MASSIVE STAR FORMATION 2007

Observations confront Theory

September 10 – 14, 2007
Convention Centre
Heidelberg, Germany

ABSTRACT BOOK & LOGISTICS

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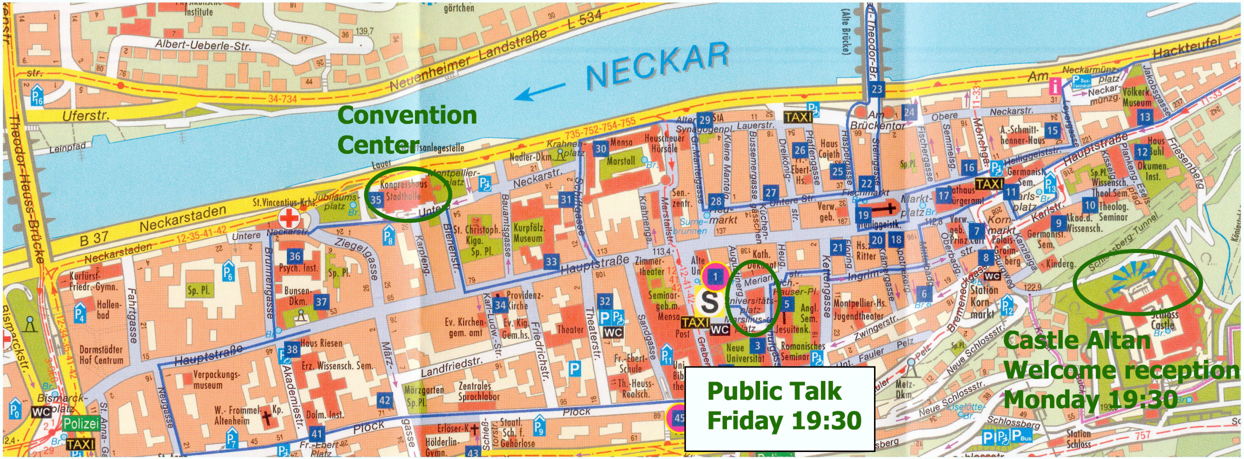
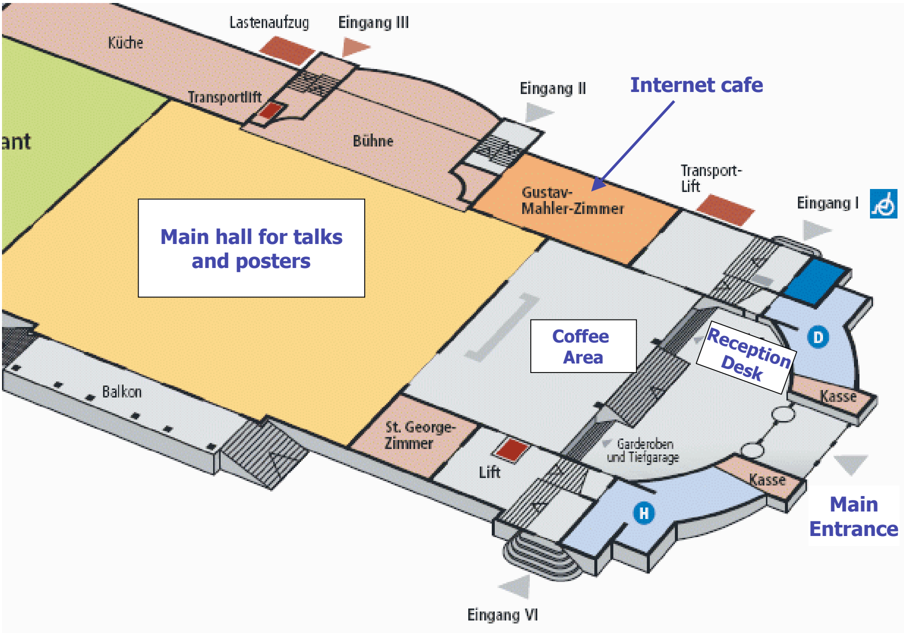
LOGISTICS

A Cutout Map of Heidelberg



The image shows a cutout from the Heidelberg map included in your conference papers. Three important locations, the Convention Centre (“Stadthalle”), the Heidelberg Castle (“Schloß”), and the University including the Old Assembly Hall are indicated with ellipses. Note that the Königstuhl Hill with the Landessternwarte and MPIA is not included here.

A Sketch of the Room Plan in the Convention Center



Internet Connection We provide an "Internet Café" with 8 computers and additional plugins for laptops. Furthermore, the Coffee Area will be wireless and you can easily connect to the Internet via a normal DHCP connection from there. The WLAN net will have the name ***Kongresshaus***.

Convention Center Telephone during the meeting The Convention Center provides a telephone number for callers from outside:
+49 (0)6221 14 22 812

Social Events

Beside the scientific program, we have arranged for some “Social Events” that, we hope, are a nice and light addition to the concentrated series of talks during the conference.

Welcome Reception
On Monday, September 10, we will have the welcome reception at the Heidelberg Castle at 19:30 in the evening. We refer you to the city map cutout on page 7 of this abstract book. It is roughly a 20 – 25 minutes walk from the convention center to castle.

Conference Dinner
On Wednesday, September 12, there will be the conference dinner at the MPIA on the Königstuhl Hill. A bus transport to the MPIA will be provided. Departure is at 18:45 just outside of the convention center.

Boat Cruise on the Neckar river
For all of you who have registered for the boat cruise, it will take place on the afternoon of Friday, September 14. The actual tickets for the cruise can be purchased from us during the course of the conference.

Public Talk by Harold Yorke
Harold Yorke will give a public lecture on the topic of massive stars on Friday evening at 19:30 at the University’s Old Assembly Hall in the old city center of Heidelberg. The talk will address the general public interested in science and astronomy and will be given in German.

Preliminary Information for the Proceedings

A contract with the Astronomical Society of the Pacific (http://www.astrosociety.org/index.html) has been arranged to publish the proceedings of our conference.

Talk Contributions :

We will have ample space for including the quite high number of registered talks in our proceedings. Since we have just two basic types of talks ("normal" talks of 20 minutes and review talks of 40 minutes length), we intend to scale the written contributions as follows:

Review talks	:	10 – 12	pages
Normal talks	:	6 – 8	pages

Although we refrained from the more and more popular policy to request the written contributions already before the conference, we want to publish the proceedings fast. Therefore, we need the cooperation from the authors. Please plan some time for writing your contribution within two months after the end of the conference. This will help us in order to obey the tight schedule given to us by the ASP publishers. More definite deadlines will be announced soon in our Deadlines section of the webpage.

The contributions have to be written in LaTeX, the figures should preferentially be done as encapsulated postscript files (eps). Figures will be printed in black & white, unless the authors explicitly ask for colour printing. Note that images may be printed in colour at a cost of $975.00 for the first image in the volume and $500.00 for each additional image. These additional costs have to be covered by the authors of the contribution. We provide a zip file containing a template LaTeX file to be used by the authors, the ASP style file, and some documentation under:
http://www.mpia-hd.mpg.de/MSF07/ASPeditor/MSF07.zip
(Note that the style file is slightly altered by us according to the latest recommendations recently given by the ASP publishers. Therefore, it might not be identical to the one downloadable on the ASP homepage.)

Further information can be obtained on the ASP webpage under:
http://www.aspbooks.org/author_information/

To make the whole procedure slightly faster, we will already arrange for the copyright forms (see the zip file content) to be signed by the potential authors during the conference.

Poster Contributions :

Due to the high number poster contributions registered, it will not be possible to include these in the printed version of the proceedings. We are still discussing whether a CDROM will be included with the PDF files in the proceedings book. In any case, such files can be made available on our conference website. The posters are a substantial contribution to our conference. To highlight this further, there will be a Poster Summary Talk by Malcolm Walmsley at the end of the conference, and the creator of the best poster (to be chosen by a small committee) will get a poster prize and will be given the opportunity to give a short presentation of the poster content after the Poster Summary Talk.

SCIENTIFIC PROGRAM

Monday September 10th

INITIAL CONDITIONS

13:30-13:40	**Th. Henning / H. Beuther** *Welcome Address*
13:40-14:20	**Friedrich Wyrowski** *Initial conditions for massive star formation*
14:20-14:40	**Fabian Heitsch** *Formation of Massive Cores in Converging Flows: Rapid & Efficient?*
14:40-15:00	**Frederique Motte** *The earliest phases of high–mass star formation in entire molecular complexes*
15:00-15:20	**Francesco Fontani** *Searching for massive pre–stellar cores through observations of N_2H^+ and N_2D^+*
15:20-17:20	**Poster session and coffee break**
17:20-17:40	**Matt Redman** *Models of cold massive cores*
17:40-18:00	**James Jackson** *Infrared Dark Clouds: Precursors to High Mass Stars*
18:00-18:20	**Nicolas Peretto** *From protocluster to infrared dark clouds*
18:20-18:40	**Steven Longmore** *Understanding the early evolutionary stages of massive star formation*
19:30	**Welcome reception at the Heidelberg castle**

Tuesday September 11th

Observational Constraints and Feedback

09:00-09:20 **Qizhou Zhang**
Centimeter to sub–millimeter view of disks

09:20-09:40 **Arjan Bik**
Infrared view of massive accretion disk (candidates)

09:40-10:00 **Jürgen Steinacker**
Evidence for disks around young massive stars from 3D radiative transfer image modeling

10:00-10:20 **Andrew Walsh**
Southern surveys of hot cores

10:20-10:40 **Diego Mardones**
Accretion and Expansion from Spectral Line profiles of southern massive cores

10:40-11:10 **Coffee break**

11:10-11:30 **Doug Gies**
Binaries in massive star formation

11:30-11:50 **Floris van der Tak**
The chemistry of high–mass star formation

11:50-12:10 **Maite Beltran**
Infall and the formation of a massive star

12:10-12:30 **Hendrik Linz**
Dissecting massive YSOs with mid-infrared interferometry

12:30-14:30 **Lunch break**

14:30-14:50 **Karl Menten**
Masers in Regions of High-Mass Star Fomation

14:50-15:10 **Wouter Vlemmings**
Maser polarization and magnetic fields

15:10-15:30 **Sharmila Goedhart**
Periodic variations in Class II methanol masers

15:30-15:50 **Thomas Preibisch**
The innermost circumstellar environment of massive young stellar objects revealed by infrared interferometry

15:50-16:20 **Coffee break**

16:20-17:00 **Mordecai-Marc Mac Low**
Feedback Processes

17:00-17:20 **John Bally**
Outflows in Massive Star Formation Regions

17:20-17:40 **Pamela Klaassen**
Outflow and Accretion in Massive Star Forming Regions

17:40-18:00 **Hsu–Tai Lee**
Dynamic Evidence of Triggered Star Formation

18:00-19:00 **Moderator: Neal Evans**
Panel discussion: What is a massive protostar? Theoretical definitions, observational criteria and evolutionary.

Participants: F. van der Tak, S. Lizano, D. Shepherd, Th. Henning, S. Bontemps

Wednesday September 12th

THEORETICAL CONCEPTS

09:00-09:40	**Harold Yorke** *Theoretical Developments in Understanding Massive Star Formation*
09:40-10:00	**Mark Krumholz** *From Massive Cores to Massive Stars*
10:00-10:20	**Paul Clark** *The conditions for competitive accretion*
10:20-10:40	**Robi Banerjee** *Collapse of Massive Cloud Cores*
10:40-11:10	**Coffee break**
11:10-11:30	**Eric Keto** *The Formation of the Most Massive Stars in the Galaxy*
11:30-11:50	**Susanna Lizano** *Theory of Ultracompact HII regions*
11:50-12:10	**Takashi Hosokawa** *Evolution of the massive protostar with the high accretion rate*
12:10-12:30	**Kaitlin Kratter** *Gravitational Instability Induced Transport in Protostellar Disks*
12:30-14:30	**Lunch break**
14:30-14:50	**Enrique Vazquez-Semadeni** *Properties of dense cores and collapsed objects in numerical simulations of turbulent clouds*
14:50-15:10	**Marc Freitag** *The role of stellar collisions in massive star formation*
15:10-15:30	**Andrea Urban** *SPH Simulation of Clustered Star Formation with Dust and Gas Energetics*
15:30-15:50	**Sami Dib** *The Evolution of the Protostellar Mass Distribution: A Coalescence–Accretion Scenario*
15:50-16:50	**Poster session and coffee break**

16:50-17:30 **Barbara Whitney**
Radiative transfer processes in massive star formation

17:30-17:50 **Mayra Osorio**
Models for the molecular and dust emission of high–mass protostars

17:50-18:10 **Ian Bonnell**
The formation of massive stars in 30 Doradus

18:10-18:30 **Richard Klein**
The Future of Theory and Simulation in Massive Star Formation

18:45 **Bus departure for conference dinner at MPIA**

Thursday September 13th

Clustered Star Formation and Massive Star Formation throughout the Galaxy

09:00-09:40	**Lori Allen** *Clustered Star Formation*
09:40-10:00	**Wolfgang Brandner** *The Milky Way starburst cluster Westerlund 1 and its siblings*
10:00-10:20	**Nanda Kumar** *Spitzer–IRAC GLIMPSE of high mass protostellar objects*
10:20-10:40	**Lise Deharveng** *Massive star formation triggered by Galactic HII regions*
10:40-11:10	**Coffee break**
11:10-11:30	**Lincoln Greenhill** *Orion Revisited*
11:30-11:50	**Jonathan Tan** *Turmoil in Orion: The Nearest Massive Protostar*
11:50-12:10	**Norbert Schulz** *X–Ray Properties of Young Massive Stars in the Orion Trapezium Cluster*
12:10-12:30	**Sidney Wolff** *Angular Momentum and the Formation of Massive Stars*
12:30-14:30	**Lunch break**
14:30-15:10	**Oliver Krause** *Surveys of the Galactic plane*
15:10-15:30	**Ed Churchwell** *Triggered Star Formation via OB Stars*
15:30-15:50	**Elena Puga** *Probing the Early Evolution of Young High–Mass Stars*
15:50-16:10	**Chris Brunt** *High Spatial Dynamic Range Molecular Cloud Surveys*
16:10-17:00	**Poster session and coffee break**

17:00-17:20 **Robert Benjamin**
The Spiral Arms of the Galaxy: Stars and Star Formation

17:20-17:40 **James Urquhart**
A Galaxy–wide Sample of Massive Young Stellar Objects

17:40-18:00 **Farhad Yusef-Zadeh**
Massive Star Formation in the Galactic Nuclear Disk

18:00-18:20 **Cormac Purcell**
The CORNISH Survey of the Galactic Plane

18:20-19:20 **Moderator: Hans Zinnecker**
Panel discussion: Theoretical models and observational constraints.

Participants: I. Bonnell, Ch. McKee, M. Walmsley, H. Yorke, F. Palla

Friday September 14th

EXTRAGALACTIC STAR FORMATION

09:00-09:40	**Jay Gallagher** *Extragalactic Star Formation*
09:40-10:00	**Eva Grebel** *Star formation in dwarf galaxies*
10:00-10:20	**Adam Leroy** *Testing star formation recipes with THINGS*
10:20-10:40	**Yancy Shirley** *Connecting The Properties of Dense Molecular Gas in Galactic and Extragalactic Star Forming Regions*
10:40-11:10	**Coffee break**
11:10-11:30	**You-Hua Chu** *Are All Massive Stars Born in OB Associations or Clusters?*
11:30-11:50	**Tom Abel** *How the first massive stars shape the first galaxies*
11:50-12:20	**Malcolm Walsmley** *Posters summary talk*
12:20-12:30	**Poster prize winner**
12:30-13:00	**Thomas Henning** *Talks summary talk*
Afternoon	**Neckar boat cruise**
19:30	**Public talk by Harold Yorke** **in the University's Old Assembly Hall**

TALK CONTRIBUTIONS

How the first massive stars shape the first galaxies

Tom Abel
KIPAC, Stanford, U.S.A.

Using ab initio three dimensional radiation hydrodynamics we follow the formation of the first objects and the physics of the earliest HII regions. The impact on the first galaxies is dramatic and we illustrate it in detail.

Clustered Star Formation

Lori Allen
Harvard–Smithsonian CfA, Cambridge, U.S.A.

I will review current work on young clusters, with emphasis on what we are learning from recent observations about how clusters form.

Outflows in Massive Star Formation Regions

John Bally
University of Colorado, Boulder, U.S.A.

I will review the properties of outflows in massive star–forming regions including Orion, Cepheus–A, and Carina.

Collapse of Massive Cloud Cores

Robi Banerjee

ITA, University of Heidelberg, Germany

Here, we present our results of numerical simulations from the gravitational collapse of massive, magnetized molecular cloud cores. We show that massive stars assemble quickly with mass accretion rates exceeding 10^{-3} $M_{\odot}$/year and confirm that the mass accretion during the collapsing phase is much more efficient than predicted by selfsimilar collapse solutions, $dM/dt \sim c^3/G$. We find that during protostellar assembly the mass accretion reaches 20 – 100 c^3/G. Furthermore, we determined the self-consistent structure of bipolar outflows that are produced in our three dimensional magnetized collapse simulations. These outflows produce cavities out of which radiation pressure can be released, thereby reducing the limitations on the final mass of massive stars formed by gravitational collapse. Moreover, we argue that the extraction of angular momentum by disk-threaded magnetic fields and/or by the appearance of bars with spiral arms significantly enhance the mass accretion rate, thereby helping the massive protostar to assemble more quickly.

Infall and the formation of a massive star

Maite Beltran

Universitat de Barcelona, Spain

We present evidence of infall in a circumstellar rotating toroid enshrouding a luminous star in the massive star-forming region G24.78+0.08. Besides being one of the rare direct detections of infall in a young high–mass star, our finding stands unique for the simultaneous presence of three elements in the same massive object: a rotating, collapsing toroid, a bipolar outflow, ejected along the rotation axis, and a hypercompact ionized HII region. The large accretion rate and the existence of a hypercompact HII region confirm that the accretion cannot be spherically symmetric and must occur in a circumstellar disk.

The Spiral Arms of the Galaxy: Stars and Star Formation

Robert Benjamin

University of Wisconsin, Whitewater, U.S.A.

We present GLIMPSE results on the structure of the Milky Way both in the old stellar population and the star forming regions. We confirm the claim of Drimmell & Spergel (2001) that the Sagittarius–Carina spiral arm of the Galaxy, while clearly a major structure in star formation, is not associated with a detectable overdensity of red giants that trace the stellar mass of the Galaxy. We calculate the amplitude of both the stellar and star forming arms of the galaxy and discuss the implications for studies of global star formation.

Infrared view of massive accretion disk (candidates)

Arjan Bik
ESO Garching & Max–Planck–Institut für Astronomie Heidelberg, Germany

Near-infrared surveys of high–mass star–forming regions start to reveal the stellar content of these regions. One particular class of objects found are the massive Young Stellar Objects. These objects are surrounded by dense circumstellar material. For some objects there is evidence for a circumstellar disk. I will present a near- and mid-infrared study of those objects which provide information on different aspects of the circumstellar material.

The formation of massive stars in 30 Doradus

Ian Bonnell
University of St. Andrews, UK

I will present recent work on the formation of a starburst–type cluster containing one million solar masses in gas and forming over 100000 masses in stars. Of particular interest is the distribution of the high-mass stars in the cluster relative to that seen in 30 Doradus. The high-mass stars form through ongoing competitive accretion is simulation. This may provide an explanation for the upper mass limit of stars due to the timescale for the accretion.

The Milky Way starburst cluster Westerlund 1 and its siblings

Wolfgang Brandner

Max–Planck–Institut für Astronomie Heidelberg, Germany

Starburst clusters with ages of a few Myr represent unique astrophysical laboratories, as stars across the entire stellar mass range from the upper mass cut–off in the mass function down to the hydrogen burning limit (and possibly beyond) are present at the same time in a homogeneous environment. The galactic starburst cluster Westerlund 1 with its estimated 250 O–stars, W–R stars, supergiants and hypergiants is among the most massive young clusters in the Milky Way. While previous studies of Westerlund 1 focused largely on optical and X–ray observations of its evolved massive stellar population, we have analyzed near-infrared data, resulting in the first in depth study of the "lower–mass" main sequence and pre-main sequence cluster population, i.e., of stars in the mass range 0.4 to 30 solar masses. We derive cluster properties like size and shape, investigate evidence for mass segregation, study the question of co-evality of the low– and high–mass stellar population, test theoretical evolutionary tracks, and determine the (initial) mass function (including the search for upper or lower mass cut–offs). We also address the question if Westerlund 1 and its galactic siblings like the NGC 3603 Young Cluster, the Arches and Quintuplet clusters in the Galactic center region, and the R136 cluster in the 30 Dor region in the LMC can be considered as proto–globular clusters.

High Spatial Dynamic Range Molecular Cloud Surveys

Chris Brunt
University of Exeter, UK

Large–scale CO surveys define the Galactic distribution, structure, and dynamics of the mass reservoir available for star formation. New FCRAO surveys of ^{12}CO and ^{13}CO J=1–0 emission in the Outer Galaxy and Cygnus/Vulpecula regions, combined with the FCRAO Outer Galaxy survey and BU–FCRAO Galactic Ring Survey, have now completed contiguous 45″ coverage of the Galaxy's molecular clouds between l=18 and l=192. I will describe recent results and future prospects for the analysis of the Outer Galaxy clouds, with emphasis on an uninterrupted 20 kpc view of the Perseus Spiral Arm at sub-parsec resolution.

Are All Massive Stars Born in OB Associations or Clusters?

You–Hua Chu

University of Illinois, Urbana, U.S.A.

It has been commonly conjectured that all massive stars ($> 10\ M_{\odot}$) are born in OB associations or clusters. Many O and B stars in the Galaxy or the Magellanic Clouds appear to exist in isolation, however. While some of these field OB stars have been ejected from their birthplaces, some are too far away from massive star forming regions to be runaways. Can massive stars form in isolation? The Spitzer survey of the Large Magellanic Cloud (aka SAGE) provides a unique opportunity for us to investigate and characterize the formation sites of massive stars in an entire galaxy. We have identified all massive young stellar objects in the Large Magellanic Cloud. The locations of these massive young stellar objects are compared with those of HII regions, OB associations, HI and molecular clouds. We will present the statistical properties of massive star formation and provide an answer to the question whether massive stars can be formed in isolation.

The Structure and Evolution of Wind– Blown Bubbles Around Young O Stars

Ed Churchwell

University of Wisconsin, Madison, U.S.A.

I will examine a prototype case of triggered star formation by the expansion of an HII region/MIR bubble into the ambient ISM. Morphologies, timescales, spectral responses, and energetics will be discussed.

The conditions for competitive accretion

Paul Clark

ITA, University of Heidelberg, Germany

We will discuss the conditions under which the competitve accretion process will dominate the formation of the stellar mass function. This will include examples of clouds in which competitve accretion fails to produce the “correct” IMF. We will also contrast this highly dynamic process with the more traditional fragmentation picture, presenting observational tests for both.

Massive star formation triggered by Galactic HII regions

Lise Deharveng

Laboratoire d'Astrophysique de Marseille, France

What kinds of stars are formed at the peripheries of HII regions, and how? I will quickly review some of the processes triggering star formation on the borders of HII regions. Then I will concentrate on three questions: Can different processes be at work in the same region? Can the collect and collapse process work in an inhomogeneous medium? And how massive can the second–generation stars be?

The Evolution of the Protostellar Mass Distribution: A Coalescence-Accretion Scenario

Sami Dib

Astronomy and Space Science Institute, Daejeon, South Korea

Using semi-analytical modelling, I will discuss the effects of coalescence, mass accretion and mass outflow onto protostellar cores in order to show how the initial protostellar mass distribution which results from the gravo–turbulent fragmentation of a turbulent molecular cloud is modified in different environments, particularly at the high mass end. I will also discuss aspects and conditions of the transition from the protostellar mass distribution to the initial stellar mass function.

Searching for massive pre–stellar cores through observations of N_2H^+ and N_2D^+

Francesco Fontani

INAF–IRA, Bologna, Italy

Pre–stellar cores are dense and cold molecular condensations where the star formation process takes place. Protostars are born from gravitational collapse of these cores, so that understanding their internal structure allows one to constrain the initial conditions of the star formation process. So far, several examples of low–mass pre–stellar cores have been identified, but a sample of high-mass pre–stellar cores is lacking. Bearing in mind that high–mass stars form in clusters, we have searched for cold and dense spots close some well–known high-mass protostellar objects successful in the identification of low–mass pre–stellar cores, namely high values of the column density ratio $N(N_2D^+)/N(N_2H^+)$ and of the CO depletion factor. I will present both single-dish and interferometric observations that have allowed us to identify massive pre-stellar core candidates in the studied sources.

The role of stellar collisions in massive star formation

Marc Freitag

Institute of Astronomy, Cambridge, UK

In young star clusters, the density can be high enough and the velocity dispersion low enough for stars to collide and merge with a significant probability. This has been suggested as a possible way to build up the high-mass portion of the stellar IMF and as a mechanism leading to the formation of one or two very massive stars ($M \leq 150$ $M_\odot$) through a collisional runaway. I will review the standard theory of stellar collisions, covering both the stellar dynamics of dense clusters and the hydrodynamics of encounters between stars. The conditions for collisions to take place at a significant rate are relatively well understood for idealised spherical cluster models without initial mass segregation, devoid of gas and composed of main–sequence stars. I will discuss the many uncertainties. They include the role of more realistic cluster structures, the effect of interstellar gas, non–main–sequence stars and the structure and evolution of merged stars.

Extragalactic Star Formation

Jay Gallagher

University of Wisconsin, Madison, U.S.A.

This review talk considers several aspects of star formation that are most readily investigated in extragalactic systems. Basic techniques for determining extragalactic star formation rates are summarized. Starting on larger spatial scales I will consider how star formation is organized in galaxies, including in the high and low density regimes and how star formation rates and intensities depend on local conditions. In closing I will briefly discuss patterns of star formation and evidence for the universality of the stellar initial mass function.

Binaries in massive star formation

Douglas Gies

Georgia State University, Atlanta, U.S.A.

Massive stars are often found with nearby companion stars. The closer companions are detected as spectroscopic binaries through measurements of orbital Doppler shifts. However, a number of high angular resolution techniques are now available to discover the wider binaries. I will review the results from several high angular resolution studies of the massive O-type stars including a second epoch, speckle interferometric survey and an adaptive optics and Hubble Space Telescope survey of the very massive stars in the relatively nearby Cyg OB2 association.

Periodic variations in Class II methanol masers

Sharmila Goedhart

Hartebeesthoek Radio Astronomy Observatory, Krugersdorp, South Africa

Class II methanol masers are believed to be associated with an early evolutionary stage of massive star formation. The 6.7 GHz transition is particularly intense and is a good tool for studying conditions in the vicinity of the protostar, in a region which is highly obscured at optical wavelengths. Temporal variations in the masers can provide clues to conditions deep in the star formation region. A programme to monitor 53 6.7-GHz masers was carried out at Hartebeesthoek Radio Astronomy Observatory from January 1999 to April 2003 and subsequently continued on 19 of the sources. Analysis of the resulting time-series stretching over eight years shows that 6 of the sources exhibit periodic variations with periods between 133 to 504 days. A few more sources show what may be classified as quasi–periodic or regular variations. This is the first reported detection of periodic phenomena in massive star forming regions and the cause of the periodicity is not known at this stage. The waveforms in individual sources range from sinusoidal to sharp flares and there can be other long term trends in the time-series. The amplitudes of the variations can also change from cycle to cycle. The masers are believed to be pumped by MIR radiation, so they will be sensitive to changes in the radiation propagating through the dust surrounding the young star. The variability could also be modulated by the seed photons, which probably originate from a hypercompact HII region. In either case, the variability of the masers is pointing to a periodic process associated with the massive star. The challenge is to find out what the masers are telling us about the process of massive star formation.

Star formation in dwarf galaxies

Eva Grebel

Astronomisches Recheninstitut, Heidelberg, Germany

I will try to summarize our current picture of star formation in dwarf galaxies based on the study of resolved stellar populations in nearby dwarfs.

Orion Revisited

Lincoln Greenhill

Harvard–Smithsonian CfA, Cambridge, U.S.A.

I will review the results of recent studies of this archetypal region of massive star formation.

Formation of Massive Cores in Converging Flows: Rapid & Efficient?

Fabian Heitsch

University of Michigan, Ann Arbor, U.S.A.

Converging flows of atomic hydrogen provide a natural mechanism to form highly structured and turbulent molecular clouds, due to a combination of thermal and dynamical instabilities. Specifically the dynamical instabilities can lead to a focusing of the incoming gas streams, and thus provide a very efficient mechanism to form massive protostellar cores of a few 100 $M_\odot$ within 10 Myr, at flow parameters typical for the Galactic disk. I will discuss the relevance of this mechanism for massive star formation, including its predictions of where massive cores would form in molecular clouds, and the consequences for stellar feedback.

Evolution of a massive protostar with high accretion rate

Takashi Hosokawa

NAOJ, Osawa, Japan

Some scenarios of the massive star formation suppose the high accretion rate, such as 10^{-4} – 10^{-3} $M_{\odot}$/yr. We investigate the evolution of the massive protostar with these high accretion rates, solving the four stellar structure equations. Our calculations show that the evolution with the high accretion rate is fairly different from that with the low rate. The protostar remains fully radiative, and the evolution is similar to that of the primordial protostar. We show how the evolution depends on the accretion rate and metallicity, and explain what causes the difference. The validity of the previous one–zone model (e.g., McKee & Tan 03), and some implications for the formation and feedback processes of the massive stars are discussed.

Infrared Dark Clouds: Precursors to High Mass Stars

James Jackson
University of Boston, U.S.A.

Infrared Dark Clouds are identified as deep extinction features against the Galactic mid–infrared background. Through ^{13}CO and CS observations, we have determined kinematic distances to over 500 IRDCs. We find characteristic sizes of several pc and masses of a few thousand $M_{\odot}$, comparable to cluster–forming molecular clumps like Orion and Ophiucus. Millimeter continuum images show that IRDCs contain compact cores with sizes < 0.5 pc and masses $\sim 100\ M_{\odot}$. About 1/3 of these cores show unambiguous evidence for active star formation, such as outflows, high densities, broad lines, evidence for shocks, and "hot core" chemistry. Several have luminosities $> 10\,000\ L_{\odot}$, conclusively demonstrating that they contain high–mass protostars. Interferometeric images often reveal binary or multiple protostellar systems, indicating cluster formation. The "quiescent" IRDC cores are probably high-mass "starless cores".

The Formation of the Most Massive Stars in the Galaxy

Eric Keto

Harvard–Smithsonian CfA, Cambridge, U.S.A.

Is the formation of massive stars significantly different than that of low mass stars? A review of observations across the mass spectrum from B through O suggests that all stars form by accretion, yet the structure of the accretion flows and accompanying outflows changes because of the intense ionizing radiation of early stars. Observations of accretion flows around O stars show a two-phased structure with the molecular inflow crossing an ionization boundary and continuing inward as an ionized accretion flow. Observations also show that the formation of O stars is associated with wide–angle ionized outflows with properties consistent with an origin in thermal pressure gradients rather than the highly collimated outflows characteristic of magnetic origin that are seen associated with the formation of B and later stars. A simple model in which a massive star ionizes the inner portion of scaled-up version of a low–mass star forming accretion flow explains how the increasing ionization first produces a small HII region that is gravitationally trapped around the star. Higher levels of ionization extend the HII region beyond the radius at which the escape velocity equals the sound speed resulting in a thermally driven outflow perpendicular to the rotational flattening.

Outflow and Accretion in Massive Star Forming Regions

Pamela Klaassen

McMaster University, Hamilton, Canada

In order to distinguish between the various components of massive star forming regions (e.g, infalling, outflowing, and rotating gas structures) within our own galaxy, we require high angular resolution observations which are sensitive to structures on all size scales. To this end, we present observations of the molecular and ionized gas towards massive star forming regions at 230 GHz from the Submillimeter array (with zero spacing from the James Clerk Maxwell Telescope) and at 22 and 23 GHz from the Very Large Array at arcsecond or better resolution. These observations (of sources such as NGC7538 IRS1, W51e2 and K3–50A) form an integral part of a multi–resolution study of the molecular and ionized gas dynamics of massive star–forming regions (i.e., Klaassen & Wilson 2007). Through comparison of these observations with 3D radiative transfer models, we hope to be able to distinguish between various modes of massive star formation, such as ionized or halted accretion (i.e., Keto 2003, or Klaassen et al. 2006, respectively).

The Future of Theory and Simulation in Massive Star Formation

Richard Klein

University of California, Berkeley, U.S.A.

The formation of massive stars remains one of the most significant unsolved problems in astrophysics, with implications for the formation of the elements and the structure and evolution of galaxies. Despite the importance of massive star formation, relatively little is known about them theoretically as they pose a major theoretical challenge. I will discuss the physics necessary for development of a comprehensive theory of massive star formation. I will review our current state of simulation of the formation of massive stars from turbulent initial conditons and discuss the computational challenges inherent in the simulations. I will outline the future advances in the theory and numerical simulation that are likely to be necessary for a complete understanding.

Gravitational Instability Induced Transport in Protostellar Disks

Kaitlin Kratter
University of Toronto, Canada

We present one zone models of the evolution of massive protostellar disks under the influence of local and global gravitational instability. By mapping out disk stability, mass, and radius through the formation lifetime of these stars, we demonstrate the efficacy of gravitational instabilities in providing the necessary angular momentum transport for accretion. We also predict some potential observables for these massive stellar disks.

Surveys of the Galactic Plane

Oliver Krause

Max–Planck–Institut für Astronomie Heidelberg, Germany

I will review large scale surveys of the galactic plane, in particular at infrared and radio wavelengths, and will discuss their implications for an unbiased view of massive star formation.

From Massive Cores to Massive Stars

Mark Krumholz

University of Princeton, U.S.A.

The physical mechanism by which massive stars form is one of the outstanding problems in astrophysics, but one that has seen much recent progress thanks to an influx of new data. In the last few years, millimeter interferometers have revealed a population of compact (r $< \sim$ 0.1 pc), massive ($M \sim$ 100 $M_\odot$) gas cores that could be the direct progenitors of massive stars. I discuss the evolution of these objects, focusing on the questions of whether they collapse to a few massive stars or many low mass ones, whether stars formed in this process undergo a phase of competitive accretion that determines the stellar IMF, and whether radiation pressure from newly formed stars is able to halt accretion. Based on a combination of analytic modeling and simulations, I argue that massive cores are indeed the precursors of massive stars, and that many of the observed properties of young star clusters can be understood as direct imprints of the properties of their gas phase progenitors.

Spitzer-IRAC GLIMPSE of high mass protostellar objects

Nanda Kumar

Centro de Astrofisica da Universidade do Porto, Portugal

I will discuss a GLIMPSE study of 230 high mass protostellar objects (HMPOs) derived from the surveys of Sridharan et al. (2001), Molinari et al. (1996), Fontani et al. (2002) and Faundez et al. (2004). Based on analysis of photometric data and images we find infrared counterparts to HMPOs. These point sources show high spectral indicies in the IRAC bands indicating dense envelopes and 2D radiative transfer model fits to the complete SEDs suggest B stars between 10 – 20 $M_\odot$. Nearly 50% of the sources are surrounded by compact 8-micron nebulae whose dimensions are in the range of 0.1 – 1 pc with a mean value of 0.5 pc and show morphologies very similar of UCHII regions. We argue that these are the true precursors to UCHII regions. The overall results show early B stars associated with HMPOs that are still accreting matter. The presence of ionised gas in many of these sources suggest that ionised accretion flows may be important. These observations therefore favour a model of continuuing accretion involving both ionised and molecular components.

Dynamic Evidence of Triggered Star Formation

Hsu–Tai Lee

Institute of Astronomy and Astrophysics, Academia Sinica, Taipei, Taiwan

We find that massive stars in Per OB1 move away from the galactic plane. Although the proper motions of the members move same direction, the members of Per OB1 do not share common proper motions. Stars located at large galactic height move faster away from galactic plane as other OB associations. At large galactic height (> 280 pc), we discover four ongoing star–forming regions which are located on a border of a superbubble. These phenomena can be explain by star formation triggered by a superbubble. The superbubble created by active star formation in Per OB1 would push and accelerate molecular cloud away from the galactic plane. At the same time, the superbubble also triggers next generation of star formation. For molecular material accelerated by the superbubble, the stars formed within this material would naturally exhibit higher velocities away from the galactic plane than first generation stars. The young stars associated with the ongoing star–forming regions are the youngest members of Per OB1. This work may help us to understand the formation of massive stars in an OB association.

Testing Star Formation Recipes with THINGS

Adam Leroy

Max–Planck–Institut für Astronomie Heidelberg, Germany

We test the ability of several star formation recipes to predict the observed star formation rate from local conditions in The HI Nearby Galaxies Survey (THINGS). We test the commonly used Schmidt Law; thresholds based on the Toomre Q criteria, shear, and H column; a fixed depletion per orbital timescale; and a pressure–based prescription. We show the results as a function of galactocentric radius and discuss the current ability of star formation recipes to reproduce observations and the key elements of a successful star formation recipe.

Dissecting massive YSOs with mid-infrared interferometry

Hendrik Linz

Max–Planck–Institut für Astronomie Heidelberg, Germany

The very inner structure of massive YSOs is difficult to trace. With conventional observation methods we often identify structures still several hundred AU in size. But we also need information about the innermost regions where the actual mass transfer onto the forming high-mass star occurs. An innovative way to probe these scales is to utilise mid-infrared interferometry. Here, we present first results of our MIDI GTO programme at the VLTI. We observed some 10 well–known massive YSOs down to scales of 20 milliarcseconds. We clearly resolve these objects which results in low visibilities and sizes in the order of 50 milliarcseconds. Thus, with MIDI we can for the first time quantify the extent of the thermal emission from the warm circumstellar dust and thus calibrate existing concepts regarding the compactness of such emission in the pre-UCHII region phase. Special emphasis will be given to the disk candidate M8E–IR, where our modelling and our efforts to gather complementary observations are most advanced.

Theory of Ultracompact HII Regions

Susana Lizano
Centro Radioastronomía y Astrofísica, UNAM, Morelia, Mexico

I will discuss current theories of the formation and dynamics of ultracompact HII regions and their observational consequences.

Understanding the early evolutionary stages of massive star formation

Steven Longmore

UNSW, Sydney, Australia

To develop our understanding of the earliest stages of massive star formation, we have recently undertaken an imaging survey of ammonia with the ATCA toward a sample of 90 sources traced by 6.7-GHz methanol maser emission – an excellent indicator of early massive star formation (Longmore et al. 2007a). With LVG modelling of multiple ammonia transitions, we were able to calculate reliable gas column densities and kinetic temperatures to separate the thermal and non-thermal contribution to the measured linewidth and hence investigate turbulent injection (Longmore et al. 2007b). Making two reasonable assumptions, first, that the cores will increase in temperature as the internal powering sources 'switch on' and second, that these internal heat sources will inject turbulence into the gas through e.g. outflows, we built a coherent picture of the core's evolutionary stage. In this way, we have isolated a sample of massive cores with very low temperature and little turbulence, which we conclude are massive protostellar cores in their earliest stages of evolution. From simultaneously observed 24 GHz continuum emission, we were also able to determine which of these regions are associated with free-free emission from gas ionised by an existing massive star. Surprisingly, we found many of the 24 GHz continuum sources at locations devoid of 8 GHz continuum emission (reported from previous surveys, e.g. Walsh et al. 1998). Comparing the 8 & 24 GHz data sets, we concluded that either: **(i)** the continuum emission is significantly extended and thus resolved/filtered-out by the more extended array configuration of the previous 8 GHz observations, or, **(ii)** the continuum emission has a spectral index ~ 2 and is thus optically thick between 8 and 24 GHz characteristic of hyper–compact HII regions. Given that the 24-GHz-only sources are always coincident with both methanol maser and ammonia emission, the latter scenario seems more likely.

Feedback Processes

Mordecai-Mark Mac Low

American Museum of Natural History, New York, U.S.A.
(& MPIA/ITA–ZAH Heidelberg, Germany)

The lack of complete efficiency of gas consumption in massive star forming regions suggests that accretion is cut off by feedback from the newly formed stars. The initial mass function of the stars might be determined by this feedback. I will review the evidence for the importance of feedback in general, and for different mechanisms including ionizing radiation, collimated outflows, and stellar winds.

Accretion and Expansion from Spectral Line Profiles of Southern Massive Cores

Diego Mardones

Universidad de Chile, Santiago, Chile

We present CS, HCO^+, and CO molecular spectral line profiles from southern dense massive cores showing evidence of contraction and expansion motions. The lines were observed at the SEST, APEX, and ASTE telescopes and are spatially resolved within cores of typically 1 arcminute diameter. Radiative transfer models are used to derive mass accretion rates.

Masers in Regions of High–Mass Star Fomation

Karl Menten

Max–Planck–Institut für Radioastronomie Bonn, Germany

Masers from the H_2O, OH, and CH_3OH molecules have been found in many hundreds of star forming regions. H_2O masers arise in outflows from very young high– as well as low–mass. CH_3OH masers, in contrast, are only found in regions of high–mass star formation. They are associated with objects in different evolutionary stages, from the very early to developed ultracompact HII regions; OH masers are only found associated with the latter. CH_3OH maser pumping requires intense far–infared radiation and fairly high densities. This places these masers in the immediate vicinity of high–mass protostars and makes them effective signposts. Ongoing and future CH_3OH maser surveys will in fact be a most effective means to find such objects. Masers from other molecular species (NH_3 and SiO) are rare and may highlight interesting objects in very short evolutionary phases. Increasingly, trigonometric parallaxes of masers yield few percent distance determinations to far away regions.

The earliest phases of high–mass star formation in entire molecular complexes

Frederique Motte

CEA–Saclay/AIM, Gif–sur–Yvette, France

The earliest phases of high-mass star formation in entire molecular complexes We have started complete studies of several high-mass star–forming regions using submillimeter continuum imagings and follow-up surveys. We here present the results we recently obtained for the Cygnus X molecular cloud complex and compare them with other preliminar studies. Indeed, we have used the MAMBO–2 camera at the IRAM 30 m telescope to make an extensive 1.2 mm continuum mosaicing study of Cygnus X. Our complete study of with $\sim$ 0.09 pc resolution provides, for the first time, an unbiased census of massive young stellar objects. Since our sample is derived for a single molecular complex and covers every embedded phases of high-mass star formation, it gives the first statistical estimates of their lifetime. In contrast to what is found for low–mass class 0 and class I phases, the infrared–quiet protostellar phase of high–mass stars may last as long as their better–known high–luminosity infrared phase. Moreover, the statistical lifetimes of Cygnus X high–mass protostars and pre–stellar cores ($\sim 10^4$ yr and $< 10^3$ yr, respectively) are one (resp. more than two) order(s) of magnitude smaller than that found in nearby, low–mass star–forming regions. We propose that high–mass pre–stellar and protostellar cores are free–falling in a molecular cloud where highly turbulent processes dominate. We anticipate to measure lifetimes variations, if they exist, from the SIMBA or MAMBO–2 imaging we are currently analyzing for a couple of massive molecular cloud complexes.

Models for the molecular and dust emission of high–mass protostars

Mayra Osorio

Instituto de Astrofisica de Andalucia (CSIC), Granada, Spain

We summarize the main results of a modeling aimed to reproduce the observed properties of the earliest phases of massive star formation. The models calculate the spectral energy distribution (SED) as well as the molecular emission of massive protostars under the hyphotesis that they form via an accrecion process. We take into account a wide base set of observational data paying special attention to reproduce the high-angular resolution observations ($< 1''$) of the dust continuun emission and molecular line of high excitation levels. Firstly, we present a model of a spherically symmetric infalling envelope that reproduce simultaneouslly the SED and VLA subarcsecond observations of ammonia (4,4) hyperfine line emission. In this case, we are able to determine temperature, density, velocity, velocity dipersion, abundance variations along the core. Secondly, we present a model of a flattened envelope to reproduce the SED obtained with Gemini observations at the mid-infrared wavelengths. In this case, we are able to constrain parameters such as the degree of elongation, rotation of the envelope, inclination of the system, etc. With these two approachs we have been able to apply to the formation of the massive stars models with a degree of detail similar to those applied to the low-mass protostars.

From protocluster to infrared dark clouds

Nicolas Peretto
University of Manchester, UK

I'll present a detailed comparison of millimeter observations of the massive NGC2264–C protocluster with hydrodynamical simulations of a collapsing cloud. I'll show how dynamical interactions of protostellar clouds associated with the large scale collapse of the parent cloud can help to form the required initial conditions for massive star formation in the central dense core of the collapsing protocluster. The initial conditions of the collapse of the parent cloud being crucial for the subsequent star formation history of the cluster, I'll present the first results of a statistical study on infrared dark clouds, believed to be the progenitors of proto–clusters.

The innermost circumstellar environment of massive young stellar objects revealed by infrared interferometry

Thomas Preibisch

Max–Planck–Institut für Radioastronomie Bonn, Germany

Infrared long-baseline interferometry provides very high spatial resolution at scales of milli–arcseconds and thus allows to directly observe the innermost regions of the circumstellar environment of massive stars, at linear dimensions of about 1 AU. We will present the results of recent interferometric studies of several massive young stellar objects at near- and mid–infrared wavelengths. These data allow us to investigate the geometry of the inner circumstellar dust- and gas-distribution and to disentangle emission from warm dust, hot gas in accretion streams, and stellar winds. In some objects, the interferometric data also reveal changes of the dust grain properties with radial distance from the star, providing direct evidence for dust processing that may be the first step of the planet formation. These data provide strong constraints for theoretical formation scenarios for massive stars and new insight into the physical processes related to accretion, outflows, and winds.

Probing the Early Evolution of Young High–Mass Stars

Elena Puga

Instituut voor Sterrenkunde, Leuven, Belgium

Near-infrared imaging surveys of high-mass star forming regions reveal an amazingly complex interplay between star formation and its effect on the environment(Churchwell et al. 2006, Kaper et al. 2007, Alvarez et al. 2005). By means of near–IR spectroscopy the embedded massive young stars can be characterized and and placed in the context of their birth site. However, so far spectroscopic surveys have been hopelessly incomplete, hampering any systematic study of these very young massive stars. New integral field instrumentation available at ESO has opened the possibility to take a huge step forward by obtaining a full spectral inventory of the youngest massive stellar populations in star forming regions currently accessible. Simultaneously, the analysis of the extended emission allows the characterization of the environmental conditions. The FEMS collaboration aims at setting up a VLT Large Programme to obtain a full census of the stellar content, ionized material, outflows and PDRs over a sample of regions that cover a large parameter space. We will also establish the connection between H+K spectroscopy and radio/infrared observations. We have obtained 40 hours of SINFONI observations for a feasibility study of our proposed strategy: mapping 8 young regions of high–mass star formation. With this systematic study we will obtain a complete inventory of high–mass stellar properties to better constrain models. In this meeting, we will present first results and discuss their potential use to answer further relevant questions of high-mass star formation and early evolution (e.g. distance and age determination, detection of warm circumstellar associated features, IMF)

The CORNISH Survey of the Galactic Plane

Cormac Purcell

University of Manchester, Jodrell Bank Observatory, UK

The CORNISH survey, a 5 GHz radio continuum survey of the Galactic Plane, focusing on the northern SPITZER GLIMPSE region. The survey has been awarded 400 hours of VLA B–array time yielding 1 arcsecond resolution at a sensitivity of 0.2 mJy/beam, sufficient to detect UCHII regions right across the Galaxy. The same region is being covered by a new near-IR survey by the UKIDSS consortium and will also be part of a submillimetre continuum survey at the JCMT. The first 200 hours of observations (between *l*=22 and *l*=48 degrees) were successfully completed in September 2006 and the remainder of the target area will be observed in September 2007. It is hoped to release the resulting images and source catalogue to the community in mid–2008. In this talk we present the results stemming from the initial observations.

Models of cold massive cores

Matt Redman

National University of Ireland, Galway, Ireland

Cold massive cores are compared with their low mass counterparts using a 3D radiative transfer code to model observational line profile data. A major difference between the two types of object is that cold massive cores are much more turbulent than low mass starless cores. We suggest that this highly supersonic turbulence is best understood as being due to a large population of clumps embedded in a more tenuous medium. Many of these clumps will eventually undergo gravitational collapse to form individual low mass stars in a cluster around the massive stars.

X–Ray Properties of Young Massive Stars in the Orion Trapezium Cluster

Norbert Schulz

MIT Kavli Institute for Astrophysics and Space Research, Cambridge, U.S.A.

The HETG Orion Legacy project aims to study plasma properties of a large number of highly resolved X–ray spectra from young stars over a large range of masses and evolutionary stages. The HETG spectra are collected throughout the lifetime of Chandra and thus not only provide highly significant X–ray line strengths for detailed plasma diagnostics but also longterm X–ray monitoring. The heart of the Orion Nebula Cluster with a dynamic age of $\sim 3 \times 10^5$ yr is one of the youngest and closest star forming regions to our Sun and contains an ensemble of the youngest massive and intermediate mass stars we know in the Galaxy. Three out of at least four of the most massive ZAMS stars, Θ^1 Ori A, C and Θ^2 Ori A show coronal properties indicative of magnetic activity that is very likely not due to existing or unseen low-mass PMS companions. Θ^1 Ori E, now identified as an intermediate mass PMS binary, is the second most luminous X–ray source in the ONC, and shows very high persistent X–ray temperatures and high plasma densities which are quite unusual properties in comparison with the coronal activities observed in low–mass PMS stars in the neighborhood. The Orion properties are compared with the ones so far observed in several other young massive cluster cores and discussed in the context of early stellar evolution.

Connecting The Properties of Dense Molecular Gas in Galactic and Extragalactic Star Forming Regions

Yancy Shirley

University of Arizona, Tucson, U.S.A.

With the development of new, sensitive receivers on submm telescopes, it has now become possible to study warm, dense gas directly associated with high-mass star formation in external galaxies. I shall describe efforts to understand the correlation of the dense gas tracer, HCN, and bolometric luminosity in term of single–dish surveys (CS, HCN, HCO^+, and N_2H^+) of galactic high–mass cores. The nearly linear galactic–extragalactic HCN correlation over 10 orders of magnitude in bolometric luminosity indicates that the star formation rate per unit mass of dense molecular gas is constant from isolated galactic high-mass cores to the central regions of ULIRGs. Understanding the basis for this relation is a current theoretical challenge. The extragalactic correlation is also updated for the higher excitation HCN (3–2) line with observations obtained with the new single-sideband ALMA 1mm receiver at the SMT 10–m. The standard extragalactic optical star formation rate tracers, Hα and OI, are calibrated with respect to the amount of dense molecular gas.

Evidence for disks around young massive stars from 3D radiative transfer image modeling

Jürgen Steinacker

Max–Planck–Institut für Astronomie & ZAH, Heidelberg, Germany

While a paradigm for the formation of low–mass stars has been established that is based on accretion of gas and dust through a circumstellar disk, there is no agreed formation scenario for stars with masses greater than 10 solar masses. New evidences for the existence of large–scale flattened structures around young massive stars and compact HII regions is presented and analyzed by radiative transfer models:
i) An analysis as well as new data of the most–extended circumstellar disk known so far including a stability analysis of extended disk structures.
ii) A comparison of K-band images of the first hypercompact HII region with a disk candidate and scattered light models.
iii) A modeling of the first candidate for a remnant disk around a massive star.

Turmoil in Orion: The Nearest Massive Protostar

Jonathan Tan

University of Florida, Gainesville, U.S.A.

I describe how massive star formation theories can be tested by a detailed comparison to the Orion Nebula Cluster and in particular the BN–KL region.

SPH Simulation of Clustered Star Formation with Dust and Gas Energetics

Andrea Urban

University of Texas at Austin, U.S.A.

Forming stars affect their environment in many ways and one of the earliest effects is the heating of the dust and, indirectly, the gas by radiation. The heating of the gas will raise the Jeans Mass and affect nearby star formation, possibly inhibiting the growth of low mass stars. We investigate this process in our SPH simulation, which includes gravity, particle splitting, sink particles, and a new technique for modeling dust and gas energetics. The dust and gas energetics are powered by the accretion luminosity of young stellar objects which heats the surrounding dust to high temperatures. At high densities, the hot dust heats the gas through collisions. At lower densities, the heated gas is able to cool via rotational molecular lines, primarily from CO. At very low densities, the gas may also be heated by cosmic rays. We consider these effects in our simulation of a clustered star forming region. We discuss our methodology and preliminary results.

A Galaxy–wide Sample of Massive Young Stellar Objects

James Urquhart

University of Leeds, UK

The Red MSX Source (RMS) survey will be described which is the largest, systematic, galaxy–wide search for massive young stellar objects (MYSOs) yet undertaken. Mid-IR bright point sources from the MSX satellite survey have been followed-up with ground-based radio, millimetre, and infrared observations to identify contaminating sources and characterise the MYSOs and UCHII regions. With initial classification now complete the distribution of sources in the galaxy will be discussed along with highlights from beginning of the exploitation phase including results from IR spectroscopy, outflow mapping and chemical surveys.

The chemistry of high–mass star formation

Floris van der Tak
SRON, Groningen, Netherlands

This talk presents an overview of chemical processes during the formation of high–mass stars. After an introduction on the use of chemistry in astrophysics and basics of astrochemistry, the concept of chemical filters is introduced and illustrated with examples. Recent results in the field are reviewed including disk–outflow systems, large–scale ionization structure, and ice evaporation fronts. The talk concludes with an outline of future opportunities to answer open questions.

Properties of dense cores and collapsed objects in numerical simulations of turbulent clouds

Enrique Vazquez–Semadeni

Centro Radioastronomía y Astrofísica, UNAM, Morelia, Mexico

I report on recent results from numerical simulations of turbulent star-forming clouds, concerning the properties of the dense cores and of the collapsed objects forming within them, as a function of the global properties of their parent clouds. Cores formed by "focused" compressions (i.e., simultaneously in various directions) can produce Bonnor–Ebert–like structures, which however are bounded by ram-, rather than thermal pressure, and grow in time, evolving from stable to unstable configurations. Cores formed in moderately magnetically supercritical clouds exhibit lifetimes and number ratios of prestellar to stellar that are in good agreement with observations. Comparison of the collapsed objects in magnetic and non–magnetic regimes show that the former tend to form fewer but more massive objects. This can be interpreted as a consequence of the density fluctuations having systematically lower amplitudes in the magnetic case (for a given rms turbulent Mach number), and therefore the Jeans mass being systematically larger.

Maser polarization and magnetic fields

Wouter Vlemmings

Argelander Institute for Astronomy, Bonn, Germany

Maser emission offers a unique opportunity to study the environment of high-mass star–formation at extremely high resolution. Masers are uniquely suited for the study of magnetic field in high density regions. While observations of OH maser polarization are fairly commonplace, water maser polarimetric observations, probing the highest densities, are still fairly rare. In this talk I will present recent results of interferometric polarization observations of water and methanol masers and discuss their importance for studying magnetic fields during high–mass star–formation.

Southern Surveys of Hot Cores

Andrew Walsh

James Cook University, Townsville, Australia

I will discuss new results from the recently upgraded Mopra radiotelescope, where the unprecedented 8 GHz instantaneous bandwidth allows for very quick line surveys. It is now possible to compare line emission from many species in many transitions towards many sources.

Radiation processes in massive star formation

Barbara Whitney
Space Science Institute, Madison, U.S.A.

The topic of “Radiation Processes” encompasses many emission / absorption processes and many wavelength regions. I will focus on infrared radiation, and on interpreting the wealth of data available from ground-based observatories (near–IR imaging and polarimetry), space-based observatories (near– and mid–IR imaging and spectroscopy), and future observatories (far–IR imaging and spectroscopy). The radiation processes in these data include thermal emission from dust, PAH/small grain emission from photo-dissociation regions, molecular line emission/absorption, and polarization from aligned grains. I will briefly describe the processes and show how radiation transfer codes can guide us in interpreting data on, e.g., massive YSOs (including their polarization), HII regions and wind- blown bubbles, and molecular cloud structures.

Angular Momentum and the Formation of Massive Stars

Sidney Wolff

National Optical Astronomy Observatory (NOAO), Tucson, U.S.A.

The rotational properties of early B-type stars in low density environments are compared with those in high density environments The data show that **(1)** independent of environment, the rotation rates for stars in the mass range 6 – 12 solar masses do not change by more than 0.1 dex during the first 15 Myr after they reach the ZAMS; and **(2)** stars formed in high density regions lack the cohort of slow rotators that dominate the low density regions. This difference may reflect a combination of initial conditions and environmental effects.

Initial conditions for massive star formation

Friedrich Wyrowski

Max–Planck–Institut für Radioastronomie Bonn, Germany

In this talk, our knowledge of the initial conditions under which massive star formation takes place is reviewed. Massive stars are born in massive clumps of giant molecular clouds (GMCs), hence first the properties of GMCs are summarized. As an early stage of molecular clouds, infrared dark clouds (IRDCs) have been discovered a decade ago as dark patches in MIR images of the galactic plane and many studies of the physical conditions within them have been conducted recently. Without the guidance of MIR absorption, large scale, unbiased cold dust surveys can be used as well to identify massive cold clumps. In the absence of indicators of ongoing massive star formation, like compact HII regions and bright IR sources, these clumps are the most promising objects for the study of the initial conditions of massive star formation. Current observational approaches to find IR quiet clumps and their physical and chemical properties are reviewed.

Theoretical Developments in Understanding Massive Star Formation

Harold Yorke

Jet Propulsion Laboratory, Pasadena, U.S.A.

The collapse of a sufficiently massive molecular clump can in principal produce one or more high mass stars, but compared to the total number of stars produced high mass stars are the rare exception and not the rule. Nevertheless, when one or more high mass stars form, they dominate the evolution of the parent molecular cloud and control subsequent star formation through their winds, ionizing radiation and, ultimately, supernova explosions. In spite of their importance to star formation, the production of heavy elements and the overall evolution of galaxies, our understanding of high mass star formation is rather sketchy. The process of forming a massive star is not a straightforward scaled-up version of low mass star formation. Massive stars seldom, if ever, form individually; multiple systems, clusters and associations are the general rule. Outflows, pressure and radiative effects from multiple sources strongly influence but do not prevent the formation of massive stars via accretion. Accretion growth of an initially low mass object up to high masses is possible through a circumstellar disk. This requires high accretion rates onto the disk and through the disk onto central star of the order of or greater than 10^{-4} $M_{\odot}$ yr^{-1}. Central hydrogen burning begins while the young massive star continues to accrete material and it simultaneously photoevaporates its circumstellar disk and nearby disks on a timescale of $\sim 10^5$ yr. The final mass of the central star and nearby neighboring systems is determined by the interplay between radiation acceleration, UV photoevaporation, stellar winds and outflows, and details of the accretion process.

Massive Star Formation in the Galactic Nuclear Disk

Farhad Yusef–Zadeh
Northwestern University, Evanston, U.S.A.

It has been more than two decades since it was recognized that the general phenomenon of higher gas temperature in the inner few hundred pcs by comparison with local clouds in the disk of the Galaxy. This is one of the least understood characteristics of giant molecular clouds having a much higher gas temperature than dust temperature in the inner few degrees of the Galactic center. We propose that the enhanced cosmic ray electrons in the nuclear disk, as evidenced recently by a number of studies, are responsible for heating directly the gas clouds and elevate the temperature of molecular gas. The higher ionization fraction and higher thermal energy due to the impact of these electrons have important implications in slowing down star formation and reducing the MHD waves damping which results a high velocity dispersion of molecular gas in the nuclear disk. To support the role of cosmic rays in star forming regions, we show evidence of nonthermal radio continuum emission associated with the Sgr B2 cloud based on low–frequency GMRT and VLA observations. In addition, the correlation of methanal maser distribution against IRAC and MIPS images of Galactic nuclear disk will be presented.

Centimeter to Sub–millimeter View of Disks

Qizhou Zhang

Harvard–Smithsonian CfA, Cambridge, U.S.A.

Accretion disks play a central role in the formation of low–mass stars. Recent years have seen accumulating evidence for flattened disk–like structures surrounding massive young stars. In this talk, I will present recent high resolution observations of massive disks from cm to sub–millimeter wavelength, and radiative transfer modeling of the kinematics for a better understanding of the infall and accretion around massive young stars.

POSTER CONTRIBUTIONS

Spitzer observations of the Herbig Be star R Mon and its associated HH 39 Herbig-Haro object

Marc Audard

ISDC & Observatoire de Genève, Versoix, Switzerland

We report on results of our Spitzer Cycle 2 program to observe the young massive star R Mon and the associated HH 39 object in the mid-infrared. The aim of this program is to study the physical links in a young massive star between accretion disk, outflows and jets, and shocks in the associated HH object. Our analysis reveals that several knots of HH 39 are clearly detected in IRAC and at 24 microns, and possibly at 70 microns. The IRS spectra of HH 39 show weak evidence of [Ne ɪɪ] 12.8 μm and 0–0 S(1) H_2 17.0 μm lines. Finally, we obtained the IRS Short–High and MIPS SED–mode spectra of R Mon. A PAH emission feature at 11.3 μm is detected on top of the strong continuum. The combined IRAC, IRS, and MIPS data of the R Mon/HH 39 system help us to understand circumstellar disk processing, and the connection between jets, outflows, and HH objects.

Hypercompact H II regions: resolved images of G34.26+0.15 A and B

Martin Avalos

Centro de Radioastronomía y Astrofísica, UNAM, Morelia, Mexico

We report high resolution observations at $\lambda = 7$ mm of hypercompact H II regions G34.26+0.15 A and B. The images and the intensity profiles obtained show limb brightening, that indicate the existence of inner "holes" in the ionized gas. Using a spherical ionized model bounded by an inner and an outer radius with an electron density gradient $n_e \propto r^{-\alpha}$, one can reproduce the 7 mm intensity profile, spectral energy distribution, and observed angular sizes of both sources.

High Resolution Observations of W51 IRS2

Cassio Barbosa

IP&D – UNIVAP, São Paulo, Brazil

We present high resolution observations of the compact HII region associated with W51 IRS2. Photometry was performed in the NIR at VLT and MIR at Gemini–South. We also present AO correct IFU spectra obtained by Gemini–North facility NIFS.

First results from CHaMP

Peter Barnes

University of Sydney, Sydney, Australia

The Census of High- and Medium-mass Protostars is a complete, uniform, unbiased survey covering 120 square degrees in Vela & Carina. The main objectives of CHaMP are to identify, and derive demographic constraints on, all major phases of higher-mass star formation. Here we present preliminary results from the first season of this 4-year project, including initial estimates of lifetimes, spectroscopic trends, and diagnostics of physical and chemical conditions.

Chemical diversity in massive star formation

Henrik Beuther

Max–Planck–Institut fr̈ Astronomie Heidelberg, Germany

Synthesizing several datasets observed towards different massive star–forming regions over recent years with the SMA, and combining these with theoretical modeling, we outline chemical characteristics during the early evolutionary stages of high–mass star formation. Special emphasis will be given to the sulphur and nitrogen chemistry.

High–resolution observations of the high–mass protostars in Cygnus X

Sylvain Bontemps

OASU Bordeaux, Floirac, France

A population of 40 high-mass protostars were recently discovered by Motte et al. (2007) in the Cygnus X molecular complex situated at 1.7 kpc (Schneider et al. 2006). A large fraction of them are bright millimeter sources but coincide with weak infrared point sources suggesting they are still cold objects in the earliest stages of formation. Since the envelope masses of these protostars are large (more than 40 $M_\odot$), they are very good candidates to be actual precursors of OB stars. In order to confirm the nature of these objects (OB protostars), and to attempt to place them in an evolutionary (mass and age) diagram, high spatial resolutions observations in the millimeter range are required. We will present our recent observations of the 12 most massive objects with the IRAM PdB interferometer in the continuum, SiO(2–1), $H^{13}CO+$(1–0) and ^{12}CO(2–1) lines at 3 and 1 mm. A spatial resolution closed to 1 arcsec is obtained (at 1 mm) which corresponds to 1700 AU and is enough to separate individual collapsing objects. We find that there is a certain level sub-fragmentation with typical separations between 3000 and 5000 AU, but also these mini–clusters are usually dominated by one or two objects with massive envelopes. Outflows and some signs of complex kinematics are also found. We can therefore conclude that at least the most massive high-mass protostars in Cygnus X are certainly hosting OB protostars in their earliest stages of formation. These objects have powerful outflows, and are not yet bright in the infrared. We speculate that they may correspond to collapsing massive protostars just before an UCHII region develops (confirmed by recent VLA observations), i.e. perhaps, before the stellar embryo reaches 8–10 $M_\odot$.

Star formation in G333 triggered by dynamical feedback – the Mopra DQS survey

Michael Burton

School of Physics, Sydney, Australia

The Mopra telescope has been used to map a 1.2 × 0.6 degree region of the southern Galactic plane in rotational transitions of 20 different molecules. The survey, made possible by the wide bandwidth and high spectral resolution capabilities of the new MOPS receiver, has produced a unique data-set that is being used to give new insights into the dynamics and chemistry of the interstellar medium. Here we present some highlights of the results, showing how combinations of molecules can be used to trace dynamical structures such as molecular shells, outflows and gas filaments, and how these are related to star formation activity within the region. For example, the molecule N_2H^+ seems to be a surprisingly good tracer of shell-like structures within the G333 cloud. This molecule is generally found to trace cool, dense quiescent gas, and in this case seems to be tracing gas compressed by the shock front of an expanding shell. In some places the shells have begun to fragment and form dense cores, leading us to conclude that within the G333 region star formation is often triggered by dynamical feedback.

The NH_3/N_2H^+ abundance ratio in AFGL 5142

Gemma Busquet

Universitat de Barcelona, Barcelona, Spain

We present the results of CARMA observations of the N_2H^+(1–0) transition, as well as continuum emission at 93 GHz of the massive protocluster AFGL 5142. The 3 mm dust emission appears marginally resolved, showing an elongated structure toward the south-west in agreement with the previous higher angular resolution observations at 1 mm. The dense gas traced by N_2H^+ shows two main cores with some extended structure. While the peak of the NH_3 (1,1) emission is located in the same position as the millimeter source(s), the two N_2H^+ cores are found toward the east and west of the NH_3 core, suggesting there is strong chemical differentiation in the region.

Mid-IR Spectra of IRAS 20343+4129 IRS 1 and IRS 3

Murray Campbell

Colby College, Waterville, U.S.A.

Spectra of the two bright mid-ir sources in IRAS 20343+4129, IRS 1 and IRS 3, have been obtained between 8 and 13 microns at low resolution using MIRSI on the IRTF and at high resolution using TEXES on Gemini North. They are members of the survey of Sridharan (2002 ApJ 566, 931) that we had found to be bright and compact in N band (10.5 μm) and at 24.8 μm in a partial follow-up survey on the IRTF. At low resolution IRS 1 has moderately strong silicate (9.7 μm) absorption with a weak peak at 8.5 μm, and stronger emission at 13 μm, while IRS 3 has flat emission at 8 μm, rising to longer wavelengths. At high resolution, [Ne ɪɪ] was detected and mapped at IRS 3, but was not detected at IRS 1. [S ɪᴠ] was searched for but not detected at IRS 3. We present simple three component models that fit the low resolution spectra and the 24.8 μm photometry, and allow us to estimate the mid-ir extinction in each HMPO. The [Ne ɪɪ] map shows less extension than a 3.6 cm VLA map, but the strength of the [Ne ɪɪ] line and the 3.6 cm flux both indicate that IRS 3 can be powered by a B2 ZAMS star.

Multiple radiojets at the core of the NGC 2071 star–forming region

Carlos Carrasco-González

Instituto de Astrofísica de Andalucía, Granada, Spain

We present high angular resolution VLA multi-epoch observations at 3.6 cm towards the core of the NGC 2071 star–forming region. Our results suggest that this region contains a multiple system of YSOs and jets in a region of 4000 AU.

Water maser emission in starburst galaxies

Paola Castagnia

Max–Planck–Institut für Radioastronomie, Bonn, Germany

The properties of H_2O masers, high brightness temperatures, small size of individual spots, and narrow linewidth, make them a powerful tool to study the structure and dynamics of the emitting gas, because can be mapped at sub-milliarcsec resolution using VLBI. The importance of the most luminous water masers, the 'megamasers', is primary, since they can be used to determine the masses of nuclear engines in AGN and to map accretion disks (e.g. NGC4258). Recently, however, also the less luminous sources, the 'kilomasers' are gaining more and more scientific relevance, because they can mark the location of massive star forming regions and can be used to determine, through measurements of proper motion, distances and three dimensional velocity vectors of their host galaxies (e.g. M33, IC10). We have searched for 22 GHz water maser emission in a sample of FIR bright galaxies and detected two new kilomaser sources. The newly detected masers have been promptly followed-up using interferometric observations to derive positions and constraints on the size and brightness temperature of the emitting spots. Here we report results related to the newly detected kilomasers, also including the well-known kilomaser source in in NGC 253, which are all found to be associated with star-forming activity in the nuclear regions of their host galaxies.

Characterizing Star Formation Activity in Infrared Dark Cloud Cores

Edward Chambers

Boston University, Boston, U.S.A.

We have found evidence for active high-mass star formation in compact millimeter cores within Infrared Dark Clouds (IRDCs). IRDCs were discovered by the ISO and MSX infrared surveys as extinction features in the mid-infrared. We examined 38 of the highest extinction IRDCs in the millimeter continuum and found 189 compact cores, 140 of which are cold, compact and unassociated with 8 μm emission. Each IRDC invariably contains at least one cold, compact core, and many contain several. These cold, compact cores have sizes and masses of ~0.5 pc and 120 $M_{\odot}$. Roughly 30 percent of these cores show evidence for active star formation including **(1)** enhanced, slightly extended emission at 4.5 μm which might arise from shocked molecular hydrogen, **(2)** broad line widths (Δv ~ 10 km/s) of HCN(4–3) and CS(3–2), and the detection of SiO(2–1), a well–known shock tracer, **(3)** bright, compact 24 μm emission that indicates a deeply embedded protostar, and **(4)** maser emission, a signpost for high-mass star formation. The large number of active cores we find toward IRDCs suggests that IRDCs are indeed the earliest stages in the formation of high–mass stars and star clusters.

Spitzer-based study of Massive star forming regions

Luis Chavarria

CfA, Cambridge, U.S.A.

As a part of our Spitzer GTO program, we present Spitzer-IRAC, 2.1-m Flamingos, Keck-NIRC, and FCRAO-SEQUOIA observations of the massive star forming complex S254–S258. Using a combination of the IRAC and NIR data, we identified and classified the YSO in the complex. We detected 62 Class 0/I, 136 Class II, and 115 Class III sources. We also identified 449 sources with IR-excess. The YSO are found in clusters surrounded by isolated YSO in a low-density distributed population. The ratio of isolated to clustered YSO is ~1/5. We identify three new clusters in the complex. The structure of the molecular cloud is examined using ^{12}CO and ^{13}CO, as well as a near-IR extinction map. We find evidence of interactions between the molecular gas and the HII regions in the complex.

Massive Star Formation in the LMC HII Complex N44

Chang-Hui Rosie Chen

University of Illinois, Urbana, U.S.A.

We have used multi-wavelength observations to study massive star formation in the LMC HII complex N44, the prime object examplified in this meeting's Objectives webpage. The Spitzer IRAC and MIPS data are used to identify massive YSO candidates. We have also obtained CTIO 4m optical (UBVI) and near-IR (JK) imaging observations of N44 to extend the spectral energy distribution (SED) and to improve angular resolution. Fifty nine YSOs are confirmed through examination on these high-resolution multi-wavelength images and the best available SEDs from 0.36 to 70 μm. Among them, half are resolved into multiples or show extended images in the K band, stressing the importance of high-resolution observations in studying massive YSOs in extragalactic systems. We will present comparisons between the SEDs of single-source YSOs and best-fit models and discuss the goodness of the fits and the inferred physical properties of the YSOs, i.e., the masses of central sources and the extent of circumstellar disks and envelopes. We will also examine the relationships between YSOs, massive stellar contents, and interstellar environments to assess how star formation proceeded throughout the HII complex.

Massive Protobinary in the Hot Core W3(H_2O)

Vivien Chen

National Tsing Hua University, Hsinchu, Taiwan

We will present a sub-arcsecond line and continuum study of the nearby hot core W3(H_2O) at 345 GHz with the Sub–millimeter Array

Direct evidence for disks and accretion with massive stars

Rolf Chini

Astronomisches Institut Bochum, Bochum, Germany

Direct imaging and spectroscopic evidence for disks and accretion is presented for high-mass objects at various evolutionary stages, including accreting massive protostars, hyper–compact HII regions and main sequence O–type stars. Likewise, the question of multiplicity is addressed for all observed stages.

Line surveys with HIFI

Claudia Comito

Max–Planck–Institut für Radioastronomie, Bonn, Germany

In the next few years, Spectral Surveys across the submm and FIR bands accessible through HIFI (on board the Herschel Space Observatory) will provide crucial information for the understanding of the physical and chemical processes ongoing in star-forming regions. We will address the technical difficulties that must be taken into account in order to make the most of these very complex datasets, and show samples of the complete (490 through 1907 GHz) spectral survey of methanol emission, carried out during the testing procedure in January-June 2007.

A massive dense core in an early stage of evolution

Yanett Contreras

Universidad de Chile, Santiago, Chile

We present molecular line observations towards the cold core G305.136-+0068 in the CO(3–2), ^{13}CO(3–2) and CS(7–6) transitions, made with the ASTE telescope, and CS(2–1), CS(3–2) and CS(5–4) transitions made with the SEST telescope. We also present Spitzer/GLIMPSE images which show that the dust core is seen in silhouette in all the four IRAC bands and is surrounded by a shell of emission. We find three sources deeply embedded in this core, two of which are candidates for young high mass protostars still in the process of formation. Our observations support the hypothesis that G305.136+0068 is a massive and dense core in an early stage of evolution, in which the formation of high-mass stars have just started.

H_2 Velocity Structure in the Molecular Outflow DR 21

Irene Cruz–Gonzalez

Instituto de Astronomía, UNAM, Mexico D.F., Mexico

The molecular outflow DR 21 H_2 velocity cubes were obtained of the entire outflow emission using a scanning IR Fabry-Pérot interferometer with a spectral resolution of 24 kms. H_2 emission was detected from both the DR 21 (E) and DR 21 (W) lobes in a velocity interval (–80.82, +46.84) kms. The most conspicuous sources found include a jet-like region and a possible counter–jet, an elliptical cavity and four bow–like structures. The four velocity moment images of the outflow are used to study the moments along the outflow axis. Turbulence in the outflow is studied via a clump find analysis. Relations between clump parameters and kinematics allowed us to derive power–law relations in agreement with Larson's Laws.

A New Approach to Identifying High Mass Protostellar Objects: Extended 4.5 μm sources in the GLIMPSE survey

Claudia Cyganowski

University of Wisconsin–Madison, Madison, U.S.A.

A new sample of high mass protostellar object (HMPO) candidates has been identified by extended 4.5 micron emission in GLIMPSE images, thought to trace shocks in protostellar outflows. In general, the new HMPO candidates are significantly offset from the nearest IRAS source (1.6 arcminutes on average) and thus have not been previously identified. We will present images of selected candidates and comparisons with other tracers of molecular outflows and star formation activity.

Maser Disks or Maser Outflows?

James De Buizer

Gemini Observatory, La Serena, Chile

I will discuss recent observations towards several site of masers thought to exist in circumstellar disks around massive stars. I will compare older observations in H_2 in the near-infrared to new observations in SiO in the mm, and even mid-infrared continuum emission, all of which trace the outflows from these sources. The result of these observations confirm that generally the masers are directly related to outflows and not disks. The significance of the results to our present understanding of massive star formation and the observational properties of massive stars will be discussed.

Intermediate-mass star formation in young embedded stellar clusters

Massimo De Luca

INAF – Osservatorio Astronomico di Roma, Roma, Italy

In the framework of a multi-wavelength observational study of the Vela Molecular Ridge, a molecular cloud complex in the southern sky, we have identified a number of star forming sites in its cloud “D” hosting small embedded young stellar clusters. These are all associated with molecular clumps detected in the CO(1–0) line, hence their age is <1 Myr. Their most massive members are intermediate-mass stars in an early evolutionary stage. Low-mass star formation is also ongoing within the clusters. We show how observations from the Near-Infrared to the mm (including recent Spitzer data) are clarifying the star formation histories within these sites.

Rotational signatures of disks in massive star formation

Cassandra Fallscheer

Max–Planck–Institut für Astronomie, Heidelberg, Germany

We have obtained multiple data sets from the SMA, PdBI, and IRAM 30-m telescope of the Infrared Dark Cloud IRDC18223-3 and High-Mass Protostellar Object IRAS18151 in order to look for clues regarding the role of rotation and disks in high mass star formation. Because IRAS 18151 is at a later evolutionary stage than IRDC 18223-3, these two objects allow us to compare the central–most regions surrounding the embedded continuum source at two different periods in the formation process. Toward both regions we see rotational structures perpendicular to molecular outflows. Similarities and differences will be discussed in the context of core and disk evolution.

Formation of jets in low mass stars – implications for high mass stars

Christian Fendt

Max–Planck–Institut für Astronomie Heidelberg, Germany

I will review basic physical processes and recent results of MHD simulations of jet formation. The low–mass star jet formation scenario is discussed in the context of high–mass star formation.

IRDCs in the Outer Galaxy: Molecular Gas in an Early Star Forming State

Wilfred Frieswijk

Kapteyn Astronomical Institute, Groningen, The Netherlands

Massive stars and stellar clusters are believed to form in the cold, dense and massive dark clouds known as Infrared Dark Clouds (IRDCs). So far, these earliest observed stages of massive star formation are identified only toward the active inner regions of the Galaxy where a bright mid-IR background is present. We have recently completed an investigation of the distribution and clustering of near-IR (2MASS) red sources in the more quiescent Outer Galaxy. Some of these grouped sources have no clear counterparts in SIMBAD to explain the reddening and we suggest that these are reddened due to “unidentified” foreground clouds. In several cases the amount of reddening indicates large column densities ($A_V > 10$ mag) and the absence of bright mid- and far-IR emission (MSX, IRAS) suggests a cold environment. Follow-up observations on candidate dark clouds (e.g., G111.80+0.58, G121.74+0.22) reveal a filamentary molecular cloud structure containing several high density cores. We determine physical properties such as temperature, LTE and virial mass and density, from the molecular line observations (NH_3, ^{13}CO, $C^{18}O$ and $C^{34}S$) and show that indeed these objects represent cold, dense and massive molecular clouds in an early star forming state, very similar to Inner Galaxy IRDCs.

Stellar Content of UCHII Regions

James Furness

University of Sheffield, Sheffield, UK

I present a Spitzer MIPS far-IR study of UCHII regions, in order to constrain their massive stellar content. The hypothesis that UCHII regions harbour massive clusters is tested, via the comparison of far-IR luminosity and Lyman continuum flux for 28 sources. Complementary, VLT/VISIR imaging of mid-IR fine structure lines in UCHII regions will also be presented, enabling individual O stars to be spatially resolved.

Candidate Rotating Toroids around Four High–Mass (Proto)Stars

Ray Furuya

Subaru Telescope, National Astronomical Observatory of Japan, Hilo, U.S.A.

Using OVRO, NMA, PdBI, and SMA, we performed a search for “disk”-outflow systems towards high-mass (proto)stars deeply embedded in Hot Molecular Cores (HMCs). In the talk, I will present our results from the detailed analysis of velocity structure of the candidate rotating toroids, and wish to present some observational constraints on theoretical models; the velocity structure was investigated through observations of CH_3CN lines at mm to submm wavelengths. Results from three out of four sources have been already submitted to ApJ (Furuya et al 2007).

Associations of molecular masers at milli-arcsec angular resolution in high-mass YSOs

Ciriaco Goddi

Harvard–Smithsonian Center for Astrophysics, Cambridge, U.S.A.

We have conducted phase-reference VLBI observations of 22 GHz water and 6.7 GHz methanol masers toward two high-mass SFRs, AFGL 5142 and G24.78+0.08. In both sources, water and methanol masers emerge at similar positions and line-of-sight velocities, which suggests that a same YSO is responsible for the excitation of the two types of emission. Although associated with the same YSO, the two maser species appear to originate in different environments. In AFGL 5142 water masers trace expansion at the base of a protostellar jet, whilst methanol masers are more probably tracing infalling than outflowing gas. In G24.78+0.08, water masers trace a fast expanding shell surrounding a HC HII region driven by a strong stellar wind. Methanol masers are most likely emerging in a rotating toroid surrounding the HC HII region. Our results give support to models of accretion and jet ejection related to the formation of high-mass stars.

VLA 44 GHz Methanol Maser Observations in 3 Massive Star-forming Regions.

Laura Gomez

Max–Planck–Institut für Radioastronomie, Bonn, Germany

We report Very Large Array observations of NGC 6334, M17, and G8.67 -0.36. These three regions of high mass star formation were observed in the 44 GHz methanol maser transition, with arc-second angular resolution. These observations complete a previous, larger VLA survey of the 44 GHz methanol maser transition in high mass star-forming regions. In this poster we present the results of the observations and discuss some of their astronomical implications.

A Hubble–Spitzer view of star–forming regions in the Magellanic Clouds

Dimitrios Gouliermis

Max–Planck–Institut für Astronomie, Heidelberg, Germany

The Magellanic Clouds (MCs) offer an outstanding variety of young stellar associations, in which large samples of low- and high-mass stars currently in the act of formation can be explored sufficiently with the Hubble and Spitzer Space Telescopes. Pre-main sequence (PMS) stars and candidate Young Stellar Objects (YSOs) identified with these telescopes provide a unique snapshot of the star formation process, as it is being recorded for the last 20 Myr, and they give important information on the Initial Mass Function (IMF) of their host environments. I will present the latest results from space observations of such star-forming regions in the MCs, and discuss the importance of Hubble and Spitzer synergy for a comprehensive understanding of star formation and the IMF in low metallicities.

Probing the close environment of massive young stars with spectro-astrometry

Jorge Grave

Centro de Astrofisica da Universidade do Porto, Porto, Portugal

We test the technique of spectro-astrometry as a tool to study the close environment of massive young stellar objects (MYSOs). Archival VLT near infrared K band spectra ($R = 8900$) of 3 massive young stellar objects were analysed to search for positional displacements of emission lines in relation to the continuum source. We have found such spectro-astrometric signatures associated with the Br_γ line and the CO(2–0) and CO(3–1) bandheads showing various shapes and magnitudes. These results imply the presence of large disks/envelopes in emission and expanding shells of ionised gas. In particular, the results obtained for the source 18006–2422nr766 provide larger estimates (> 300 AU) for the CO emitting regions, indicating that in MYSOs, CO emission may also arise from the inner regions of extended dense envelopes. The overall results demonstrate the utility of a spectro–astrometric analysis of MYSOs to constrain the sizes of different physical entities in the close environment of such objects.

The Methanol Multibeam Survey

James Green

Jodrell Bank Observatory, University of Manchester, Macclesfield, U.K.

A new 7-beam methanol multibeam receiver is being used to survey the Galaxy for newly forming massive stars, that are pinpointed by strong methanol maser emission at 6.668 GHz. The receiver, jointly constructed by Jodrell Bank Observatory (JBO) and the Australia Telescope National Facility (ATNF), was successfully commissioned at Parkes in January 2006. The first 75 days of observations with the Parkes telescope have yielded over 650 methanol sources, of which over 250 are new discoveries. We present the survey methodology as well as preliminary results and analysis.

A Complete Inventory of High- and Intermediate-Mass YSOs in the LMC

Robert Gruendl

University of Illinois, Urbana, U.S.A.

We have used archival Spitzer observations of the Large Magellanic Cloud (LMC) comprised mostly of observations by the SAGE Legacy program to search for high- and intermediate-mass YSOs in the LMC. We then use optical and near-IR observations to minimize the contamination of this sample by evolved stars with IR excesses, such as Asymptotic Giant Branch (AGB) and post-AGB stars, and extended sources, such as background galaxies and nebular emission knots. The resulting sample of YSOs is unique in that they all have a common, well-established distance (50 kpc) and are close enough that both existing and follow-up observations can be used to better establish their nature, physical properties, and interstellar environment. We will present the methodology used to identify these YSO candidates and show examples where the combination of Spitzer IRAC and MIPS observations along with near-IR and optical observations are used to more precisely assess the physical properties of some YSO candidates.

Turbulence and feedback from high mass stars

Maiken Gustafsson

Max–Planck–Institut für Astronomie, Heidelberg, Germany

Feedback in the form of outflows, jets and winds is known to be significant in the early stages of star formation. Feedback processes from especially high mass stars may have a profound effect on the gas distribution in the immediate vicinity of the protostar and may be the determining factor whether or not further condensations will collapse to form stars or the ambient gas will be removed. Detailed insight into where and how either of the above scenarios takes place can only be gained by observations and simulations ability to reproduce the observations. We present a first statistical study of the gas motions in the close surroundings of a group of young high mass stars, namely the OMC1 region. In order to observationally resolve structures on the smallest possible scale we use infrared observations of shock–excited H_2 at 2.12 micron to characterise the velocity field. Using methods traditionally used in the study of turbulence, e.g. structure functions, we find that the data generally follow the trends observed at larger scales in turbulent clouds. This is true down to scales of 70 AU. However, the structure functions do show the presence of preferred scales which may be related to outflow processes. We compare the observations with simulations of hydrodynamical turbulence which are forced at large scales and without self-gravity. The general trend and the scaling of struture functions found in the observations are reproduced by the simulations. However, the simulations are unable to reproduce the preferred scales. As a next step we want to introduce outflows and/or winds in the simulations in order to get a better match to the observations.

Water masers in W3(H_2O)

Kazuya Hachisuka
Shanghai Astronomical Observatory, Shanghai, China

Water masers in W3(H_2O) have been known as a bipolar outflow whose driving source is a synchrotron emission source, the Turner–Welch (TW) object. Most masers are distributed inside the TW object, however, recently we found extreme high velocity components at the outside of, and perpendicular to, the TW object's elongated structure. We will present the kinematics of water masers in W3(H_2O) and the models.

Far–infrared selected high–mass starless cores and protostars

Martin Hennemann

Max–Planck–Institut für Astronomie, Heidelberg, Germany

The far-infrared continuum is excellently suited to detect high-mass starless cores and protostars: Due to their very low temperatures such objects are expected to radiate most of their emission in the thermal dust continuum beyond 100 μm. The 170 μm ISO Serendipity Survey was the first large-scale sky survey beyond the IRAS limit and resulted in the detection of more than 50 massive sources during the earliest stages of star formation. Utilizing submillimeter mapping and Spitzer observations allows us to characterize the starless cores and protostars in detail: They exhibit cold dust temperatures of 20 K and less, masses of tens to hundreds of solar masses and we can distinguish between genuine prestellar objects and deeply embedded protostars detected at 24 μm. Additional molecular line observations reveal infall signatures of an early collapse as well as outflow activity. Excellent examples are submillimeter cores in the ISOSS J23053+5953 and ISOSS J18364-0221 regions which may represent the youngest high-mass protostellar cores observed so far. They feature infalling envelopes and molecular outflows confirmed by high-resolution interferometry. These observational findings provide new constraints on the initial conditions of massive star formation and support the scenario of accretion to build up high-mass stars. Far-infrared missions like Akari and Herschel provide outstanding possibilities to extend our detection strategy for early evolutionary stages of high-mass stars in the near future. References: Stickel, Krause, Klaas, Lemke: The ISOPHOT 170 μm Serendipity Survey. IV. The far-infrared sky atlas, A&A 466, 1205 (2007); Krause, Lemke, Toth et al.: A very young star forming region detected by the ISOPHOT Serendipity Survey, A&A 398, 1007 (2003); Birkmann, Krause, Lemke: Very Cold and Massive Cores near ISOSS J18364-0221: Implications for the Initial Conditions of High-Mass Star Formation, ApJ 637, 380 (2006); Birkmann, Krause, Hennemann et al.: ISOSS J23053+5953: A massive protostellar core with an infalling envelope, accepted for publication in A&A (2007)

Kinematics of IRDCs

Audra Hernandez

Department of Astronomy – University of Florida, Gainesville, U.S.A.

Massive stars and star clusters are important throughout astrophysics due to their effects on many systems, from galaxy evolution to planetary formation. Galactic massive stars and star clusters form from the densest gas clumps within Giant Molecular Clouds. These clumps reveal themselves by IR extinction and are known as Infrared Dark Clouds (IRDCs). The McKee & Tan (2003) and Tan et al. (2006) models for massive star and star cluster formation assume that IRDCs are near virial equilibrium. To test this, we use ^{13}CO Galactic Ring Survey (GRS) data to determine kinematic distances and dynamical masses of a sample of 9 IRDCs and their embedded cores. First we employ a simple virial relation, ignoring external pressure, to derive cloud masses and compare those with the extinction mass results of Butler et al. (2007). We find that the cloud masses derived from the average ^{13}CO line width are within a factor of about three of the extinction masses. Cloud masses derived from the dispersion of the peak velocities of embedded cores are much smaller. We have also derived pressure-bounded virial masses of cores by assuming the density and pressure are power-laws in radius, and the external pressure is related to the mass surface density of the surrounding cloud material. These core masses are also compared with the core extinction masses of Butler et al. (2007).

High luminosity hot cores in the southern hemisphere

Carolin Hieret

Max–Planck–Institut für Radioastronomie, Bonn, Germany

We have started a survey of potential high mass star forming regions in the southern hemisphere with the APEX telescope. The sources were selected based on diverse signposts (both presence and absence of masers, UCHII regions, IR colours etc.), since we were trying not to limit ourselves to an evolutionary stage. Due to our frequency selection which covers the whole sub-mm window accessible from the lines, we can study lines originating from many different states of excitation, including highly excited ones. This probes regions from the very innermost center of star forming sites. With this approach we hope to be able to classify evolutionary stages for a statistically significant sample of sources. In this talk I would like to introduce the survey and present in more detail the work done on three high luminosity hot cores, which form a precursor study to the survey and have also been followed up with the ATCA.

A study of the physical relation between embedded clusters and their natal clumps by using the Nobeyama 45m telescope with the 25-Beam Array Receiver System (BEARS)

Aya Higuchi

Tokyo Institute of Technology, Tokyo, Japan

To reveal the relation between the clusters and the natal clumps, we have carried out a survey of the dense clumps associated with 11 embedded clusters in the $C^{18}O$ (J= $1-0$) line emission with the Nobeyama 45-m telescope in the period from 2005 December to 2006 May. The target sources were selected to be still embedded within molecular gas and well–studied by means of near–infrared observations. In this survey we made typically $6' \times 6'$ maps around the center of the 11 regions. We have succeeded in obtaining the maps of all the clumps with sizes of 0.6–1.8 pc, masses of 200–1500 $M_{\odot}$ and velocity widths of 1.8–3.4 km/s. The $C^{18}O$ clumps are located towards clusters. Our analysis showed that all the clumps are most likely to be in virial equilibrium, suggesting that the dense clumps have the potential for cluster formation. On the basis of the physical properties (size, mass, and velocity width) of the clumps, we suggest that the $C^{18}O$ clumps almost retain the initial conditions for the cluster formation. We have found an interesting correlation between the highest stellar masses of the clusters and the velocity widths of the $C^{18}O$ clumps. The best–fit power–law function is $M_{\rm max}[{\rm M}_{\odot}] = (1.43 \pm 0.38) \times (\Delta V_{\rm clump}[{\rm km/s}])^{(2.3\pm0.29)}$. Considering that the $C^{18}O$ clumps most likely reflect the mass, size, and velocity width just before the cluster formation, we interpret the power–law relation as follows: The most massive stars form within individual cores through the dynamical accretion in a similar way to the case of the low–mass star formation. Furthermore, the coefficient of the relation seems to support the initially gravitationally unstable state of the cores as assumed in the Larson–Penston solution.

Identifying Young Massive Stars

Tracey Hill

Sterrewacht Leiden, Leiden, The Netherlands

I will present the results of spectral energy distribution (SED) analysis of the sources in the SIMBA sample of Hill et al. (2005). Analysis reveals the mm-only sources (those without masers and UC HII regions) to be cooler, less luminous but of comparable mass and radii to sources with a methanol maser and/or radio continuum source. The mm-only population is also bimodal in terms of temperature. Analysis of this bimodal mm-only temperature distribution will be presented and conclusions about the mm-only sample and their role in the formation of massive stars discussed.

Astrometry of H_2O maser sources in Orion KL with VERA

Tomoya Hirota

National Astronomical Observatory of Japan, Tokyo, Japan

We will report on the recent results of astrometic observations of the H_2O masers in Orion KL with VERA, a newly constructed Japanese VLBI network. We have measured annual parallax of Orion KL to be 2.29 ± 0.10 mas, corresponding to the distance of 437 ± 19 pc from the Sun. We will also present the absolute proper motions of the H_2O masers in Orion KL.

Disc Winds from Massive Young Stellar Objects

Melvin Hoare

University of Leeds, Leeds, U.K.

I will discuss the evidence for radiatively driven disc winds from massive young stellar objects (YSOs). Radiation hydrodynamic models predict that the radiation pressure due to an OB star at the centre of an accretion disc will drive an equatorial wind away from the surface of the disc at several hundreds of km/s. Such a wind morphology has been seen in high resolution radio maps of a few massive YSOs. These winds should also give rise to double-peaked or flat-topped profiles in the infrared HI emission lines. New evidence for such profiles will be presented from a new sample of massive YSOs.

The youngest massive cluster in the Galaxy?

Vera Hoffmeister

Astronomisches Institut, Ruhr–Universität Bochum, Germany

The young cluster NGC 6618 (M17) has been investigated by optical and NIR imaging and spectroscopy with unprecedented sensitivity. New, deeply embedded high-mass stars could be identified, leading to a consistent picture of the energy balance for the H II region. The HR diagramm suggests at least two generations of several thousand new-born stars, most of which - including early B-type stars - have not yet reached the main sequence. X-ray emission and IR-excess frequency are studied as a function of stellar mass and age.

Formaldehyde Masers in Massive Star Forming Regions

Peter Hofner
New Mexico Tech and NRAO, Socorro, U.S.A.

The 6 cm maser transition of H_2CO has been found exclusively toward massive star forming regions. We have recently conducted dedicated surveys for this maser and increased the number of known 6 cm H_2CO masers sources from 3 to 7. We report here results from these surveys as well as results from interferometric observations which are aimed at exploring the astrophysical scenarios of the H_2CO maser emission sites. We also comment on results of variability studies and the possible relation to the massive star formation process.

The Spitzer Legacy Survey of the Cygnus–X Region

Joseph Hora

Harvard–Smithsonian Center for Astrophysics, Cambridge, U.S.A.

We describe the recently accepted Spitzer Legacy program that will survey the Cygnus-X region, a massive star formation complex containing the richest known concentration of massive protostars and the largest OB associations in the nearest 2 kpc. This unbiased survey of 24 sq degrees in Cygnus-X with the IRAC and MIPS instruments will have the sensitivity to detect young stars to a limit of 0.5 solar masses. With this survey we will **(1)** analyze the evolution of high mass protostars with a large and statistically robust sample at a single distance, **(2)** study the role of clustering in high mass star formation, **(3)** study low mass star formation in a massive molecular cloud complex dominated by the energetics of 100 O-stars, **(4)** assess what fraction of all young low mass stars in the nearest 2 kpc are forming in this one massive complex, and **(5)** provide an unbiased survey of the region and produce a legacy data set which can be used in conjunction with future studies of this region (e.g., with Herschel and JWST). The Cygnus-X survey will be an important step in constructing one of Spitzer's greatest legacies: surveying with high sensitivity and spatial resolution a representative sample of Galactic star forming regions, from Bok globules to complexes containing millions of solar masses of gas and hundreds of O-stars. The data will be made available to the astronomical community in the form of images, source catalogs, and 3 – 70 micron photometry. We present the plans for the Spitzer Cygnus-X observations, and initial results from previous Spitzer and ground-based optical imaging of the survey field.

Suzaku X-ray spectroscopy of a peculiar hot star near the Galactic center

Yoshiaki Hyodo

Kyoto University, Kyoto, Japan

We present the results from a Suzaku study of a bright point-like source located at a projected distance of 100 pc from the Galactic center. We detected an intense Fe XXV 6.7 keV emission line from this source, CXOGC J174645.3–281546. The overall spectrum is described very well by a heavily absorbed ($N_{\mathrm{H}} = 2 \times 10^{23}$ cm^{-2}) 50 MK plasma. The probable counterpart in the infra-red bands has a very red (J–Ks = 8.2 mag) spectral energy distribution (SED), which is fitted by a blackbody emission of 1000 K attenuated by a visual extinction of 31 mag. The high plasma temperature and the large X-ray luminosity (3×10^{34} erg/s @ 8 kpc in the 2–8 keV band) are consistent with a wind-wind colliding Wolf-Rayet binary. The similarity of the SED to those of the eponymous Quintuplet cluster members suggests that the source is a WC-type source.

Circumstellar disks of massive protostars revealed by high–resolution near infrared polarimetric images

Zhibo Jiang

Purple Mountain Observatory, Nanjing, China

Observations of two B-type protostars – How do the extreme conditions of massive star formation affect outflow and accretion properties?

Katharine Johnston

School of Physics and Astronomy, University of St. Andrews, St. Andrews U.K.

We have observed two early B-type protostars in outflow - AFGL2591 and Mol 12. With multi-configurational VLA observations, we have begun to map the HII regions and ionized outflows associated with these protostars. With complementary CARMA observations of Mol 12 we have mapped the molecular outflow in ^{12}CO and ^{13}CO, and several lines to trace the core, disk and torus: CH_3OH, CH_3CN and $HCOOCH_3$. Combining these we hope to link cause and effect: how do the more extreme conditions of massive star formation - a forming HII region, strong stellar winds, and a more massive and possiblly more turbulent disk - affect the accretion and outflow properties of the protostar? This poster presents our preliminary results.

Star Formation in the NGC 7538 region

Osamu Kameya

National Astronomical Observatory of Japan, Oshu, Japan

The detailed distribution of water masers at the IRS 1–3 complex and IRS 11 in the NGC 7538 region is shown by VLBI observations. The distribution is compared with the shape of CO outflows, ultracompact HII regions, and other activities in this region.

NANTEN2: A Submillimeter Telescope for Large Scale Surveys at Atacama

Akiko Kawamura

Nagoya University, Nagoya, Japan

We have installed the 4-m telescope, NANTEN2, at Pampa la Bola at an altitude of 4,800m to realize a large-scale survey at submm wavelengths. We have been carrying out extensive molecular cloud surveys in the Galaxy and the Magellanic system for seven years with the 4-m mm-telescope, NANTEN, at Las Campanas observatory, Chile. In this new NANTEN2 project, we will make large-scale surveys in a 100-800 GHz range by using mainly CO and CI lines. The purpose is an elucidation of evolution of interstellar matter and the mechanism of star-formation in the Local Group by revealing the distribution, kinematics, and physical conditions of interstellar gas in the atomic-molecular phases. The highest observing frequencies will be covered by the KOSMA SMART receiver, a dual-frequency array receiver operating between 490 and 810 GHz bands, and array AOS and digital Fourier spectrometer as backends. The installation started at the beginning of 2004. We successfully started submm observations in September 2006, with a 490/810 GHz single-channel receiver. In this workshop, we will present the most recent results by the NANTEN2 submm observations toward the Galaxy, Magellanic Clouds, and nearby galaxies. This project is in collaboration between universities in Japan (Nagoya Univ. and Osaka Prefecture Univ.), in Germany (Univ. of Cologne and Univ. of Bonn), in South Korea (Seoul National Univ.), in Chile (Univ. of Chile), in Australia (Univ. of New South Wales, Sydney Univ. and Macquarie Univ.), and Switzerland (ETH Zurich).

Survey of Molecular Clouds in the Magellanic Clouds by NANTEN; Properties of the Molecular Clouds and Star Formation

Akiko Kawamura

Nagoya University, Nagoya, Japan

High mass stars and massive clusters characterize star formation activity in galactic scales; massive stars have substantial effects on triggering further star formation from at their early stages to at the end stages. The Large and Small Magellanic Clouds (LMC and SMC) make us possible to study how the interstellar medium evolves and how stars are formed in detail because of their proximity to us. Its favourable viewing angle also let us study the properties of the molecular clouds and star formation activity without contamination along the line of sight especially for the LMC. We have made large-scale surveys of the molecular clouds in the Magellanic Clouds by NANTEN. The surveys gave us a complete set of about 300 molecular clouds with an angular resolution as high as about 40 pc. The GMC dataset includes those with different star formation activities through out the galaxies. Futher observations by sub-mm telescopes, ASTE and NANTEN2 made us possible to detect dense cores in these clouds. Optical, Infrared and Radio continuum observations have been indicating large samples of formation sites of stars or clusters. Recent infrared observations, Spitzer and Akari, revealed the distribution and properties of the YSOs. We will present the properties of the molecular clouds and star formation activities.

Star-Formation in the vicinity of Cygnus 0B7

Tigran Khanzadyan

National University of Ireland in Galway, Ireland

(not final)SiO maser observation towards Orion KL with VERA

Mikyoung Kim

National Astronomical Observatory of Japan – Univ. of Tokyo, Tokio, Japan

(not final)We made multi-epoch observations of SiO masers in Orion-KL using VERA and measured the proper motions of SiO maser spots.

Induced star formation in S 235

Maria S. Kirsanova
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S235 is an optical HII region situated in the Perseus Spiral Arm. It is the brightest HII region in the degree-sized star forming complex containing giant molecular cloud (mapped with the FCRAO multibeam array in CO(1–0) and ^{13}CO(1–0) lines by Heyer et al., 1996) with several embedded star clusters. Presence of methanol maser at 6.7 GHz means that there is at least one recently formed massive star. Star counts based on the data of 2MASS survey reveal presence of several young stellar clusters in the S 235 vicinity. Their formation was probably induced by the shocks propagating from the expanding HII region. In order to investigate star formation phenomena in the S 235 region we performed mapping of CS(2–1) and ^{13}CO(1–0) molecular lines with the 20m Onsala telescope. The maps display that molecular gas around S 235 HII region forms clumps with the sizes of $1-2$ pc. It was found that he clumps seen in CS(2–1) emission are associated with embedded young stellar clusters. Maps in ^{13}CO(1–0) line reveal presence of more numerous clumps which can be divided into 3 groups which have different velocities. Clumps emitting in the range of velocities –18 km/s $< V_{\rm lsr} <$ –15 km/s are generally weaker and more distant from the border of HII region. Their velocities are in agreement with those of the bulk of the gas of the giant molecular cloud which has relatively smooth distribution (according to the map of Heyer et al., 1996). These clumps are very poorly pronounced in CS(2–1) emission (which traces dense gas) and show no association with the stellar clusters. So, these clumps probably represent “primordial” molecular gas which was not affected by the propagation of the shocks from expanding HII region and by the star formation processes. Emission in the $V_{\rm lsr}$ range from –21 km/s to -18 km/s is more concentrated to the HII region. These clumps are well pronounced in CS(2–1) emission and show clear association with the young stellar clusters. This is most probably the gas entrained in motion by the expansion HII region. This expansion produced a shock which compressed the gas. The gravitational instability in compressed layer caused subsequent formation of the young stellar clusters which are still embedded in parental molecular gas. Distribution of the gas with these velocities in the giant molecular cloud around S 235 is patchy (according to Heyer et al., 1996) which supports its association with the active processes. Emission in the V_{lsr} range from –25km/s to -21km/s is projected on the borders of the young stellar clusters. This V_{lsr} range corresponds to the blue-shifted velocity extreme of the giant molecular cloud (see map by Heyer et al., 1996). These clumps are not bright in CS(2–1) line and probably represent a wind from the recently formed stellar clusters. Distribution and kinematics of the gas as well as locations of the embedded stellar clusters in the S 235 region are in good agreement with the case when the formation of the young stellar clusters and at least one massive star are induced by expansion of HII region. Physical conditions of the gas in this region and relevant scenario of the star formation process are subject to further investigation.

Triggered Star Formation in W5

Xavier Koenig
Harvard University, Cambridge, U.S.A.

Observations of massive star forming regions with Spitzer (SSC) IRAC and MIPS have been invaluable in contributing to the study of their formation and feedback effects on their surroundings. Aided by its unprecedented sensitivity in the mid-IR 3 – 24 microns, astronomers are now able to map large regions at high resolution, gaining new insights into both small scale and large parsec-scale interactions and processes. We have carried out a 2 × 1.5 degree imaging survey of the W5 star forming region with SSC - we detect several massive star clusters that are carving out two large HII region bubbles and triggering a second generation of star formation in the remnant molecular material. The largest of these, a double cluster, contains at least 340 stars, 38% of them with infrared excess emission characteristic of circumstellar disks. We present initial results from our analysis - we model the age sequence of star formation in the context of recent models of the collect and collapse paradigm of triggered star formation. We also examine the effects of the FUV emission from massive O and B stars (there are at least 11 O stars and ~159 B stars in W5) on stellar accretion disks throughout the region by constructing a map of the radiation field across W5. Our results show exciting prospects for advances in understanding the evolution of massive star formation in a large region like W5.

Outflows from the high-mass protostar NGC 7538 IRS1/2 observed with bispectrum speckle interferometry

Stefan Kraus

Max–Planck–Institute for Radioastronomy, Bonn, Germany

NGC 7538 IRS1 is a high mass protostar with a CO outflow, an associated ultracompact HII region, and a methanol maser linear structure, likely tracing a Keplerian-rotating circumstellar disk. We present near-infrared bispectrum speckle images obtained with the 6.5m MMT and the 6m BTA telescopes, showing a fan-shaped outflow structure, in which we detect 18 stars and several blobs of diffuse emission. We find a misalignment of the axes associated with the various outflow tracers, which is interpreted in the context of a disk precession model.

Infrared ionic and molecular line imaging of high-mass star-formation regions

John Lacy
University of Texas, Austin, U.S.A.

We have observed NGC 7538 IRS1, W3 IRS5, and Orion KL with TEXES on Gemini and the IRTF with $0\farcs4$ – $1\farcs4$ spatial resolution and 4 km/s Doppler resolution. The [Ne II] (12.8 μm) ionic line was observed and spatially resolved in NGC 7538 IRS1. The line profile varies markedly on scales as small as $0\farcs4$ (~1000 AU). C_2H_2 and HCN were observed in absorption toward the compact continuum sources in all three high-mass regions and in emission, or resonant scattering, toward the surrounding gas in W3 and Orion. Apparently, the C_2H_2 and HCN have enhanced abundances in close vicinity to massive stars, likely because of evaporation of icy grain mantles and subsequent warm gas chemistry. The spatial and Doppler distribution of the ionic and molecular gas toward these prototypical sources provides new insights into the structure of high-mass star-formation regions on scales of 1 000–10 000 AU.

A Catalog of Infrared Dark Clouds: Starless or Starred Massive Core Candidates

Chang Won Lee

Korea Astronomy & Space Science Institute, Daejeon, Republic of Korea

We present a new catalog of 1870 Infrared Dark Clouds (IRDCs) manually selected by using the darkness of the IRDCs caused by the dust extinction over the bright background Galactic plane at 8.28 μm. Unlike the extensive catalog published previously by Simon et al., our catalog better identifies compact IRDCs over the bright Galactic background which were usually missed in their catalog. Nearly half of the IRDCs in our catalog are not listed in other catalogs or reported elsewhere. We tested possible association of the IRDCs with YSO candidates such as IRAS and GLIMPSE point sources, water and methanol masers, and NVSS radio sources. Among 1325 IRDCs in the GLIMPSE region, 583 (44%) are found to contain at least one YSO candidate while 742 (56%) are starless. Interestingly, half of the IRDCs with stars have more than two YSO candidates, indicating that many IRDCs are likely the site of multiple star formation. We note that 236 IRDCs have protostar candidates and the ratio of [N(IRDC with protostars)]/[N(starless IRDCs)] is about 0.32. The ratio should be affected by the minimum detectable luminosity of the GLIMPSE point sources (of order 2.2 $L_\odot$ at 4 kpc) and treated as a lower limit. We find that IRDCs containing more YSO candidates tend to be larger, more elongated, and more opaque than the IRDCs with few or no YSOs.

Stellar and Mass–loss properties of young embedded O–type stars

Annique Lenorzer
Instituto de Astrofísica de Canarias, La Laguna, Spain

The impact of stellar mass-loss during the earliest phases of massive star evolution is a crucial part of the puzzle toward the understanding of massive star formation. Occurring behind large amounts of extinction, inside their natal molecular cloud these evolutionary stages can only be observed at near-infrared wavelengths. Recent investigations by Lenorzer et al. (2004) and Repolust et al. (2005) proved that the near-infrared lines present in the spectra of O-type stars can be used to determine their stellar and wind parameters in a similar fashion as in the optical. We make use of this important advance and carry out the first investigation of the wind properties of some of the youngest massive stars of our Galaxy. We present results for a few early O-type stars, analysed with FASTWIND (Puls et al. 2005), among which: an O5 stars shows the presence of a low density disk, while another present a very large wind density. We estimated the clumping factor and distribution of its wind and discuss its evolutionary status.

IRAS 17233: a new exceptionally line-rich hot core in the southern hemisphere

Silvia Leurini

ESO, Garching, Germany

In a recent survey of massive YSOs at $\delta < -20°$ carried out with the APEX telescope, we detected exceptionally strong and rich molecular emission towards the star forming region IRAS 17233–3606. These observations were followed up with the SMA at 1.3mm, which show a bright single object on a scale of 0.04 pc with a mass of 120 $M_\odot$ (assuming a dust temperature of 50 K). These observations also reveal a well collimated outflow (collimation factor $\sim$ 4) originating from the source. From VLA archive observations, the Lyman continuum flux corresponds to a B1 zero age main sequence star.

Kinematics of the bipolar outflow from the high-mass protostellar candidate in M17

Ina Lingner

Astronomisches Institut Bochum, Germany

High-resolution spatial and spectral observations of the outflow from the huge disk in M17 are presented. The profiles of H and [Ca II] lines are discussed in terms of outflow and accretion as a function of distance from the protostellar object.

A massive disk candidate scrutinised with AO imaging and spectroscopy

Hendrik Linz

Max–Planck–Institut für Astronomie, Heidelberg, Germany

The details of the mass accumulation onto a forming massive star are still not clarified. Although the general picture of a modified accretion disk scenario dominates the discussion, the number of bona fide massive disks is very scarce. We present new results for a disk candidate for which indications came from methanol maser alignment. We show AO-mediated L’ and M band NACO imaging where we were able to spatially resolve the warped emission from the circumstellar hot dust. We discuss the interpretation of these findings which, at first glance, also allow for an elephant-trunk-like configuration. Furthermore, we provide a new look on the distribution of Br gamma emission in this star-forming region by means of Fabry-Perot spectroscopy. TIMMI2 spectra provide a measure for the optical depth, while the detection of the [NeII] line in connection with the narrow-band imaging in the HeI 2.057 micron line allows an estimation of the local ionisation properties. We discuss how this information together with an critical assessment of the local extinction properties can lead to an integral picture of this star-forming region.

The Chemical Impact from Massive Star Formation - IRAS 20126+4104 as a showcase

Sheng-Yuan Liu

Academia Sinica Institute of Astronomy and Astrophysics, Taipei, Taiwan

The energetic processes associated with star formation activities not only result in the physical transformation of molecular clouds but also modifies the chemical environments within. While great progress has been made for understanding the chemical evolution around low mass protostars, similar studies for regions harboring young massive stars have been severely hindered by the clustering and distant nature of such objects. With its well-defined spatial and kinematic structures, the massive star forming region IRAS 20126+4104 offers a great opportunity for probing the impact in chemical evolution due to massive star formation. I will present the results from SMA observations at 230 GHz and 345 GHz which outline distinctly the chemical signatures in the pre/post-shocked region induced by the outflow/jets and those in the dense molecular core immediately surrounding the star. This study represents a showcase for understanding the impact of massive star formation to its surrounding environments.

Detection of SiO from a massive cold core

Nadia Lo

University of New South Wales, Sydney, Australia

From a continuing multi-molecular line survey of the giant molecular cloud complex G333 with the Mopra Telescope, we have detected SiO (J=2–1) transition from the massive cold dense core G333.125-0.562. The core is undetectable at wavelengths shorter than 70 um and has compact 1.2 mm dust continuum. Other detected molecules in the core include ^{13}CO, $C^{18}O$, CS, HCO^+, HCN, HNC, CH_3OH, N_2H^+, SO, HC_3N, NH_3, and some of their isotopes. In addition, from NH_3 (1,1) and (2,2) inversion lines, we obtain a temperature of 13 K. From fitting to the spectral energy distribution we obtain a colour temperature of 18 K. We have also detected a 22-GHz water maser in the core, together with methanol maser emission, suggesting the core will host massive star formation.

Near-IR photometric and spectroscopic studies of three massive cluster candidates

Antonio Marin-Franch

Instituto de Astrofísica de Canarias, La Laguna, Tenerife, Spain

Using near-IR protometric and spectroscopic analysis, the fundamental cluster parameters (distance, mass, age, highest stellar mass and upper IMF) and the stellar parameters of selected stars have been derived for three galactic obscured massive star cluster candidates.

BLAST: Sub-mm surveys of massive star formation

Peter Martin

CITA – University of Toronto, Toronto, Canada

I will present results from three large Galactic plane fields surveyed during the northern flight of the Balloon-borne Large Aperture Submillimeter Telescope in June 2005 (Kiruna, Sweden to Victoria Island, Canada). These new measurements in the 250 to 500 micron spectral range are useful for constraining temperatures and bolometric luminosities, ranging from cold pre-stellar clumps to those with embedded protostars and compact H II regions. These foreshadow similar surveys to be carried out using SPIRE on Herschel.

The molecular emission of the contracting irradiated dense core ahead of HH 80N

Josep-Maria Masque

Universitat de Barcelona, Spain

HH 80N is the optically obscured northern counterpart of the Herbig-Haro 80/81 objects, with an associated quiescent molecular dense core. Although molecular clumps ahead of HH objects appear to be small and starless, the clump ahead of HH 80N is more massive (20 $M_\odot$) and shows clear star formation signatures, namely a CO bipolar outflow and a contracting ring structure of 0.24 pc of radius traced with CS, with an anomalous supersonic infall speed of 0.6 km/s. We present in this work the results from the exhaustive study, carried out with the BIMA array, of several species and transitions, first to trace the infall motion detected in CS, and second to study the behavior of the molecular tracers as a result of the peculiar chemistry found in this core, possibly induced by the UV photons coming from the HH 80N object.

Temporal Variability in the SiO Maser Line Profiles toward Orion Source I: Clues to the Dynamic Nature of a High–Mass Protostar

Lynn Matthews

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Orion BN/KL is one of only three star-forming regions known to have associated SiO maser emission. In this region the SiO emission arises from within ~10–100 AU of the high-mass protostellar candidate Source I, providing a powerful kinematic probe of the regions where accretion is expected to occur and where outflows are expected to be launched and collimated. Although the SiO emission is variable, it has persisted since its discovery in 1974 and has maintained a double-peaked velocity structure, suggestive of rotation and/or expansion. Using the VLBA, the KaLYPSO team (http://www.cfa.harvard.edu/kalypso/) has obtained monthly observations of Source I in the SiO v=1 and v=2 transitions over a three–year period. Our monitoring campaign is the first for Source I that has included imaging and well as spectral information, permitting unique constraints on the origin and stability of various line components and their relationship to the source. Here we will present an analysis of the integrated SiO spectra based on thirteen months of data. We will discuss implications of the temporal changes in the observed line profiles for understanding the gas dynamics and formation process of this nearest high-mass protostar.

Massive star formation in G331.552–0.11

Manuel Merello

Universidad de Chile, Santiago de Chile, Chile

We present continuum dust emission and molecular line emission observations towards the massive star forming region G331.55-0.11 located in the Norma spiral arm. This region corresponds to one of the most luminous and extended cores of a GMC. Observations at 1200 μm made with SIMBA bolometer array at the SEST (La Silla) show six massive and dense dust condensations over a region of $6'$ in diameter. Observations of several molecular lines made with Atacama Submillimeter Telescope (ASTE) and Atacama Pathfinder Experiment Telescope (APEX) reveals the presence of a unresolved, extremely-high velocity molecular outflow towards the brighter and most massive dust condensation. Using the Australia Telescope Compact Array (ATCA), we detected a compact radio continuum source located at the center of the outflow, likely to be its driving energy source.

SiO and CH_3CCH abundances and dust emission in high-mass star-forming cores

Oskari Miettinen

Observatory, University of Helsinki, Finland

We present the results of SiO and CH_3CCH spectral line and 1.2 mm dust continuum observations of 15 high-mass star-forming cores made with the SEST. The SiO emission regions are extended and typically half of the integrated line emission comes from the velocity range traced out by CH_3CCH emission. The upper limit of SiO abundance in this 'quiescent' gas component is 10^{-10}. The average CH_3CCH abundance is about 7×10^{-9}. It shows a shallow, positive correlation with the temperature, whereas SiO shows the opposite tendency. We suggest that the high CH_3CCH abundance and its possible increase when the clouds become warmer is related to the intensified desorption of the chemical precursors of the molecule from grain surfaces. A possible explanation for the SiO decrease is that warmer cores represent more evolved stages of core evolution with fewer high-velocity shocks and thus less efficient SiO replenishment.

SED and Luminosity Evolution in the Early Stages of Massive Star Formation

Sergio Molinari
IFSI – INAF, Rome, Italy

A sample of 42 sites of massive star forming regions were studied in detail both at mid-IR and millimetric wavelengths, with the aim of achieving the best possible estimates of circumstellar mass and bolometric luminosity for the most luminous sources in each field. The sample was extracted from a larger list of sources which we have extensively been studying in the course of the last decade. Examined fields were of HIGH (UCHII-like YSO) as well as LOW type, where independent evidence suggests that pre-HC objects could be found in higher fractions. Careful SED analysis using state-of-the-art radiative transfer models spanning a wide range of embedded ZAMS stars and envelope properties (masses, radii, inclination angles, polar cavity apertures) provided a consistent global fit in a limited number of cases. Overall, only in about half the examined target fields the most massive YSO could be plausibly fit with a model of heavily embedded ZAMS object which may be assimilated to a classical Hot Core/UCHII (for which IRAS20126+4104 is the template). In the other half of the cases a two-component fit allowed us to disentangle a massive cold core invisible in the mid-IR, from a more evolved and relatively much less massive ZAMS object (a situation for which IRAS23385+6053 is the template). Such massive cold cores may be pre-ZAMS objects completing their luminosity rise to become Hot Cores, and are found in large majority in the group of LOW sources. We are then able to put these various types of sources in a consistent L vs M evolutionary scenario which extends to the intermediate and high-mass regimes the classical Class 0/I/II picture already consolidated for the low-mass regime. We use analytical simulations to show that the formation timescales are of the order of 1 to few times 10^5 years and are consistent with the paradigm of accelearating accretion as in the turbulent core model. The majority of the massive YSOs are associated with young stellar clusters of median ages of few times 10^6 years, confirming that the massive objects are the last one to form.

The star-forming content of the W3 GMC

Toby Moore

Liverpool John Moores University, Birkenhead, U.K.

We have surveyed a ~0.9–square–degree area of the W3 giant molecular cloud and star-forming region in the 850 μm continuum, using the SCUBA bolometer array on the James Clerk Maxwell Telescope. A complete sample of 316 dense clumps was detected with a mass range from around 13 to 2500 solar masses. Part of the W3 GMC is subject to an interaction with the HII region and fast stellar winds generated by the nearby W4 OB association. We find that the fraction of total gas mass in dense, 850-μm traced structures is significantly altered by this interaction, being around 5% to 13% in the undisturbed cloud but ~25 - 37% in the feedback–affected region. This is the first quantified measurement of the effect of local triggering on the efficiency with which a molecular cloud produces potential star–forming structures.

Star formation triggered by strong radiation from massive stars

Kazutaka Motoyama
Theoretical Institute for Advanced Research in Astrophysics, Hsin–Chu, Taiwan

Strong UV radiation from massive stars impacts surrounding molecular clouds, and may trigger star formations nearby. Radiation driven implosion (RDI) is one possible scenario for such triggered star formation. UV radiation from massive stars ionize surface of surrounding molecular gas, and expansion of the hot ionize gas drive shock wave into cloud. This compression is expect to trigger star formation. Many studies have been made on RDI model. However, little attention has been given to how massive stars formed by RDI. We simulated evolution of molecular clouds exposed to strong UV radiation from massive star. Our simulations include self-gravity of gas, and trace accretion onto new born protostar. We investigated how massive stars form in clouds compressed by RDI, and how it depends on cloud density and strength of UV flux.

Infrared Observations of Massive Young Stellar Objects in the RMS Survey

Joseph Mottram

University of Leeds, Leeds, United Kingdom

The RMS survey is returning a well-selected sample of massive young stellar objects (MYSOs) in our Galaxy. As a part of this survey, we present 9.7 micron silicate spectroscopy towards a sample of our sources. Using radiative transfer models we derive the silicate optical depth and so measure the degree of embeddedness of these objects.

The protostar within the large disk in M 17

Markus Nielbock

Max–Planck–Institut für Astronomie, Heidelberg, Germany

For the first time, we resolve the elongated central infrared emission of the large accretion disk in M 17 into a point source and a jet–like feature that extends to the northeast. We regard the unresolved emission as to originate from an accreting intermediate to high–mass protostar. In addition, our images reveal a weak and curved southwestern lobe whose morphology resembles that of the previously detected northeastern one. We interpret these lobes as the working surfaces of a recently detected jet interacting with the ambient medium at a distance of 1700 AU from the disk centre. The accreting protostar is embedded inside a circumstellar disk and an envelope causing a visual extinction of $A_V \geq 60$. This and its K-band magnitude argue in favour of an intermediate to high-mass object, equivalent to a spectral type of at least B4. For a main–sequence star, this would correspond to a stellar mass of $4\,M_\odot$.

Comparing the hot and cold gas structure of OMC1

Henrik Nissen

University of Aarhus, Aarhus, Denmark

OMC1 is the type-site for a massive protostellar region. Using observations from the CFHT, SMA and IRAM we have made a comparative study of the hot and cold gas components in OMC1. In earlier work we have described the structure of the hot gas component in great detail (Nissen et al. 2007, Gustafsson et al. 2006). This was done using the H_2 v=1–0 S(1) line, showing the structure of hot (> 1500 K), recently shocked gas. Using observations of the J=2–1 transistion of CO, ^{13}CO and $C^{18}O$ we have performed a similar study of the cold gas structure and compared the two studies, looking for differences and similarities in the spatial and velocity structure of the hot and cold gas components. In this talk we present the first results from this work.

The Bolocam 1.1mm Galactic Plane Survey and Initial Comparison to Spitzer GLIMPSE Data

Miranda Nordhaus
University of Texas, Austin, TX, USA

We have mapped ∼100 square degrees of the Galactic Plane at 1.1mm with Bolocam on the Caltech Submillimeter Observatory. The survey coverage includes the Galactic Center, most of the molecular ring, and many active star-forming regions such as Cygnus X and the W3/4/5 region. This is the first unbiased survey of emission from cold dust associated with massive star and cluster formation. Images and source catalogs will be publicly available. We also present the results of an effort to inventory the protostellar content of 20 massive star-forming regions seen in the Bolocam survey using GLIMPSE and 2MASS catalogs and images.

Formation of high mass stars in violent cluster environments

Dieter Nürnberger

ESO, Santiago, Chile

High mass stars are usually forming deeply embedded in their natal environment which can be penetrated only at wavelengths beyond the mid IR. In my presentation, I will summarize our recent efforts to search for and to characterize high mass protostars in interfaces between Galactic HII regions and their adjacent molecular clouds, e.g. in NGC 3603 (Nürnberger 2003) and in M17 (Chini et al. 2004, 2006; Hoffmeister et al. 2006; Nielbock et al. 2007; Nürnberger et al. 2007). Taking advantage of 'curtain-lifting' stellar winds and energetic photons from the central clusters of early type main sequence stars and making use of sensitive, high angular resolution observations in the near and mid IR, we have identified promising candidates which play a decisive role in our understanding of the basic formation processes of high mass stars. In particular, as we see strong evidence for the existence of (accretion) disks around these sources, one has to favour the accretion scenario against the collision (coalescence) scenario.

Evolution of young star-disc systems in dense stellar clusters

Christoph Olczak
I. Physikalisches Institut, Köln, Germany

The life time and evolution of protoplanetary discs is a key to the understanding of planet formation. Numerical calculations of planet formation predict evolution times from several up to tens of Myr, depending on the underlying scenarios. However, the natal environment of young stars has an impact on the disc life-time mainly by two scenarios, photoevaporation and stellar encounters. We investigate the relevance of encounters for a variety of cluster models and evaluate the conditions under which planet formation can take place.

The binarity of pre-main sequence Herbig Ae/Be stars

Rene Oudmaijer

University of Leeds, Leeds, United Kingdom

Studies of the binarity of pre-main sequence stars show that many stars are formed in a binary system. Here we present new results for the more massive Herbig Ae/Be stars for which we have employed a new technique, spectro-astrometry to detect binary stars and measure their properties. We find a binary fraction of 70%, the highest fraction measured by any single technique, and a good illustration of the sensitivity of spectro-astrometry to discover binary stars. A study of the orientation of the binary position angles and those of the circumprimary disks, the first one ever performed for young pre-main sequence stars, indicates that disk fragmentation is more likely to form young binaries than stellar capture. The results are discussed and expectations for the future are outlined.

Unveiling the nature and interaction of the intermediate/high-mass YSOs in IRAS 20343+4129

Aina Palau

Laboratorio de Astrofísica Espacial y Física Fundamental - INTA, Madrid, Spain

IRAS 20343+4129 was suggested to harbor one of the most massive and embedded stars in the Cygnus OB2 association, IRS1, which seemed to be associated with a north-south molecular outflow. However, the dust emission peaks do not coincide with the position of IRS1, but lie on either side of another massive Young Stellar Object (YSO), IRS3, which is associated with centimeter emission. The goal of this work is to elucidate the nature of IRS1 and IRS3, and study their interactions with the surrounding medium. The Submillimeter Array (SMA) was used to observe with high angular resolution the 1.3 mm continuum and CO(2–1) emission of the region, and we compared this millimeter emission with the infrared emission from 2MASS. Faint millimeter dust continuum emission was detected toward IRS1, and we derived an associated gas mass of ~0.8 $M_\odot$. The IRS1 Spectral Energy Distribution (SED) agrees with IRS1 being an intermediate-mass Class I source of about 1000 $L_\odot$, whose circumstellar material is producing the observed large infrared excess. We have discovered a high-velocity CO(2–1) bipolar outflow in the east-west direction, which is clearly associated with IRS1. Its outflow parameters are similar to those of intermediate-mass YSOs. Associated with the blue CO(2–1) outflow lobe, detected with single-dish observations, we only found two elongated low-velocity structures on either side of IRS3. The large-scale outflow lobe is almost completely resolved out by the SMA. Our detected low-velocity CO structures are coincident with elongated H_2 emission features. The strongest millimeter continuum condensations in the region are found on either side of IRS3, where the infrared emission is extremely weak. The CO and H_2 elongated structures follow the border of the millimeter continuum emission that is facing IRS3. All these results suggest that the dust is associated with the walls of an expanding cavity driven by IRS3, estimated to be a B2 star from both the centimeter and the infrared continuum emission. IRS1 seems to be an intermediate-mass Class I YSO

driving a molecular outflow in the east-west direction, while IRS3 is most likely a more evolved intermediate/high-mass star that is driving a cavity and accumulating dust in its walls. Within and beyond the expanding cavity, the millimeter continuum sources can be sites of future low mass star formation.

Probing Galactic Structure using 6.7 GHz Methanol Masers

Jagadheep Pandian

Max–Planck–Institut für Radioastronomie, Bonn, Germany

The 6.7 GHz methanol maser line is an excellent signpost of massive star formation, and is hence expected to be a tracer of spiral density waves in the Galaxy. Except for a few sources, most distances to methanol masers are calculated using kinematics, which suffers from an ambiguity between two distances in the first and fourth quadrants. We present the results of an effort to resolve the kinematic distance ambiguity towards a sample of sixty methanol masers using HI observations, and their implications on Galactic structure.

SCUBA identification of hot molecular cores

Harriet Parsons

University of Hertfordshire CAR, Hertfordshire, UK

An investigation into the feasibility of using flux profiles from SCUBA to identify hot molecular cores. After analysis of 15 candidate hot molecular cores it was found that there was no strong correlation as to how tightly peaked the flux of the candidate cores were to the temperatures derived.

Mid-IR images of HMSFRs associated with CH_3OH and H_2O masers

Paolo Persi

IASF–Roma/INAF, Roma, Italy

We present the results of mid-IR images from 8.8 to 18.7 micron of 15 high mass star forming regions (HMSFRs) associated with methanol and water vapor masers The ground based images obtained with the CID camera at the 2.1m telescope of San Pedro Martir (B.C. Mexico) are compared with the IRAC/Spitzer images.

What methanol masers tell us about high-mass star formation

Michele Pestalozzi

University of Hertfordshire, Hertfordshire, UK

In this presentation I will show the advantage of studying methanol masers in order to acquire important insights on high-mass star formation. In particular, the statistical analysis of the general catalogue of methanol masers yielded the luminosity function of the masers, and the in depth study and modelling of one particular source (NGC7538 IRS1) gave us a way to unambiguously discriminate an outflow from a rotating disc geometry. In this respect, I will show that the main maser feature in NGC7538 traces an edge-on disc, and this can be counted among the clearest evidences of such a disc in a high-mass star forming region.

SCAMPS: The SCUBA Massive Precluster Survey

Michele Pestalozzi
University of Hertfordshire, Hertfordshire, UK

In contrast to low-mass star formation, the study of the earliest stages of evolution of high-mass stars still lacks both theoretical and observational dedicated investigations. The earliest high-mass stage that we can conclusively identify occurs around 10^5 years after the birth of the high-mass star. This is known as ultracompact (UC) Hɪɪ region, and is traced by bright mid/far-infrared thermal & cm-wave free-free emission. These objects represent an already luminous YSO that has begun to ionise and disperse its birthplace. Much observational effort is being expended to find earlier evolutionary stages to UC Hɪɪ regions (massive protostars and YSOs) so that we can determine the formation mechanisms and evolutionary sequences for high-mass star formation. However, most of the current searches base their target selection upon either the IRAS or the MSX infrared surveys and are therefore biased towards hotter, more evolved objects. Here we describe a wide-field sub-mm continuum imaging survey for the earliest stages of high-mass star formation, which we term massive preclusters. SCAMPS (for the SCUBA Massive Precluster Survey) has the main goal of identifying a large statistically relevant sample of massive preclusters and determining their physical properties through a wide range of follow-up observations. We have used the rapid wide-field mapping capability of SCUBA to image large fields around known UC Hɪɪ regions and search for nearby objects. So far we have made wide-field maps around more than 30 UC Hɪɪ regions and have detected around 150 massive dust cores, with roughly 25 of these being MSX-dark and/or GLIMPSE-dark cold precluster candidates. The focus is now upon building on the successful SCUBA results with a follow-up campaign of observations designed to confirm the candidate preclusters and determine their physical properties. Our follow-up programme includes Effelsberg & VLA ammonia observations, GLIMPSE data, VLA continuum mapping, IRAM PdBI observations, IRAM 30m/JCMT depletion and deuteration studies and finally, a large JCMT survey for infall motions associated with the cores to verify that the cores are gravitationally bound and collapsing. In this talk/poster we present some of the initial results from SCAMPS, focusing in particular upon the initial SCUBA wide-field sub-mm continuum survey, the VLA continuum mapping and the JCMT infall follow-up.

The special role of massive stars in young dense clusters

Susanne Pfalzner
I. Physikalisches Institut, Köln, Germany

Massive stars play a special role in the dynamics of young stellar clusters as they function as gravitational foci for the stars of lower mass. We use simulations of the ONC as model to study the effect of the cluster dynamics on the massive stars themselves but as well the discs initially surrounding them. The gravitational interaction of the stars in such a dense young cluster has a number of consequences. It will be shown that the results for the massive stars is a higher binary frequency, increased disc mass loss, higher angular momentum transport in the disc and connected with this a increased accretion rate than for the stars with a lower mass. The latter means that in the late stages of the formation of massive stars a different processes than in the early stages will play a dominant role in massive star mass acquisition — cluster-assisted accretion.

Internal structure of massive pre-protocluster cores: SMA results

Thushara Pillai

Harvard–Smithsonian CfA, Cambridge MA, USA

We have selected 6 candidate pre–protocluster cores from two dust emission surveys that are massive, very dense, highly deuterated and depleted, with no signs of active star formation. The sample was observed in the SMA sub–compact configuration in line (N_2H^+ 3–2) and continuum emission. We detect significant continuum and line emission with evidence of sub–structure. With total clump mass in these regions ranging from 300 – 3000 $M_\odot$, and an absence of mid–infrared emission (Spitzer data) argues for a high mass pre–protocluster stage. In several cases, the observed sub–structure is on size scales comparable to that of low–mass dense cores. Combined with the higher resolution data obtained with a more extended array configuration, we are able to place constraints on their density structure. Furthermore, the N_2H+ line observations reveal excitation conditions, and the complex velocity structure within these objects.

A Spectral Survey of W49 from 9 - 22 GHz

Rene Plume

University of Calgary, Canada

We will results from the first spectral survey of W49 taken from the Green Bank Telescope.

Triggered Star formation in RCW 120

Melanie Pomares

Laboretoire d'Astrophysique de Marseille, Marseille, France

The mechanisms leading to the formation of massive stars are not well understood. Bright IR sources are observed on the borders of Galactic HII regions and recent observations have shown that the expansion of these regions may favor the formation of a new generation of stars, via the collect and collapse process. To better characterize this way of forming massive stars we have observed a series of Galactic HII regions, candidate for this process (Deharveng et al. 2005). RCW 120 is one of these regions, located in the direction of the Galactic Center. We present a multi-wavelength study of this region, using 2MASS and Spitzer-GLIMPSE data together with new 1.2 mm data. We find clear evidence for the collect and collapse process being at work there. We have studied the young star population in the direction of this region, especially near the most massive condensations detected at 1.2 mm and located on its borders. The general properties found for this region are compared with results of numerical simulations.

Excited OH 6035 MHz Masers in Star Forming Regions

Lyshia Quinn
University of Manchester, Manchester, UK

The OH molecule is one of the most commonly observed astrophysical maser species. Recently the relationship between OH maser emission and massive star formation has been undergoing a revision: OH masers are not just common towards HII and UC HII regions, but also toward less evolved high mass young stars (Edris et al. 2006; Szymczak & Gérard 2003). The Methanol Multibeam Project (MMB) is currently surveying the Galactic plane, with a new seven beam receiver, for 6668 MHz Class II methanol masers, and simultaneously, 6035 MHz excited OH masers. When complete this survey will provide a complete catalogue of methanol and excited OH masers over the whole Galactic Plane, $|b| < 2^{o}$. Interferometric follow–up observations of both the methanol and OH masers initially detected in the single dish survey are an integral component of the survey. The sub–arcsecond interferometric positions will allow detailed inter–comparison of the excited OH and methanol masers together with previously published positions of ground state OH masers, excited OH masers near 4700 MHz and water masers. The 6035 MHz excited OH masers are especially useful as many of them exhibit circular polarization, a characteristic of Zeeman splitting, which is used to measure an intensity and direction of the magnetic field.

High Resolution Mid-Infrared Imaging of UCHII Regions

James Radomski
Gemini Observatory, La Serena, Chile

We will present observations of a mid-IR imaging survey of UCHII regions oberved with T-ReCS on the Gemini South 8m telescope.

Characterizing massive and clustered star formation: a detailed look at infrared dark clouds

Sarah Ragan

University of Michigan, Ann Arbor MI, USA

We present a detailed structural and kinematic study of a sample of infrared dark clouds, the likely precursors of massive stars and stellar clusters. With Spitzer IRAC images we have resolved absorbing structures at high angular resolution (~2″). Based on MIPS 24 micron data we have found that most dense absorbing condensations are starless. Our structural analysis finds that the the clump mass function (CMF) is $dN/dM \propto M^{-0.5}$. This is comparable to that estimated from CO emission studies in local clouds but flatter than estimated from dust emission studies in these same local clouds (e.g. Ophiuchus). We conclude that these objects are in early stages of cloud fragmentation and that the initial physics of this process leads to a flat CMF. To supplement these data, we have performed interferometric observations of high-density gas tracers to provide us with kinematical information at with high velocity resolution and comparable spatial resolution. We will discuss these results in the context of current theories of massive and cluster formation.

A GLIMPSE of massive star formation in the Milky-Way Galaxy

Thomas Robitaille

University of St Andrews, UK

This poster presents a high reliability catalog of near- and mid-infrared sources selected from the GLIMPSE I & II surveys of the Galactic mid-plane. Many of these sources are likely to be intermediate and high-mass young stellar objects. The spatial distribution of IR excess sources shows clusters, some of which are associated with well known sites of star formation, as well as a more uniform background distribution. We hope to use this catalog to improve our understanding of where massive stars form in the Milky-Way galaxy.

Fragmentation in Massive Star Formation

Javier A. Rodón

Max-Planck-Institute für Astronomie, Heidelberg, Germany

With high spatial resolution PdBI dust continuum observations we disentangle the cluster-like structure of the young massive star-forming region IRAS 19410+2336. We detect about twenty continuum sources at 1.36 mm wavelength, distributed in two sub-regions. The "southern" sub–region has about 14 individual sources, clearly clustered within a radius of $\sim 20,000$ AU, while the remaining 6 detected individual sources are in the "northern" sub-region, also distributed in a cluster-like mode within $\sim 30,000$ AU. We also observed H_2CO lines, a well known and reliable thermometer in star forming regions (Mangum & Wootten 1993), to derive a temperature structure for the region. However, the line observations suffered of a strong spatial filtering, and they will not be useful until we complement them with single-dish observations, already scheduled for November 2007 at the IRAM 30-meter Telescope. Nevertheless, assuming an average dust temperature from previous single-dish observations we derive and discuss a cumulative core mass function for the region.

W3 IRS 5: A Trapezium in its making

Javier A. Rodón

Max-Planck-Institute für Astronomie, Heidelberg, Germany

Achieving a spatial resolution of $\sim 0.35''$ we resolve the inner $\sim 4,000$ AU of the high–mass star–forming region W3 IRS 5. In our PdBI 1.4 mm dust continuum map we find sources matching the positions of at least 3 of the 7 already detected near-infrared objects. We also trace the compact SiO emission, detecting an outflow for each of the 2 main mm (and NIR) sources. Both outflows appear to be relatively close into the line–of–sight direction, which would explain why we can detect those 2 sources both in mm and NIR wavelengths, since we would be observing directly the collapsing protostar through the cavity carved by the outflow.

Winds from clusters with non-uniform stellar distributions

Ary Rodriguez-Gonzalez
Ciencias Nucleares, UNAM, Mexico

We present analytic and numerical models of the “cluster wind” resulting from the multiple interactions of the winds ejected by the stars of a dense cluster of massive stars. We consider the case in which the distribution of stars (i. e., the number of stars per unit volume) within the cluster is spherically symmetric, has a power–law radial dependence, and drops discontinuously to zero at the outer radius of the cluster. We carry out comparisons between an analytic model (in which the stars are considered in terms of a spatially continuous injection of mass and energy) and 3D gasdynamic simulations (in which we include 100 stars with identical winds, located in 3D space by statistically sampling the stellar distribution function). From the analytic model, we find that for stellar distributions with steep enough radial dependencies the cluster wind flow develops a very high central density and a non–zero central velocity, and for steeper dependencies it becomes fully supersonic throughout the volume of the cluster (these properties are partially reproduced by the 3D numerical simulations). Therefore, the wind solutions obtained for stratified clusters can differ dramatically from the case of a homogeneous stellar distribution (which produces a cluster wind with zero central velocity, and a fully subsonic flow within the cluster radius). Finally, from our numerical simulations we compute predictions of X–ray emission maps and luminosities, which can be directly compared with observations of cluster wind flows.

HCN in hot cores

Rainer Rolffs

Max–Planck–Institut für Radioastronomie, Bonn, Germany

We present observations of (highly excited) HCN toward hot cores. Radiative transfer modelling allows conclusions to be drawn about the source structure.

Cold cores in massive high extinction clouds: Effelsberg NH_3 data

Kazi Rygl

Max–Planck–Institut für Radioastronomie, Bonn, Germany

In search of the earliest signs of massive star formation, we employed a new method to find the most massive clouds in our Galaxy: by selecting high extinction clouds. First scans done with the MAMBO bolometer show that some of these clouds have interesting internal structures; clumps, multiple clumps, elongated structres etc. Recently we obtained ammonia data of some of these clumps, observing the NH_3 (1,1) to (4,4) lines with the Effelsberg 100 meter telescope. We can now constrain some physical conditions, such as hydrogen density and the rotational temperature, study velocity gradients, and separate the "cold" cores from the "warm" cores.

High-Resolution Studies of the Multiple Cores System toward Cluster Forming Regions

Hiro Saito

Nobeyama Radio Observatory, National Astronomical Observatory of Japan, Nagano, Japan

We present the results of $C^{18}O$ observations by Nobeyama Millimeter Array toward the dense clumps in nine cluster-forming regions. We identified 199 cores with a size scale of 0.05 pc. Many cores with various line widths exist in one clump, and this indicates that the degree of the dissipation of the turbulent motion varies in one clump. Although the mass of the cores increases with the line width, most of the cores are gravitationally bound by the external pressure. In addition, the line width and the external pressure of the cores decrease with the distance from the center of the clump, and there would be a relation between these decreases and the H_2 density structure of the clump. From these results, the physical conditions of cores strongly depends on the inner H_2 density structure of the clump. We suggest that the cluster would be formed in the clump through the formation of such multiple cores.

Survey of high-mass star-forming regions at centimeter and millimeter wavelengths

Alvaro Sanchez-Monge
Universitat de Barcelona, Barcelona, Spain

We present the results of millimeter and centimeter continuum observations toward 10 high-mass star-forming regions (located at distances < 3 kpc, and with bolometric luminosities $> 10^3$ $L_\odot$) not previously mapped in the cm and mm range. We find centimeter emission associated with the IRAS source for 9 regions, with a flat/positive spectral index tracing free-free emission from HII regions. We detect millimeter large-scale extended emission toward all the regions. While for some cases the millimeter emission is very extended and weak, in other cases the emission has a clearly peak surrounded by emission with some substructure. Finally, by combining our data with infrared surveys, we try to classify the different star-forming regions according to an evolutionary sequence.

New results on the high-mass protostar NGC7538S

Göran Sandell

SOFIA–USRA, Moffett Field CA, USA

I will present observational results from BIMA, CARMA, VLA, and Spizer, which confirm that NGC7538S is a very young high-mass star surrounded by a rotating accretion disk and which drives a hot compact outflow.

What SOFIA can do for high-mass star formation studies

Göran Sandell

SOFIA–USRA, Moffett Field CA, USA

Molecular Outflows within the Filamentary Infrared Dark Cloud G34.43+0.24

Patricio Sanhueza

Universidad de Chile, Chile

We present molecular line observations of the filamentary infrared dark cloud G34.43+0.24 (also known as IRAS 18507+0121) at submillimeter and millimeter wavelengths. The submillimeter data were obtained using the 12-m APEX telescope [^{12}CO(3–2), ^{13}CO(3–2), C^{18}O(3–2) and CS(7–6) transitions], whereas the millimeter data were obtained using the 45-m Nobeyama telescope [CS(2–1), SiO(2–1), C^{34}S(2–1), HCO^+(1–0), $H^{13}CO^+$(1–0) and CH_3OH(2–1) transitions] and the 15-m SEST telescope [CS(2–1) and C^{18}O(2–1) transitions]. The morphology of the ambient molecular emission is similar to that of the 1.2 mm dust continuum emission reported by Garay et al. (2004). We report the discovery of strong wing emission towards each of the four dust continuum cores reported by Rathborne et al. (2005). The morphology and velocity structure of the high velocity gas suggest that the bipolar outflows have their axis of symmetry quite close to the line of sight. The outflows are massive and energetic, (masses in the range 11–33 $M_\odot$; momentum 59–227 $M_\odot$ km s^{-1}), indicating that they are driven by luminous, high-mass young stellar objects. These young stellar objects are embedded in dense cores with masses between $1.2--1.8\times10^3$ $M_\odot$ and sizes between 0.3 and 0.6 pc. We conclude that the excess 4.5 μm emission detected towards these cores by Rathborne et al. (2005) is due to shocked gas.

VLBI observations of MASER emissions towards high-mass YSOs

Alberto Sanna

INAF – Osservatorio Astronomico di Cagliari (OAC), Capoterra, Italy

Superbubble Motion Away from the Galactic Plane Traced by Water Masers in NGC 281 Observed with VERA

Mayumi Sato

The University of Tokyo / Mizusawa VERA Observatory, NAOJ, Tokyo, Japan

We will discuss a superbubble motion away from the Galactic Plane traced by systematic absolute proper motions of water masers in NGC 281 West measured with VERA, in the context of massive star formation on a Galactic scale.

Star formation in young star cluster NGC 1893

Sharma Saurabh

Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, India

We present a comprehensive multi-wavelength study of the star-forming region NGC 1893 to explore the effects of massive stars on low-mass star formation. Using near-infrared colours, slitless spectroscopy and narrow-band $H\alpha$ photometry in the cluster region we have identified candidate young stellar objects (YSOs) distributed in a pattern from the cluster to one of the nearby nebulae Sim 129. The $V, (V - I)$ colour-magnitude diagram of the YSOs indicates that majority of these objects have age between 1 Myr to 5 Myr indicating an age spread in the star formation in the cluster. The slope of the KLF for the cluster is estimated to be 0.34 ± 0.07, which agrees well with the average value ($\sim$ 0.4) reported for young clusters. For the entire observed mass range $0.6 < M/M_{\odot} \leq 17.7$ the value of the slope of the initial mass function, 'Γ', comes out to be -1.27 ± 0.08, which is in agreement with the Salpeter value of -1.35 in the solar neighborhood. However, the value of 'Γ' for PMS phase stars (mass range $0.6 < M/M_{\odot} \leq 2.0$) is found to be -0.92 ± 0.09 which is shallower than the value (-1.71 ± 0.20) obtained for MS stars having mass range $2.5 < M/M_{\odot} \leq 17.7$ indicating a break in the slope of the mass function at $\sim 2M_{\odot}$. Estimated 'Γ' values indicate an effect of mass segregation for main-sequence stars, in the sense that massive stars are preferentially located towards the cluster center. The estimated dynamical evolution time is found to be greater than the age of the cluster, therefore the observed mass segregation in the cluster may be the imprint of the star formation process. There is evidence for triggered star formation in the region, which seems to govern initial morphology of the cluster. The circumstellar disc half-life time is found to be $\sim$ 2 Myr which is consistent with the value (3 Myr) suggested by Haisch, Lada & Lada (2001).

Surviving the flood - data analysis maps and spectra toward line-rich sources

Peter Schilke

Max–Planck–Institut für Radioastronomie, Bonn, Germany

Current, new or upgraded instruments such as APEX, SMA or the IRAM telescopes give us a glimpse at what Herschel/HIFI and ALMA will deliver from line rich sources. The outlook is frightening, since we will be flooded by extremely complex spectra or, even worse, maps of hundreds or thousands of transitions. In this poster, we will present approaches to handle this flood by attempting to extract as much of the information as possible, as opposed to mere filtering, which is the easiest and, currently, only feasible approach.

The star forming region NGC 602 in the Small Magellanic Cloud

Markus Schmalzl

Max–Planck–Institut für Astronomie, Heidelberg, Germany

NGC 602 is located in the wing of the SMC and it is a young stellar association. This poster will point out the influence of the massive stars on the star formation process in this region.

S106 as part of the Cygnus X molecular cloud complex

Nicola Schneider

CEA/Saclay, Gif–sur–Yvette, France

The distance to the well-known bipolar nebula S106 and its associated molecular cloud is highly uncertain. Values between 0.5 and 2 kpc are given in the literature, favoring a view of S106 as an isolated object at 600 pc in the 'Great Cygnus Rift'. By employing a part of an extended ^{13}CO and $C^{18}O$ 1–0 survey (see poster by R. Simon et al.), performed with the FCRAO, and data from MSX and Spitzer, we find evidence that several molecular clouds including S106 are directly shaped by the UV radiation from members of various Cygnus OB clusters (mainly NGC 6913). They are thus located at the distance of these clusters that is approximately 1.5-1.7 kpc in the Cygnus X complex. S106 is thus a more massive and more luminous star forming site as previously thought. We also show that the definition of OB associations in terms of spatial extent and stellar content in the Cygnus X south region has to be revised.

Gas infall and bow shocks in the vicinity of the young 8–10 $M_\odot$ star AFGL 490

Katharina Schreyer

Astrophysikalisches Institut und Universitäts–Sternwarte Jena, Germany

We detected inverse CH_3OH P-Cygni line profiles towards the close environment of the young deeply embedded 8-10 $M_\odot$ star AFGL 490 using the Plateau de Bure Interferometer indicating on-going gas infall at least from the from the envelope to the circumstellar disk. Moreover, bipolar, denser gas clumps along the line of the large-scale high-velocity outflow could be found although no collimated jet is known.

A population of young massive stars in the central molecular zone

Frederic Schuller

Max–Planck–Institut für Radioastronomie, Bonn, Germany

Using large scale mid-infrared surveys (ISOGAL, MSX) we have found a population of 360 luminous red sources which are probable massive stars still embedded in their natal cloud. We have obtained spectro-imaging data for a sample of 69 sources with the Spitzer telescope. A sub-sample has been recently observed at high spatial resolution in the mid-infrared with VISIR (observing run in July 2007). In this talk, I will present the main physical characteristics that we derived from these observations, and their implications concerning recent star formation in the centre of the Galaxy.

Diagnosis of Gravitational Instability in Models of Star-Forming

Jonathan Sellon

American Museum of Natural History, NYC NY, USA

Prior work supported under this grant has established that gravitational instability plays a dominant role in determining the star formation properties of galaxies (Li, Mac Low, & Klessen 2005ab, 2006). Models of galactic disks including isothermal gas (with sound-speed of order 10 km/s), collisionless stars, and dark matter, were evolved with the smoothed particle hydrodynamics code GADGET. A strong correlation was found between the initial strength of gravitational instability in the galaxies, as measured by the minimum value of the Toomre (1964) Q parameter in the disk, and the timescale for the gas to collapse gravitationally to form stars. This relationship between disk instability and collapse timescale was derived using the initial value of the instability parameter in the disks. However, that is not an observable quantity, as observers can only measure the instantaneous instability parameter of the disks for comparison to their star formation rates. The measurement of the instantaneous instability parameter has been done, for example, by Martin & Kennicutt (2001), who measured the gas instability parameter, or by Dalcanton et al. (2004) who measured the combined instability parameter for stars and gas following Rafikov (2001). It is therefore important to extend the study of the correlation in the models to a study of the current collapse rate compared to the observable value of the instantaneous instability parameter. We will perform this study on the ensemble of models described in Li, Mac Low, & Klessen (2005b).

Star Formation in the Large Magellanic Cloud: Young Stellar Objects Revealed by the Spitzer SAGE Survey

Marta Sewiło

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Star Formation in the Large Magellanic Cloud: Young Stellar Objects Revealed by the Spitzer SAGE Survey PresAbstract: We present a list of candidate Young Stellar Objects (YSOs) in the Large Magellanic Cloud revealed by the Spitzer SAGE (Surveying the Agents of a Galaxy's Evolution) survey. The initial sample of candidate YSOs was color-magnitude selected from the SAGE point source catalog from regions least occupied by other known populations (e.g. PNe, Wolf-Rayet stars, AGB stars). The sample was increased by the slightly extended sources extracted from the SAGE mosaic images that fulfill the color-magnitude criteria for candidate YSOs. Since the YSOs are detected by their infrared excess emission, they represent young stages of evolution, surrounded by disks and envelopes of intermediate to high-mass forming stars. We present preliminary analysis of the spatial distribution of the YSOs relative to the interstellar matter. We also examine some properties of the population as determined from radiative transfer modeling.

Molecular & Ionized Outflows – Synergy between the EVLA, CARMA, Spitzer & ALMA

Debra Shepherd

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Magnetically collimated outflows launched from accretion disks around young stellar objects (YSOs) can be detected and studied in several ways. When the flow entrains material from the ambient cloud, we can trace the molecular flow using CO, SiO, HCO^+ and other outflow tracers with CARMA and soon, ALMA. Using the VLA, an ionized outflow can often be detected very close to the source, especially for more luminous YSOs. Yet, the high luminosity YSOs can turn onto the main sequence and begin burning hydrogen and generating an HII region even while they are still accreting. Exactly how the engulfing HII region affects the outflow collimation and dynamics and how the material is entrained is unclear at this time. I will present recent observations of molecular and ionized flows from young, early B (proto)stars with the VLA, OVRO and Spitzer and show how existing observatories can begin to shed light on these issues and illustrate the importance of coordinated observations with CARMA, the SMA, ALMA and the EVLA in the future.

Physical Properties of An Isolated Massive Dense Core

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We report an observational study on an isolated massive dense core that hosts an early B-type massive (proto)star (7 $M_{\odot}$). Physical properties of the core and substructures are presented in this paper.

The Cep OB2 Association

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The Cep OB2 Association is a bubble-shaped region containing two main clusters (NGC 7160 and Tr 37) in addition to numerous globules and ongoing star formation. The presence of three related stellar populations (aged 12, 4 and 1 Myr) suggest star formation episodes being triggered by the strong winds of the most massive O and B stars in the region.

Molecular line surveys of Cygnus X: I. ^{13}CO and $C^{18}O$

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I. Physikal. Institut, Universität zu Köln, Germany

The Cygnus X region, located at less than 3 kpc from the Sun, harbors one of the richest giant molecular cloud and high mass star forming complexes in the Milky Way. In this first of two posters, we present high spectral resolution imaging of the high mass star forming Cygnus X complex in the ^{13}CO and $C^{18}O$ 1–0 transitions. The data have been taken with the SEQUOIA array at the FCRAO 14 m telescope and cover 35 square degrees at 45″ resolution. While ^{13}CO traces the large scale distribution of cold and warm gas throughout the region, the high column density filaments and clumps are outlined by $C^{18}O$ emission. We characterize the global properties of the different velocity components of the complex together with available other large scale data at optical and infrared wave lengths, their relation to the active centers of star formation, investigate their structure, and discuss the distance to the complex.

The Evolution of Clumpy Structure in Molecular Clouds

Rowan Smith

University of St. Andrews, Scotland

Clumpy structure is universally observed in star forming regions of all size scales. However, it is unclear how dynamically stable clumps are, and their direct relevance for stellar masses. In this poster we present preliminary results of the evolution of clumpy structure in an SPH simulation of a collapsing molecular cloud with decaying turbulence.

Massive YSOs and outflows in the W3(H_2O)/W3(OH) region

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BIMA observations of emission in the SiO (2–1) and SiO (5–4) lines display a main region with a size $\sim 10''$ encompassing the cluster of water masers W3(H_2O) plus 3 compact components. One of the compact clumps is located $\sim 20''$ southwest from W3(H_2O) and is seen also in methanol emission. The other two clumps are located $\sim 25''$ and $\sim 50''$ to the northeast from W3(H_2O) and are seen in infrared lines of molecular hydrogen, that obviously indicates their association with shock waves. The arrangement of clumps tells that they most likely correspond to periodic ejections of substance from the young stellar object located in the region of the cluster of water masers W3(H_2O). Observations of radiocontinuum and molecular lines display presence in the W3(H_2O) region of two YSOs surrounded with own envelopes emitting in CH3CN and possible common envelope emitting in lines of methanol and other molecules. The proximity of positions (angular separation $\sim 1''$) and radial velocities (differ by ~ 2 km/s) of the young stellar objects testify that they are likely to form a binary system with mass $\sim 15\ M_\odot$. One of these YSOs is known as the TW object and is associated with disk or jet producing synchrotron emission in the $\sim 1\farcs 2$ structure extended east - west. The second YSO designated as Wyr C is located on a continuation of this structure in the western part of the water maser cluster W3(H_2O). The peak of emission of some molecules with non-stationary chemistry (C_2H_5CN, HDO, etc.) coincides with Wyr C. This testifies that the source of periodic emissions with is more likely the Wyr C object. This hypothesis is supported by the fact that the direction of periodic ejections is greatly inclined (45°) with respect to the synchrotron structure of the TW object. Extended areas of SiO and methanol emission trace zones where the shock waves which have arisen due to the ejection of material from the YSO interact with a dense cloud on on the border of which the young stellar objects of W3(OH)/W3(H_2O) region were formed. Further, the outflow probably induces formation of new stars in objects swA and swB seen in methanol emission.

H-alpha observations of the outflows in S235A/B region using Fabry-Perot interferometer at 6-meter telescope of SAO RAS

Andrey Sobolev

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We will describe the spatial and velocity structure of the ionized part of the outflows from the massive YSOs in S235A/B star forming region.

A survey for near-IR H_2 outflows from massive protostar candidates

Thomas Stanke

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We present a near-infrared survey for H_2 outflows towards a sample of candidate high-mass protostellar objects (HMPOs). We found evidence for H_2 emission only for a fraction of the sources observed, presumably due to excessive extinction towards the rest of the sample. Wherever H_2 emission suggestive of outflow shocks were found, its structure suggests well-collimated outflows.

Getting more than a GLIMPSE : Outflows from massive YSOs

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The sensitivity, wavelength range, and spatial resolution of Spitzer/IRAC permits the detection of emission from shocked gas caused by outflows from the youngest massive protostars. We identified numerous candidate flows in the GLIMPSE survey by their excess emission in continuum–subtracted 4.5 micron band images. The sample comprises about 50 targets which are both luminous and extremely young as indicated by their frequent association with 6.7 GHz methanol masers. Follow–up narrow–band imaging with NTT/SOFI will prove whether the excess emission indeed arises from shocked molecular hydrogen or not. The verification of the presence of bipolar outflows will substantially increase the number of massive YSOs for which unanimous evidence of disk accretion exists.

Hot Molecular Cores In Infrared Dark Clouds

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Infrared Dark Clouds (IRDCs) are a new class of molecular cloud, identified as deep extinction features in the mid-IR, are characterized by high column densities, high volume densities, and low temperatures. Because heir sizes and masses are identical to high-mass star forming molecular clumps, they probably represent the earliest phases in high-mass star formation and cluster formation. I will present high-angular resolution spectral line millimeter observations obtained with the IRAM Plateau de Bure Interferometer toward two high-mass IRDC cores. A very rich molecular spectrum, with emission line from complex molecules (e.g. CH_3CN,CH_3OH, CH_3OCHO, CH_3OCH_3, C_2H_5CN, CH_3CH_2CN) in both cores, indicates that the forming high-mass stars are in the hot core phase, an early stage in the formation of a high-mass protostar.

High-Velocity Outflowing Gas toward Luminous Young Stellar Object IRAS 20126+4104

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IRAS 20126+4104 (I20126) is a nearby prototypical high-mass disk/jet system. The outflow orientation on a large scale (∼2’) is dramatically different from that seen on a scale of 20″. This has been attributed to outflow precession. We have imaged the outflow associated with I20126 with the Submillimeter Array in CO (3–2), HCN (4–3), and SiO (5–4) at 1″ – 2″ resolutions within a radius of ∼20″ from the central driving source. Our observations reveal at least three different components of the outflowing gas: **(i)** a well-collimated outflow with an extent of ∼20″ along a P.A. of 120° previously detected in SiO (2–1). Both morphology and kinematics favor this component being a jet-driven bow shock system. **(ii)** a compact (∼4000 AU) bipolar outflow toward the central young stellar object. The dynamical timescale of this component is ∼120 years, indicating a very new activity of the outflow/jet in I20126. **(iii)** an S-shaped CO gas with an extent of ∼40″ along a P.A. of ∼150°. The S-shaped outflow records the precession history very well, and demonstrates a distinctive kinematic feature, i.e., the velocity increasing with distance from the YSO. The kinematic structure provides an independent method to deduce the precessing direction, and the results indicate that the NW lobe is moving away from the observer and the SE lobe is approaching us. All the three outflow components are unlikely related to the so-called “classical” component which comprises entrained ambient gas, but have a close relation to the unseen primary jet. The well-collimated component is also detected in HCN (4–3) and SiO (5–4), while a spatial differentiation between the two lines can be discerned — the latter mainly arises from the bow tops and the former the shock wings. The physical conditions in I20126 shocks are estimated using the large velocity gradient calculations. The inferred SiO abundances of 5-10$\times10^{-9}$ in I20126 outflow lobes are comparable to that at outflows from low-mass YSOs L1448-mm and L1157-mm, and are consistent with the picture of enhancement at shocked regions.

Wide-Field Near-Infrared Polarimetry of Massive Star Forming Regions

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We have recently developed a wide-field near-infrared polarimeter on the 1.4 m IRSF telescope in South Africa. The instrument is the first to provide deep and wide-field infrared polarimetric images, and can in principle measure polarizations of all the 2MASS-detected sources within a field-of-view of $7.7' \times 7.7'$ in the JHKs bands simultaneously with 1% polarization accuracy. In this paper, we present imaging polarimetry of several massive star forming regions in Orion, Monoceros, and LMC, and discuss the circumstellar material around YSOs that produces scattering and delineate magnetic field structures in molecular clouds and in galaxies via dichroic polarization.

SMA images on dust polarization and molecular lines in the UCHII region G5.89-0.39

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I will present the images of the polarization of the dust grains, the molecular environment and possible model on the high mass star formation region G5.89-0.39. It has been proved in many star formation regions that the polarized light emitted by the elongated dust grain can be used to measure the morphology and strength of the magnetic field via the Chandrasekhar-Fermi method. The polarization vectors detected form a ring like structure, which is observed the first time by measuring the polarized light from the dust grains. More than 10 molecular lines are detected and can give us the information of kinematics and physical conditions of this Ultra-Compact HII region.

The isolated embedded cluster IRAS 17136–3617 revisited

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New deep infrared observations of the isolated small embedded cluster GM24 = IRAS 17136–3617 covering the wavelength range 1 to 20 μm will be presented. The characteristics of the young stellar population and the physical conditions of associated gas and dust will be discussed.

Physico-chemical Conditions in Galactic Infrared Dark Clouds

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We present a detailed physico-chemical analysis of a population of massive condensations initially detected as absoprtion patches in the ISOGAL survey (7 and 15 microns, Hennebelle et al. 1999), and followed-up at millimetre wavelenghts in a handful of molecular and continuum tracers (Teyssier et al. 2002). In the present work, we derive most representative parameters for these objects and assess their state in the framework of massive star formation. Typical temperatures and densities are found in the range 8-15K and some 10^4-10^5 cm^{-3} respectively, these later corresponding to the different gas layers reached by the tracers used ($C^{18}O$, HC_3N). In cases where mid-IR embedded sources are identified, temperatures in excess of 25K are observed. These values translate into cloud masses in the range 100-10000 $M_\odot$. We show that molecular depletion is affecting the coldest parts of the clouds, suggesting that the areas associated to material prior to collapse are extended (0.5 pc), and likely to further form massive star in clusters. The analysis of position-velocity cuts reveal strong velocity gradients within the filaments, suggestive in some cases of collapse. In starless regions, strong magnetic fileds are invoked as support to counter-balance the gravitational collapse expected from the low virial masses observed in comparison of LVG masses.

Millimeter wave spectral line surveys and line mapping studies of NGC6334I and I(N)

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Latest results from our SEST millimeter wave line surveys of NGC6334 I and I(N) will be presented, which have been observed at wavelengths of 3, 2, and 1.3 mm. Particularly NGC6334 I shows rich emission from many different molecules, comparable in line density to prototypical hot cores such as Orion-KL and SgrB2(N). In addition, a $4' \times 4'$ region enfolding NGC 6334 I and I(N) has been mapped at a wavelength of 3 mm (75 to 116 GHz) with the Mopra telescope. This investigation has made use of the recently installed new 3 mm MMIC receiver and the new University of New South Wales Mopra spectrometer (MOPS) with broadband capabilities permitting total coverage of the entire frequency range with just five different setups. The spatial distribution of nineteen different molecules plus additional isotopic variants has been studied.

Molecular Ensembles: Chemical and Radiative Modelling of Super Star Clusters

David Tideswell

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Super star clusters are the result of some of the most extreme regions of star formation known in the local universe. They have been observed at optical wavelengths as dense clusters of high-mass stars and at radio wavelengths they have been observed as deeply embedded star formation sites. How these objects form and what evolutionary path they follow remain unanswered questions. We are currently developing chemical & radiative transfer models of these objects using an 'ensemble' of individual star formation sites (e.g. molecular clouds and hot cores). These models will hopefully reveal the physical conditions inside these clusters and determine how and why they form. The models may also be used to interpret observations of super star clusters where their structure cannot be resolved and the individual star forming regions are entangled in the telescope beam.

The circumstellar disk and excitation effects around the massive Cep A-HW2 object

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Probing the environment of methanol masers

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We are carrying out a program to characterise the physical and chemical conditions of the thermal methanol gas in regions of high-mass star-formation associated with 6.7 GHz methanol maser emission. These are crowded regions in the earliest stage of massive star-formation. In this poster we present our first results, based on data taken with HARP-B at the JCMT.

Water Masers and Radio Continuum Emission in Massive Star-forming Regions

Miguel Trinidad

Universidad de Guanajuato, Mexico

We present interferometric observations of radio continuum and water maser emission carried out with the VLA toward five massive star–forming regions. Radio continuum sources were detected toward all star-forming regions, which seem to be associated with ZAMS B stars. We also found that binary and multiple systems are common in massive star–forming regions. In addition, water maser emission was found in all massive star–forming regions, however, the water masers are not spatially associated with all detected continuum sources. Based on the analysis of the distribution of water masers and the characteristics of the continuum emission, we determine the nature of the young high–mass stars.

A CO, ^{13}CO and C^{18}O survey of cold IRAS sources

Nikita Troitskiy

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We present observation results of massive star formations regions. In the assumption of local thermodynamical equilibrium masses and H_2 densities were calculated. The ranges are: M_{LTE} from 200 to 21400 $M_{\odot}$, $n(H_2)$ from $2 \cdot 10^3$ to $7.5 \cdot 10^4$ cm^{-3}. Using virial theorem assumption M_{vir} can be derived, the value varies from 100 to 7800 $M_{\odot}$, $M_{\mathrm{vir}}/M_{\mathrm{LTE}}$ varies from 0.3 to 2 with mean average 0.8±0.1. Peak temperatures of CO which can be assumed as a measure of kinetic temperature in the object varies from 13 K to 45 K. The correlations between physical parameters are derived, e.g., the correlation between masses and sizes of the cores – $M \propto R^2$, between mean densities and sizes – $n \propto R^{-1}$ and widths of the lines and sizes – $\Delta V \propto R^{0.3}$.

An X-ray Imaging Study of the Stellar Population in RCW49

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We present the results of a high-resolution X-ray imaging study of the stellar population in the Galactic massive star-forming region RCW49 and its central OB association Westerlund 2. We obtained a 40 ks X-ray image of a 17'x17' field using the Chandra X-ray Observatory and deep NIR images using the Infrared Survey Facility in a concentric 8'3x8'3 region. We detected 468 X-ray sources and identified optical, NIR, and Spitzer Space Telescope MIR counterparts for 379 of them. The unprecedented spatial resolution and sensitivity of the X-ray image, enhanced by optical and infrared imaging data, yielded the following results: (1) The central OB association Westerlund 2 is resolved for the first time in the X-ray band. X-ray emission is detected from all spectroscopically-identified early-type stars in this region. (2) Most (86%) X-ray sources with optical or infrared identifications are cluster members in comparison with a control field in the Galactic Plane. (3) A loose constraint (2–5 kpc) for the distance to RCW49 is derived from the mean X-ray luminosity of T Tauri stars. (4) The cluster X-ray population consists of low-mass pre–main-sequence and early-type stars as obtained from X-ray and NIR photometry. About 30 new OB star candidates are identified. (5) We estimate a cluster radius of 6'–7' based on the X-ray surface number density profiles. (6) A large fraction (90%) of cluster members are identified individually using complimentary X-ray and MIR excess emission. (7) The brightest five X-ray sources, two Wolf-Rayet stars and three O stars, have hard thermal spectra (Tsujimoto, Feigelson, Townsley et al. 2007, ApJ in press).

[O I] 6300Å Doppler Tomography of the Inner Regions of Protoplanetary Disks Surrounding Three Intermediate-Mass Young Stars

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We have obtained high spectral resolution (R ~ 77000) data with VLT/-UVES of the [O I] 6300Å line from 3 Herbig Ae/Be stars. This line is created through photo- dissociation by UV photons of the OH molecules in the upper layer of the inner circumstellar disk and will be used to determine the structure and distribution of the gas in the inner disks, possibly revealing evidence of planet formation. This work is part of a larger program aimed at studying the dust gas thermal coupling state in protoplanetary disks, and especially at the validity of the much made assumption of such coupling.

Revealing the structure of southern IRDCs: dust extinction and 1.2 mm emission mapping

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Infrared Dark Clouds (IRDCs) are considered to be ideal sites to look for the first stages of massive star formation. However, the number of IRDCs with well characterised properties is still small to date, especially regarding the southern hemisphere. To enlarge the sample of well-investigated IRDCs, we selected 21 IRDCs in the southern hemisphere and started a still ongoing research programme to measure the gas and dust properties of these IRDCs. First, we obtained 1.2 mm maps with SIMBA at the ESO/SEST telescope. In combination with the now available mid- and far infrared data from the Spitzer Galactic Plane surveys (GLIMPSE at 3-9 micron, MIPSGAL at 24 and 70 micron), we will present a first assessment of critical characteristics of our clouds, such as the distribution of column density and total mass. The typical range (0.08 - 0.3 g/cm^2, 200 - 4000 $M_\odot$) qualify these to form massive stars and even clusters. As a general trend we find that most IRDCs are associated with compact IR sources, but the majority of clouds is rather filamentary in morphology, and some clouds exhibit substructures (still) devoid of such sources.

A statistical evolutionary probe to study the structure of molecular clouds

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The wavelet transform modulus maxima (WTMM) representation has become a standard method to extract characteristic features of images such as sharp transitions and singularities. The WTMM formalism in few parameters provides a global estimate of signal complexity through a multiscale decomposition of the analysed data. The aim to use multiscale approach is a natural consequence of the underlying physical process of interstellar cloud formation. In molecular clouds the turbulent gas dynamics produces hierarchical structures in the density and velocity fields what can be best described by multi-scale formalisms (e.g., structure functions). This connection between the analysing method and the turbulent physical phenomena makes the WTMM method very sensitive characterizing the underlying generator process of clouds. In the present application the WTMM is proposed as a hypothesis testing tool to find optimized parameters of simulations of star forming molecular clouds at their various evolutionary stages. The performance of the method is demonstrated on multifractal random cascade cloud models where cascade generator parameters are being correlated with the WTMM measured multiscale parameters.

VLTI / MIDI Observations of the Massive Protostar NGC 3603 IRS 9A

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We used MIDI, the mid-infrared interferometric instrument of the VLTI, to observe the massive protostar IRS 9A, located close to the NGC 3603 star cluster at a distance of about 7 kpc. Due to the strong stellar winds and ionising radiation produced by the hot O and B stars in the centre of the cluster, IRS 9A has been liberated from most of the gas and dust of its natal molecular cloud, and is now only embedded in gravitationally bound material of its circumstellar envelope. This offers the unique possibility to observe a high mass star during its short pre-main sequence phase. The ongoing analysis of our MIDI data shows that MIDI almost fully resolves the object on all our baselines, yet below 9 μm, towards the short wavelength end of the atmospheric N band, we detect a steep rise of the visibility. This feature is modelled as a combination of a compact hot component and a resolved warm envelope which lowers the correlated flux at longer wavelengths. The envelope can already be seen in MIDI's acquisition images, but also on complementary data from aperture masking observations at the Gemini South telescope. Its shape is asymmetric, which could indicate a disk seen at an angle to the line of sight. The compact component is possibly related to the inner edge of an accretion disk. The uncorrelated mid-infrared spectrum is featureless and could be caused by optically thick emission without a significant disk atmosphere, but with a hint towards absorption at the blue end. This could help to explain the steep rise of the visibility, if it is the extended flux which is absorbed.

IRAS 18511+0146: A proto Herbig Ae/Be cluster?

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The evolution of a young protocluster depends on the relative spatial distribution and dynamics of both stars and gas. IRAS 18511+0146 and the cluster associated with it has been investigated using the submm (JCMT-SCUBA), infrared (Spitzer-GLIMPSE, Spitzer-MIPSGAL, Mt. Palomar) and radio (VLA) continuum data. Cluster simulations have been carried out in order to understand the nature of objects comprising the cluster by comparing them with the observations. Based on the luminosity and size of the cluster as well as on the evolutionary stages of the cluster members, IRAS 18511+0146 is likely to be a protocluster associated with a precursor to a Herbig type star.

Chandra X-ray Observations of the Rosette Complex

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The Rosette star-forming complex provides an ideal testbed for studying sequential formation of clusters, which consists of an expanding blister HII region on the edge of a giant molecular cloud perpendicular to the line-of-sight. We present high spatial resolution X-ray images of the NGC 2244 cluster and the embedded clusters in Rosette Molecular Cloud, and compare the stellar populations and structures to the theories of massive star formation and formation of star clusters.

Anatomy of Infrared Dust Bubbles

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We present an analysis of wind-blown, parsec-sized bubbles and associated star-formation using GLIMPSE/IRAC, MIPSGAL/MIPS and MAGPIS/VLA survey imaging. Three bubbles from the Churchwell et al. (2006) catalog were selected. The relative distribution of the ionized gas (based on 20 cm emission), PAH emission (based on 8 μm, 5.8 μm and lack of 4.5 μm emission) and hot dust (24 μm emission) are compared. The stellar-wind and ionizing source for each bubble is identified based on SED fitting to numerical models. Other YSOs are also identified using SED fitting, including several sites of triggered star-formation.

Massive Star Formation In The Galactic Plane

Jennifer Williams
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Large-scale Gravitational Instability and Star Formation in the Large Magellanic Cloud

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Large-scale star formation in disk galaxies is hypothesized to be driven by global gravitational instability. The observed gas surface density is commonly used to compute the strength of gravitational instability, but according to this criterion star formation often appears to occur in gravitationally stable regions. One possible reason is that the stellar contribution to the instability has been neglected. Here, we examine the gravitational instability of the Large Magellanic Cloud (LMC) considering the gas alone, and considering the combination of collisional gas and collisionless stars. We compare the gravitationally unstable regions with the on-going star formation revealed by *Spitzer* observations of young stellar objects. Although only 62% of the young stellar object candidates are in regions where the gas alone is unstable, some 85% lie in regions unstable due to the combination of gas and stars. The combined stability analysis reliably predicts where star formation occurs. In agreement with other observations and numerical models, a small fraction of the star formation occurs in regions with gravitational stability parameter $Q > 1$. We further measure the dependence of the star formation timescale on the strength of gravitational instability, and quantitatively compare it to the exponential dependence expected from numerical simulations.

Spitzer Observations of Triggered Star Formation

Erick Young

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We present observations from the Spitzer guaranteed time observations of the interaction between massive young stars and the nearby interstellar medium. We show examples of the triggering of new stars as well as the ablation of protoplanetary disks.

Circumbinary Molecular Rings Around Massive Young Stars

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Circumbinary Molecular Rings Around Massive Young Stars PresAbstract: I present high angular resolution 1.3 mm continuum, methyl cyanide molecular line, and 7 mm continuum observations made with the Submillimeter Array and the Very Large Array, toward the most highly obscured and southern part of the OMC1S region located behind the Orion Nebula. I find two flattened and rotating molecular structures with sizes of a few hundred astronomical units suggestive of circumbinary molecular rings produced by the presence of two very compact circumstellar disks with sizes and separations of about 50 AU. These objects are associated with early massive OB(proto)stars. This result supports the idea that massive stars will form through circumstellar disks and jets/outflows, as the low mass stars do. However, when massive stars are in multiple systems they seem to form a circumbinary ring similar to those seen in young, multiple low-mass systems (e.g., GG Tau and UY Aur).

Molecular multiline and dust continuum studies of high mass star forming regions

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In recent years we observed a sample of high mass star forming regions in various molecular lines (HCN, HCO^+, CS, $C^{18}O$, NH_3, HNCO, SO, N_2H^+, etc.) and in mm wave continuum emission. Here we discuss the effects of chemical differentiation in these regions and physical properties of dense clumps. In particular, variations of density, temperature and ionization fraction are considered. Candidate high mass protostellar objects are identified.

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