the PACS and SPIRE instruments. To maximise the scientific return of the SPIRE and PACS photometric data sets, we are in the process of building the Herschel Point Source Catalogue (HPSC) from all primary and parallel mode observations, including those of all key programs that targeted star forming regions. Our homogeneous source extraction enables a systematic and unbiased comparison of sensitivity across the different Herschel fields that single programs will generally not be able to provide. The catalogue will be made available online through archives like the Herschel Science Archive (HSA), the Infrared Science Archive (IRSA), and the Strasbourg Astronomical Data Center (CDS). An overview of the dataset used in the process of making the HPSC and details of our method will be presented, describing the way we performed source detection and photometry in the large variety of environments observed by Herschel. Also, I will briefly summarise the basic properties of our catalogue.

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Axisymmetric radiation transfer modelling of the near-infrared to submm emission of the Milky Way

G. Natale, C.C. Popescu, R.J.Tuffs

We present an axisymmetric radiation transfer model of the Milky Way which is able to reproduce the observed longitude and latitude average surface brightness profiles derived from COBE, IRAS and PLANCK data. The model consists of both diffuse and clumpy stellar/dust components and it has been obtained by utilising both 2D and 3D dust radiation transfer codes. We derived self-consistently the spatial distribution of UV/optical/infrared radiation fields and dust emissivity in the Galaxy as well as the projected emission maps, at the position of the sun, of the radiation emitted by both dust and stars. The model will be of fundamental importance for all applications requiring knowledge of the UV to sub-mm radiation fields in the Galaxy, and studies comparing the large-scale distribution of gas to the distribution of dust. Furthermore, it will be the natural starting point for the future full 3D modelling including non axisymmetric features such as the bar and spiral arms.

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Filament properties and star formation in M17 giant molecular cloud complex

Atsushi Nishimura, Tomofumi Umemoto, Tetsuhiro Minamidani, Nario Kuno, Tomoka Tosaki, Shinji Fujita, Mitsuhiro Matsuo, Yuya Tsuda, Satoshi Ohashi

We present the ^{12}CO (J=1-0), ^{13}CO (J=1-0), and C^{18}O (J=1-0) maps of M17 molecular clouds obtained as part of the FOREST Ultra-wide Galactic Plane Survey In Nobeyama (FUGIN). The observations cover the entire area of M17 cloud N and M17 SW with an angular resolution of ~15" which corresponds to ~0.15 pc, and they can be used to trace the formation and evolution of filamentary structure of molecular clouds in GMC scale. The N cloud consists of a couple of twisted filaments, they are extended in parallel toward the HII region. The typical width of the filaments is ~0.4 pc in ^{13}CO intensity map. They are twisted with an interval of ~5 pc, and an amplitude of ~2 pc. Some filaments have a bright rim structure in 8μm at the filament edge facing the HII region. Therefore, the filaments might be formed by the feedback of the HII region. The mass distribution have a gradient depending on the distance of M17 HII region. Most of the filaments have points where the line mass exceed the critical value of 16 M_{sun} pc^{-1}. This indicates that the high- density cores can be formed on the most of the filaments in the N cloud. In addition, YSOs distribution from MYStIX infrared excess source catalog shows that the most of YSOs are on the filaments in the N cloud. Hence the filamentary structure plays an important role to form stars in N cloud. However, the fact that most of the OB stars are located away from filaments suggests that the N cloud filaments could not trigger the formation of the M17 cluster including OB stars. We found high-velocity clumps (V_{lsr}~23 km sec^{-1}) which are associated with OB stars. The distribution of high-velocity clumps is anticorrelated with N cloud and SW cloud. The N cloud filaments (V_{lsr}~20 km sec^{-1}) are corresponding to IRDCs identified by Spitzer, while the high-velocity clumps have no IRDC counterpart. Therefore, N cloud filaments are located near side of the HII region and the high-velocity clumps are located far side of the HII region. One possibility which satisfy the results is that the high-velocity clumps collided to M17 main clouds from near side and this event triggered to form the M17 cluster.

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Herschel,Spitzer and near-IR observations of the star forming region IRAS 12272-6240

Paolo Persi, Mauricio Tapia, Miguel Roth, Davide Elia, Hugo Saldano

IIRAS12272-6240 is a complex star forming region associated with OH, H_2O and 6.7 GHz Methanol masers . Radio continuum emission at 18 and 22 GHz and 1.2 mm (Beltran et al. 2006) has been detected in this region. We present here new sub-arcsec near-IR broad and narrow-band images and low-resolution near-IR spectroscopy. Our near-IR data were compared with the Herschel far-IR images and with Spitzer/IRAC mid-IR images in order to derive the physical parameters of this high mass star forming region.

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Galactic Scale Flows and the Triggering of Star Formation

Gerardo Ramon-Fox and Ian Bonnell

Large scale flows feed the growth of molecular clouds where stars form in high-density cores. These also have a role in injecting the energy that drives the internal dynamics of these clouds, which affects their overall stability and star formation activity. The triggering of the formation of stars involves a connection between large and small-scale processes in galaxies, which can be explored in simulations.

We present results of on-going work in high-resolution N-body and Smoothed Particle Hydrodynamics simulations of a spiral galaxy with a realistic morphology. These simulations have mass resolutions down to about 100 solar masses per gas particle, allowing to trace the least massive clouds. These permit the study of gas flows in a self-consistent galaxy with and their effect on the formation and growth of molecular clouds. They also provide a ground for studying cloud properties in different environments of a galaxy, the effects of spiral arms on large scale flows and for understanding global star formation properties.

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A new perspective on turbulent Galactic magnetic fields through unification of linear polarisation decomposition techniques

Jean-Francois Robitaille, Anna Scaife

In Robitaille & Scaife (2015) we presented a new multi-scale method to calculate the amplitude of the gradient of radio polarisation, P, using a wavelet-based formalism. This new analysis technique revealed different filamentary networks present on different angular scales in the Galactic plane. The wavelet formalism allows us to calculate the power spectrum of the gradient of P, which give a complete measure of the magnetic field fluctuations. Part of fluctuations seen on larger scales are probably not associated with turbulent fluctuations of the magnetic field but rather with the ordered large-scale field. In the case where a coherent subset of filaments are correlated across multiple scales, which trace the sharpest changes in the polarisation vector P within the field, we suggested that these structures may be associated with highly compressive shocks in the medium.

Our current analysis of radio synchrotron emission using a combination of polarisation gradient analysis and E- and B-mode decomposition indicates that some filaments have magnetic fields aligned with the filament direction and some have fields perpendicular to the filament. The wavelet-based formalism also allows us to locate the position of E- or B-mode features responsible for the local asymmetries between the two polarisation types.

These asymmetries, representing intermediate and small-scale ordered magnetic fields, are trigged by star clusters associated with HII regions, Galactic superbubbles and radio spurs. These techniques, currently applied on Galactic radio synchrotron emission, will be soon applied on submillimeter polarimetric data in order to develop a better understanding of the relative importance of magnetic fields and turbulence to star formation.

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[CII] 158µm and [NII] 205µm emission from IC 342

M.Röllig, R.Simon, R. Güsten, J.Stutzki, F.P. Israel and K. Jacobs

We investigate the question of how much of the [C II] emission in the nucleus of the nearby spiral galaxy IC 342 is contributed by PDRs and by the ionized gas. The ionized gas in the center of IC 342 contributes much more strongly to the overall [C II] emission than is commonly observed on larger scales and then is predicted, e.g. by numerical models of HII- and Photodissociation Regions. Averaged over the central few hundred parsec we find for the [C II] contribution a H II-to-PDR ratio of 70:30

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Formation of stellar clusters in galactic flows

Romas Smilgys, Ian A. Bonnell

We investigate the triggering of star formation and the formation of stellar clusters in molecular clouds that form as the ISM passes through spiral shocks. We use the Lagrangian nature of SPH simulations to trace how the star forming gas is gathered into self-gravitating cores that collapse to form stars. We find that the large-scale flows are necessary to produce the dense clouds where gravitational collapse and star formation occur.

Local gravitational collapse requires densities in excess of $n > 10^3$ cm $^{-3}$ which occur on size scales of ≈1 pc for low-mass star forming regions ($M < 100M_{sun}$), and up to sizes approaching 10 pc for higher-mass regions ($M > 10^3M_{sun}$). Star formation in the 250 pc region lasts throughout the 5 Myr timescale of the simulation and produces stellar clusters up to several 10^4M_{sun} with half-mass radii of 1-2 pc. These clusters grow through accreting both gas and stars. The hierarchical merging process also results in significant age spreads of up to several Myr.

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The role of the magnetic field in the formation of density structure in molecular clouds as revealed by dust polarization

Juan D. Soler and Patrick Hennebelle

ESA's Planck satellite has produced the first all-sky map of the polarized emission from dust at submillimetre wavelengths. These observations constitute an unprecedented data set in terms sensitivity, coverage, and statistics for the study of the interstellar magnetic field, projected on the plane of the sky and integrated along the line of sight.

In a set of 10 nearby MCs, we find that the high-N_H structures are preferentially perpendicular to the field, suggesting that they may have formed by converging flows or gravitational collapse along the magnetic field lines. We present the analysis of this observational result in terms of the physical conditions in a set of molecular clouds selected from numerical simulations of turbulent, magnetized, self-gravitating, multi-phase, supernovae-regulated medium within a 1-kiloparsec-side stratified box. We describe the relative orientation trends found in the density and magnetic field structures in 3D, and in the corresponding synthetic observations of column density and polarization, and discuss its connection with the role of the magnetic field, turbulence, and gravity in the formation of density structures in the ISM.

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Investigating the presence of a transition to coherence in magneto-hydrodynamical simulations

Rachael Spowage, Paul C. Clark

Evidence for the presence of supersonic turbulence in molecular clouds dates back to Larson (1981), who discovered a power-law relation between the velocity dispersion and size of the cloud observed. Later studies have expanded this relation into a wide range of scales, from small-scales (~0.5 pc) to giant molecular clouds (GMCs, sizes of ~100 pc). Since the velocity dispersion of a molecular cloud cannot fall beneath its sound speed, it is predicted that at some scale, the internal velocity dispersion must fall to transonic and even subsonic.

We investigate whether a "transition to coherence" was present in synthetic NH_3 observations of hydrodynamical simulations, using the moving-mesh code AREPO. We present the results of a simulation of a typical Galactic spiral-arm molecular cloud. Cores were identified by considering the smallest scale at which regions were gravitationally bound and only considering the first instance in time for each core. Synthetic observations of the NH_3 (1,1) transition were conducted using RADMC3D. A number of cores detected show promising signs of a near-constant, subsonic velocity dispersion within the core boundaries, mirroring the observations by Pineda et al. (2010) in the B5 region of Perseus.

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Estimating the Star Formation Rate of the Milky Way from Extragalactic Gas Infall

Kwang Hyun Sung & Kyujin Kwak

The study of galactic chemical evolution works as a useful tool for inferring the mechanism of how a galaxy has been formed, making a chronological order of events that happened within a given system, and therefore allowing better predictions for the evolution of stellar systems. While inflowing gas has been considered one of the most important elements in modelling the chemical evolution of spiral galaxies, our numerical simulations show that the "infall rate" used in many previous evolution models does not necessarily represent the actual supply rate of material which must remain in the galactic disk to become fuel for the star formation.

We define such supply rate as "fuel rate". The discrepancy between "infall rate" and "fuel rate" could be significantly large when kinematic consequences from the collision between infalling gas and the disk were considered. Furthermore, we take into account the spatial configurations of the approaching extragalactic gas considering that aggregates of patchy clouds could be observed to have the same column density as a single large cloud but result in a diverse range of fuel rates. We test our idea of fuel rate by applying it to solve the G-dwarf problem. In this way, we suggest a modified chemical evolution model which includes a more reasonable estimation of star formation rate from extragalactic gas infall in the Milky Way.

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Starless Clumps in the Milky Way from the Bolocam Galactic Plane Survey

Brian Svoboda, Yancy Shirley, Cara Battersby, Erik Rosolowsky, Adam Ginsburg, Timothy Ellsworth-Bowers, Neal Evans II, John Bally, Jason Glenn

We sort 4683 molecular clouds between 10^0-65^0 longitude from the Bolocam Galactic Plane Survey based on observational diagnostics of star formation activity: compact 70 µm sources, mid-IR color-selected YSOs, H_2O and CH_3OH masers, and UCHII regions. We identify a subsample of 2223 (47.5%) starless clump candidates, the most robust sample identified from a blind survey to date. Clump physical properties such as mass, column density, and radius show strong (>1 dex) progressions when sorted by star formation indicator. The median starless clump candidate is marginally sub-virial (α~0.7) with >75% of clumps with known distance being gravitationally bound . The GBT W-band observations towards a remarkable high-mass starless clump showed infall motions. We shall also describe preliminary results of a high-resolution ALMA survey towards a sample of the most high-mass starless clumps.

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Dynamical model of the Milky Way disk

Kseniia Sysoliatina

To construct a self-consistent Milky Way disk model we use an approach, which lies in the core of a sequence of researches, being started in early 80-th. Namely, we use the classical Jeans analysis to model an axisymmetric disk in a steady state. As a starting point we took the model of our local solar cylinder known as JJ-model (Just&Jahreiß, 2010) and extended it to other galactocentric distances. Our disk consists of a set of isothermal subpopulations, representing thin and thick disks, gas and dark matter. Radial density profiles of baryonic matter components are given as simple exponential laws with scale-length of 2.5, 1.5 and 4.5 kpc for thin and thick disks and gas. Their effective thickness is assumed to be constant and be approximately of 400, 1200 and 150 pc respectively, which is valid for the range of middle galactocentric distances. New observations expected in Sept. 2016 will enable us to pin down values of model's free parameters. The next step will be to include radial and tangential velocity distribution functions in the model.

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Formation of Filamentary Molecular Cloud Lupus I via Expansion of an HI Shell

Kengo Tachihara

Filamentary structure is a common feature of molecular clouds. Because the fragmentations of the filamentary clouds give rise to dense core and star formations, formation mechanism of filaments is a hot topic in astrophysics. Magnetic fields are suggested to play an important role in the formation as the field lines run perpendicular to the filamentary axis. Lupus I is a typical example demonstrated by optical and sub-mm polarization observations. The filamentary cloud is located at the edge of expanding HI shell created by old supernova shock wave, and exhibits asymmetric density structure with respect to the axis. Faint striation along the field lines is observed in CO with velocity gradient implying the mass aggregation by snowplow effect onto the main filament. Because such agitation by the passage of shock wave is a common phenomenon, we propose a filament formation model by shock wave propagation.

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Investigating the dynamical influence of the Milky Way's spiral structure with kinetic tomography

Kirill Tchernyshyov, Josh Peek

Much of what we know about gas flows in spiral arms and their influence on star formation processes and the lifecycle of molecular clouds comes from observations of other galaxies, often two-arm grand-design spirals. Measuring gas flows in and around the arms of less-cleanly structured, e.g. flocculent, spiral galaxies has been, naturally, more difficult; measuring them in our own Milky Way even more so. To address the second of these challenges, we have developed a suite of techniques, collectively called kinetic tomography, to combine observations of gas emission and/or absorption in position-position-velocity (PPV) space and dust reddening in position-position-distance (PPD) space to produce maps of the line-of-sight component of the velocity field of the Milky Way's interstellar medium (ISM) as a function of on-sky position and distance. These velocity maps allow us to visualize and quantify deviations from Galactic rotation, i.e. streaming motions, in the Milky Way as a function of all three spatial dimensions. We briefly explain how kinetic tomography works and how we have empirically checked its results, show our maps of the streaming motions, and present results on gas flows in spiral arms within 3 kiloparsecs of the Sun.

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Using Spinning Dust Emission To Constrain The Abundance Of Small Dust Grains In Dense Cores

C. T. Tibbs, R. Paladini, K. Cleary, S. J. C. Muchovej, A. M. M. Scaife, M. A. Stevenson, R. J. Laureijs, N. Ysard, K. J. B. Grainge, Y. C. Perrott, C. Rumsey and J. Villadsen

Within many molecular clouds in our Galaxy there are cold, dense cores in which stars form. These dense environments represent a crucial step in the life cycle of dust and provide a great location in which to study dust grain evolution. However, the size distribution of dust grains in these environments is still the subject of much debate. In this analysis we constrain the abundance of very small dust grains in a sample of dense cores using cm observations of spinning dust emission. If very small dust grains are present in these cores, then even though stellar photons cannot penetrate deep enough to excite them to emit at mid-IR wavelengths, the very small dust grains will be spun-up by collisions and emit spinning dust radiation. Therefore spinning dust emission can be used as a direct probe of the very small dust grains in these cores. With this in mind, we present the first attempt to observe spinning dust emission in molecular cores and use it to constrain the abundance of very small dust grains, and hence help to determine the evolution of dust within these dense environments.

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O star formation via cloud-cloud collision in the galactic HII region M20

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O stars are strong in UV radiation, stellar winds, and the supernova explosion at their death, influencing significantly the interstellar medium and the galaxy as a whole. It is therefore of vital importance to elucidate the formation mechanism of O stars. Recent observational studies in the several high-mass star forming regions (e.g., massive clusters and the isolated O stars) in the Milky Way have revealed that cloud-cloud collisions play an important role on the high-mass star formation. Among these regions, the galactic HII region M20 dominated by a single O star has a young age of 0.3 Myrs, providing an unique opportunity to investigate the high-mass star formation.

In 2011 our CO observations with NANTEN2 indicate that two molecular clouds having a velocity separation of ~7km/s are both physically associated with the O star in M20. The large velocity separation can be understood neither as the gravitational binding nor as the expanding motion driven by the stellar feedbacks. We discussed that the O star in M20 was formed by the collision of the two clouds and M20 may be a case which traces the early evolutional stage of the cloud-cloud collision. In this talk, we present the results of our new CO J=1-0 and J=3-2 observations toward the central 3 pc of M20 performed with ASTE and Mopra at higher spatial resolutions of 20”-30”.

The two colliding clouds are well resolved in the new CO dataset and show the interesting nested distribution near the O star. In addition, it is clearly seen that the two clouds are partly connected with each other in the longitude-velocity diagram with diffuse intermediate velocity features. Compared with the recent numerical calculations of the cloud-cloud collisions, we will discuss that the nested distribution and the intermediate velocity features identified in the present observations can be interpreted as the characteristic structures observable in the early evolutional stage of the cloud-cloud collision. The young age of M20 is consistent with this discussion, lending support for the cloud-cloud collision scenario. We will also present the recent studies of the high-mass star formation with the CO data set obtained in the “FOREST Ultra-wide Galactic Plane Survey In Nobeyama (FUGIN)” project with the NRO 45m telescope.

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Studies of cold ISM from sub-pc to kpc scales with PGCCs

L. Viktor Toth, and the Galactic Cold Cores team

The project Cold Cores is investigating the cold interstellar medium (ISM) within the Milky Way. Our goal with a combined multi-scale analysis is to provide a detailed global picture of the star formation process. The study is enabled by the list of cold clouds that were located by the Planck Space observatory. The physical parameters and structure of cold ISM was studied from sub-pc to kpc scales using objects from the Planck Catalogue of Galactic Cold Clumps (PGCCs). On small scales, PGCCs were followed up by Herschel FIR measurements and various ground-based molecular line observations. The data have been used to study the structure of interstellar filaments, to identify cores and protostars, and to draw general conclusions on the criteria of star formation. Further studies have been conducted on the sub-millimetre properties of the interstellar dust. On intermediate scales, the Minimum Spanning Tree (MST) method was used to uncover clustering properties of PGCC clumps. Our MST analysis located 137 clusters when applied to the 870 clumps in Taurus, Perseus, Auriga and Orion, at distances from 140 to 420 pc. Cluster sizes, shapes and masses were derived, and regions compared. The MST results were also compared to the Planck polarization maps to investigate the relationships between the magnetic fields and the ISM structure. We have also used CO observations to study the kinematics of the cold ISM in PGCC clusters. On large scales, the PGCC distribution was compared to Milky Way structure and especially to models of the Galactic spiral arms.

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A stacked analysis of cirrus observed by Fermi-LAT and Planck

Ruizhi Yang, Richard Tuffs, Cristina Popescu

Due to the low density the diffuse warm ionized medium is largely unexplored in gamma-ray band, although they occupy most of the volume in the Milky Way and can be a significant component of the diffuse gamma-ray emission. We selected 130 cirrus targets by investigating Planck opacity map and perform a stack analysis on this sources by using Fermi LAT gamma-ray data and adopting a aperture photometry method. We found that below 10 GeV the observed gamma-ray emissivity is well explained by hadronic interaction between cosmic rays (CR) nuclei and ISM, while above 10 GeV there are strong hint for inverse Compton scatterings of relativistic CR electrons or FIR background photon fields.

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Galactic Filaments and the Spiral Structure of the Milky Way

Catherine Zucker, Alyssa Goodman, Cara Battersby

In 2014, Goodman et al. showed that the 160 pc long filamentary infrared dark cloud "Nessie" lies directly in the Galactic mid-plane and traces out a bone-like feature of the Scutum-Centaurus arm in position-position-velocity space. Since then, several follow-up studies have been conducted to determine the physical properties of large-scale (10-500 pc) Galactic filaments and their potential association with spiral structure. These studies, aimed at finding Giant CO Molecular filaments, Large-scale Herschel filaments, and ultra-dense IRDC "Bones", respectively, have used different selection criteria and methodology. As a result, the relationship of these classes of filaments to each other, and the properties of elongated Galactic filaments as a whole, remain uncertain. We compile existing large-scale filament catalogs from the literature and perform a uniform analysis of their physical properties and association with spiral arm models in position-position-velocity space. Finally, we discuss how these filaments might be combined with existing tracers of Galactic structure (extinction mapping, high-mass star forming regions, etc.) within a linked data 3D viewer to refine our understanding of Milky Way structure.

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Origins and Implications of MHD Turbulence in Galaxies

Blakesley Burkhart

Magnetic fields and turbulence are vital components in galactic processes, including cosmic ray transport, ISM structure formation, and star formation. However turbulence is difficult to measure observationally and the role of simulations is vital for both testing theories of ISM turbulence and gauging observational diagnostics via synthetic observations. I will discuss the origins of turbulence in galaxies from the perspective of analytic theories of feedback and gravity driven turbulence.

Using Hα observations and Illustris AREPO simulations, I will show that both the feedback and gravitational driving paradigms can explain low velocity dispersion systems however only gravitational accretion driving can account for galaxies with the highest velocity dispersions. I will also highlight how turbulence can be measured in the Milky Way in spectral line observations of molecular clouds and diffuse gas in galaxies in order to constrain and test simulations as well as obtain important properties of turbulence such as the injection scale, spectral index and Mach number.

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Hi-GAL Catalogs and Image server at ASI Science Data Center

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Scientific product of the Hi-GAL survey are composed by a huge amount of data, Images and source Catalogs. We have build a user friendly interface to easily access to these products and give the possibility to the users to conduct an initial visual inspection of a selected region, analyzing both images and detected source simultaneously for all the 5 bands. Furthermore ASDC gives the possibility to redo "on the fly" the image analysis running CuTEx, customizing the input parameters to optimize the source extraction in a specific region of interest. To provide this service was needed to port the original IDL code to an open-source language, as GDL. We are actually exploiting this experience to develop the C++ pipeline software, based on the CuTEx algorithm, in the Euclid environments to extract the OU-NIR catalogue.