Scientific Rationale

Theoretical and observational studies over the last decade have given a new impetus in our understanding of star and planet formation. New powerful ground-based and space telescopes are currently unveiling the secrets of young stars from their earliest stages of formation until planets form around them. At the same time old theories are tested, new ideas are born, and new theories are emerging. Thus, instead of being on the top of a mountain admiring the “star formation view”, we are still in a labyrinth looking for answers.

This meeting will honour the contributions to star formation of Prof. Anthony Whitworth (Cardiff University, UK), and offer the opportunity to celebrate his 66th birthday. The program will be designed so as to reflect his past and current interests and it will include both invited and contributed talks. In the spirit of ancient Greek symposia it would be full of science, but also fun and story-telling.

Topics

- The initial stages of star formation
- The formation of binary stars
- The minimum mass for star formation: low-mass stars and brown dwarfs
- The connection between star formation and planet formation
- Triggered star formation, HII regions
- The CMF-IMF relation and the statistical properties of low- and high-mass stars
- New frontiers in computational methods of star formation

SOC

Philippe André
Matthew Bate
Ian Bonnell
Cathie Clarke
Patrick Hennebelle
Simon Goodwin (Co-Chair)
Shu-ichiro Inutsuka

Ralf Klessen
Pavel Kroupa
Mark Krumholz
Mark McCaughrean
Jan Palouš
Derek Ward-Thompson (Co-chair)
Hans Zinnecker

LOC

Annabel Cartwright
Thomas Bisbas
David Hubber
Spyros Kitsionas
Dimitris Stamatellos
Steffi Walch
Richard Wünsch
Conference Organization

Dimitrios Stamatellos Organizing Committee Chair, 
Cardiff University, UK
Annabel Cartwright Cardiff University, UK
Thomas Bisbas UCL, UK
David Hubber University of Sheffield, UK
Spyros Kitsionas Hellenic-American Educational 
Foundation, Psychico College, Greece
Stefanie Walch MPA Garching, Germany
Richard Wünsch Academy of Sciences of the Czech 
Republic, Czech Republic

Scientific Organizing Committee

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Matthew Bate University of Exeter, UK
Ian Bonnell University of St. Andrews, UK
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Patrick Hennebelle Observatoire de Paris, France
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Shu-ichiro Inutsuka Nagoya University, Japan
Ralf Klessen ITA Heidelberg, Germany
Pavel Kroupa University of Bonn, Germany
Mark Krumholz UC Santa Cruz
Mark McCaughrean ESA, The Netherlands
Jan Palous Academy of Sciences of the Czech 
Republic, Czech Republic
Derek Ward-Thompson (Co-chair) UCLAN, UK
Hans Zinnecker UC Santa Barbara, USA
Scientific Program

Sunday, June 17, 2012

19:30 - 22:00 Welcome reception & registration

Monday, June 18, 2012

Session 1: Review of Ant’s work

09:00 The life and times of A.P. Whitworth Derek Ward-Thompson
09:30 The work of A.P. Whitworth Simon Goodwin
10:00 35 years of star formation Hans Zinnecker

10:30 Coffee break & Posters

Session 2: Low-mass star formation

11:00 Review: The formation of low-mass stars Dimitrios Stamatellos
11:30 From the companion mass ratio distribution to the planetary mass function Maddalena Reggiani
11:45 Radio emission from YSOs: Tackling the (reverse) Luminosity Problem Anna Scaife
12:00 Radiation magnetohydrodynamic simulations of protostellar core formation Kengo Tomida
12:15 Implications of protostellar disk fragmentation Eduard Vorobyov
12:30 The GPS/GLIMPSE360 search for Red Objects Basmah Riaz
12:45 ALMA view of the CO outflow in HH46/47 Diego Mardones

13:15 Lunch Break

Session 3: Circumstellar discs

16:00 Review of circumstellar discs Ken Rice
16:30 The formation and early evolution of protostars and protoplanetary disks Shu-ichiro Inutsuka
16:45 The lifetime of protoplanetary discs: Observations and Theory Barbara Ercolano
17:00 Coffee break & Posters

17:30 Herschel observations of gas and dust in protoplanetary discs
   Christophe Pinte
17:45 The viability of the MRI in protostellar disks: Dead, undead and Zombie zones
   Subhanjoy Mohanty
18:00 Protoplanetary disk formation and transport of angular momentum during magnetized core collapse
   Marc Joos
18:15 Disk formation in turbulent cores: Circumventing the magnetic braking catastrophe
   Daniel Seifried

20:00 Dinner

Tuesday, June 19, 2012

Session 4: Computational Star formation: Models, Techniques, & Predictions

09:00 Review of computational star formation
   David Hubber
09:30 Modelling magnetised protostellar jets with SPH
   Matthew Bate
09:45 Impact of tangled magnetic fields on the fragmentation of cores and star formation
   Philipp Girichidis
10:00 Star formation in Ophiuchus
   Oliver Lomax
10:15 Gas cooling by dust during dynamical fragmentation
   Simon Glover

10:30 Coffee break & Posters

11:00 On the origin of interstellar turbulence: less SNe and more galactic dynamics
   Diego Falceta-Goncalves
11:15 Instabilities in cloud-cloud collisions
   Andrew McLeod
11:30 Radiative transfer in star formation: Testing FLD and Hybrid Methods
   James Owen
11:45 Expected observations of the star formation process: from molecular cloud core to first hydrostatic core
   Kohji Tomisaka
12:00 Observing Simulated Protostars with Stella: Outflows: How accurate are protostellar
   Stella Offner
properties inferred from SEDs?
12:15 Gravitationally contracting molecular clouds and their star formation rates Enrique Vazquez-Semadeni
12:30 Shocks, cooling and the origin of star formation rates Ian Bonnell
12:45 A new grid of model spectral energy distributions for young stellar objects Thomas Robitaille

13:15 Lunch

**Session 5: Triggered Star Formation**

16:00 Review of triggered star formation Stefanie Walch
16:30 Triggered star formation Jan Palous
16:45 Triggered formation of filamentary clouds Evangelia Ntormousi

17:00 Coffee break & Posters

17:30 Triggering star formation - From the Pillars of Creation to the formation of our Solar System Matthias Gritschneder
17:45 Positive and negative ionizing feedback Jim Dale
18:00 Gravitational fragmentation of the Carina Flare supershell Richard Wünsch
18:15 A nebula in your computer: simulating the dynamics and chemistry of an HII region Thomas Bisbas

20:00 Dinner

**Wednesday, June 20, 2012**

**Excursions**

**Thursday, June 21, 2012**

**Session 6: Probing the initial stages of star formation**

09:00 Review: The Herschel Gould Belt survey Jason Kirk
09:30 Unravelling the labyrinth of star formation with Herschel  
Philippe Andre

09:45 First results from CaLYPSO: the IRAM Plateau de Bure Large Program on Class 0 protostars  
Anaelle Maury

10:00 The density structure of molecular clouds and its relation to star formation  
Jens Kauffmann

10:15 Initial results from SCUBA2  
David Nutter

10:30 Coffee break & Posters

11:00 Surveying pre-stellar gas in the Galactic Plane with Bolocam and Herschel  
Adam Ginsburg

11:15 Origin of high-mass stars and stellar clusters  
Sylvain Bontemps

11:30 Recent star formation in the Lupus clouds as seen by Herschel  
Kazi Rygl

11:45 The bimodal distribution of core masses in the Orion A L1641 clouds  
Danae Polychroni

12:00 Characterizing interstellar filaments in nearby molecular clouds  
Doris Arzoumanian

12:15 The Aquila prestellar and protostellar population revealed by Herschel  
Vera Konyves

12:30 HOBYS observations of ridges and filaments, and the evolution of massive dense cores  
Martin Hennemann

12:45 Star formation in the nearby Lupus molecular cloud  
Milena Benedettini

13:00 Lunch

Session 7: The stellar initial mass function

16:00 Mapping the Core Mass Function onto the stellar IMF  
Ant Whitworth

16:30 The clump mass function is NOT the origin of the IMF  
Paul Clark

16:45 The birth of an IMF  
Rowan J. Smith

17:00 Coffee break & Posters
17:30 The Salpeter Slope of the IMF Explained Sally Oey
17:45 A top-heavy IMF in star bursts Pavel Kroupa
18:00 Four-parameter fits to the IMF using Stable Functions Annabel Cartwright
18:15 A stochastic model of accretion Thomas Maschberger

20:00 Dinner

Friday, June 22, 2012

Session 8: High-mass star formation

09:00 Review of high-mass star formation theories Patrick Hennebelle
09:30 Results from the HOPS + MALT90 + HiGAL Galactic Plane Surveys Steven Longmore
09:45 Feedback in massive star formation Rolf Kuiper
10:00 Star formation rates and cloud structures in high-mass star-forming regions Quang Nguyen Luong
10:15 Global collapse and massive star formation: an ALMA view of a massive IRDC Nicolas Peretto

10:30 Coffee break & Posters

11:00 Filaments, ridges and a mini-starburst - HOBYS’ view of high mass star formation with Herschel Tracey Hill
11:15 GLIMPSE Extended Green Objects and the early stages of massive star formation Claudia Cyganowski
11:30 Radiation-hydrodynamics of massive star formation using Monte-Carlo transfer Tim Harries
11:45 Age spread in high-mass star forming region W3 Main Arjan Bik
12:00 The impact of protostellar outflows: From low to high mass protostars Ana Duarte Cabral
12:15 Young clusters in nearby, grand-design spirals Preben Grosbol
12:30 Clustered star formation in the Dimitrios Gouliermis
Magellanic Clouds

12:45 MYStIX first results: spatial structures of massive young stellar clusters
Michael Kuhn

13:00 Lunch

Session 9: Clustered star formation

16:00 Review of clustered star formation Richard Parker
16:30 The fraction of star formation occurring in bound stellar clusters Diederik Kruijssen
16:45 Dynamics and multiplicity of young star clusters: Getting the most out of single epoch radial velocity data Michiel Cottaar

17:00 Coffee break & Posters

17:30 Dynamics of an expanding star cluster Nicholas Wright
17:45 Conference summary
18:15 Conference ends

20:00 Dinner
Excursions

On Wednesday 20/6/2012 there will be no formal scientific presentations/discussions as this day will be dedicated to our exploration of Crete. We are organizing two full-day excursions: one to Heraklion, visiting the treasures of the ancient Minoans (Cretans) at Knossos Palace and the Heraklion museum; and one to the gorge of Samaria, hiking down the gorge towards the sea in the South-West of Crete. We have booked three buses (their cost is included in the conference fee) to take us to our destinations: the conference participants will declare at registration their preferred destination for this day and according to their choices we will organise the number of buses for each of the excursions.

1.) Samaria gorge:
Due to the length of the hiking and the afternoon temperatures that may rise close to 40 degrees, a very early start is required for this excursion (also useful to avoid the hordes of tourists). We plan to depart from the conference location at ∼06:00 am. The expected arrival at the entrance of the gorge (the area of Omalos, at an altitude of ∼1250 m) and the national park is at ∼07:30 am. The flat entrance fee of 5 euros per person will be covered by your registration. Walking or hiking shoes are recommended. The total distance to be walked is 16 km: ∼13 km in the gorge and ∼3km from the exit of the gorge (iron gates!) to the seaside village of Agia Roumeli. For the first couple of km the terrain is steep downhill and it is recommended to take your time as it may be slippery (this is where most of the accidents happen) and it is also strenuous for the knees. The terrain is mostly stony for the greatest part of the walking distance. Half way through the distance is situated the abandoned village of Samaria. This is a place where one can take a rest. Do not rest for more than half an hour as you may start getting stiff before the second part of your walk. A total of 6 to 7 hours is the average time for completing the walk, including rests that will make it a comfortable experience and time to take photos (be careful always to watch where you are stepping: make sure you stop walking when you want to see something or take a picture around). Things to take with you:

- A water bottle which you can refill on the way (there are several springs). Make sure to drink a lot of water.
- Sun cream and a hat, especially for the last part of the walk which has very little shade.
- Good shoes. These don’t have to be hiking boots but you won’t be contributing to your enjoyment by wearing tennis shoes or sandals.
- Some food. There is no food available inside the National Park. You will have a lunch snack pack with you prepared at the kitchen of the conference centre.
- A jumper for the early morning: it can be cold at 1200m.
- A supply of plasters in case of blisters.
- There are several toilets along the way.
• Children younger than 8-9 years old may be difficult to walk the complete distance ending up to be carried along by their parents!

At Ag. Roumeli we will have 3-4 hours to spend and rest at the various cafes, tavernas and restaurants. We will have to stay there until our boat to Sougia departs at 17:30: there is NO access to Ag. Roumeli by road!! The boat costs 8 euros for adults and 4.50 euros for children (travel time 1 hour). It will also be covered by your registration fee. The conference bus(es) will wait for us at Sougia to take us back to the conference centre by 20:00, where we will have a relatively late dinner. Info taken from http://www.west-crete.com/samaria-gorge.htm (in two parts) where one can get more details and also read some useful safety tips.

2.) Heraklion - Knossos Palace and Archeological museum
Since a ∼2 hour drive to Heraklion is required this excursion will also start early, perhaps at around 07:00. We will have a tour guide with us in the bus to give us some historical background info along the way. We will visit a) the archeological museum of Heraklion and b) the Knossos Palace (the exact order for the visit of the two sites will be determined by the tour guide). The combined ticket of ∼10 euros per person for both sites will be covered by the conference fee.

• Heraklion museum: The collections of the Herakleion Archaeological Museum include unique works of Cretan art, found in excavations across the central and eastern part of the island and which cover a chronological span of roughly 5500 years, from the Neolithic (5000 BC) to the Late Roman period (late fourth century AD). Most objects date to prehistoric times and to the so-called Minoan period, named after the island’s mythical king, Minos. They include pottery, carved stone objects, seals, small sculpture, metal objects and wall-paintings, which were discovered in palaces, mansions, settlements, funerary monuments, sanctuaries and caves. (http://odysseus.culture.gr/h/1/eh151.jsp?obj_id=3327)

• Knossos Palace: Knossos is the site of the most important and better known palace of Minoan civilization. According to tradition, it was the seat of the legendary king Minos. The Palace is also connected with thrilling legends, such as the myth of the Labyrinth with the Minotaur, and the story of Daidalos and Icaros. (http://odysseus.culture.gr/h/3/eh352.jsp?obj_id=2369).

• Depending on the time it takes us to visit the two sites, we may be able to have a walk in the town of Heraklion before or after the visit to the museum. In the town of Heraklion, we may be able to rest at one of the many cafes and tavenas. In any case, a lunch snack pack will be offered to the participants of this excursion as well.

• Departure from Heraklion is expected at ∼16:30. On our way back we plan to stop at Rethymnon (half way between Chania and Heraklion) and visit the picturesque Venetian harbour for 1-1.5 hours before riding the bus(es) for the final stretch to the conference centre, where we are also expected to arrive at 20:00 for a late dinner.
Abstracts

Monday 18 June

Session 1:
Review of Ant’s work
Simon Goodwin - The work of A.P. Whitworth

Abstract: I will look back at some of the highlights of Ant’s work over the last nearly 40 years, and also talk about what it’s like to work with the man who put the ’ant’ in ’pedant’...
Hans Zinnecker - 35 years of star formation - a personal view

Abstract: I will attempt to summarize major developments, both in theory and observations, in star formation studies in the last 35 years (since the days of my PhD), including studies of stellar multiplicity and the stellar initial mass function. Major changes have happened since 1977, supercomputers and Internet have entered the scene; satellites like IRAS, ISO, Spitzer, Herschel, and HST have revolutionized the field. I will also highlight the role of the Star Formation Newsletter, created and edited by Bo Reipurth and the importance of the Protostars and Planets I-V publication series.
Abstracts

Monday 18 June

Session 2:
Low-mass star formation
Dimitris Stamatellos - Review: The formation of low-mass stars

Abstract: Most of the stars in our Galaxy have masses below 0.2 Msun. Their formation mechanism is still uncertain. I will review the main theories for the formation of low-mass stars and brown dwarfs; (i) the turbulent fragmentation theory, (ii) the ejection of protostellar embryos, (iii) the fragmentation of protostellar discs, (iv) the photo-erosion of star-forming cores. I will present their predictions for the IMF, for the properties of low-mass binaries, and for the abundance of free-floating planets, and compare these predictions with observations. I will also discuss in what way more realistic physics, like e.g. radiative feedback from young protostars, episodic accretion, and magnetic fields, may affect these predictions.
Maddalena Reggiani - From the Companion Mass Ratio Distribution to the Planetary Mass Function

Abstract: We present new results regarding the companion mass ratio distribution (CMRD) of stars, and sub-stellar objects. Considering the new survey of multiples for solar type field stars (Raghavan et al. 2010) and M dwarfs (Bergfors et al. 2010), we test the universality of the CMRD derived in Reggiani and Meyer (2011). Whereas we do not find significant differences in the CMRD for M dwarfs compared to previous results, the solar type CMRD appears to inconsistent with the previously derived CMRD from Reggiani & Meyer (2011). Despite the fact that this survey spans a wider range of angular separations than the previously studied sample from Metchev & Hillenbrand (2009), there is no evidence for variations in the CMRD as a function of orbital separation. Assuming that we can extrapolate both (1) the stellar CMRD into the BD regime and (2) the radial velocity planetary Companion Mass Function (e.g. Cumming et al. 2008) to larger separations, we can run MC simulations to test in which mass range we expect the planet population to become more important than BDs as companions to stars. This tool can be useful to predict the outcome of future surveys for very low mass companions or to analyse already existing datasets.
Anna Scaife - Radio Emission from YSOs: Tackling the (Reverse) Luminosity Problem

Abstract: The ‘classic luminosity problem’ has been known for some time, where the minimum accretion luminosities produced by the standard spherical collapse model are up to several orders of magnitude larger than those observed for embedded protostars. The solution to this problem has been proposed as non-steady or episodic accretion rate onto such objects, and recent radiative transfer simulations have demonstrated that a combination of these effects can indeed reproduce the observed luminosity distribution. However, this work has also predicted a ‘reverse luminosity problem’, whereby an overabundance of objects is expected at very low luminosities relative to those observed. Although this effect is currently ascribed to observational completeness issues, further accurate comparison will not be possible without directed observational studies. Unfortunately, such low luminosity sources are difficult to identify in the infra-red as they are typically heavily embedded in thick dust cores, and the molecular emission from their outflows is frequently so weak that it is not easily or consistently detected. Radio emission from these objects provides a reliable alternative method for detection, as the dense dust cores are optically thin to the longer wavelength emission. I will present results from a number of recent radio surveys specifically targeted at low and very low luminosity objects and discuss the new physical insights into star formation processes which can be drawn from these data.
Kengo Tomida - Radiation Magnetohydrodynamic Simulations of Protostellar Core Formation

Abstract: We perform 3D nested-grid radiation magnetohydrodynamic simulations of the formation of proto-stellar cores from molecular cloud cores with and without Ohmic dissipation of magnetic fields. In the ideal RMHD models, the evolution of the protostellar core is very similar to that in the spherically symmetric non-rotating model due to the efficient angular momentum transport. However, if the resistivity presents, the angular momentum transport is considerably suppressed due to the loss of magnetic flux, and rotationally-supported circumstellar disks are rapidly built up in the vicinity of the protostellar cores. Magnetic fields are amplified by rotation and fast outflows are launched from the protostellar cores via magnetic pressure gradient force. To our knowledge, these are the first 3D RMHD simulations resolving the protostellar cores in the world.
Eduard Vorobyov - Implications of protostellar disk fragmentation

Abstract: Gravitational instability and fragmentation in the early evolution of embedded protostellar disks is a common occurrence. Nevertheless, the importance of disk fragmentation has not been fully appreciated until recently. It has long been known that disk fragmentation may lead to the formation of gas giants and brown dwarfs on wide orbits. However, the implications of disk fragmentation are not limited by the giant planet and brown dwarf formation. I will demonstrate how disk fragmentation can trigger episodic accretion onto the star, an effect that can explain both the spread and magnitude of luminosities in young star-forming regions. Formation of freely-floating brown dwarfs and even giant planets can also be caused by disk fragmentation and subsequent ejection of the fragments into the intercluster medium. Finally, I will show how disk fragmentation can account for the presence of crystalline silicates in the Solar System comets and also explain the flattening of the mass accretion – stellar mass relation in T Tauri stars.
Basmah Riaz - The GPS/GLIMPSE360 Search for Red Objects

**Abstract:** We present results from a correlation study of the near-infrared UKIDSS Galactic Plane Survey (GPS) and the mid-infrared Spitzer Galactic Legacy Infrared Midplane Survey Extraordinaire (GLIMPSE) 360 survey. These surveys are mainly targeted towards the outer regions of the Galactic plane, at Galactic longitudes of 65-230 degrees and latitudes of -3 to 3 deg. The depth of the GPS JHK survey is well-matched to the GLIMPSE360 [3.6][4.5] survey, and thus a cross-correlation between the two surveys should be capable of detecting a factor of 10 higher number of YSOs than those detected by any of these surveys alone. Our correlated catalog of red sources (objects with hot circumstellar dust) consists of 142, 690 candidate YSOs. The YSO selection criteria is based on colour constraints applied in the (H-K) versus (K-[4.5]) colour-colour space, which provides the best distinction between young stars with modest colour excesses from the extincted field stars. We estimate a 5% contamination to the candidate YSO catalog from other red sources, such as, the asymptotic giant branch (AGB) stars, planetary nebulae, and background galaxies, with the AGB stars being the most dominant contaminant. We find a 63% fraction of red sources in the inner Galaxy, compared to 37% in the outer Galaxy regions. The red sources density is found to be 3100–3700 per square degree and 500–700 per square degree in the inner and the outer Galaxy, respectively, indicating a factor of 5 higher number density of candidate YSOs in the inner regions. I will compare the census of YSOs in the inner and outer regions of the Galactic plane, and discuss whether the star-formation environment in the outer Galaxy is significantly different than in the inner regions.
Diego Mardones - ALMA view of the CO outflow in HH46/47

Abstract: I will present the results of ALMA cycle 0 mapping of the HH46/47 molecular outflow. We mapped both outflow lobes in CO 1-0 in a 29-point mosaic with a synthesized beam of 4” and a velocity resolution of 0.2 km/s. We expect the data to be optimal for the study of the entrainment process at low velocities close to the source and to be sensitive to detect high velocity bullets not yet detected. We will use the 2-D Iguazu-A hydrodynamic code to model a jet-driven outflow. Note: the observations have been carried out but we have not received them yet, thus I prefer to present it as a poster to err on the safe side.
Abstracts

Monday 18 June

Session 3:

Young circumstellar discs
Ken Rice - Review of circumstellar discs

Abstract: We now know that much of the mass that ultimately forms a low-mass star must first pass through a protostellar disc. In this talk I will review our current understanding of these discs. I will focus on their formation through the collapse of a molecular cloud core, what processes lead to outward angular momentum transport (resulting in mass accretion onto the central star), the possibility of fragmentation into gaseous planets, brown dwarfs and low-mass stars, and how these discs are finally dispersed. I will aim to show where our theoretical understanding is consistent with observations, but will also highlight aspects of disc formation and evolution that is still uncertain and what we might do to enhance our understanding of discs and the role they play in star and planet formation.
Abstract: The formation and early evolution of protostars are described in this talk. I explain how the processes can be understood in terms of the well-known self-similar solutions developed by Anthony Whitworth and his colleagues. Recent advance in the modeling with resistive magnetohydrodynamical codes with various numerical techniques has enabled our understanding on the driving of outflows/jets and the formation of protoplanetary disks in a self-consistent manner from molecular cloud cores. This provides improved description for the realistic environments for planet formation in the gaseous disks. We find that gaseous planetary-mass objects can be formed by gravitational instability in the regions that are de-coupled from the magnetic field and surrounded by the injection points of the magneto-hydrodynamical outflows during the formation phase of protoplanetary disks. Magnetic de-coupling enables massive disks to form and these disks are subject to gravitational instability, even at 10 AU. The frequent formation of planetary mass objects in those disks suggests the possibility of constructing a hybrid scenario of planet formation, where the rocky planets form later under the influence of the giant planets in the protoplanetary disk.
Barbara Ercolano - The lifetime of protoplanetary discs: Observations and Theory

Abstract: The lifetime of protoplanetary discs around solar and low-mass stars is of crucial importance to assess the planet making potential of a system. Discs hold the reservoir of material from which gas and dust may form and hence assessing the factors that influence/dominante their dispersal is a question that intimately links the star and the planet formation processes. I will review the observational evidence that the dispersal mechanism is probably fast and it destroys discs from the inside-out, for solar type stars as well as low mass stars. Finally I will explore how current models succeed/fail to reproduce the observational data.
Christophe Pinte - Herschel observations of gas and dust in protoplanetary discs

Abstract: Primordial protoplanetary discs consist of 99% gas, and only 1% dust. Despite this, the gas phase remains poorly understood, primarily as it has thus far been difficult to observe. Herschel offers a unique opportunity to probe the warm atomic and molecular layers of discs, from low mass T Tauri stars to intermediate and high mass Herbig Ae/Be stars. We present the results from the Herschel Open Time Key Program GASPS (Gas in Protoplanetary Systems), which is observing a sample of 250 discs, concentrating on emission lines of \([\text{OI}], [\text{CII}], \text{H}_2\) and CO and analyses these results using state-of-the-art radiative transfer and chemical codes. We will discuss the main gas heating mechanisms as a function of the spectral type of the central object and compare the line emission from transition discs and young discs, offering insights on the relative evolution of the dust and gas phases in discs. The GASPS survey has detected warm water emission in a significant fraction of discs. Water - in particular in its ice form - plays a central role in the coagulation of planetesimals, the assembly of planetary atmospheres, and the emergence of life. We will compare water emission between T Tauri and Herbig Ae/Be stars and discuss the nature of the water reservoirs in discs and their implications for planet formation.
Subhanjoy Mohanty - The Viability of the MRI in Protostellar Disks: Dead, Undead and Zombie Zones

Abstract: Very recent simulations have shown that, in the presence of small grains, ambipolar diffusion can quench the MRI in X-ray-ionized protostellar disks around solar-type stars, producing accretion rates orders of magnitude too low compared to observations. Using the detailed x-ray radiative transfer/dust code MOCCASIN, we extend these results to very low-mass M dwarf disks and to various degrees of dust settling. We find that: (1) ambipolar diffusion is very efficient here as well; (2) even a small population of sub-micron sized grains can quench the MRI severely; (3) previous studies, that did not take the radial change in the magnetic field into account, overestimated the resulting accretion rates, which turn out to be even lower compared to observations; (4) conversely, if small grains are severely depleted through grain growth / settling, the Dead Zone might completely disappear around M dwarfs; and (5) the partitioning of the disk into various resistive regions (Ohmic, Hall, ambipolar) has vital implications for the radial pressure gradient, and hence for planet formation and migration in these disks.
Marc Joos - Protoplanetary disk formation and transport of angular momentum during magnetized core collapse

Abstract: Theoretical studies of collapsing cloud found that magnetic field has strong impact, possibly affecting the formation of disk and fragmentation. As most previous studies were restrained to cases where magnetic field and rotation axis are aligned, we study non-aligned configurations for various magnetic intensities. We perform 3D AMR high resolution numerical simulations of a magnetically supercritical collapsing dense core using the RAMSES MHD code. We show analytically and numerically that within collapsing cores, the magnetic transport of angular momentum acts more efficiently when magnetic field and rotation axis are aligned, at variance to the clouds having uniform field lines. Early massive disks, having at least 10% of the core mass, can therefore form with moderate magnetic intensities corresponding to mass-to-flux of 3-5 times the critical value, in misaligned configurations. For stronger fields, early massive disk formation is prevented in any magnetic field inclination we explored. As class I disks appear to be ubiquitous, we speculate that disks will form later, when most of the envelope will has been accreted.
Daniel Seifried - Disk formation in turbulent cores: Circumventing the magnetic braking catastrophe

Abstract: In recent years numerous simulations of low- and high-mass star formation in strongly magnetized cloud cores have revealed the problem of so-called "magnetic braking catastrophe". This states that angular momentum removal due to the magnetic fields is so strong that the build up of Keplerian protostellar disks is largely inhibited for cores with magnetization in agreement with observations. Also the inclusion of non-ideal MHD effects fails to produce large scale (10 - 100 AU), rotationally supported disks. In our work we present collapse simulations of 100 M\(_\odot\), turbulent cloud cores threaded by a strong magnetic field (mass-to-flux ratio = 2.6). During the initial collapse phase filaments are generated which fragment quickly and form several protostars. Around these protostars Keplerian disks with typical sizes of a few 10 AU build up which is in contrast to previous simulations neglecting turbulence. We will discuss three mechanisms potentially responsible for reducing the magnetic braking efficiency and therefore allowing for the formation of the Keplerian disks. Analysing the condensations in which the discs form, we show that the build-up of Keplarian discs is neither caused by magnetic flux loss due to turbulent reconnection nor by the misalignment of the magnetic field and the angular momentum. The formation of Keplerian disks is rather a consequence of the turbulent surroundings of the disks which exhibit no signs of a large-scale, coherent rotation structure. We can show that in such a turbulent environment the magnetic braking efficiency is reduced while the inwards angular momentum transport remains high due to local shear flows. We have performed several simulations with different initial conditions each revealing similar results. Hence, we suggest that the "magnetic braking catastrophe" is a consequence of the idealized, non-turbulent initial conditions and that turbulence provides a natural and simple mechanism to circumvent this problem.
Abstracts

Tuesday 19 June

Session 4:

Computational Star formation: Models, Techniques, & Predictions
Abstract: We will review the current state of computational star formation discussing past limitations of both grid and particle methods and their consequences on interpreting star formation models. We will also discuss recent algorithmic advances and their scope for future numerical investigations.
Abstract: I will present results of smoothed particle magnetohydrodynamics (SPMHD) simulations of the collapse of magnetised molecular cloud cores that successfully produce long-lived, highly collimated protostellar jets. I will discuss the new method for modelling ideal MHD within the SPH formalism that we have developed, along with results for how protostellar jets depend on initial conditions.
Philipp Girichidis - Impact of tangled magnetic fields on the fragmentation of cores and star formation

Abstract: Recent observations with increasing resolution show evidence for small-scale tangled magnetic fields instead of large-scale coherent field structures in star-forming cores. Previous numerical work has mainly focused on the effects on large-scale magnetic fields, finding that magnetic fields strongly reduce the star formation efficiency and the number of fragments. In this study, we show that tangled magnetic fields attenuate this fragmentation crisis, allowing for the formation of perceptibly more fragments than in the case of homogeneous fields of the same strength. We show why variations in the structure of the magnetic field can easily have a stronger impact than the strength of the field by analysing the coupling between the magnetic field and the turbulent velocity and the resulting energy transport between small and large scales.
Oliver Lomax - Star formation in Ophiuchus

Abstract: We model the evolution of prestellar cores in Ophiuchus using initial conditions informed as closely as possible from observational surveys of the region. The aim is to provide insight into the relationship between the present-day core mass function and the stellar initial mass function. Observational data provides estimates on core masses, line of sight velocity dispersions and projected spatial extent; three dimensional spatial and velocity information needs to be inferred by modeling. We constrain the intrinsic three-dimensional extent of cores by comparing the observed distribution of projected ellipses to those of a Monte Carlo model. Here we invoke a three-parameter ensemble of triaxial ellipsoid cores defined by a log-normal distribution of sizes and a scale factor through which the intrinsic axes vary. Assuming isotropic variation in the line of sight we constrain the parameters using Monte Carlo Markov chain methods. We argue that given current observational constraints, it is difficult to justify more sophisticated models and we provide statistical evidence to support this point. We explore the form of core velocity fields using SPH with various prescriptions of turbulence. Here we present results from simulations demonstrating the profound effects of triaxiality and turbulence on prestellar evolution.
Simon Glover - Gas cooling by dust during dynamical fragmentation

Abstract: Almost fifteen years ago, Whitworth and collaborators suggested that the transition that occurs within pre-stellar cores between a low-density regime dominated by line cooling and a high-density regime dominated by dust cooling is responsible for determining many of the properties of the stars that form within the core. We have recently re-examined this idea using state-of-the-art numerical simulations that self-consistently capture the thermal evolution of the gas as it moves from the line cooling to the dust cooling regime. Our simulations account for the chemical evolution of the gas, and also include a detailed prescription for the heating and cooling of the dust, including an accurate treatment of the attenuation within the core of the ambient interstellar radiation field (ISRF). We find that the transition between the line-cooling and dust-cooling regimes does indeed have a large influence on the properties of the stars that form. In particular, it appears to play an important role in setting the characteristic stellar mass, by acting as a "thermostat" that fixes the temperature at a well-defined density in a fashion that is relatively insensitive to the larger scale cloud environment. Indeed, we find that the characteristic stellar mass seems to have little dependence on the strength of the local ISRF or the size of the local cosmic-ray ionization rate. Finally we show that accurate dust temperatures alone are not sufficient to determine the true energy balance of the prestellar cores, since the gas and dust temperatures can differ by a factor of two at radii of ~10,000 AU.
Diego Falceta-Goncalves - On the Origin of Interstellar Turbulence: less SNe and more Galactic Dynamics

Abstract: Turbulence is ubiquitous in the ISM, from large (galactic) scales down to planet-sized eddies within pre-stellar accretion disks. The ISM turbulence is known to operate in both ends of triggering star formation when occurring at molecular clouds, as well as quenching the process at HII regions. Its origin, however, is still controversial. Supernovae are generally accounted as the main source of the turbulent energy of the ISM. However, recent observations of stellar orbits and the gravitational potential of the Galaxy revealed a new possibility: ISM gas flows driven by the global galactic gravitational potential. In this work we provide the first numerical simulations of the dynamics of the diffuse and molecular ISM interacting with the gravitational potential wells of the Galaxy. These reveal the generation of arms and the triggering of turbulence at large scales (> 100 pc). During the interactions, molecular clouds may be disrupted and dense cores be formed. We compare the statistics of the obtained turbulent media with the observations.
Andrew McLeod - Instabilities in cloud-cloud collisions

Abstract: Instabilities play an important role in supersonic cloud-cloud collision. We examine two instabilities: the non-linear thin shell instability (NTSI) and gravitational instability. We extend the work of Vishniac 1994 by exploring the growth rate and other properties of the NTSI triggered by a variety of initial perturbations. We then simulate a supersonic cloud-cloud collision at a range of velocities, and find that at low velocities the gravitational instability is dominant, while at higher velocities the NTSI becomes dominant and eventually suppresses star formation. Different instabilities lead to different patterns of fragmentation but do not cause significant differences in the stellar mass function.
Abstract: The role of radiation in star formation has yet to be fully quantified, and its role is believed to be increasingly important, particularly in high mass star formation. A common approach is to use the grey Flux Limited Diffusion approximation (FLD), in this talk I will discuss the where FLD breaks down and discuss an improvement upon FLD that includes a frequency dependant ray tracing algorithm to calculate the direct radiation field (Hybrid). Furthermore, comparing both methods with full Monte-Carlo radiative transfer calculations, I will show the hybrid scheme is more accurate for use in star formation simulations, particularly when the optically thin region is dynamically important.
Kohji Tomisaka - Expected Observations of the Star Formation Process: from Molecular Cloud Core to First Hydrostatic Core

Abstract: We did MHD simulations of the contraction of rotating, magnetized molecular cloud cores. In the molecular cores, B-field and angular momentum (J) vector are not always aligned. When a first hydrostatic core forms, axisymmetric structure appears and average B and J are parallel in small scale. However, in large scale, the configuration is far from this. This means that contraction process is imprinted on the snapshot. We calculated two mock observations of MHD simulations (1) the polarization from dust thermal emission to reveal the magnetic evolution and (2) the line emissions from interstellar molecules to reveal the evolution of density and velocity. Comparing the mock observations with true ones, we can answer several questions: in which case the hourglass-shaped and S-shaped magnetic fields are seen; how the distribution of polarized intensity is understood; how the first hydrostatic core should be observationally identified.
Stella Offner - Observing Simulated Protostars with Outflows: How Accurate are Protostellar Properties Inferred from SEDs?

Abstract: The properties of unresolved protostars and their local environment (e.g., disk, envelope and outflow characteristics) are frequently inferred from spectral energy distributions (SEDs) using radiative transfer modeling. However, without the ability to map the inner regions directly, it is difficult to evaluate the accuracy of these inferred properties. In this talk, I will present recent work comparing the properties inferred from synthetic observations of realistic simulations using the Orion AMR code with the actual simulated properties. To obtain the dust temperature distribution and SEDs of the forming protostars, we post-process the simulations using HYPERION, a state-of-the-art Monte-Carlo radiative transfer code. We find that the ORION and HYPERION dust temperatures typically agree within a factor of two. We compare synthetic SEDs for a range of evolutionary times, simulation resolutions, aperture sizes, and viewing angles. We demonstrate that complex, asymmetric gas morphology leads to a variety of classifications for individual objects as a function of viewing angle. We derive best-fit source parameters for each SED through comparison with a pre-computed grid of radiative transfer models. We show that the disk and source parameters can be very discrepant from the simulated values. Parameters such as the stellar accretion rate, stellar mass, and envelope mass show better agreement, but can still deviate significantly. Lack of correlation between the model and simulation properties in many individual instances cautions against over interpreting properties inferred from SEDs for unresolved protostellar sources.
Enrique Vazquez-Semadeni - Gravitationally contracting molecular clouds and their star formation rates

Abstract: I present evidence that molecular clouds may be gravitationally contracting as a whole. This includes numerical evidence that gravitational contraction begins shortly after the cloud condenses out of the warm atomic phase, and is possibly still composed of mostly (cold) atomic gas. The simulations (both magnetic and non-magnetic) also suggest that star formation begins long after the gravitational contraction has started (roughly 10 Myr later), so that the feedback from the newly formed stars must act against the ongoing contraction. Stellar feedback from ionization heating reduces the star formation efficiency (SFE) to observed values, but does it by redirecting some of the infalling gas to the warm medium, rather than by maintaining the clouds in approximate hydrostatic equilibrium. A semi-analytical model based on this phenomenology reproduces correctly the locus of clouds in the Kennicutt-Schmidt diagram, the durations of evolutionary stages of GMCs, and the observed stellar age distribution in individual clouds. Finally, I discuss the recent result that the free-fall time in flattened or filamentary clouds is longer than the canonical, spherical free-fall time, implying that the Zuckerman-Palmer free-fall value of the star formation rate (SFR) is probably an overestimate. I conclude that self-regulation of the SFR is sufficient to bring the SFE to agreement with observations in the framework of gravitationally contracting clouds.
Abstract: Star formation occurs due to the large scale processes of a galaxy but occurs on the local scale region of molecular clouds. We present the first numerical simulations that resolve the star formation process on sub-parsec scales, whilst also following the dynamics of the interstellar medium (ISM) on galactic scales. In these models, the warm low density ISM gas flows into the spiral arms where orbit crowding produces the shock formation of dense clouds, held together temporarily by their external pressure. Cooling allows the gas to be compressed to sufficiently high densities that local regions collapse under their own gravity and form stars. The star formation rates follow a Schmidt-Kennicutt relation with the local surface density of gas. Cooling is the primary driver of the star formation and the star formation rates as it determines the amount of cold gas available for gravitational collapse and star formation. Intriguingly, it appears that a spiral or other convergent shock and the accompanying thermal instability can explain how star formation is triggered, generate the internal structure and turbulence in molecular clouds and explain why star formation rates are tightly correlated to the gas properties of galaxies.
Thomas Robitaille - A new grid of model spectral energy distributions for young stellar objects

Abstract: In 2006, we made available a grid of model spectral energy distributions (SEDs) for young stellar objects (YSOs) that has since been used by the community to model thousands of sources in nearby and more distant star forming regions in the Milky-Way and Magellanic clouds. In this talk I will present a new and much larger grid of model SEDs that addresses many issues with the original model grid, such as parameter space coverage, the dependence on stellar evolutionary tracks, and is well suited to modeling long-wavelength observations such as Herschel and longer-wavelength data. The new models were computed with HYPERION, a new Monte-Carlo radiative transfer code (Robitaille, 2011). I will present the design of the model grid, initial modeling results, and I will discuss some of the open issues and limitations in using model SEDs to interpret observations of YSOs.
Abstracts

Tuesday 19 June

Session 5:

Triggered Star Formation
Stefanie Walch - Review of triggered star formation

Abstract: Photo-ionization and stellar wind feedback from massive stars strongly shape the surrounding interstellar medium throughout their lifetime and before they explode as Supernovae. These feedback processes may lead to new, triggered star formation through a variety of mechanisms. In this talk I will review the process of triggering star formation within molecular clouds by feedback from massive stars. I will provide an overview of theoretical work on this subject, state-of the art simulations as well as the current observational constraints.
Abstract: The small, medium and large scale triggering will be discussed. On small scales, the triggered star formation is due to the collapse of shells collecting the interstellar medium, due to the formation of bright rimmed pillars, and due to the radiative implosions of preexisting cold gas condensations. On medium scales, the triggered star formation is connected to ISM compression by galaxy spiral arms. On large scale, the galaxy collisions compress molecular clouds triggering formation of super star clusters.
Evangelia Ntormousi - Triggered formation of filamentary clouds

Abstract: The violent feedback from massive stars has been observed since a long time to trigger the formation of molecular clouds at the wake of giant shocks. We simulate this process in high resolution, introducing realistic, time-dependent stellar feedback in the RAMSES hydrodynamics code. Two giant shells are followed from their birth until their collision. Filamentary clumps form naturally in this environment and are found in a variety of physical states. The clumps host internal motions high enough to support them against gravitational collapse. We also study the global efficiency for cold gas formation from the passage of the shocks and the efficiency for mixing material from the hot phase, containing metals from the massive stars, to the newly-formed cold clumps.
Matthias Gritschneder - Triggering Star Formation - From the Pillars of Creation to the Formation of our Solar System

Abstract: We study the structural evolution of turbulent molecular clouds under the influence of ionizing radiation emitted from a nearby massive star by performing a high-resolution parameter study with the smoothed particle hydrodynamics (SPH) code iVINE. In our simulations, the ionizing radiation enhances the initial turbulent density distribution and thus leads to the formation of pillar-like structures observed adjacent to HII regions in a natural way. Gravitational collapse occurs regularly at the tips of the structures. We find a clear correlation between the initial state of the turbulent cold cloud and the final morphology and physical properties of the structures formed. To enable a close comparison with observations we investigate the LOS-velocity profiles. The profiles from the ionization of a turbulent molecular cloud show a single peak, consistent with e.g. observations of the Dancing Queen trunk, whereas the radiation driven implosion (RDI) of pre-existing clumps leads to double peaked features. However, very recent studies of the Carina nebula indicate that double peaked features are observed as well. We then go on to present simulations on the future evolution of these pillars as soon as the massive star explodes in a supernova. We are able to show that a surviving core at the border of the HII-region (D~5pc) is getting enriched sufficiently with supernova material and is triggered into collapse fast enough to be consistent with the tight constraints put by meteoritic data of e.g. Al26 on the formation of our Solar System. We therefore propose that the formation of the Solar System was triggered by the shock wave of a type IIa supernova interacting with surviving cold structures similar to the Pillars of Creation at the border of HII-regions.
Jim Dale - Positive and negative ionizing feedback

Abstract: I will present SPH simulations of the effects of ionizing radiation on star-forming clouds covering a broad parameter space in mass and radius with examples of initially bound and unbound objects. I will compare the positive (in the sense of triggering star formation) and the negative (in the sense of gas expulsion and aborting star formation) influence of feedback on the clouds and their embedded star clusters.
Richard Wünsch - Gravitational fragmentation of the Carina Flare supershell

Abstract: We study the gravitational fragmentation of a thick shell comparing the analytical theory to 3D hydrodynamic simulations and to observations of the Carina Flare supershell. We use both grid-based (AMR) and particle-based (SPH) codes to follow the idealised model of the fragmenting shell and found an excellent agreement between the two codes. Growth rates of fragments at different wavelength are well described by the pressure assisted gravitational instability (PAGI) - a new theory of the thick shell fragmentation. Using the APEX telescope we observe a part of the surface of the Carina Flare super-shell (GSH287+04-17) in the $^{13}$CO line. We apply a new clump-finding algorithm DENDROFIND to identify 50 clumps. We determine the clump mass function and we construct the minimum spanning tree connecting clumps positions to estimate the typical distance among clumps. We conclude that the observed masses and distances correspond well to the prediction of PAGI.
Thomas Bisbas - A nebula in your computer: simulating the dynamics and chemistry of an HII region

Abstract: In this talk we will concentrate on numerical simulations of HII regions. Using the Smoothed Particle Hydrodynamics code SEREN we will discuss on the dynamical expansion of an HII region. We will focus on the particular case of radiation driven implosion and the associated triggered star formation. In addition, using MO-CASSIN and the recently developed astrochemistry code 3DucLpdr we will discuss on modelling the chemistry of both the interior and the PDR of an HII region thus offering an important tool in understanding their overall structure.
Abstracts

Thursday 21 June

Session 6:

Probing the initial stages of star formation
Abstract: The whole of the Taurus region (a total area of 52 sq. deg.) has been observed by the SPIRE and PACS instruments at wavelengths of 70 μm, 160 μm, 250 μm, 350 μm and 500 μm as part of the Herschel Gould Belt Survey. In this paper we present the first results for the Barnard 18 and L1536 clouds. Extended sources are extracted from the data using the CSAR hierarchical source finding algorithm and plotted on a mass-size diagram. Previous studies showed that gravitationally bound prestellar cores and unbound starless cores appeared in different places on the diagram. However, it was unclear whether this was due to a lack of instrumental dynamic range or whether they were actually two distinct populations. The excellent sensitivity of Herschel shows that our sources fill the gap between these populations and gives the first clear supporting evidence for the theory that unbound cores evolve into prestellar cores.
Abstract: The Herschel Space Observatory is providing us with unprecedented images of the initial conditions and early phases of star formation at far-infrared and submillimeter wavelengths. I will present an overview of recent results obtained on the structure of molecular clouds as part of the Herschel Gould Belt survey. The role of filaments in the star formation process and their likely connection to interstellar turbulence will be emphasized. Overall, the Herschel results suggest that it may be possible to understand both the IMF and the global rate of star formation in galaxies by studying the physics of how dense structures (e.g. filaments, cores) form and grow in the ISM of our own Galaxy. Despite an apparent complexity, global star formation may be governed by relatively simple universal laws from filament to galactic scales.
Anaelle Maury - First results from CaLYPSO: the IRAM Plateau de Bure Large Program on Class 0 protostars

Abstract: Despite some progress in the past two decades, the physics of the youngest protostars (Class 0 objects) remains poorly understood. The mere existence of accretion disks and proto-binaries at the Class 0 stage is highly controversial. Likewise, the launching mechanism of protostellar jets and their net contribution to mass and angular momentum extraction during protostar formation is strongly debated. The complex velocity and density structure shaping the inner protostellar environment is also a great puzzle to star formation models. Solving these issues, which all have a strong bearing on the long-standing angular momentum problem of star formation, is of paramount importance. To this aim, we obtained a comprehensive, systematic study of the nearest low-luminosity Class 0 objects with the A & C arrays of PdBI, also supported by a parallel MHD simulation effort. The CaLYPSO (Continuum and Line Young ProtoStellar Object) survey, carried out with both the IRAM 30-m telescope and Plateau de Bure Interferometer, targets 17 nearby Class 0 protostars in 3 different spectral setups, at sub-arcsecond resolutions reaching 50AU scales. It is the most complete high-resolution survey of Class 0 objects carried out so far. I will present our first completed set of observations, and I will discuss the complementarity of continuum observations and line tracers to draw a comprehensive picture of the small scale infall/accretion processes in Class 0 envelopes. I will also show how our observations allow us to put unprecedented constraints on inner (50-500 AU) envelope properties and chemistry, as well as the disk and binaries formation scenarios.
Abstract: The density structure of a molecular cloud determines the number and sort of stars that can form within the cloud boundaries. Unfortunately, to date relatively little information is available on the absolute values and spatial gradients of gas densities in clouds; past research focussed on "cores" of relatively small size (smaller 0.1pc), but neglected the cloud structure on larger spatial scale. This problem resulted from (a) a lack of data probing clouds on spatial scales much larger 0.1pc, and (b) insufficient data analysis methods to properly exploit such data — and was aggravated by (c) insufficient analysis of theoretical models to use observations to constrain these models. I report on progress made on all three of these issues. First, I present new tools to extract column density information from clouds, which yields reliable wide-field maps of molecular clouds from dust emission data obtained with the Herschel satellite (Kelly et al., ApJ, submitted). Second, I show how these and other column density maps can be exploited using new hierarchical structure analysis tools. This yields the most comprehensive overview of cloud density information available to date (Kauffmann et al., 2010a,b,c). In addition, this work permits to understand column density probability density functions (PDFs) from a new angle, i.e., as a result of core density distributions and core mass functions (in prep.). Third, theoretical models of star-forming clouds are analyzed with the same tools used to study actual clouds in space. This permits to connect theoretical models to observations of cloud structure on large spatial scales (Parmentier et al., 2011; and in prep.). In practice, we used this work to demonstrate the limited potential of Infrared Dark Clouds (IRDCs) to form high-mass stars (Kauffmann et al. 2010c). However, we sometimes also find active star formation in regions not thought to be dense enough to form stars (e.g., the VeLLO L1148-IRS, a candidate proto Brown Dwarf; Kauffmann et al. 2011). Most interestingly, we now study the Galactic Center Cloud G0.253+0.016: this cloud concentrates the mass of Orion A into a volume of 3pc — but it does not form stars at any significant rate. In fact, our data from the SMA and CARMA interferometers shows that this cloud has not yet formed significant dense cores. In summary, this shows that G0.253+0.016 has a very limited star formation potential (Kauffmann et al., ApJ, submitted in March). Similar clouds may populate the centers of other normal and starburst galaxies. G0.253+0.016 may thus be a key object for understanding star formation under extreme conditions in the nearby and early cosmos.
David Nutter - Initial Results from SCUBA2

Abstract: I will show some of the initial SCUBA2 data obtained by the JCMT Gould Belt Survey and the SCUBA2 Guaranteed Time consortium. These data cover star-formation regions with a range of scales, from the relatively modest star formation in Taurus, through the intermediate MonocerosR2, to the star forming powerhouse Orion. At the wavelengths of 450 and 850 microns, SCUBA2 is sensitive to the coldest dust, which is mapped with sub-10 arcsec angular resolution. This cold material allows SCUBA2 to map the very earliest stages of star formation.
Adam Ginsburg - Surveying Pre-Stellar Gas in the Galactic Plane with Bolocam and Herschel

Abstract: I report on the most massive and dense proto-massive-clusters in the Bolocam Galactic Plane Survey. These include the most massive star-forming regions in the Galaxy, e.g. W49 and W51. Throughout the Galactic plane, all "clumps" above about 5000 solar masses show clear signs of star formation, indicating that massive star forming regions evolve through their pre-stellar state in a timescale no longer than about 0.6 MYr. The BGPS is the first survey to be complete to a useful mass limit (5000 solar masses) over a significant fraction of the Galactic disk (25%) and is therefore the first survey useful for identifying what we don’t see in the Galaxy. I will discuss the survey methods and the work involved in determining completeness and distances to the brightest objects in the BGPS. I will include follow-up from the Herschel Hi-Gal survey and present the roadmap towards a galaxy-wide complete survey.
Abstract: With the HOPS, MALT90 and HiGAL Galactic plane surveys we are mapping a significant fraction of the dense, star-forming, molecular gas in the Galaxy. I will present results from two projects based on this combined dataset, namely, i) looking for variations in the star formation (SF) rate across the Galaxy as a function of environment, and ii) searching for molecular cloud progenitors of the most extreme (massive and dense) stellar clusters. We find the SF rate per unit mass of dense gas in the inner 250pc of the Galaxy is at least an order of magnitude lower than that in the disk, directly challenging proposed universal column/volume density thresholds for SF to occur. I will present one molecular cloud we have studied as part of project ii) which is clearly extreme compared to the rest of the Galactic population. With a mass of 105 Msun, a radius of only 3pc and almost no signs of star formation it appears to be the progenitor of an Arches-like stellar cluster. We speculate this may be a local-universe-analogue of the initial conditions of a super star cluster or potentially even a small globular cluster. This object appears to be unique in the Galaxy, making it extremely important for testing massive cluster formation models. We have been awarded 6 hours of ALMA Cycle 0 observing time to study this object in detail. I hope to present first results from this ALMA dataset at the meeting.
Kazi Rygl - Recent star formation in the Lupus clouds as seen by Herschel

Abstract: We present a snapshot of the star formation histories of the Lupus I, III, and IV clouds using the Herschel 70-500 micron maps obtained by the Gould Belt Survey Key-Project. We find 38 new candidate prestellar cores (of which 26 are located in Lupus I), one Class 0 object, 15 new candidate Class I sources, and most of the protostars previously detected by Spitzer. We propose that Lupus I is currently undergoing an event of accelerated star-formation, while Lupus III had its star formation rate peak more than 2 Myr ago and its star formation is now decelerating. Lupus IV may have a slightly increasing star formation rate. The star formation efficiency of the Class I and younger objects is similar \(~0.50\%\) in all three clouds, but it is much larger \(3.6\%\) in Lupus III than in Lupus I and IV when more evolved objects are included. This difference indicates that the past star formation event in Lupus III may have been externally triggered, possibly by the nearby OB associations.
Danae Polychroni - The bimodal distribution of core masses in the Orion A L1641 clouds

Abstract: The Herschel Gould Belt Survey far-IR maps of the Orion L1641 molecular clouds have revealed a wealth of interconnected filaments and dense cores in the region. We present, here, our analysis of the physical properties of dense cores as a result of their immediate environment. We have extracted a robust and statistically significant sample of 405 dense cores with which we built the Core Mass Function (CMF) of the region that spans a mass range of 0.1 to 20 M. We show that the CMF of the region is, in fact, a bimodal distribution that depends on the location of the dense cores on or off the identified filaments. Furthermore, we report the first estimate of the mass of the l1641 clouds as derived from the dust (3.7x104 M) which is in agreement with previous estimates of the mass derived from the gas content of the region. Finally, we find that while the Core Formation Efficiency is generally quite low (1.5%) as expected, it is significantly higher (4.4%) when considering only the filamentary regions.
Doris Arzoumanian - Characterizing interstellar filaments in nearby molecular clouds

Abstract: Herschel observations of molecular clouds reveal the presence of complex filamentary structures which are shown to be the main sites of core and protostar formation (Andre et al. 2010). Understanding the properties of these filaments is a first step toward establishing a broader scenario of star formation in the Galaxy. Thanks to their unprecedented spatial dynamic range in the submillimeter regime, the Herschel images provide detailed quantitative information on these filaments, making it possible to characterize their properties in a statistical manner (Arzoumanian et al. 2011). I will discuss the properties of filaments seen by Herschel in 5 regions from the Gould Belt survey (IC5146, Aquila, Pipe, Taurus, Polaris), located at distances from 140 pc to 460 pc and having different star formation activities (filaments with column densities from \( \sim 10^{20}\) cm\(^{-2}\) in Polaris to \( > 10^{23}\) cm\(^{-2}\) in Aquila). The radial density profiles of the filaments show a power-law behaviour at large radii of \( r^{-2} \) (shallower than the hydrostatic isothermal Ostriker model described by \( \sim r^{-4} \)) with a flat inner part, which is remarkably uniform (\( \sim 0.1\) pc) for all filaments in our sample (\( \sim 150 \) filaments) regardless of column density. The observed filaments are not strictly isothermal, their dust temperature profiles show a slight (\( \sim 3\) K) but significant decrease in temperature toward the centre. I will complement the analysis based on Herschel with preliminary line-width measurements with the IRAM 30m telescope. We find evidence of an increase in non-thermal velocity dispersion with column density, denser filaments being more turbulent than more diffuse ones (Arzoumanian et al. in prep.).
Vera Konyves - The Aquila prestellar and protostellar population revealed by Herschel

Abstract: The Herschel Gould Belt survey (Andre et al. 2010) will soon provide an unprecedented census of starless cores, embedded protostars, and cloud structures, down to the lowest column densities in all nearby molecular clouds. Here, we summarize the results obtained in the huge field of the Aquila Rift complex, at a distance of 260 pc, which was observed during the Science Demonstration Phase of Herschel. We are currently working on a more detailed study of this field (Konyves et al. 2012, in prep.). I will discuss the core mass function (CMF) for hundreds of starless cores derived from SPIRE and PACS (500-70 μm) data. Most of these cores appear to be gravitationally bound, and thus prestellar in nature. Our Herschel results confirm that the shape of the prestellar CMF resembles the stellar initial mass function (IMF), with much better statistics (Konyves et al. 2010) than earlier submillimeter continuum ground-based surveys. In the entire region, we also find approximately 100 young stellar objects, most of which is newly discovered by Herschel. Their basic properties ($M_{env}$, $L_{bol}$) and distribution suggest that they are probably younger than the Spitzer protostars in the most active subregion of Aquila (Bontemps et al. 2010). The spatial distribution of prestellar cores and protostars is in good correspondence with the regions of gravitationally unstable filaments which shows that these filaments are actively forming stars, and filaments play a key role in star formation processes (Andre et al. 2010, Arzoumanian et al. 2011).
Martin Hennemann - HOBYS observations of ridges and filaments, and the evolution of massive dense cores

Abstract: Herschel 100pc-scale observations of close-by massive star-forming regions as obtained by HOBYS, the Herschel imaging survey of OB Young Stellar objects (Motte, Zavagno, Bontemps et al. 2010), now provide an unbiased view on the detailed cloud column density structure and its population of massive dense cores - excellent candidates for high-mass star precursors. We present evidence that structures like the DR21 ridge, the most massive cloud structure in Cygnus X with a column density above $10^{23}$/cm$^2$ over 4 pc$^2$, a total mass of 20000 M$_\odot$, hosting 9 massive dense cores that dominate its structure, could be formed by the merging of filaments or flows: Several ”subfilaments connected to it are resolved with Herschel, extending the previous velocity study (Schneider et al. 2010). We find that the subfilaments are gravitationally supercritical and form cores and protostars which may become low-mass members of the OB star cluster(s) in formation in the DR21 ridge. The pronounced North-South elongation of the DR21 ridge resembles individual filaments as found towards low-mass star-forming regions, but at positions not dominated by compact massive dense cores we find wider, substructured perpendicular profiles, consistent with the observed convergence of two filaments at the endings of the ridge. The present mass in the subfilaments is a factor of 10 lower than the ridge mass, so they merely represent remnant flows. They show decreasing dust temperature towards their connection with the ridge, maybe indicating the pile-up of material to high densities which cools down to a minimum of 14K seen towards the Northern part of the ridge. However, their link to the clumps around DR21 and DR21(OH) means that these flows could have been important to build-up massive clumps inside the ridge. Extrapolating, we would expect the assembly of massive clumps towards the Northern part of the DR21 ridge where the most massive subfilaments connect, in continuation of the evolutionary sequence of star-formation along the ridge from South to North. We also use the large coverages obtained by HOBYS including Cygnus X (7000 pc$^2$) and Rosette (2000 pc$^2$) to establish a complete sample of compact massive, cold, and dense cores in the region and constrain their luminosities, dust temperatures, and envelope masses. For core masses of 20 to 1000 M$_\odot$, we find typical dust temperatures of around 18K. These key parameters are used to construct an evolutionary diagram of massive protostellar objects, and we use a set of simple evolutionary tracks for classification. In particular we will discuss the low luminosity-to-mass ratio found for part of the sample which may relate to the fragmentation of the cores. The number of massive dense cores is compared to the total mass of the host structures to estimate star formation efficiencies, rates, and rate densities. The very active star-forming sites like the ridges IRDC G035.39-00.33 and DR21 show values comparable to starbursts, i.e. rather unusual in the Milky Way. Given that 1/4 of the massive dense cores in e.g. Cygnus X formed in the DR21 ridge, and several such very active sites are found in HOBYS fields, we will discuss the tight link of high-mass star formation and the
star formation rate to ridge structures.
Abstract: We present maps of the nearby Lupus 1, 3 and 4 molecular clouds carried out with Herschel at 70, 160, 250, 350 and 500 micron and with Mopra at 3 and 12 mm. In the Herschel continuum maps we identified the dense and cold dust cores as well as the cold extended dust emission while the Mopra lines maps revealed the gas dense cores, traced by $N_2H^+$(1-0), $NH_3$(1,1) and HC3N(10-9) as well as the more diffuse gas component traced by CS (2-1). The properties of the compact sources (mass, size and temperature) have been derived from the fitting of their spectral energy distribution. These allow us to classify the detected cores in three main categories: 1. protostars, cores internally heated by a compact central source, 2. prestellar cores, cores without an internal luminosity source but dense enough to eventually become stars, and 3. unbound cores, dense condensations with a mass much lower that the Bonnor-Ebert mass that are not able to form a star. The mass and temperature distributions of both the prestellar cores and protostars will be discussed. For the cores detected in the line maps we derived the gas temperature and an indication of their evolutionary status from the chemical abundance ratio of the observed species. The classification based on the SED fitting agree with the classification based on chemical clocks. Both the Herschel and the CS maps show a well defined filamentary structure with most of the dense cores being on the filaments. The spatial distribution of the protostars and prestellar cores reveals that the present star formation activity is mainly confined in some part of the clouds. The comparative analysis of the Herschel photometric and Mopra spectroscopic data allow us to reconstruct the dynamics of the filaments from which we propose a 3-D view of the clouds.
Abstracts

Thursday 21 June

Session 7:
The initial mass function of stars
**Abstract:** If the shape of the Stellar IMF is determined by the shape of the CMF, as suggested both by observers and theorists the mapping from the CMF to the stellar IMF must be self-similar, and one is obliged to explore the consequences of this rather challenging conclusion. We demonstrate that two almost inevitable consequences are that a core typically spawns between 3 and 4 protostars, and that the star formation efficiency (the fraction of the core’s mass going into stars) is high (60% to 100%). The alternative (i.e. that the mapping is not self similar) sits more happily with most people’s perceptions, but in this case theories for the origin of the CMF should be presented as such, and not as theories for the origin of the IMF. Moreover there are consequences here too. For example, if the mean number of stars spawned by a core increases with the core’s mass, the CMF should have a shallower slope than the stellar IMF at high masses, that is unless this is compensated by the star formation efficiency increasing with core mass at the same rate.
Abstract: Over the past 14 years, the data from observational surveys has shown that the mass function of pre-stellar cores (CMF) and the mass function of stars (IMF) are similar, suggesting that we can directly observe the creation of the IMF in the early stages of the cloud fragmentation process. Despite strong support in the literature for a direct mapping between the CMF and the IMF, a number of studies have highlighted problems with this simplistic picture. Numerical simulations have provided an interesting insight, demonstrating that the CMF and IMF can both have the same shape, but be completely unrelated. Also, observational studies have demonstrated that many (if not most) of the clumps that are reported are not bound, in keeping with the predictions from the simulations. Further, it has been pointed out that as cores of different masses are likely to collapse at different rates, the observed IMF and observed distribution of pre-stellar cores in a given region should not match. In this contribution, we review the observational and theoretical case against the CMF-IMF mapping, with illustrated examples from recent high-resolution numerical simulations of star-forming clouds. In particular, we show that the thermodynamic coupling between the gas-dust is so weak, that the dust temperature is often a poor proxy for the gas temperature, making it difficult to estimate the dynamical state of the cores.
**Rowan J. Smith - The Birth of an IMF**

**Abstract:** The Initial Mass function contains a wide morphology of both high and low mass stars all forming together in clusters. In this contribution I will use simulations to examine the various morphologies and environments of collapsing protostellar cores and examine how they are transformed into an IMF. Radiative transfer models of the line profiles from the collapsing cores will be used to critically compare to observations. Low mass stars typically form in situations where there accretion is confined to a small core surrounding the protostar. Recent Herschel observations show many such cores embedded within filaments. I will present line modelling of filaments from simulations and show that they have low internal line-widths and mild velocity gradients of a few km/s across their length. In high density clustered regions, internal filament velocities can interfere with collapse signatures from their embedded collapsing cores in up to 50% of cases. High mass stars, on the other hand, tend to form at the focal point of large scale convergence motions and accrete material from a larger volume. This is due to massive stars forming at the bottom of the potential-well of its parent protocluster. The resulting line profiles are less variable with viewing angle than their low mass analogues, and often display a characteristic saw-tooth line profile instead of the predicted double peaked blue asymmetric profile.
Sally Oey - The Salpeter Slope of the IMF Explained

Abstract: If we accept a paradigm that star formation is a self-similar, hierarchical process, then the Salpeter slope of the IMF for high-mass stars can be simply and elegantly explained as follows. If the intrinsic IMF at the smallest scales follows a simple -2 power-law slope, then the steepening to the -2.35 Salpeter value results from fact that the most massive stars cannot form in the lowest-mass clumps. It is stressed that this steepening MUST occur if the lowest-mass clumps can form stars. This model is consistent with a variety of observations as well as theoretical simulations.
Pavel Kroupa - A top-heavy IMF in star bursts

Abstract: By analysing the present-day stellar content of well observed globular clusters and of ultra-compact dwarf galaxies it has emerged that the stellar IMF appears to become increasingly top-heavy with increasing star-formation rate density and decreasing metallicity. The result of our recent work is a much more complete understanding of the stellar and sub-stellar IMFs and of the variation of the IMF with star-formation environment. Indeed, it emerges that the theoretically predicted systematic variation of the IMF seems to have been uncovered for the first time.
Annabel Cartwright - Four-parameter fits to the Initial Mass Function using Stable Functions

Abstract: We propose the use of the statistically well-founded Pareto-Levy family of Stable Distributions for the characterisation of the mass distributions of Stellar and Pre-stellar populations. This family of distributions, which includes the Gaussian, Levy and Cauchy distributions, can be shown to obey the central limit theorem. This makes them statistically justifiable models for populations resulting from the combination of many independent variables. Applying publicly available software to raw datasets we find probability distributions which fit the data to 95% confidence levels. This automatic process is much simpler, faster and more objective than the normal procedure of deciding upon bin sizes and thresholds, and only four parameters are required to define the best fit Stable Distribution. As there is only one function to describe the whole mass range, there is no need to speculate upon the physical significance of 'thresholds' between different subranges. Using Stable Distribution fits we demonstrate that the modal peaks and widths of the peaks for Core Mass Functions from Ophiuchus, Aquila and Orion are measurably different, width increasing with peak mass. The slopes of the high mass power laws are indistinguishable.
Thomas Maschberger - A stochastic model of accretion

Abstract: Star formation occurs in flocculent, chaotic environments. Therefore the accretion rates of proto-stars moving through a cloud will not be completely smooth and may contain a random noise term. Stochastic accretion can be described with a non-linear stochastic differential equation for the accretion rate, i.e. $\frac{dm}{dt} = m^2 (dt + dW)$, where $dW$ describes the fluctuations. A sample of seeds growing in this model develops a mass function that follows the whole shape of the initial mass function. Both the log-normal low-mass part to the high-mass power law are a consequence of the same stochastic growth equation. Another natural outcome of this model is the temporal evolution of the initial mass function, which grows a power-law tail over time, similar to what is seen in hydrodynamical sink-particle simulations. Thus, such model might perhaps serve as an anlytical theory of competitive accretion.
Abstracts

Friday 22 June

Session 8:
High-mass star formation
Patrick Hennebelle - Review of high-mass star formation theories

Abstract: I will review the theoretical ideas which have been put forward along the years to explain the formation of massive stars. In particular, I will discuss the accretion problem induced by the strong radiative feedback and its widely accepted solution based on radiation anisotropy, the flashlight effect. I will also discuss the fragmentation problem that arises during the collapse of massive cores and the possible solutions which have been proposed, namely competitive accretion and radiative, magnetic or magneto-radiative stabilisation. Finally, I will finish by stressing the large uncertainties which remain on the present calculations and the future challenges that need to be solved.
Abstract: I will present and discuss the most recent observational and theoretical results which may explain the formation of massive stars. Theoretically it is not clear how molecular clouds can form large Jeans masses to collapse into a single new star. The pre-collapse gas could be warm, turbulent, magnetic on a small scale to explain a large effective Jeans mass (e.g. McKee & Tan 2003, ApJ 585, 850). Alternatively the high-mass stars are collapsing from large scales which could correspond to large Jeans mass due to the low average density at such large scale (Bonnell & Bate 2006, MNRAS 370, 488; Vazquez-Semadeni et al. 2007; Hennebelle & Chabrier 2009, ApJ 702, 1428). Our recent observations in Cygnus X indicate that super-Jeans mass cores can form in the densest regions of the complex (Bontemps et al. 2010, A&A 524, 18), and which are collapsing as single high-mass stars. The gas in these massive cores is not warm but it shows some strong dynamics (Csengeri et al. 2011, A&A 527, 135) which point to large to small scale collapsing flows which converge to these single gravitational dwells (Schneider et al. 2010, A&A 520, 49; Csengeri et al. 2011, ApJ 740, L5). We will discuss these results in comparison with the above theoretical scenarios, and with the most recent MHD simulations (e.g. Commerçon et al. 2011, ApJ 742, L9). The massive collapsing cores in Cygnus X appear to be part of small groups of massive stars and may correspond to the embryos of forming stellar clusters. It seems that the IMF is locally biased toward high-mass stars in the center of these protoclusters which would explain the primordial mass segregation of stellar clusters (Bontemps et al. 2010).
Rolf Kuiper - Feedback in Massive Star Formation

Abstract: Massive stars easily achieve luminosities that their radiation pressure, stellar winds, and ionization play a major role in shaping the circumstellar environment. On top of the impact of the radiation pressure (Kuiper et al. 2010b, 2011, ApJ), we are now studying the effects of these subsequent feedback mechanisms. Their influence on the accretion disk, the outflow, and large-scale rotating tori (compare observations by Beltran et al., 2011, A&A) is determined in 1D, 2D, and 3D radiation hydrodynamics simulations of collapsing pre-stellar cores of gas and dust. Therein, the evolution of the stellar environment is resolved down to the order of 1 AU (logarithmically decreasing towards larger distance to the star) and the stellar irradiation feedback is computed by use of a highly accurate frequency-dependent ray-tracing (RT) approach (Kuiper et al. 2010a, A&A). Recently - in Kuiper et al. (2012), A&A - we depicted the importance of this RT step in revealing the sustained stability of radiation-pressure-dominated outflow cavities during the formation of massive stars. In contrast, making use of the gray flux-limited diffusion approximation (FLD) highly underestimates the absorption probability in the cavity shell. As a result, FLD artificially leads to a configuration prone to the so-called radiative Rayleigh-Taylor instability (Krumholz et al., 2009, Science). The evolution of the pre-stellar environment is computed for several 100 kyr (up to a maximum of 14 free-fall times), including the whole accretion phase of the forming star. In this manner, we are able to conclude on the importance of the various feedback effects also regarding their role in determining the upper mass limit of stars in general.
Quang Nguyen Luong - Star formation rates and cloud structures in high-mass star-forming regions

Abstract: Motte, Nguyen-Luong, Hill, Hennemann, Bontemps, Schneider, Didalon et al. The HOBYS key program (Motte, Zavagno, Bontemps et al. 2010; see http://hobys-herschel.cea.fr) is essentially imaging at far-infrared to submillimetre wavelengths all of the regions forming OB-type stars at distances less than 3 kpc from the Sun. The observations reveal thousands of young stellar objects (YSOs), among which hundreds probable precursors of OB stars (e.g. Hennemann et al. in prep.). The maps also display cloud structures including low-density filaments and high-density, dominating, and structured cloud features we call ridges (e.g. Hill et al. 2011). We use the number of burgeoning YSOs to measure the star formation activity in sub-regions of the W48, Cygnus X, Vela, and W43 molecular cloud complexes and show a definite increase with the mass surface density measured for Herschel column density images. The star formation activity is particularly large in ridges like the IRDC G035.39-00.33 where Nguyen-Luong et al. (2011b) measured a mini-burst with SFE\textlesssim{}15\%, SFR\textlesssim{}300M_{\odot}Myr^{-1}, and \Sigma_{\text{sfr}}\sim{}40M_{\odot}yr^{-1}kpc^{-2} within a \sim{}8pc^2 area with a mass density of 600M_{\odot}pc^2. These ridges represents mini-starburst regions, i.e. molecular clouds which have a mass density and a star formation activity rather unusual in the Milky Way but which is reminiscent of starburst galaxies. Molecular cloud surveys suggest that such ridges/mini-starburst regions could be formed by the merging of flows and/or filaments (e.g. Schneider et al. 2010, Motte et al. in prep.). This last point will be illustrated in the case of W43, using the large atomic, molecular line, and continuum database built for the molecular complex (100 pc) and its ridges (a few pc) (Nguyen-Luong et al. 2011a, Motte et al. in prep.).
Nicolas Peretto - Global collapse and massive star formation: an ALMA view of a massive IRDC

**Abstract:** Despite their crucial impact on galactic evolution, the process by which massive stars form remain elusive. However, there are observational evidence now that large-scale kinematics of dense molecular clouds play an important role for the formation of massive star progenitors. In this talk, I will present the first ALMA observations of a massive Infrared dark cloud hosting, in its centre, two of the most luminous young stellar objects (YSOs) in the Galaxy. I will investigate the scenario of large-scale (1pc) collapse of the surrounding gas along the observed filaments, potentially feeding the two massive YSOs. I will compare these observations to dedicated MHD simulations.
Tracey Hill - Filaments, ridges and a mini-starburst - HOBYS’ view of high mass star formation with Herschel

Abstract: With its unprecedented spatial resolution and high sensitivity, Herschel is revolutionising our understanding of high-mass star formation and the interstellar medium (ISM). In particular, Herschel is unveiling the filamentary structure and molecular cloud constituents of the ISM where star formation takes place. The Herschel Imaging Survey of OB Young Stellar objects (HOBYS; Motte, Zavagno, Bontemps, see http://www.herschel.fr/cea/hobys/en/index.php) key program targets burgeoning young stellar objects with the aim of characterising them and the environments in which they form. HOBYS has already proven fruitful with many clear examples of high-mass star formation in nearby molecular cloud complexes (e.g. Motte et al., 2010). Through multi-wavelength Herschel observations I will introduce some of the regions of the HOBYS program, including Vela C, M16 and W48. These works draw together a comprehensive data set with which to study the initial conditions of star formation and the CMF-IMF relation of high-mass and low-mass stars. For example, these data are rich with filamentary structures and a wealth of sources which span a large mass range from low to high-mass objects in the pre-collapse of protostellar phase of formation. The natal filaments themselves come in many shapes and sizes, they can form thick ridge-like structures, be dispersed in low column density regions or cluster in high-density regions. In Vela C, high-mass star formation proceeds preferentially in high column density supercritical filaments, called ridges, which may result from the constructive convergence of flows (Hill et al. 2011). Many other HOBYS regions display evidence of a potential ridge. I will also present the latest Herschel results from the Eagle Nebula (M16), which trace the cold, dense early prestellar phase of star formation, and their natal filaments in this star-forming complex. The nearby OB cluster NGC6611 serves to heat the local stellar neighbourhood, which is clearly seen in the dust temperature gradient running away from the centre of the cavity carved out by this cluster. Two prominent filaments are heated by the NGC 6611 cluster to a depth of 10-15pc. I will discuss the implications that this has on the future sites of star formation, modifying the initial conditions for collapse and casting doubt on the evolutionary criteria as drawn from spectral energy distributions (Hill et al., submitted). Finally, I will discuss the presence of mini-starbursts within HOBYS regions, a potential one in M16, and another in the IRDC G35.39-00.33 (Nuygen-Luong et al., 2011).
Claudia Cyganowski - GLIMPSE Extended Green Objects and the Early Stages of Massive Star Formation

Abstract: Large-scale Spitzer surveys of the Galactic plane have yielded a new tracer of massive young stellar objects (MYSOs) that are actively accreting and driving outflows: extended emission in the IRAC 4.5 micron band, believed to arise from shocked molecular gas. The GLIMPSE catalog of extended 4.5 micron sources (called EGOs, Extended Green Objects, for the common coding of 3-color IRAC images) is a unique sample, well-suited for studying the initial stages of massive star formation and establishing an observation-based MYSO evolutionary sequence. I will present results from extensive recent high-resolution VLA and SMA observations of EGOs at cm-mm wavelengths, including maser, molecular line, and continuum studies. We find exceptionally high detection rates for methanol Class I and II masers, which respectively trace outflows and high-mass protostars, providing strong evidence that the EGOs are indeed MYSOs driving outflows. The cm continuum emission towards EGOs is weak, with most harbouring an earlier phase of massive star formation than UC HII regions. Complementary high-resolution mm observations reveal high-velocity, well-collimated molecular outflows coincident with the 4.5 micron lobes, driven by compact mm continuum cores with hot-core spectral line emission. We often find clusters exhibiting chemical and evolutionary diversity, including new evidence that Class I methanol masers can be excited by both young (hot core) and older (UC HII) sources in the same massive star-forming region. Finally, I will present the results of a new Nobeyama 45-m water maser and ammonia survey of EGOs. In combination with the 1.1 mm continuum Bolocam Galactic Plane Survey, this survey provides the necessary data to fully explore correlations between maser and clump properties, and test evolutionary interpretations.
Abstract: I present AMR radiation-hydrodynamical simulations of massive star formation that employ Monte-Carlo methods for the radiation transport. The thermal and ionization balance of the gas, and the radiation-pressure terms, are calculated using detailed microphysical processes that properly treat the polychromatic nature of the problem and do not rely on ray-tracing or flux-limited diffusion approximations. We emphasise the importance of this detailed treatment on the formation and dynamics of the radiation-pressure dominated cavities that are blown out by the massive protostar. We present time-series SEDs and images in both the continuum and lines that may be used to directly compare the RHD simulations with a wide range of observational diagnostics.
Arjan Bik - Age spread in high-mass star forming region W3 Main

Abstract: Massive stars are typically observed to form in clustered environments, with spatial scales ranging from a few parsec (starburst clusters) to tens of parsecs (associations). OB associations and clusters are morphologically and dynamically different and it is not clear if these differences arise from different initial conditions in the star formation process or environmental effects, like triggered star formation. We have started a large observational campaign to derive the star formation history of several massive star formation complexes in order to reconstruct the star formation mechanisms. By means of near-infrared spectroscopy and photometry using LBT and VLT we can derive ages of the massive and intermediate mass pre-main-sequence stars. I will present our recent results on W3 Main where we derive an age spread of 2-3 Myrs.
Ana Duarte Cabral - The impact of protostellar outflows: From low to high mass protostars

Abstract: Despite their importance in removing angular momentum and mass from the envelope of young protostars, we struggle to understand how outflows are generated, and how much they can influence the dynamics of proto-clusters. Nevertheless, it has been possible to establish, observationally, a picture of the evolution of outflow properties with source evolution for low mass protostars. But even here, we have not yet been able to understand whether outflows play a significant role in the fate of the gas that surrounds the forming protostars. Are they capable of inducing and sustaining turbulence in the gas of a proto-cluster? And is this injection capable of disrupting the gas or halting further fragmentation? For the more powerfully accreting massive protostars, the scenario is even less clear as we are yet to understand if massive protostars and their outflows are a scaled up version of their low mass counterparts. Will their impact in the surroundings and their turbulence injection be, therefore, scaled up? Will this have an impact on the fragmentation of massive dense cores? Here I will present my recent observational work that tries to address these questions. Firstly, I will present my study of the outflow energetics in a low mass star forming region (B59), and a direct observational measurement of the impact and turbulence injection from the outflows. This ”quiet” region is exceptionally prone to the impact of outflows, allowing a quantification of the outflow injected turbulence and its contribution to the overall balance of the cloud. Secondly, I will present a test of the low mass evolutionary models on a sample of high mass protostars in Cygnus X, to understand how the energetics from the outflows change with mass and evolution. Knowing this is the first step to then understand how/if the injected outflow-generated turbulence will change with mass and with outflow energetics.
Michiel Cottaar - Dynamics and multiplicity of young star clusters: Getting the most out of single epoch radial velocity data

Abstract: The velocity distribution of stellar systems in a cluster and its binary population provide powerful constraints on theories concerning the formation and subsequent evolution of these clusters. Unfortunately radial velocity variations due to binary orbits tend to mask the underlying velocity distribution of a low mass cluster. One possibility to solve this is to identify the binaries through multi-epoch observations. Here we present an alternative procedure. Even with only a single epoch of data, the radial velocity distribution due to the binary orbital motions are expected to be significantly different to the underlying velocity distribution, that it is possible to separate these distributions. This allows the underlying velocity distribution of a cluster, as well as the binary fraction, to be estimated from a single epoch of radial velocity data. We show that the measured velocity distribution depends only weakly on assumptions made about the binary properties. The procedure successfully reproduces the radial velocity distribution in the open cluster NGC 188 and we are testing it on other clusters and associations.
Abstract: Whilst the study of young stellar populations in HII regions is not the study of the star formation process per se, it allows for understanding the clustered nature of the formation of stars from its immediate products. Low-mass pre–main-sequence (PMS) stars, well resolved down to the sub-solar regime in star-forming regions of the Magellanic Clouds, provide the long-desired rich stellar samples necessary for the thorough investigation of stellar cluster formation in external galaxies. The study of these stars, possible only with HST observations, allowed us to achieve a first clear insight on the sub-solar stellar Initial Mass function, the hierarchical behaviour of stellar clustering, and the recent star formation history of their natal HII regions. These results will be presented and discussed in an attempt to sketch a comprehensive picture of clustered star formation on length scales of few tens pc and timescales of few Myr in our neighbouring galaxies.
Abstract: The spatial statistics of projected stellar distributions in HMSFR may powerfully link observations of star-forming regions to theories of clustered star formation. The MYStIX project provides rich samples of young stars for such studies in and around the nearest (<3 kpc) high-mass star-forming regions. The stellar surface density for MYStIX clusters is first mapped using non-parametric methods such as kernel density estimation and kriging. These maps reveal diversity of subclustering in different regions. We next apply parametric models to the 2-dimensional spatial distribution of clusters using isothermal ellipsoids to estimate the number of subclusters. Finally, second moment summary statistics of spatial point processes are useful for characterizing clusters with different morphologies. We investigate the two-point correlation function, (inhomogeneous) Ripley's K function, and Cartwright & Whitworth's Q statistic, which indicates whether clusters are centrally concentrated or dominated by subclustering.

Mass segregation in complex star-forming regions is investigated with methods that do not depend on a radial distance from a hypothetical center. We instead examine the correlation between inferred stellar mass and stellar surface density, spatial variations in mean mass, and second-moment summary functions designed to search for segregation. Similar methods are used to investigate segregation of disk-bearing and diskless stars, which may provide insight on the history of star-formation in a high mass star forming region.
Abstracts

Friday 22 June

Session 9:
Clustered star formation
Richard Parker - Review of clustered star formation

Abstract: I will review our current knowledge and understanding of clustered star formation. Firstly, I will discuss various definitions of what constitutes a cluster, before describing observations of the IMF and binary properties in star clusters, as well as their global structure and morphology. I will then discuss recent theoretical and numerical work on star formation in clusters, which attempts to not only reproduce the IMF, but also the binary properties observed in the galactic field.
Abstract: The cluster formation efficiency (CFE), i.e. the fraction of star formation resulting in bound stellar clusters, is a key quantity that reflects (1) how the star formation process proceeds initially, and (2) how spatially concentrated the injection of energy into the ISM by feedback from young stellar populations is. During recent years it has been argued that the CFE is set by gas expulsion (infant mortality), tidal perturbations by GMCs in the natal environment (the cruel cradle effect), and the possibly inherently unbound nature of stellar associations. In this contribution, I will present an analytic theory for the CFE, in which all of these effects are accounted for. In this theory, the eventual CFE is largely determined by the properties of the ISM at the onset of star formation. The density spectrum of the ISM is used to predict the fraction of the star formation that inherently remains bound after gas removal, and the fraction of young stellar clusters that might be dispersed by tidal heating on similar time scales. The theory is shown to be in excellent agreement with observations of star cluster populations in nearby dwarf and spiral galaxies. This allows the prediction of the spatial variation of the CFE throughout galaxies, as well as its variation in time and space over the galaxy population from high-redshift starbursts to nearby quiescent galaxies. The presented theory has several applications within theoretical and numerical work, and I will propose tests that can supply further observational verification.
Preben Grosbol - Young clusters in nearby, grand-design spirals

**Abstract:** The distributions of stellar clusters in 10 nearby, grand-design spiral galaxies were studied using deep JHK-maps from HAWK-I/VLT. The final images had a typical seeing of 0.4” and reached 90% completeness around K = 20 mag. Although this did not allow the resolution of individual sources, the cluster populations could be probed down to an absolute magnitude Mk = -11 mag for most of the galaxies. The properties of the cluster complexes were analyzed using (H-K)-(J-H) diagrams. The youngest clusters (i.e. < 7 Myr) could be identified by comparing their colors with Starburst99 evolutionary tracks. The cluster distribution functions (CDF) were well fitted by power laws with exponents around -2 and no evidence of a high luminosity cut-off. The brightest clusters reached Mk = -15.5 mag corresponding to masses close to 106 M⊙. There were strong indications that the CDF’s for clusters in the strong spiral arms were shifted to brighter magnitudes by at least 0.4 mag. Also the star formation rates in the strong arms were found to be 2-5 times higher than those in the inter-arm regions.
Nicholas Wright - Dynamics of an Expanding Star Cluster

Abstract: I will present results from a 3D dynamical study of the massive OB association, Cygnus OB2, offering a glimpse of the disruption of a massive star cluster and a chance to probe the physical processes at work. Cygnus OB2 is the most massive cluster of young and massive stars within 2 kpc of the Sun and an ideal environment to study the dynamical evolution of star clusters. We have combined proper motions and radial velocities to produce the first ever 3D kinematic dataset of a massive star cluster, using X-ray and mid-IR observations to identify the young stellar population. Our results show that the cluster is gravitationally unbound and expanding, but there is evidence that stellar velocities in the cores of the association are much lower and therefore these cores may remain gravitationally bound as the association expands. I will show how this data can be used to distinguish between different theories for cluster disruption such as infant mortality and tidal stripping.
1. Ray Furuya - The Initial Conditions for Gravitational Collapse of a Low-Mass Star-Forming Core

Without accurate knowledge of the initial conditions of gravitational collapsing process of a molecular cloud core, one cannot understand how a low-mass protostar forms. One of the major limiting factors is that the initial conditions of core collapse are not necessarily revealed by observations in detail. In this context, we performed detailed study of a natal cloud core and its environment using mm and submm single-dish telescopes and interferometers. The core (3 Msun), located in a filamentary shaped cloud, is believed to harbor an exceptionally young low-mass protostar, which has *NOT* generated an extensive molecular outflow, yielding a rare opportunity to investigate core collapse history free from the disturbance by the outflow. The presence of the protostar is strongly suggested by the H2O maser emission and a compact submm emission with an order of 0.01 Msun. Our analysis showed that: (1) the ongoing collapse has a reasonable consistency with expectation from the runaway collapse scenario, i.e., the Larson-Penston-Hunter solution, (2) the core gas is infalling onto the protostar with a rate of 3e-5 Msun/yr, (3) the age of the protostar should be less than 5e3 yrs on the basis of radial density profile analysis, and (4) the collapse of the core is likely to be initiated by dissipation of turbulence. References – Furuya, R. S. et al. 2006, ApJ 653, 1369; 2008, PASJ 60, 421; 2009, ApJL 692, L96; 2012 in prep.

2. Carlo Felice Manara - An X-Shooter analysis of chromospheric activity of Class III low mass sources

In order to have a clear understanding of one of the most important process in the star formation process, the accretion of mass onto the star, it is needed a clear and detailed comprehension of the photospheric activity of PMS sources. This allows to discriminate chromospheric activity from accretion related emission, to accurately estimate the uncertainties in the accretion rate estimate and the minimum value of accretion that can be detected. Using VLT/X-Shooter spectra I have analyzed a
sample of Class III in the Spectral Types between K5 and M8 and I will report on the implications that this work has for the present understanding of the accretion process in PMS.

3. Shih-Ping Lai - Discovery of Toroidal Magnetic Fields around Protostars in NGC1333 IRAS 4A from Dust Polarization Measurements
The magnetic field in the low-mass protostellar core NGC1333 IRAS4A (hereafter IRAS4A) have an hourglass morphology in the scale of few thousands AU (Girart et al. 2006, Science). Here we further explore the magnetic field structure within the central 1000 AU region of IRAS4A with the sub-arcsecond resolution dust polarization data taken with SMA at 345 GHz. The SMA observations reveal that except for the regions perpendicular to the center of IRAS4A1, the magnetic field appears to be parallel the protostellar binary, IRAS4A1 and IRAS4A2, and perpendicular to the large scale hourglass structure. We model the observed polarization with a large-scale poloidal (hourglass-like) field and a small-scale toroidal field within central 1000 AU, and show that the toroidal component is necessary for producing the observed polarization pattern. This modified geometry is in agreement with the expectation of star formation theories with ideal MHD conditions and nonzero angular momentum.

4. Mario Guarcello - Probing externally induced disk photoevaporation in Cygnus OB2
CygnusOB2, the most massive OB association of the Cygnus-X region, hosts more than 2000 OB stars and a population of young pre-Main Sequence stars. It is 1.45kpc distant from the Sun and the best target to study star formation and disk evolution in the presence of a large number of massive stars. I will present a multiwavelength study of protoplanetary disks in Cyg OB2, based on new deep optical and X-ray data obtained with OSIRIS@GTC and Chandra/ACIS-I (the Cygnus OB2 Chandra Legacy Survey), and on archival data from 2MASS, UKIDSS, IPHAS and the Spitzer Legacy Survey of the Cygnus-X Region. I classify the disk-bearing and disk-less population of the cluster and compare the spatial variation of disk frequency with the intensity of the ionized flux emitted by the OB members of CygOB2. I show how the disk frequency decreases gradually with increasing intensity of the ionizing flux. The results suggests protoplanetary disks suffer long-range photoevaporation in Cyg OB2.
induced by the OB star population. This is different than the results obtained in the study of NGC6611 (i.e. Guarcello et al. 2007), NGC2264 (i.e. Balog et al. 2007), and the Trapezium in Orion (i.e. Storzer & Hollenbach 1999), where disk frequency drops only at close proximity to the OB stars. I will discuss this difference in terms of the larger ionizing flux and larger age in Cyg OB2 with respect to these other clusters and touch upon the relevance of this work for planet formation in the universe.

5. Yusuke Tsukamoto - The effect of mass accretion for formation and thermal evolution of circumstellar disks

We carried out radiative hydrodynamics simulations to investigate formation and evolution of circumstellar disks from molecular cloud cores. We employed FLD-SPH method (Whitehouse & Bate 2004, 2005) to treat radiative transfer. We neglected irradiation from protostars. Our results are as follows. The formation and evolution processes of the first core are not qualitatively different from those with barotropic approximation. But the second collapse delay because the gas temperature of central region of first core becomes higher than that with barotropic approximation. At the early phase of disk evolution (until 104 years after the protostar formation), disk is heated up by mass accretion rather than cooled down by radiation. In the region at the several tens of AU, Toomres Q value is less than the critical value for non-axisymmetric perturbation growth and strong spiral arms arises. With moderate accretion, the disk fragmentation seems to be difficult during this phase because of the accretion heating. In this talk, we will also report the disk evolution with various initial conditions.

6. Seung-Hoon Cha - The entropy condition of Godunov SPH

A new version of GodunovSPH (hereafter GSPH) has been developed and tested. Contrary to the old version, the new GSPH can satisfy the entropy condition, which is an essential property of the convergence of numerical schemes. The thermal compatibility has been identified as an important point for the entropy condition. The continuity equation and the density estimation has been modified to implement the thermal compatibility in the new GSPH. Both the entropy and energy can be conserved in the new GSPH. The derivation of the new GSPH is very similar to the finite volume method (FVM), and it can be reduced to the standard SPH and the previous
7. Sami Dib - Feedback Regulated Star Formation
I will summarise results from a model which describes star formation in protocluster clumps of different metallicities. In this model, gravitationally bound cores form uniformly in the clump following a prescribed core formation efficiency per unit time. After a contraction timescale which is equal to a few times their free-fall times, the cores collapse into stars and populate the IMF. Winds from the newly formed OB stars remove gas from the clump until core and star formation are quenched. The power of the radiation driven winds has a strong dependence on metallicity and increases with increasing metallicity. Thus, winds from stars in the high metallicity models lead to a rapid evacuation of the gas from the protocluster clump and to a reduced star formation efficiency, SFEexp, as compared to their low metallicity counterparts. By combining SFEexp with the timescales on which gas expulsion occurs, we derive the metallicity dependent star formation rate per unit time in this model as a function of the gas surface density $\Sigma_g$. This is combined with the molecular gas fraction in order to derive the dependence of the surface density of star formation $\Sigma_{\text{sfr}}$ on $\Sigma_g$ in galactic disks. This feedback regulated model of star formation reproduces very well the observed star formation laws extending from low gas surface densities up to the starburst regime. Furthermore, the results show a dependence of $\Sigma_{\text{sfr}}$ on metallicity over the entire range of gas surface densities.

8. Thomas Haworth - The effect of the diffuse field on triggered star formation
Triggered star formation as the result of ionizing radiation from massive young stars has been the subject of a large amount of numerical and observational study. To date computational models have treated the radiation field using the 'on the spot' approximation, neglecting the effect of diffuse field radiation. This talk communicates the findings of an investigation into the effect including the diffuse field when modelling the radiatively driven implosion of a Bonnor-Ebert sphere. The, sometimes drastic, differences in model evolution when the diffuse field is included in calculations have important implications for developing our understanding of star formation efficiency, star formation rates and the role of radiative feedback in sculpting bright rimmed
clouds and elephant trunks.

9. Veronica Lora - The photoevaporation of a neutral structure by an EUV+FUV radiation field
The EUV photoionizing radiation and FUV dissociating radiation from newly born stars photoevaporate their parental neutral cloud, leading to the formation of dense clumps that could in principle eventually form stars. We study the effects of including a photodissociating FUV flux in models of the fragmentation of a photoevaporating, self-gravitating molecular cloud. We have computed 3D simulations of the interaction of an inhomogeneous, neutral, self-gravitating cloud with an external EUV and FUV radiation fields, and compute the number and mass of the collapsing clumps. The presence of an outer photodissociation region has an important effect on the formation of dense structures due to the expansion of an HII region. In particular, including a FUV field leads to the earlier formation of a larger number of dense clumps, which might lead to the formation of more young stars.

10. Ignazio Pillitteri - Mapping the star formation in Orion A / L1641
First phases of the process of star formation are characterized by excess in infrared and high X-ray emission. With Spitzer and XMM-Newton we have surveyed the Orion A part relative to the L1641 filament. We show that more evolved PMS stars are copiously found around Iota Orionis and in L1641N while stars with disks and proto-stars are found in small subgroups along the filament.

11. Paola Mucciarelli - The young stellar population in the S255-258 region: an X-rays/IR study
In the S254-S258 region a dense cluster of very young stellar objects is sandwiched between two HII regions. This remarkable configuration has led to conjectures that the two B stars exciting the HII regions may have been ejected from the central cluster, or, alternatively, that the current star formation activity in the central cloud is
triggered at the intersection of the expanding HII regions. In the second case, the two B stars should belong to a slightly older stellar generation, but no associated young low-mass stars could be identified so far around them. In order to solve this puzzle, we have performed a deep Chandra X-ray observation of this extraordinary star forming region, and here we present the results of our X-ray analysis and the correlation with near and mid IR data. We detected 364 X-ray sources, providing, for the first time, a sample of all young stars in the region down to 0.5 Msun. The spatial distribution of the sources is characterized by a central clump (corresponding to the embedded cluster) plus a widely scattered population of young stars, strongly supporting the second formation scenario. Comparison of the X-ray luminosity function to Orion suggests a total population 2000 young stars in the region. The cross correlation with IR data permit us to estimate the individual properties of the protostars and YSOs associated to the S254-S258 complex.

12. Faviola Molina - Can we trust CO emission as a probe of the densities and temperatures of molecular clouds?
We have analyzed the distributions of CO and temperature in a large suite of simulated molecular clouds, in order to help us understand how to interpret CO line emission from real molecular clouds. The simulations were performed using a fully dynamical 3D model of magnetized turbulence coupled to a chemical network simplified to follow the dominant pathways for CO formation and destruction. We also implemented the Monte Carlo radiative transfer code RADMC-3D to calculate the emergent CO line intensity. We find that most of the CO is located at densities over 10^3 cm^-3 where the temperature is roughly 10-40 K independently of the mean density, metallicity and UV field strength. Although most of the volume has temperature that spread for hundredths Kelvin and has regions with densities below 10^3 cm^-3, CO photodisociation is more efficient there making the CO abundance small. It follows that CO is a biased tracer of the gas. Therefore, complementary observations of the lower density, warm gas, are required.

13. Roberta Paladini - Preliminary results from deep Warm Spitzer observations
I will describe the preliminary results obtained from deep Warm Spitzer observations
of a large sample of cold clumps selected from the newly released Planck Early Cold Cores Catalog. The survey, characterized by uniform depth, is providing the first unbiased investigation of the coreshine effect in Galactic cold condensations. The coreshine effect, recently identified by Pagani et al. (2010) and Steinacker et al. (2010), is interpreted as direct evidence for dust growth in the dense, cold environments in the interior of molecular clouds. Understanding of the coagulation process is crucial for the investigation of further coagulation taking place in protostellar disks, and fundamental for improving our knowledge of the mechanisms regulating the formation of planets. In addition, grain coagulation in dense molecular environments could in principle change the global scenario of dust particles in the diffuse ISM, as a retransfer of grains from these cold condensations back into the diffuse medium is indeed likely (Ossenkopf 1993). Last but not least, the existence of a larger population of grains will have strong implications on our interpretation of both thermal continuum and emission line data, therefore impacting our present view of how stars form.

14. Paul Kalas - New observations and analysis of Fomalhaut b
Fomalhaut is a nearby, 450 Myr old A4V star surrounded by dust belt roughly three times the size of our Kuiper Belt. Fomalhaut b is an optically detected common proper motion companion residing 18 AU interior to the belts inner edge. The HST detections of Fomalhaut in 2004, 2006 and 2010 have been confirmed by two independent groups. Dynamical arguments and non-detections in the infrared suggest that the mass of Fomalhaut b is less than one Jupiter mass, and the optical brightness is due to reflection from a circumplanetary dust ring. Here we present a reanalysis of the existing data, and show new observations with HST/STIS to be obtained in early June 2012. The 2012 epoch will clarify whether or not the orbit of Fomalhaut b is nested within the belt inner boundary.

15. Thomas Gerner - Mapping the chemistry of the interstellar medium
Understanding the chemical evolution of young (high-mass) star-forming regions is a central topic in star formation research. The chemistry serves twofold, on the one hand in a general sense to study the evolution from simple to complex molecules, and on the other hand as a tool to investigate the underlying physical processes. With these aims in mind, we observed a diverse sample of 60 high-mass star-forming re-
regions in different evolutionary stages from the early starless stages of Infrared Dark Clouds (IRDCs) over High Mass Protostellar Objects (HMPOs) to Hot Molecular Cores (HMCs) and finally Ultra Compact HII (UCHII) regions. The new broadband receiver and backend capabilities of the IRAM 30m telescope allow us to cover broad spectral ranges with many molecular lines, and based on that to determine their large-scale chemical abundances. To set these results into context, we model the chemical evolution in such environments with state-of-the-art chemical networks. This enables us to put constraints on the chemical evolution in the early stages of high-mass star-forming regions, the age of the molecular clouds and the cosmic ionization rates.

16. Catarina Alves de Oliveira - The low mass end of the IMF unveiled by the WIRCam/CFHT survey of nearby young clusters
C. Alves de Oliveira, E. Moraux, J. Bouvier, L. Spezzi, E. Winston, N. Huelamo, S. Guieu, H. Bouy, G. Duchene, A. Burgess
The observational characterization of the stellar mass function in galactic clusters, the field, and even other galaxies, has resulted in a wealth of parameters that must be reproduced and explained by any successful star formation theory. To extend our knowledge on the mass function to the substellar regime, we have conducted a large observational survey of six nearby young clusters (Rho Oph, IC 348, NGC 1333, Serpens, Lambda Ori, and NGC 2264). We adopted a twofold approach to this study, using both near-IR photometry to find all candidate substellar members and extensive spectroscopic follow-up to derive a spectroscopic IMF, and deep methane imaging to search for the lowest mass members. I will present the results of this longterm endeavor, where we have found no evidence for variations in the substellar mass function across different clusters, and have uncovered a handful of candidate young T dwarfs likely to represent the minimum mass for star formation.

17. Francesco Fontani - Probing the earliest phases of high-mass star cluster formation through observations of N2D+
To probe the initial conditions of the high-mass star and star cluster formation process and put constraints on competing theories one needs to know physics, dynamics and chemistry of massive cores in very early evolutionary stages. These properties can be determined through observations of deuterated molecules. In fact, chemical models
predict that deuterated species are excellent tracers of cold, dark cores, where most other molecules are not usable because depleted from the gas phase. I will present IRAM-30m and brand new ALMA cycle-0 observations of the N2D+ molecule, a species eminently suitable to trace cold and dense gas, in a sample of massive cores supposed to harbour different stages of the massive star formation process. These observations demonstrate that: 1- the deuterated fraction $\text{N}_2\text{D}^+$/N$_2$H$^+$ can be used as evolutionary tracer of massive cores, and 2- the most promising massive starless cores are close to virial equilibrium conditions, as determined from targeted high-angular resolution ALMA N2D+ observations.

In the last decade, we have started to spatially resolve the relatively small gas and dust condensations in high-mass star-forming regions that will eventually become a massive star or system. We call these condensations of sizes on the order of 0.01pc ”cores”, and by estimating their masses we can construct the so-called Core Mass Function (CMF) of a region, to compare with the IMF and try to determine the evolutionary process from a core to a star. For massive star-forming regions, the relationship between the CMF and the IMF is not yet well understood. This is, among other factors, due to the fact that there are not many massive CMF determined. Even then, some of those few CMF seem to tell a story of evolution, by presenting different slopes than that of the Salpeter IMF while others, seem to be very similar to the IMF. Are we in fact observing regions at different evolutionary stages? One way to answer that is by determining the relative age of those regions. In this talk I will show you the CMF of a few massive star-forming regions, and our attempt to establish an age scale among them with observations of deuterated molecules.

19. Frederic Schuller - The next generation of high-mass stars and clusters traced by ATLASGAL
Submillimeter continuum emission traces high column densities and, thus, dense cloud regions in which new stars and clusters are forming. Surveys of the Galactic plane in such emission are ideal tools to provide an unbiased view of present high-mass star formation throughout the Milky Way. The APEX Telescope Large Area Survey
of the Galaxy (ATLASGAL), which covers 420 square degrees of the inner Galactic plane at 870 microns, reveals thousands of cold, dense, dusty clumps, potential sites of star formation in its early stage. Initial results of this survey will be presented, as well as selected results from the many ongoing spectroscopic follow-up programmes. Perspectives for high resolution studies with ALMA and the EVLA will also be discussed.

20. Esteban Morales - Galactic young star clusters and their environment

Practically all star formation in the Galaxy occurs in groups or "clusters" correlated in time and space, and embedded in their parent molecular clouds. Whether these young stellar agglomerates, the so-called "embedded clusters", end up as classical open clusters depends on the complex interplay between the physical properties of the star-forming clouds, the process of star formation itself, the stellar feedback mechanisms, and the dynamical evolution of the young cluster after the removal of the residual gas. The study of embedded clusters is thus fundamental to account for most star formation activity in the Galaxy, and to investigate the interaction of recently formed massive stars with the surrounding interstellar medium. In the last years, many embedded stars clusters have been discovered in the IR (mainly using 2MASS; e.g., Dutra et al. 2003, Bica et al. 2003). In this work, we study the molecular environment of them, searching for physical correlation with submm continuum emission (ATLASGAL survey at 870 um, Schuller et al. 2009), which traces the cold dust. We performed a huge compilation from the literature of 695 open and embedded clusters in the inner Galaxy (within the ATLASGAL coverage), including 70 new embedded clusters discovered by us using the GLIMPSE survey. A qualitative recognition of different scenarios of cluster-environment interaction was done by comparing the ATLASGAL morphology with IR images from 2MASS and GLIMPSE, suggesting an evolutionary sequence: A) cluster deeply embedded, central position matches the submm peak; (B) cluster partially embedded, submm emission not covering the whole cluster area; (C) cluster has cleared out the nearby material (submm emission) which surrounds the cluster area and is illuminated by stellar feedback (visible at 8 um); (D) exposed cluster. We found that nearly 50% of our sample are in an embedded or partially embedded phase, which lasts at most 3 Myr, according to a small subsample of cluster for which age estimates are available from the literature. In this talk, I will present the characteristics and statistics of our catalog, and discuss about the implications for cluster survival, and the effect of the stellar feedback. I will also present a detailed study we carried out of the molecular environment of the stellar cluster associated with the IR bubble G10.31-00.15, for which we mapped CO
emission to investigate the kinematics of the removed gas.

21. Hans Moritz Guenther - IRAS 20050+2720 - clustering of low-mass stars
IRAS 20050+2720 is young star forming region at a distance of 700 pc with a mass of 430 M\(_\odot\), but without apparent high mass stars. We want to characterize the distribution of young stellar objects (YSOs) in this region and compare evolutionary trends with other young star forming clusters. We present results of our multiwavelength study of IRAS 20050+2720 which includes observations by Chandra, Spitzer, and 2MASS and UBVRI photometry. In total, about 300 YSOs in different evolutionary stages are found. We newly identify a second subcluster, which consists mostly of class II objects, about 10' from the center of the cloud. YSOs of earlier evolutionary stages are more clustered than more evolved objects. Within the class II objects the X-ray detected sources are more clustered. The X-ray luminosity function (XLF) of IRAS 20050+2720 is roughly lognormal, but steeper than the XLF of the more massive Orion nebula complex. IRAS 20050+2720 seems dust enriched compared to the ISM.

22. Giacomo Beccari - An HST study of star formation in star-burst clusters
We are attempting a systematic study of Pre-Main Sequence (PMS) objects in starburst clusters, spanning a wide range of masses (0.5 - 4 Msolar), metallicities (0.1 - 1 Zsolar) and ages (0.5 - 30 Myr). We developed a novel method which allows us to identify bona fide PMS stars through a proper combination of optical imaging in V, I and Halpha bands from cameras on board of the Hubble Space Telescope. In this talk I will present the main results concerning the characterization of PMS population and SFH of the star-burst cluster NGC 3603 in the Galaxy and NGC 602 in the SMC. I will briefly demonstrate the strength of the proposed photometric approach in identifying stars with Halpha excess emission, a key observational proof of an object actively undergoing mass accretion from a disc. The results obtained so far allow us to undertake a detailed study of the time-scale of star formation in clusters with possible implication on the definition of initial mass function.
23. Elaine Winston - Clusters within Clusters: A Spitzer & Chandra view of the YSO population in RCW 38.
The majority of young stars are believed to form in clustered environments. The effect this has on their circumstellar environments will depend on the star formation history and structure of the cluster itself. In this talk I will present Spitzer and Chandra observations of the massive star forming region RCW 38. At a distance of 1.7kpc, and containing an estimated 20-40 OB stars, RCW 38 is one of the richest nearby high mass regions, after Orion, with an estimated cluster membership of 10,000 members. Previous studies have focused on the cluster surrounding IRS2, the central O5.5 binary. Here, I will use the mid-IR observations to identify young stellar objects with circumstellar emission in an extended region surrounding this cluster. The elevated X-ray emission of young stars is used to locate diskless young members. Through a study of the spatial distribution of the YSOs I will present evidence of structure and subclustering in the region, where four new subclusters and an extended population are identified. I will comment on a new very young core of star formation in the region identified with Spitzer, with evidence of an outflow from one young member which indicates a younger age for this outlying subcluster than that of the centre. An examination of the gas to dust ratio, through NH ν Ak measurements, show that they are consistent with that expected of the ISM, and dissimilar to results found in lower mass clusters, indicating that environment can play a role in the processing of dust in these clouds. Finally, I will present five newly identified mid-IR bowshocks, none of which have trajectories indicating that they are undergoing ejection from RCW38.

24. Tsuyoshi Inoue - 3D MHD Simulation of Molecular Cloud Formation
Using 3D MHD simulation with the effects of radiative cooling/heating, chemical reactions, and thermal conduction, the formation of molecular cloud is studied. As suggested by recent observations, we consider the shock compression of HI clouds as a trigger of the molecular cloud formation. We find that the timescale of the CO molecule formation in the cloud and the timescale of virialization are roughly the same, approximately 5-10 Myr. The formed molecular cloud is very turbulent whose size-velocity dispersion relation is consistent with observations. However, the turbulence is highly anisotropic that affects distribution of magnetic field and leads small polarization angle dispersion in synthetic sub-mm emissions. This effect raises a problem in the estimation of magnetic field strength using the Chandrasekhar-Fermi effect. We also find that dense molecular clumps in the cloud gradually evolve toward magnetically supercritical cores due to the clump-clump collisions.
25. Steve Boudreault - Astrometric and photometric mass function of the old open cluster Praesepe based on the UKIDSS Galactic Clusters Survey

Here we present the results of a wide-field (36 sq. deg.) near-infrared (ZYJHK) survey of the Praesepe cluster using the Data Release 9 (DR9) of the UKIRT Infrared Deep Sky Survey (UKIDSS) Galactic Clusters Survey (GCS). We selected cluster candidates of Praesepe based on astrometry and photometry. With our candidate list, we have obtained the luminosity function of Praesepe in the Z and J bands, and we have derived the mass function (MF) of Praesepe from 0.6 down to 0.072 Msol. We observe that our determination of the MF of Praesepe differ from previous studies: while previous MFs present an increase from 0.6 to 0.1Msol, our MF presents a decrease. We looked at the MF of Praesepe in the inner radius (1.5 deg) and outer (1.5-3.0 deg) regions and we conclude that both regions present a MF which decreases to lower masses. We have compared our Praesepe MF with the ones of the Hyades, the Pleiades and Alpha Per. We conclude that our MF of Praesepe is more similar to the MF of Alpha Per although they are respectively of 70 and 600 Myr. Moreover, we have estimated the binarity of the Praesepe members in the 0.5-0.1 Msol mass range and as well as their variability.

26. A-Ran Lyo - Millimeter Observations of the Transition disk around HD135344B (SAO206462)

Transition disks classified by the signature of a gap/hole in the disk from the SED are suggested as the right sites of the current planet formation. It is, therefore, important to study the gas and dust clearing process of the transition disk. We present 1 resolution 1.3mm dust continuum and spectral line observations of the transitional disk system HD135344B obtained with the Submillimeter Array. The disk shows a Keplerian rotation pattern with an inclination of around 11 degree, based on the spatially and spectrally resolved 12CO and 13CO emission. The data show clear evidence for both dust and gas surface density reductions in the inner region of the disk (radius 50AU) from the continuum and 13CO (J=2-1) data, respectively. The presence of this inner cavity in both the dust and gas is more consistent with clearing by giant planet formation than by photoevaporation or by grain growth. There is also an indication of global CO gas depletion in the disk, as the mass estimated from 13CO emission ($\sim 3.8 \times 10^{-4}$ solar mass) is about two orders of magnitude lower than that derived from the 1.3mm continuum ($\sim 2.8 \times 10^{-2}$ solar mass).
27. Andrea Gatto - Estimating the Galactic coronal density via ram-pressure stripping from dwarf satellites
According to the current cosmology, the Milky Way like other disk galaxies should be embedded in a corona of hot gas containing a large fraction of missing baryons. To date, no convincing detection of this corona have been presented. We have attempted to detect and characterize the corona of the Milky Way using the effect that it has on the surrounding population of dwarf galaxies. In particular we studied the effect of gas stripping from dwarfs and assumed that this is the main effect that causes the loss of gas from dwarf spheroidal galaxies. We considered two dwarfs, Sextans and Carina, and simulated their last gas stripping event that we assumed to have happened at their pericentric passages. We found that the coronal density needed to remove all the gas from these dwarfs is about $n = 2 \times 10^{-4} \text{cm}^{-3}$ at the Galactocentric radii in the range [50, 90] kpc. The Galactic corona can then be described by a flat isothermal profile with a coronal number density within 250 kpc from the Milky Way always greater than $n = 10^{-4} \text{cm}^{-3}$. The corresponding total gas mass is $1.1 \times 10^{11} \text{M}_{\odot}$, or about 40 percent of the expected missing baryon mass associated with the dark matter halo of the Milky Way.

28. Ciara Quinn - Lonely Cores Observed In Molecular Lines
Isolated star-forming cores are the ideal laboratory for the study of the low-mass star formation process. They have a relatively simple nature and are free from the confusing effects experienced in larger, more crowded molecular clouds and clusters, where multiple star formation events lead to a more complicated picture that is harder to interpret. The Spitzer legacy program From Molecular Clouds to Planet-Forming Disks and its follow-up program Lonely Cores mapped more than 100 nearby, isolated cores across a range of evolutionary stages. To study the cores in detail, however, complementary high-resolution spectral-line mapping is needed. Using the ATNF Mopra Telescope, a 22-m radio telescope, situated in NSW, Australia, we have mapped the $12\text{CO}(J=1-0)$, $13\text{CO}(J=1-0)$ and $\text{C}^{18}\text{O}(J=1-0)$ emission from 40 southern cores from the Lonely Cores sample, primarily targeting low density starless cores that may or may not be gravitationally bound, to study possibly the youngest cores. By conducting an LTE analysis, we have calculated excitation temperatures, optical depths, column densities and masses of the most isolated subset of these cores. By comparing our column density maps with mid-infrared extinction maps, we find that $13\text{CO}$ and $\text{C}^{18}\text{O}$ are excellent tracers of extinction conditions within these dense cores.
29. Ngoumou Judith - Effects of a momentum driven stellar wind on the surrounding ISM
Massive stars shape the surrounding ISM by emitting ionizing photons and ejecting material through stellar winds. We present a numerical study on the impact of the momentum conserving snowplow expansion of a wind bubble, on the surrounding ionized material. We used the Smoothed Particle Hydrodynamics code SEREN (Hubber et al. 2010) including the HEALPix-based photoionization algorithm described in (Bisbas et al. 2009) and implemented a HEALPix-based momentum conserving wind scheme. We find the momentum driven wind to have little direct effect on the structures and clouds mostly shaped by the ionizing radiation. However indirectly the increase in pressure in the HII region due to the wind appears to have some influence on when and where stars can form.

30. Yuri I. Fujii - Magnetohydrodynamics with Time-Dependent Ionization Degree in Protoplanetary disks with Grain Evolution
Understanding of the ionization degree is required to study disk dynamics, especially when the magnetorotational instability is the main mechanism of disk accretion. Since the balance of chemical reactions determines the ionization degree, we have to solve the reaction equations to investigate the ionization degree. In many cases, timescales of the various reactions are very different, and this requires a time-consuming calculation of time-dependent evolution. To do this, we develop a fast and accurate method to calculate the ionization degree. Our method enables us to calculate the ionization degree even with dust grains as large as 1cm that tend to be highly charged, and can be conveniently plugged into various magnetohydrodynamics codes. Since formation of millimeter or centimeter size grains is thought to be necessary step towards planetesimal formation, our method is useful for the study of long-term disk evolution toward planet formation.

31. Tzu-Cheng Peng -The APEX-CHAMP+ view of the Orion Molecular Cloud 1 core
A high density portion of the Orion Molecular Cloud 1 (OMC-1) contains the prominent, warm Kleinmann-Low (KL) nebula that is internally powered by an energetic event plus a farther region in which intermediate to high mass stars are forming. Its
outside is affected by ultraviolet radiation from the neighboring Orion Nebula Cluster and forms the archetypical photon-dominated region (PDR) with the prominent bar feature. Its nearness makes the OMC-1 core region a touchstone for research on the dense molecular interstellar medium and PDRs. We have imaged the line emission from the multiple transitions of several carbon monoxide (CO) isotopologues over the OMC-1 core region by using the Atacama Pathfinder Experiment telescope (APEX). Our observations employed the 2X7 pixel submillimeter CHAMP+ array to produce maps (300”X350”) of 12CO, 13CO, and C18O from mid-J transitions (J=6-5 to 8-7). We also obtained the 13CO and C18O J=3-2 images toward this region. The 12CO line emission shows a well-defined structure which is shaped and excited by a variety of phenomena, including the energetic photons from hot, massive stars in the nearby Orion Nebula’s central Trapezium cluster, active high- and intermediate-mass star formation, and a past energetic event that excites the KL nebula. Radiative transfer modeling of the various isotopolog CO lines implies typical H2 densities in the OMC-1 core region of 104-106 cm-3 and generally elevated temperatures (~50-250 K). We estimate a warm gas mass in the OMC-1 core region of 86-285 solar masses.

32. Loredana Spezzi - Herschel’s view of Chamaeleon II
The Gould Belt Herschel guaranteed time program (HGB) is devoted to an extensive survey of the densest portions of the Gould Belt with the two Herschel imaging instruments, SPIRE and PACS (100-500µm), thus mapping the same area observed by the Spitzer Gould Belt (SGB) and Core to Disk (c2d) surveys (3.6-160µm). Together with the detection of thousands Class 0 protostars and pre-stellar condensations, which should allow to derive an accurate pre-stellar core mass function down to 0.01-0.1 M☉ in the nearby (d<0.5 kpc) molecular cloud complexes, Herschel allows the detection of the far-IR and sub-mm emission from more evolved Class I and Class II stars. These data are crucial to estimate their circumstellar disk properties and study the transition from the young optically thick disks to the evolved debris-type disks. In this contribution we present our first results from PACS and SPIRE observations of the Chamaeleon II star forming region in combination with optical, near-IR and Spitzer observations already available in the literature.

33. Eric Feigelson - MYStIX: Massive Young Stellar Cluster Study in In-
Infrared and X-rays

Fundamental questions concerning the origin of OB-dominated young star clusters: fast or slow formation; monolithic or merging clumps evolution; OB stars forming early or late; OB feedback and triggered star formation; and protoplanetary disk survival. The stellar census underlying studies to address these issues have often been inadequate. Infrared (IR) studies alone, suffering contamination from nebular emission and Galactic field stars, are typically restricted to stars with IR-excess disks, missing the disk-free populations that dominate many clusters. High-resolution X-ray surveys are complementary, tracing low-mass magnetic flaring and high-mass wind shocks that are independent of disks. Combining IR, X-ray and spectroscopic OB samples provide the best available census of cluster members. MYStIX constructs young stellar populations for 20 clusters at distances 0.4

34. Pekruhl, Stephanie - Clump Mass Function of the Dense Clouds in the Carina Nebula

In the Carina Nebula the feedback of the numerous hot stars disperses the parental Giant Molecular Cloud but also triggers the formation of new generations of stars. We obtained wide-field maps with the LABOCA camera at the APEX telescope, which provide the first spatially complete survey of the dust clouds in the Carina Nebula Complex and used the three common clump-finding algorithms CLUMPFIND, GAUSSCLUMPS and SExtractor to sample the Clump Mass Function in this region. To investigate the influence of the cloud temperatures on the CMF we also assumed individual cloud temperatures for the clumps, resulting from an empirical relation between cloud column densities and temperature. In general we find a power-law of \( dN/dM \propto M^{-1.95} \), what is in good agreement with CMF slopes found in previous studies of the CMFs of other regions, but also that the shape of the resulting CMF is highly dependent on the used extraction methods. While CLUMPFIND CMF is clearly described by a power-law the CMFs based on the extractions with GAUSSCLUMPS and SExtractor are better represented by a log-normal distribution. This implies that the interpretations of a log-normal CMF shape as a signature of turbulent pre-stellar clouds versus power-law CMFs as a signature of star forming clouds only from observational determinations can be misleading.
35. Sarah Ragan - Internal Kinematics in Infrared-dark Clouds

Infrared-dark clouds (IRDCs) contain a range of the earliest phases of cluster formation. Infrared observations have established that IRDCs often host deeply embedded protostars, the local heating from which can be seen in both the dust and gas. Using interferometric maps of high-density molecular tracer, NH$_3$, we examine the kinematic structure and energy content of a sample of IRDCs with differing geometries and varying levels of protostellar activity. In our sample, protostellar feedback – seen in enhanced linewidths near the sites of embedded protostars – contributes only moderately to the global energetics in IRDCs. The velocity fields are otherwise well-organized, and, overall, the kinetic energy content is drastically insufficient to support the IRDCs against collapse, and the spatial distribution of energy is inconsistent with the turbulent cloud support scenario. We interpret the organized velocity fields as a signature of active global collapse and fragmentation.


This project aims to perform the spectroscopic characterization of stars located in the Sh2-296 nebula, an ionized region with the form of an arc located in the Molecular Cloud Complex in Canis Major (CMa R1). It is a subject of great debate due to the open questions related to the sequential star formation in this region. We study a sample of stars located in the vicinity of young clusters associated with the nebula, identified by our X-ray observations with the XMM-Newton satellite. In order to study the optical counterparts of the X-ray sources, medium-resolution spectra were obtained with the Gemini South telescope for multi-object spectroscopy (GMOS) for 85 stars. A sample of 53 candidates for young stellar objects (YSOs) were selected for further analysis through the identification of spectral characteristics typical of YSOs, like H-alpha emission and strong absorption on the Li I line at 670.8 nm. In the present work we present the spectral classification of this candidates and also the characterization of the possible T Tauri and Herbig Ae/Be stars identified based on H-alpha line widths and the presence of Li I absorption, which also allows a better assessment of the evolutionary stage of the sample and its relation to the Sh2-296 nebula in terms of spatial distribution.
37. Dimitris Stamatellos - Dynamical evolution of brown dwarf systems formed by disc fragmentation
Brown dwarfs and low-mass stars may form by fragmentation of young circumstellar discs. Usually a few objects form in each disc and their orbits are unstable. Therefore, newly-formed systems generally dissolve within a relatively short time. Here we present the results of our study on the dynamical evolution of such systems, and discuss the binary properties of low-mass objects produced by disc fragmentation.

38. Cara Battersby - The Kinematics of Filaments and Their Role in High-Mass Star Formation
Filaments have gained a lot of attention in the last few years as their ubiquity in star-forming regions becomes universally acknowledged. Through a systematic analysis of a large sample of filaments, we investigate their context, preponderance, and importance in high-mass star formation. We have selected a statistically significant, relatively unbiased sample of dense pre- to star-forming clumps and filaments. Through an analysis of their large-scale kinematics using the H2O southern Galactic Plane Survey (HOPS), we address quantitatively the prevalence of filaments in high-mass star formation and whether or not there is a global trend for converging flows along filaments. We identify a sample of “pole-on” filaments and discuss filament orientation as a function of Galactic location. We compare the large-scale filament kinematics with high-resolution ammonia data from the EVLA on a quiescent hub/filament group.

39. Nicolas Lodieu - The photometric & astrometric mass functions in the Pleiades, Alpha Per, and Praesepe clusters
The latest release of the UKIRT Infrared Deep Sky Survey (UKIDSS) Galactic Clusters Survey (GCS) made public not only near-infrared photometric in six passbands (ZYJHK1K2) but also accurate proper motions due to the baseline between the first and second epochs. We selected photometrically and astrometrically hundreds of cluster member candidates in the Pleiades, Alpha Per, and Praesepe open clusters imaged as part of the UKIDSS GCS. The cluster sequences are well defined in several colour-magnitude diagrams and the positions of cluster members pop up in the vector point diagrams. This contribution will focus on major results obtained from
the study of these 3 clusters:
1) comparison of the mass functions in the low-mass and substellar regimes
2) comparison of the photometric binary fractions in the low-mass and brown dwarf regimes with the latest hydrodynamical simulations of Bate (2012)
3) comparison of the cluster sequences with the "old" NextGen+DUSTY models and the most recent BT-Settl models from the Lyon group
4) discussion on the K-band variability of 90, 120, and 600 Myr low-mass stars and brown dwarfs
This contribution is based on a paper recently posted on astropH (Lodieu et al. 2012a) and 2 more submitted to MNRAS (Lodieu et al. 2012b; Boudreault et al. 2012).
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