Welcome

This interdisciplinary conference will explore the deep links between the processes of star and planet formation, highlighting recent advances in observations (Kepler, Herschell), theory, and computation.

The conference features 9 interdisciplinary and interleaved sessions, each with an invited Review Speaker, who will set up the session with a true review of the current state of that field, as well a Keynote Speaker who will focus more on their own contributions to the subject. The conference will feature a total of 44 contributed talks, 9 keynote talks, and 9 review talks. Two days will also feature discussion sessions meant to provide a stimulating forum for the key results and issues raised in the presentations.

Local Organizing Committee

Ralph Pudritz (chair), James Wadsley, and Christine D. Wilson – Origins Institute (OI), McMaster University
Mikhail Klassen (graduate student representative), Rory Woods, Kevin Sooley, Aaron Maxwell, and Rachel Ward-Maxwell – McMaster University

Scientific Organizing Committee

Isabelle Baraffe
Shantanu Basu
Nuria Calvet
Cathie Clarke
James Di Francesco
Thomas Henning
Shigeru Ida
Ray Jayawardhana
Wilhelm Kley
Ralf Klessen
Mark Krumholz
Alessandro Morbidelli
Norm Murray
Eve Ostriker
Ralph Pudritz (chair)
Dimitar Sasselov
James Wadsley
Christine Wilson

Contents

Schedule

THE ORIGINS OF STARS AND THEIR PLANETARY SYSTEMS

June 10-15, Origins Institute, McMaster University

The conference venue is the Michael DeGroote Centre for Learning and Discovery (MDCL) building, Room 1105. For a map of McMaster University's campus, please refer to pages 114 and 115

Final program

Note:
(R) = Review (45 min including questions)
(K) = Keynote (30 min including questions)
(C) = Contributed (20 min including questions)

Sunday June 10, MDCL Lobby

5:30pm - 8:30pm – Registration / Reception

The schedule for Monday begins on the next page.

Monday June 11

7:30am:	Mounting of Posters available in MDCL lobby
7:30am:	Conference registration (continued) in MDCL lobby
8:00am:	Morning coffee
8:20am:	Welcome and conference notes

Session 1: Star Formation in Clusters

Chair: Christine Wilson

8:30am	(R)	Charlie Lada	Embedded Clusters As Laboratories for Star and Planet Formation Studies
9:15am	(C)	Jason Ybarra	The Progression of Star Formation in the Rosette Molecular Cloud
9:35am	(C)	Pamela Klaassen	Ionized and Molecular Gas Dynamics in K3-50A
9:55am	(C)	Mikhail Klassen	Simulating Protostellar Evolution and Radiative Feedback in Stars and Clusters
10:15am		COFFEE + Poster Mounting	
10:50am	(K)	Cathie Clarke	The imprint of formation in clusters on the field
11:20am	(C)	Philip Myers	Evolution, ages, and birthrates of YSOs in clusters

Session 2: Planets-Statistical Properties

11:40am	(C)	Jason Rowe	The Reflective and Thermal Properties of Transiting Extrasolar Planets
12:00pm		LUNCH, Centro@Commons	
Chair: Ray Jayawardhana			
1:30pm	(R)	Dimitar Sasselov	Planetary Architectures: From Interior Design to Urban Planning
2:15pm	(C)	Brendan Bowler	A High Contrast Adaptive Optics Imaging Search for Giant Planets Around Young M Dwarfs
2:35pm	(C)	Michael Liu	The Gemini NICI Planet-Finding Campaign
2:55pm	(C)	Sebastian Elser	The origin of elemental abundances of the terrestrial planets
3:15pm		COFFEE	
3:50pm	(K)	Shigeru Ida	The theoretically predicted distributions of mass and orbital elements of exoplanets
4:20pm	(C)	Yasuhiro Hasegawa	Planet traps and the origin of the observed mass-period relation
4:40pm	(C)	Mariangela Bonavita	Clues on the frequency of circumbinary planets in wide orbits
5:00pm		Ralph Pudritz – Discussion	
6:00pm		End	
6:30pm		SOCIAL at Slainte Irish Pub. Bus departure from residence	

Tuesday June 12

8:00am: Morning coffee
8:00am: Conference registration (continued)
8:25am: Conference notes

Session 3: Planets in Cluster Contex

Chair: Ralph Pudritz

8:30am	(R)	Fred Adams	Effects of the Cluster Environment on Forming Planetary Systems
9:15am	(C)	Richard Parker	The effects of dynamical evolution on planets in young substructured clusters
9:35am	(K)	John Bally	Planet Formation in Clusters: From Orion to Starbursts
10:05am		COFFEE	

Session 4: Young, gas-rich disks

10:35am	(R)	Nuria Calvet	The gas-rich disks: structure and evolution
11:20am	(C)	Sean Andrews	Millimeter-Wave Observations of Protoplanetary "Transition" Disks
11:40am	(C)	Ruobing Dong	The missing cavities in the polarized NIR scattered light images of transitional protoplanetary disks
12:00pm		LUNCH, Centro@Commons	
Chair: James Wadsley			
1:30pm	(K)	Kaitlin Kratter	How young disks shape the growth of stellar systems
2:00pm	(C)	Myriam Benisty	Unveiling the structure of pre-transitional disks
2:20pm	(C)	Chunhua Qi	Resolving the CO snow line in protoplantary disks
2:40pm	(C)	Jacob Simon	Turbulence in Protoplanetary Disks: Defining the Environment for Planet Formation
3:00pm		COFFEE	
3:40pm	(C)	John Carpenter	Observational Constraints on Spatial Variations of Grain Growth in Circumstellar Disks
4:00pm	(C)	Marina Galvagni	An improved model for grain growth in the outer part of a protoplanetary disc
4:20pm	(C)	François Ménard	Radial dust migration in the TW Hydra protoplanetary disk
4:40pm	(C)	Xuening Bai	Launching of Magnetocentrifugal Winds in the Inner Region of Protoplanetary Disks
5:00pm		POSTER SESSION + WINE AND CHEESE – MDCL lobby	
6:30pm		End	
8:00pm		2012 Whidden / OI Public Lecture: by Ray Jayawardhana *Rocks, Ice and Penguins: Searching for Clues to Planetary Origins in Antarctica.* Chester New Hall (CNH) 104	

Wednesday June 13

8:00am: Morning coffee
8:00am: Conference registration (continued)
8:25am: Conference notes

Session 4: Young, gas-rich disks (continued)

Chair: Gilles Chabrier

8:30am	(C)	Mark Wardle	The magnetically-active surface layers of protoplanetary discs
8:50am	(C)	Raquel Salmeron	Formation of chondrules in disk winds

Session 5: Atmospheres and Evolutionary Models

9:10am	(R)	Isabelle Baraffe	A review on the structure and evolutionary properties of substellar objects: from brown dwarfs to exoplanets
9:55am	(C)	Takashi Hosokawa	On the reliability of stellar ages and age spreads inferred from pre-main-sequence evolutionary models
10:15am		COFFEE	
10:50am	(K)	Jonathan Fortney	Examing the Structure of Transiting Planets, from Super Earths to Gas Giants
11:20am	(C)	Ian Dobbs-Dixon	Atmospheric Dynamics of Short Period Planets
11:40am	(C)	James Owen	The Evaporation of Close in Planets
12:00pm		LUNCH, Box Lunches	
12:45pm		Bus departure for Excursion on: Niagara Falls and Maid of the Mist + tasting and conference	

Thursday June 14

8:00am:	Morning coffee
8:00am:	Conference registration (continued)
8:25am:	Conference notes

Session 6: Cores and Small Scale Collapse

Chair: Fred Adams

8:30am	(R)	Phillipe André	From the filamentary structure of molecular clouds to the formation and properties of prestellar cores
9:15am	(C)	Jaime Pineda	Direct Observation of the Transition to Coherence and Isothermal Filaments in a Dense Core
9:35am	(C)	Joseph Mottram	Herschel water observations: revealing envelope dynamics in low-mass protostars
9:55am	(C)	Scott Schnee	An Observed Lack of Substructure in Starless Cores
10:15am		COFFEE (POSTER Session)	
10:50am	(K)	Shu-Ichiro Inutsuka	From Cloud Cores to Protostars and Protoplanetary Disks
11:20am	(C)	Benoit Commerçon	Theoretical and observational predictions of collapsing dense cores using 3D radiation-magneto-hydrodynamics

Session 7: Planet Formation - Early Stages in Disks

11:40am	(C)	Christian Gräfe	Constraints on the early stages of planet formation from multi-wavelength observations and modeling of the circumstellar disk of the Butterfly Star
12:00pm		LUNCH, Centro@Commons	
Chair: Shigeru Ida			
1:30pm	(R)	Kees Dullemond	From dust to planetary embryos
2:15pm	(C)	Farzana Meru	SPH simulations of dust aggregate collisions: the effects of aggregate porosity and mass on the threshold velocities for fragmentation
2.35pm	(C)	Jean-Philippe Berger	First PIONIER-VLTI images of protoplanetary disks inner dusty rim
2:55pm	(C)	Paola Pinilla	Trapping dust particles in the outer regions of protoplanetary and transitional disks
3:15pm		COFFEE	
3:50pm	(K)	Anders Johansen	From pebbles to planetesimals and beyond
4:20pm	(C)	Fredrik Windmark	Planetesimal formation by sweep-up: How the bouncing barrier can aid growth
4:40pm	(C)	Wladimir Lyra	Vortex excitation at dead zone boundaries in 3D resistive magnetohydrodynamical global models of protoplanetary disks
5:00pm		Ralf Klessen: Discussion	
6:00pm		End	
6:45pm		Dine Around Town – Selected restaurants	

Friday June 15

8:00am:	Morning coffee		
8:25am:	Conference notes		

Session 7: Planet Formation - Early Stages in Disks (continued)

Chair: Kaitlin Kratter

8:30am	(C)	Jarrett Johnson	The First Planets: the Critical Metallicity for Planet Formation
8:50am	(C)	Zhaohuan Zhu	Transitional Disks: multiple planets, dust filtration or dust growth?

Session 8: Planet Formation - Late Stages

9:10am	(C)	Andrew Shannon	Growth of Debris Disks
9:30am	(R)	Willy Kley	Planet-disk interaction and orbital evolution
10:15am		COFFEE	
10:50am	(C)	Bertram Bitsch	Implications of the disc structure on planetary migration
11:10am	(C)	Cristobal Petrovich	New developments in the old problem: revisiting disk-planet tidal interaction
11:30am	(K)	Brenda Matthews	Herschel surveys of debris disks: incidences, outcomes and surprises
12:00pm		LUNCH BBQ: 1280 Bistro	
Chair: Ralf Klessen			
1:30pm	(C)	Geoffrey Bryden	SKARPS: The Search for Kuiper belts Around Radial-velocity Planet Stars

Session 9: Brown Dwarfs

1:50pm	(K)	Matthew Bate	The formation and properties of stars and brown dwarfs
2:20pm	(C)	Patrick Rogers	Forming Gas-Giants Through Gravitational Instability: 3D Radiation Hydrodynamics Simulations and the Hill Criterion
2:40pm	(R)	Gilles Chabrier	Brown dwarf and star formation and the bottom of the IMF: a critical look
3:25pm		COFFEE (unmount posters)	
4:00pm	(C)	Shantanu Basu	A Hybrid Scenario for the Formation of Brown Dwarfs and Very Low Mass Stars
4:20pm	(C)	Luca Ricci	Testing the models of early evolution of solids in disks through sub-mm interferometry
4:40pm			END CONFERENCE
6:30pm			Evening Event – for those staying on, TBA.

Talks

Session 1: Star Formation in Clusters

Name: Charlie Lada
Affiliation: Harvard-Smithsonian Center for Astrophysics
Email: clada@cfa.harvard.edu
Presentation: Review
Title: **Embedded Clusters As Laboratories for Star and Planet Formation Studies**
Author(s): Charlie Lada
Abstract: In this talk I will review basic physical properties of embedded clusters in Galactic molecular clouds and discuss their role in the star and planet formation process. Topics reviewed will include cluster and stellar mass functions, ages and lifetimes of embedded clusters, star formation rates in clusters, the structure of embedded clusters, and the nature and evolution of circumstellar disk populations in clusters.

Name: Jason Ybarra
Affiliation: University of Florida
Email: jybarra@astro.ufl.edu
Presentation: Contributed Talk
Title: **The Progression of Star Formation in the Rosette Molecular Cloud.**
Author(s): Ybarra*, J. E., Roman-Zuniga, C., Wang, J., Balog, Z., Feigelson, E., Lada, E. A.
Abstract: Using Spitzer Space Telescope and Chandra X-ray Observatory data, we identify YSOs in the Rosette Molecular Cloud (RMC). Through the selection of cluster members and subsequent classification into YSO types, we study the spatial and age distributions of the YSOs in the cloud. We investigate the progression of star formation locally within the cluster environments and globally within the cloud. We employ nearest neighbor method (NNM) analysis to explore the density structure of the clusters, Gaussian mixture modeling to estimate cluster properties, and ratio mapping to study age progressions in the cloud. We find a relationship between the YSO ratios and extinction which suggests star formation occurs preferentially in the densest parts of the cloud.

Name: Pamela Klaassen
Affiliation: Leiden Observatory
Email: klaassen@strw.leidenuniv.nl
Presentation: Contributed Talk
Title: **Ionized and Molecular Gas Dynamics in K3-50A**
Author(s): P.D. Klaassen* et al.
Abstract: Despite great strides in the field, it is still not clear how high-mass protostars continue to accrete material once an HII region has formed. With sensitive new instruments, we can characterize the dynamics of both the molecular and ionized gas in these regions. By studying infall, outflow and rotation on thousands of AU scales, we can quantify the byproducts of accretion Does accretion continue beyond the formation of an HII region? Early results suggest yes. In some regions (e.g. W51e2) the ionized and molecular gas appear to be co-rotating. In others, (e.g. G10.6), the ionized and molecular infall signatures are consistent. In K3-50A, there are previous observations of an ionized outflow, but no molecular one. Here, we present a study of both the ionized and molecular gas dynamics in K3-50A using H41a and HCO+ (J=1-0) observations from CARMA. We find evidence that the ionized outflow in this region is indeed entraining some of the molecular gas as it escapes the HII region, but that the bulk of the molecular gas (as traced by HCO+) is continuing to infall onto the HII region perpendicular to this outflow.

Name: Mikhail Klassen
Affiliation: McMaster University
Email: klassm@mcmaster.ca
Presentation: Contributed Talk
Title: **Simulating Protostellar Evolution and Radiative Feedback in Stars and Clusters**
Author(s): Mikhail Klassen*, Ralph E. Pudritz, Thomas Peters
Abstract: Modeling stellar feedback accurately is one of the foremost technical challenges in star formation simulations. Massive stars dominate their birth environments through a host of powerful feedback processes. Among the effects of radiative feedback are heating and ionization, which alter the environment for star formation by suppressing gas fragmentation and creating expanding bubbles of hot, ionized gas (HII regions). Hydrodynamic simulations involving stellar feedback must include stellar models that accurately describe the properties of protostars as they evolve towards the main sequence. We implement various protostellar models in simulations of clustered star formation and individual stellar evolution, comparing their results to ZAMS-based models. One-zone protostellar evolution models resulted in less early-phase heating and ionization our cluster simulations, which may alter the final mass spectrum of stars. In simulations of individual protostars, hypercompact HII regions were seen to fluctuate on timescales shorter than 3000 years due to the pre-main-sequence evolution of the protostar. We conclude therefore that accurate protostellar modeling is important and that HII region variability can serve as a probe of early-phase stellar evolution. We are now implementing these models in simulations of turbulent molecular cloud clumps to study stellar feedback effects and present some of our early results.

Name: Cathie Clarke
Affiliation: IOA, Cambridge
Email: cclarke@ast.cam.ac.uk
Presentation: Keynote
Title: **The imprint of formation in clusters on the field**
Author(s): C. Clarke
Abstract: I will describe how recent hydrodynamical and Nbody calculations throw light on the manner in which clusters dissolve into and form the field star population. In particular I discuss the recent finding that star clusters in hydrodynamic simulations are locally gas poor at birth, which would imply that cluster dispersal is an essentially stellar dynamical process. I show that this picture readily reproduces the observed distribution of stellar surface densities in nearby star forming regions. I also describe how the formation of ultra-wide binaries in dissolving clusters provides a diagnostic of the membership number of 'typical' star forming clusters.

Name: Philip Myers
Affiliation: Harvard-Smithsonian Center for Astrophysics
Email: pmyers@cfa.harvard.edu
Presentation: Contributed Talk
Title: **Evolution, ages, and birthrates of YSOs in clusters**
Author(s): Philip Myers*
Abstract: A model of protostar mass and luminosity evolution gives new estimates of cluster age, protostar birthrate, accretion rate and mean accretion time. In this model, protostars are born at a constant rate and grow by core-clump accretion. They stop accreting with equal likelihood and become pre-main sequence (PMS) stars. The protostar and PMS populations, and their distributions of mass and luminosity, are predicted as functions of time. The model reproduces the initial mass function, and distributions of protostar luminosity observed in nearby star-forming regions. It predicts that massive stars start accreting earlier, and stop accreting later, than do most low-mass cluster stars. Cluster ages and birthrates are derived from the observed numbers of protostars and PMS stars, and from the modal value of the protostar luminosity. In 31 embedded clusters and complexes the inferred age is 1-3 Myr, in accord with estimates based on optical spectroscopy and evolutionary tracks. The typical birthrate is 60-180 protostars per Myr for clusters, and thousands of protostars per Myr for complexes. The core-protostar accretion rate is ~ 1 solar mass per Myr, and the mean accretion duration is ~ 0.2 Myr, each in accord with estimates for low-mass star formation.

Notes

Notes

Session 2: Planets - Statistical Properties

Name: Jason Rowe
Affiliation: NASA-Ames/SETI-Institute
Email: jasonfrowe@gmail.com
Presentation: Contributed Talk
Title: **The Reflective and Thermal Properties of Transiting Extrasolar Planets**
Author(s): Jason F. Rowe*, The Kepler Team
Abstract: Extrasolar planets found in orbits of a few days provide an opportunity to determine planet atmospheric properties from high precision photometric lightcurves. Such studies have been successful on a limited number of highly irradiated Jupiter sized extrasolar planets. Now, with over two years of observations obtained by the Kepler mission one can now begin to statistically survey planets of various radii, mass and the degree of irradiation. I will show how our observation are able to determine atmospheric properties such as: reflectivity, cloud formation and thermal transport for a variety of dense rocky and gaseous planets.

Name: Dimitar Sasselov
Affiliation: Harvard-Smithsonian Center for Astrophysics
Email: dsasselov@cfa.harvard.edu
Presentation: Review
Title: **Planetary Architectures: From Interior Design to Urban Planning**
Abstract: The review will cover statistical properties of exoplanets and planetary systems as revealed by 15 years of observations and theoretical interpretation. The different discovery techniques have provided us with orbital architectures at small and at very large scales. The planets bulk properties are still only limited to the small scales. A successful planet formation paradigm is likely to require understanding the overlap in scales - in orbital sizes and in planet masses.

Name: Brendan Bowler
Affiliation: University of Hawaii
Email: bpbowler@ifa.hawaii.edu
Presentation: Contributed Talk
Title: **A High Contrast Adaptive Optics Imaging Search for Giant Planets Around Young M Dwarfs**
Author(s): Brendan Bowler*, Michael Liu, Evgenya Shkolnik, Motohide Tamura
Abstract: Direct imaging planet searches are revealing the architecture of planetary systems at large separations (>10 AU) where disk instability is likely to operate. Low-mass stars are generally being neglected from these surveys in part because of the dearth of known nearby young M dwarfs compared to young intermediate- and high-mass stars. As a result, even though M dwarfs are the most common denizens of our galaxy, there are few constraints on giant planet formation around low-mass stars at moderate (5-100 AU) separations. We will present results from an ongoing high-contrast adaptive optics imaging survey of nearby (<30 pc) young (<300 Myr) M dwarfs with Keck-2/NIRC2 and Subaru/HiCIAO. We have already discovered two brown dwarf companions, one of which will yield a dynamical mass in the near future. Altogether our survey is sensitive to planet masses a few times that of Jupiter at separations down to ∼10 AU. With a sample size of roughly 80 single M dwarfs, this program represents the deepest and most extensive imaging search for planets around young low-mass stars to date.

Name: Michael Liu
Affiliation: University of Hawaii
Email: mliu@ifa.hawaii.edu
Presentation: Contributed Talk
Title: **The Gemini NICI Planet-Finding Campaign**
Author(s): Michael Liu* and the NICI Planet-Finding Campaign Team
Abstract: We are currently completing a 500-hour, 250-star observing campaign to directly image and characterize young (<∼1 Gyr) extrasolar planets using the Near-Infrared Coronagraphic Imager (NICI) on the Gemini-South 8.1-meter telescope. NICI is the first instrument designed from the outset for high-contrast imaging on a large telescope, comprising a high-performance adaptive optics (AO) system with a simultaneous dual-channel coronagraphic imager. In combination with state-of-the-art AO observing and data analysis, the NICI Campaign achieves about 2 magnitudes better contrast compared to any previous ground-based or space-based planet-finding efforts. We describe the Campaign's design, on-sky performance, and results, including individual discoveries of interest and robust statistical results on companion frequency and orbital separations. Overall, the NICI Planet-Finding Campaign represents the largest and most sensitive imaging survey to date for brown dwarfs and Jovian-mass planets around other stars.

Name: Sebastian Elser
Affiliation: University of Zurich
Email: selser@physik.uzh.ch
Presentation: Contributed Talk
Title: **The origin of elemental abundances of the terrestrial planets**
Author(s): Sebastian Elser*, Michael R. Meyer, Ben Moore
Abstract: The abundances of elements in the Earth and the terrestrial planets provide the building blocks of life and clues as to the history and formation of the Solar System. We follow the pioneering work of Bond et al., 2010, and combine circumstellar disk models, chemical equilibrium calculations and dynamical simulations of planet formation to study the bulk composition of rocky planets. We found that the choice of the initial planetesimal disk mass and of the disk model has a significant effect on composition gradients. We observed a trend that massive planets and planets with relatively small semi-major axis are more sensitive to these variations than smaller planets at larger radial distance. Only these large variations can potentially explain the bulk composition of the Solar System planets. On the other hand, colder disk models provide the condensation of solids containing biologically important elements like H in the planetesimal belt. In this case, the variation in the bulk composition of planets due to the dynamical simulations vanishes for almost all elements.

Name: Shigeru Ida
Affiliation: Tokyo Institute of Technology
Email: ida@geo.titech.ac.jp
Presentation: Keynote
Title: **The theoretically predicted distributions of mass and orbital elements of exoplanets**
Author(s): Shigeru Ida
Abstract: The distributions of mass and orbital elements (semimajor axis, eccentricities) of exoplanets are discussed. First, I briefly summarize the statistical properties of the distributions inferred by radial velocity, transit, microlensing and direct imaging surveys. Next, I talk about the distributions theoretically predicted by core accretion model, make clear what observational data the theory cannot explain, and discuss about what are missing in the theory. I will point out disk structures regulate planet formation. For examples, migration traps due to radial pressure bumps and disk radius may play crucial roles in formation of planets in inner and outer planets.

Name: Yasuhiro Hasegawa
Affiliation: McMaster University
Email: hasegay@physics.mcmaster.ca
Presentation: Contributed Talk
Title: **Planet traps and the origin of the observed mass-period relation**
Author(s): Yasuhiro Hasegawa* and Ralph E Pudritz
Abstract: The large number of observed exoplanets (>700) provides fundamental constraints on their origin deduced in a mass-period diagram. In the diagram, the most surprising features are the (apparent) pile up of gas giants at a period of ~500 days (~1 AU) and the so-called mass-period relation which indicates that planetary mass is an increasing function of period. We show that analyses of evolutionary tracks of growing planets in inhomogeneities in evolving protoplanetary disks provides a good physical understanding of how these observational trends arise. The fundamental contribution of the disk inhomogeneities is to give rise to multiple (up to 3) trapping sites for rapid (type I) planetary migration of cores of gas giants and subsequent slow transport of the cores from large to small orbital radii. We provide a number of invaluable predictions; that distinct sub-populations of planets that reflect the properties of disk inhomogeneities where they have grown result in the mass-period relation; that the presence of these sub-populations naturally explains a pile-up of planets at ~1 AU; that evolutionary tracks from the ice line fill an earlier claimed "planet desert"; that new planet deserts can exist in the range of masses (1-50 Earth masses) and semi-major-axes (1-10 AU).

Name: Mariangela Bonavita
Affiliation: University of Toronto
Email: bonavita@astro.utoronto.ca
Presentation: Contributed Talk
Title: **Clues on the frequency of circumbinary planets in wide orbits**
Author(s): M.Bonavita*, S. Desidera, G. Chauvin, A. Vigan, M. Janson, R. Jayawardhana,
Abstract: Regardless of the details of the formation processes, there are by now many indications that the presence of a close stellar companion influences the formation and evolution of a planetary system. Various studies have been conducted on the impact of binary on the properties of planets, mainly focusing on circumstellar planets in moderately close and wide binary systems. The recent discoveries of planets orbiting both the components of very tight binary systems has drawn the attention of the community towards these challenging targets, known as circumbinary planets. Direct imaging (DI) represent a complementary technique to search for these planets at wider separations than those explored with transit technique, also considering binaries with larger separations. Here we present the results of a detailed statistical analysis on a sample of 30 close binaries for which DI observations were available in the literature, and deep enough to reach the planet domain at separations consistent with stable circumbinary orbits. The aim of the analysis is to put some constraint on the frequency of planets in wide circumbinary orbits, by testing several assumptions on the planet formation methods.

Name: Ralph Pudritz
Affiliation: McMaster University
Email: pudritz@physics.mcmaster.ca
Presentation: Discussion

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Session 3: Planets in Cluster Context

Name: Fred Adams
Affiliation: University of Michigan
Email: fca@umich.edu
Presentation: Review
Title: **Effects of the Cluster Environment on Forming Planetary Systems**
Author(s): Fred C. Adams
Abstract: Most stars – and hence most solar systems – form within groups and clusters. This talk will review how these background environments can affect the solar systems forming within them. One important effect that clusters exert on their constituent solar systems is disruption through dynamical scattering. These interactions can be quantified through N-body simulations. Cluster evolution depends on cluster size and initial conditions. Multiple realizations of equivalent cases must be used to build up a robust statistical description of these systems, e.g., the distributions of closest approaches and radial locations. These results provide a framework from which to assess the possible effects of clusters on solar system formation. Distributions of radial positions can be used in conjunction with UV luminosity distributions to estimate the radiation exposure of circumstellar disks. Photoevaporation models determine the efficacy of radiation in removing disk gas and thereby compromising planet formation. The distributions of closest approaches can be used in conjunction with scattering cross sections to determine probabilities for solar system disruption. The result of this body of work allows for a quantitative determination of the effects of clusters on forming solar systems.

Name: Richard Parker
Affiliation: Institute for Astronomy, ETH Zurich
Email: rparker@phys.ethz.ch
Presentation: Contributed Talk
Title: **The effects of dynamical evolution on planets in young substructured clusters**
Author(s): Richard J. Parker* and Sascha P. Quanz
Abstract: Most stars form in clustered environments, and therefore the effects of dynamical interactions on planetary systems that form in clusters could be important. Furthermore, young, unevolved clusters appear to be highly substructured, due to the filamentary nature of star formation. I will present the results of N-body simulations of substructured clusters in which half of the stars are orbited by a single Jupiter-mass planet. I will show the effect of cluster dynamics on the planets' semi-major axes, eccentricity, and orbital inclination, and discuss the planets that are liberated from their host star and become free-floating within the cluster. Finally, I will extend these concepts to discuss the effect of cluster dynamics on planets orbiting the component of a primordial binary system.

Name: John Bally
Affiliation: University of Colorado at Boulder
Email: John.Bally@colorado.edu
Presentation: Keynote
Title: **Planet Formation in Clusters: From Orion to Starbursts**
Author(s): John Bally
Abstract: Most stars and their planetary systems form in transient star clusters which dissolve soon after birth. The abundance of the decay products of short-lived species such as 60Fe in primitive meteorites provides evidence that our Solar System formed in a transient massive cluster and experienced a nearby supernova injection event during its birth 4.5 billion years ago. At the time, the Galactic ISM probably contained considerably more mass, and therefore may have produced massive clusters more efficiently than today. Studies of the most massive "mini-starburst" regions in our Galaxy such as W49, W51, W43, NGC3603, and Sgr B2, combined with detailed investigation of the nearby regions such as Orion and Carina, provide clues about the conditions in which our planetary system was assembled. I will review some recent observations which shed light on processes operating in dense cluster environments such as secondary Bondi-Hoyle accretion onto disks, dynamic perturbations by sibling stars, externally-induced photo-ablation by massive stars, LBVs, and SN flashes, contamination by SN ejecta, and stripping of debris-disks dust by massive stellar winds.

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Session 4: Young, Gas-Rich Disks

Name: Nuria Calvet
Affiliation: University of Michigan
Email: ncalvet@umich.edu
Presentation: Review
Title: **The gas-rich disks: structure and evolution**
Abstract: In the past decade, observations with Spitzer, Herschel, HST, and ground-based interferometers have brought a new wealth of information on the gas-rich disks formed by the collapse of slowly rotating molecular cloud cores. These observations have allowed us to get a closer look at the properties of the gas and of the dust in young disks, and to the possible evolutionary paths towards their dissipation. I will review the observations as well as the inferences about disk structure and evolution provided by their analysis.

Name: Sean Andrews
Affiliation: Harvard-Smithsonian Center for Astrophysics
Email: sandrews@cfa.harvard.edu
Presentation: Contributed Talk
Title: **Millimeter-Wave Observations of Protoplanetary "Transition" Disks**
Author(s): Sean M. Andrews
Abstract: Young circumstellar disks are thought to experience a rapid "transition" phase in their evolution that can have a considerable impact on the formation and early development of planetary systems. I will present high angular resolution (0.3" = 20-60 AU) millimeter-wave observations from a Submillimeter Array (SMA) survey of such transition disks in nearby star-forming regions. With those data, we directly resolve dust-depleted disk cavities on scales comparable to the extent of our Solar System. Surprisingly, these large cavities are common, comprising at least 1 in 3 of the disks at the high end of the disk mass distribution. Using these results, I assess the physical mechanisms proposed to account for transition disk structures. I will argue that neither photoevaporation or particle growth alone can reproduce the observations. Instead, the data are more commensurate with the substantial disk structure perturbations expected from dynamical interactions with low-mass (planetary) companions.

Name: Ruobing Dong
Affiliation: Princeton University
Email: rdong@astro.princeton.edu
Presentation: Contributed Talk
Title: **The missing cavities in the polarized NIR scattered light images of transitional protoplanetary disks**
Author(s): Ruobing Dong, Roman Rafikov, Zhaohuan Zhu, Lee Hartmann, Barbara Whitney, and the SEEDS team
Abstract: Transitional disks around YSOs have a distinctive infrared deficit around 10 microns in their SED (IRS), suggesting dust depletion in the inner regions. They have been confirmed to have giant central cavities by imaging of the sub-mm continuum emission using the SMA. However, the polarized NIR scattered light images for most objects in a systematic IRS/SMA cross sample, obtained by HiCIAO on the Subaru telescope, show no evidence for the cavity, in clear contrast with SMA and Spitzer observations. Radiative transfer modeling indicates that these NIR images are consistent with a smooth spatial distribution for micron-sized grains, with little discontinuity in the surface density of the micron-sized grains at the cavity edge. We present a generic disk model that can simultaneously account for the general features in IRS, SMA, and particularly Subaru observations. Decoupling between the spatial distributions of the micron-sized dust and mm-sized dust inside the cavity is suggested, which if confirmed, necessitates a dust-differentiating mechanism, such as dust filtration. Our model also suggests an inwardly increasing gas-to-dust-ratio in the inner disk, and different spatial distributions for the small dust inside and outside the cavity, echoing the predictions in grain coagulation and growth models.

Name: Kaitlin Kratter
Affiliation: Harvard-Smithsonian CfA
Email: kkratter@cfa.harvard.edu
Presentation: Keynote
Title: **How young disks shape the growth of stellar systems**
Abstract: Young, gas rich accretion disks serve as the primary mass reservoir for growing stars. I will provide a brief overview of angular momentum transport theory, and then focus on the role that disks play in regulating the multiplicity and mass of stellar systems. I will conclude by describing how circumbinary disks and planets can inform our understanding of the star formation process.

Name: Myriam Benisty
Affiliation: IPAG, Grenoble, France
Email: Myriam.Benisty@obs.ujf-grenoble.fr
Presentation: Contributed Talk
Title: **Unveiling the structure of pre-transitional disks**
Author(s): M. Benisty*, J. Olofsson, JP. Berger, A. Carmona, C. Pinte, F. Menard
Abstract: On a timescale of a few tenths of Myrs, circumstellar disks dissipate and quickly evolve into more mature systems around which hundreds of planets have now been discovered. Pre-transitional disks are the best laboratory to study the early phase of dust and gas removal around young stellar objects. However, such systems are rare and present a complex geometry on different spatial scales (sub-AU to 100s of AUs). In particular, the first few AUs provide the conditions for terrestrial planet formation, and giant planet migration, but are very poorly constrained. With its milli-arcsecond resolution, infrared interferometry is the only technics able to spatially resolve the first few AUs of the disk. In this talk, I will present detailed studies of a small sample of pre-transitional disks, that all show evidences for a large gap that may originate in interactions with forming planets. We gathered a large amount of new interferometric data using the PIONIER/VLTI, AMBER/VLTI and MIDI/VLTI instruments in the H- and K- and N-bands to spatially resolve the warm inner disk, constrain its structure, surface density profile and its mineralogy. Combining these measurements with photometric and spectroscopic observations, we analyze these data in the light of a passive disk model based on 3D Monte-Carlo radiative transfer. We find that the inner disks are very thin radially, and slightly non-coplanar with their outer disk. Ultimately, we interpret our observations and modeling results in the context of hydrodynamical simulations and dust growth and fragmentation evolution codes in order to test the hypothesis of ongoing planet formation.

Name: Chunhua Qi
Affiliation: Harvard-Smithsonian Center for Astrophysics
Email: cqi@cfa.harvard.edu
Presentation: Contributed Talk
Title: **Resolving the CO snow line in protoplantary disks**
Author(s): C. Qi*, P. D'Alessio, K. I. Oberg, D.J. Wilner, A. M. Hughes, S.M. Andrews, S. Ayala
Abstract: The condensation front (snow line) of planet-forming volatiles in protoplanetary disks plays an important role in the process of planet formation. Here we report the detection of the CO snow line in the disk around a Herbig Ae star HD 163296. Using an accretion disk model with a temperature structure constrained by the broadband spectral energy distribution, spatially resolved millimeter dust continuum and multiple CO lines (J=2–1, 3–2 and 6–5) observed with the Submillimeter Array (SMA), we fit the optically thin emission from CO isotopologues (13CO, C18O and C17O) with the CO freeze-out temperature and the fractional abundances as free parameters. The derived CO freeze-out temperature (19 K) produces the observed significant drop in the gas-phase CO column density beyond a radius of 155 AU, effectively a CO snow line that is resolved directly by the observations. This detailed investigation of the HD 163296 disk demonstrates the potential of a staged, parametric technique for constructing unified gas and dust structure models and constraining the distribution of molecular abundances using resolved multi-transition, multi-isotope observations. Future ALMA observations with greater sensitivity will be capable of resolving the snow lines of CO and other volatiles in protoplanetary disks.

Name: Jacob Simon
Affiliation: JILA, University of Colorado
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Presentation: Contributed Talk
Title: **Turbulence in Protoplanetary Disks: Defining the Environment for Planet Formation**
Author(s): Jacob B. Simon
Abstract: In this talk, I will discuss the nature of turbulence in protoplanetary disks driven by the magnetorotational instability (MRI) and how this turbulence may affect the very earliest stages of planet formation. In particular, I will present a series of high resolution gas dynamics simulations that are focused on several radial regions in a model protoplanetary disk. These simulations indicate strong features in the gas pressure, which could potentially trap particles for long periods of time. I will also present a series of turbulent velocity distributions calculated from these simulations. These distributions roughly agree with recent observational measurements of turbulence, and through future comparison with observations, predictions from these simulations will be used to test the MRI-driven accretion model for these disks. Finally, I will conclude with future directions, including the addition of more complex physics and further study of the interaction between turbulent gas and particles.

Name: John Carpenter
Affiliation: Caltech
Email: jmc@astro.caltech.edu
Presentation: Contributed Talk
Title: **Observational Constraints on Spatial Variations of Grain Growth in Circumstellar Disks**
Author(s): John Carpenter*, Laura Perez, Andrea Isella, Sean Andrews, Claire Chandler, and the Disks@EVLA Collaboration
Abstract: The first step toward planet formation in protoplanetary disks is the growth of particles from sub-micron size grains to centimeter-sized pebbles. Observationally, grain growth can be inferred by measuring the spectral energy distribution at millimeter wavelengths, where the spectral slope will depend on the grain size distribution as well as the dust properties. While grain growth in disks has been inferred for some time from multi-wavelength submillimeter photometry, resolved images of the dust emission now permit constraints on the spatial variation of grain growth within disks. We will present sub-arcsecond interferometric observations from the Combined Array for Research in Millimeter-wave Astronomy (CARMA), the Expanded Very Large Array (EVLA), and the Submillimeter Array (SMA), that span more than an order of magnitude in wavelength from sub-millimeter to centimeter wavelengths. These observations constrain the radial distribution of circumstellar material and characterize the spatial variations on the dust opacity spectral slope that may originate from particle growth. The most recent results of this observational program will be presented and compared with theoretical predictions of grain size evolution in circumstellar disks.rn

Name: Marina Galvagni
Affiliation: Institute for theoretical physics, zurich
Email: galva@physik.uzh.ch
Presentation: Contributed Talk
Title: **An improved model for grain growth in the outer part of a protoplanetary disc**
Author(s): Galvagni*, Meru, Garaud, Olczak
Abstract: One of the main challenges raised by recent mm-observations of protoplanetary disks is the inferred presence of mm- to cm-size grains far out in the disk (from 10 to 100AU) (e.g. Wilner et al. 2005). Current models of grain growth via particle-particle sticking cannot explain these observations. In order to improve our understanding of this process, we developed a new coagulation-fragmentation solver, GrOG (Growth Of Grains). We improved the collisional description by considering that the colliding velocity for two dust particles is not a single value, as has been used in the past (e.g. Brauer et al. 2007), but a tridimensional probability distribution function (depending on many mechanisms involved in dust dynamics, i.e., radial drift, vertical settling, turbulence, brownian motion). This affects the sticking probability such that there is always a non zero, albeit small, chance of sticking. In this way every collision is a possible channel for particle growth. This improved description of the collisional velocity leads to an easier particle growth and to the formation of larger objects in the outer part of the protoplanetary disc, pointing toward size values closer to the observational data.

Name: François Ménard
Affiliation: IPAG, Grenoble
Email: menard@obs.ujf-grenoble.fr
Presentation: Contributed Talk
Title: **Radial dust migration in the TW Hydra protoplanetary disk**
Author(s): C. Pinte*, F. Ménard, E. Pantin, J.F. Gonzalez, S. Maddison, C. Ubach
Abstract: Proto-planetary disks are the birthplaces of planets. During the very first stages of planet formation, the dust particles grow by coagulation. In parallel, the gas drag on dust particles results in vertical settling and subsequent radial migration towards the central star. Dust migration and settling are central processes for the formation of planets as they concentrate material in the disk mid-plane and increase the local density, a necessary process for efficient dust grain growth and subsequent planet building. Hydrodynamical simulations show that radial migration of the dust is most efficient for grains of mm and cm sizes and should occur on timescales smaller than 100 000 years. In this contribution, we present 7 mm observations of the disk surrounding the T Tauri star TW Hydra, obtained with the ATCA interferometer. These observations allow us to measure the full extension of the disk as well as its brightness profile. The comparison with data obtained at shorter wavelengths (850 microns, which probe the distribution of smaller grains), shows a less rapid falloff of the amplitude as a function of uv-distance, suggesting radial migration of mm/cm-sized grains. The analysis of these data, with state-of-the-art radiative transfer models, allows us to establish, for the first time, quantitative constraints on the degree of dust migration in a T Tauri disk. We discuss the implications of our findings on planet formation.

Name: Xuening Bai
Affiliation: Princeton University
Email: xbai@astro.princeton.edu
Presentation: Contributed Talk
Title: **Launching of Magnetocentrifugal Winds in the Inner Region of Protoplanetary Disks**
Author(s): Xuening Bai*, James M. Stone
Abstract: Gas in protoplanetary disks (PPDs) is widely believed to be turbulent as a result of the magnetorotational instability (MRI). We perform vertically stratified shearing-box simulations of gas dynamics of PPDs that for the first time, simultaneously take into account the effects of both Ohmic resistivity and ambipolar diffusion in a self-consistent manner. We show that in the presence of a weak net vertical magnetic field (beta$\sim$1e5 at midplane), the MRI is completely suppressed in the inner region of PPDs due to ambipolar diffusion (around 1AU in the standard solar nebular model). The gas in this region is laminar throughout the entire vertical extent of the disk and the flow structure is essentially one dimensional. Instead of MRI-driven accretion, a strong magneto-centrifugal wind is launched that carries away the disk angular momentum. The flow structure is different from the disk wind model of Wardle & Konigl (1993) in its symmetry, and a current sheet near disk midplane is present in order for the flow to match to a global disk wind. On the other hand, MRI is able to operate in the outer region of PPDs (beyond $\sim$5AU). These results have important implications on the theory of planet formation.

Name: Mark Wardle
Affiliation: Macquarie University
Email: mark.wardle@mq.edu.au
Presentation: Contributed Talk
Title: **The magnetically-active surface layers of protoplanetary discs**
Author(s): Mark Wardle
Abstract: I explore the consequences of Hall drift and ambipolar diffusion for the extent of MHD turbulence in protoplanetary discs. I illustrate the critical effect that magnetic field-line drift has on the depth of magnetically-active surface layers by applying a local, linear analysis of the magnetorotational instability to a model of the minimum-mass solar nebula. Hall drift increases or decreases the MRI-active column density by an order of magnitude or more, depending on whether B is parallel or antiparallel to the rotation axis, respectively. Ambipolar diffusion is also destabilising if the initial magnetic field has a toroidal component, in addition perturbations with near-radial wave vectors are unstable on all length scales. As ambipolar diffusion tends to dominate near the surfaces of protoplanetary discs, it also may play a critical role in determining the depth of the magnetically-active surface layers. Existing estimates of the depth of magnetically active layers in protoplanetary discs, based on ohmic resistivity or ambipolar diffusion in the presence of a strictly vertical field, are likely to be wildly inaccurate.

Name: Raquel Salmeron
Affiliation: The Australian National University
Email: raquel@mso.anu.edu.au
Presentation: Contributed Talk
Title: **Formation of chondrules in disk winds**
Author(s): Raquel Salmeron* and Trevor Ireland
Abstract: Chondrite meteorites are a mixture of objects that experienced extremely high temperatures (chondrules and refractory inclusions), set in a matrix that remained relatively cold. Chondrules are ubiquitous components of primitive meteorites, however the nature of the thermal processing responsible for their formation in the cold environment of the early solar system is a long-standing puzzle in planetary science. Clearly a more complete model of the planet formation process would need to incorporate a suitable mechanism to produce this thermal processing. Here we show how these high-temperature objects could have been thermally processed in a radially-extended, magnetocentrifugal wind accelerated from the surfaces of a protostellar disk. We show that processing at distances of about 1–3 AU can heat the precursors to their melting points and explain their basic properties, while retaining association with the colder material that provides the chondrite matrix. In the proposed scenario, chondrule precursors are heated while being lifted in the wind, growing through amalgamation, and eventually becoming heavy enough to sink back to the disk, where they assemble with the matrix material. This mechanism is very general, as these powerful winds are commonly associated with young stars. (Salmeron & Ireland EPSL 327, 61-67, 2012)

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Session 5: Atmospheres and Evolutionary Models

Name: Isabelle Baraffe
Affiliation: University of Exeter
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Presentation: Review
Title: **A review on the structure and evolutionary properties of substellar objects: from brown dwarfs to exoplanets**
Abstract: I will describe our present understanding and current modelling of the internal structure and evolution of brown dwarfs and Extra-solar planets. The detection of transiting planets around their parent star allows the determination of their mass and radius, and thus of their mean density. Such valuable information indicates that a significant fraction of these planets are enriched in heavy elements (ice, rocks), as observed in the giant planets of our Solar System, The treatment of heavy materials in planetary interiors and the resulting uncertainties on the mass-radius relationship will be discussed. Inferring the heavy element content and its distribution in a planetary mass object is crucial since these properties are linked to its formation process. For objects in the overlapping mass regime between planets and brown dwarfs, they can provide a diagnostic to distinguish these two classes of objects. I will also address the case of short-period, strongly irradiated planets and discuss some of the physical mechanisms which have been suggested to explain anomalously large observed radius. I will finally discuss the early evolution of planets versus brown dwarfs and I will critically analyse the suggestion that young planets should be fainter than young brown dwarfs.

Name: Takashi Hosokawa
Affiliation: NASA Jet Propulsion Laboratory
Email: hosokwtk@gmail.com
Presentation: Contributed Talk
Title: **On the reliability of stellar ages and age spreads inferred from pre-main-sequence evolutionary models**
Author(s): Takashi Hosokawa*, Stella Offner, Mark Krumholz
Abstract: In this contribution, I present our systematic modeling of the protostellar evolution with different accretion histories, stellar initial radius, and radiative properties of the accretion flow. We compare our numerical results to both non-accreting isochrones and to the positions of observed stars in the HRD, with a goal of determining whether both the absolute ages and the age dispersions inferred from non-accreting isochrones are reliable. We show that non-accreting isochrones can sometimes overestimate stellar ages for more massive stars. However, we also find the only way to produce a similar overestimate for the ages of cooler stars is (i) these stars grow from =∼ 0.01 Msun seed protostars that are an order of magnitude smaller than predicted by current theoretical models, and (ii) the size of the seed protostar correlates systematically with the final stellar mass at the end of accretion. We therefore conclude that, unless both of these conditions are met, inferred ages and age spreads for cool stars are reliable. We also note that, with thermally inefficient accretion (”cold accretion”), the time-dependence of the mass accretion rate has remarkably little effect on low-mass stars' evolution on the HRD.

Name: Jonathan Fortney
Affiliation: University of California, Santa Cruz
Email: jfortney@ucolick.org
Presentation: Keynote
Title: **Examaning the Structure of Transiting Planets, from Super Earths to Gas Giants**
Author(s): Jonathan Fortney*
Abstract: We have now reached the point in studying transiting planets that we can begin to examine the Jupiter-class planets as a class of astrophysical objects. At the same time, thanks to Kepler, the number of transiting planets below 10 Earth masses is now moving beyond just a handful. For the Jovians, we show that there is an emerging population of planets that are relatively cool (Teff<1000 K) that appear to be unaffected by whatever is inflating the radii of the hottest members of this class. We have searched this cool group for correlations, and we find several interesting properties regarding the amount of heavy elements within these planets. For the lowest-mass planets, such as the 6-planet Kepler-11 system, signs point to an unexpectedly large populations of mini-Neptunes—low-mass, low-density planets with hydrogen-dominated envelopes. We show that a model that couples the radius evolution of the planets and evaporative mass loss XUV heating can explain striking features in planet period vs. planet density, for the lowest-mass planets.

Name: Ian Dobbs-Dixon
Affiliation: University of Washington, Seattle
Email: ianmdd@gmail.com
Presentation: Contributed Talk
Title: **Atmospheric Dynamics of Short Period Planets**
Author(s): Ian Dobbs-Dixon*
Abstract: Short-period transiting gas-giant planets remain the best characterized of all exoplanets, allowing us glimpses into planetary composition, structures, and exo-weather. I will present 3D radiative-hydrodyamical atmospheric models of these highly irradiated planets, exploring the atmospheric dynamics and energy redistribution efficiency for a range of parameters. The interplay between the upper atmosphere and the convecting interior is thought to play an important role in the overall evolution of the planet. I will discuss models that resolve the vitally important radiative-convective boundary and describe the implications for planetary structure and evolution. Finally, one feature common to many atmospheric models (over a wide range of physical parameters) is the formation of circumplantary, super-rotating equatorial jets. I will discuss a new set of observational diagnostics that allows us to deduce the strength of this jet via primary transmission spectra.

Name: James Owen
Affiliation: CITA
Email: jowen@cita.utoronto.ca
Presentation: Contributed Talk
Title: **The Evaporation of Close in Planets**
Author(s): James Owen*
Abstract: I will present the results of hydrodynamic calculations for the evaporation of the atmospheres of close in planets. In particular I will discuss the interaction between X-ray and EUV irradiation, and which radiation field drives the evaporation in different regions of parameter space. I show that most close in planets ($a<0.1$AU) will be evaporating hydrodynamically rather than loosing mass via Jean's escape. I will then discuss the results of coupling the evaporation rates to an evolutionary model of the star's high energy emission, in order to follow the evolution of the evaporation over Gyr time-scales. Thus, determining the role evaporation may play in the complete destruction of close in gas planets.

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Session 6: Cores and Small Scale Collapse

Name: Philippe André
Affiliation: CEA Saclay
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Presentation: Review
Title: **From the filamentary structure of molecular clouds to the formation and properties of prestellar cores**
Author(s): Philippe André
Abstract: The seeds or direct progenitors of stars within molecular clouds are believed to be gravitationally-bound, starless cloud fragments known as prestellar cores. Improving our understanding of the formation and evolution of prestellar cores is crucial to gain insight into the origin of stars of all masses, including very low mass stars and brown dwarfs. I will review observational progress in this area, with a particular emphasis on recent results obtained with the Herschel Space Observatory. Altogether, the Herschel results favor a scenario in which interstellar filaments and prestellar cores represent two fundamental steps in the star formation process: First, large-scale magnetohydrodynamic turbulence generates a complex web of filaments in the ISM; second, the densest filaments grow and fragment into prestellar cores (and ultimately protostars) via gravitational instability.

Name: Jaime Pineda
Affiliation: University of Manchester and ESO
Email: jaime.pineda@manchester.ac.uk
Presentation: Contributed Talk
Title: **Direct Observation of the Transition to Coherence and Isothermal Filaments in a Dense Core**
Author(s): J.E. Pineda*, A. Goodman, H. Arce, P. Caselli, J. Foster, P.C Myers, E. Rosolowsky, S. Longmore, S. Corder
Abstract: We present NH3 observations of the B5 region in Perseus obtained with the GBT and EVLA. The GBT map covers a region large enough (11'×14') that it contains the entire dense core observed in previous dust continuum surveys. The dense gas traced by NH3(1,1) covers a much larger area than the dust continuum features found in bolometer observations. The velocity dispersion in the central region of the core is small, presenting subsonic non-thermal motions which are independent of scale. However, it is thanks to the coverage and high sensitivity of the observations that we present the detection, **for the first time**, of the transition between the coherent core and the dense but more turbulent gas surrounding it. This transition is sharp, increasing the velocity dispersion by a factor of 2 in less than 0.04 pc (the 31" beam size at the distance of Perseus, 250 pc).The change in velocity dispersion at the transition is ~3 km s^{-1} pc^{-1}. The existence of the transition provides a natural definition of dense core: the region with nearly-constant subsonic non-thermal velocity dispersion. The EVLA observations (27 pointing mosaic) are combined with the GBT map to achieve a 6" beam. This map (~6.8'x8') covers the region of subsonic non-thermal velocity dispersion observed with the GBT. These observations reveal, for the first time, the presence of striking filamentary structure (20" wide or 5,000 AU at the distance of Perseus) in this low-mass star forming region. The integrated intensity profile of this structure is consistent with models of an isothermal filament in hydrostatic equilibrium. Also, the observed separation between the B5–IRS1 young stellar object (YSO), in the central region of the core, and the northern starless condensation matches the Jeans length of the dense gas. This suggests that the dense gas in the coherent region is fragmenting. The region observed displays a narrow velocity dispersion, where most of the gas shows evidence for subsonic turbulence, and where little spatial variations are present. It is only close to the YSO where an increase in the velocity dispersion is found, but still displaying subsonic non-thermal motions. Finally, we'll discuss the implications of these results on the "core" identification/definition and the importance of the region of subsonic turbulence in the formation process of low-mass stars.

Name: Joseph Mottram
Affiliation: Leiden Observatory
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Presentation: Contributed Talk
Title: **Herschel water observations: revealing envelope dynamics in low-mass protostars**
Author(s): J.C. Mottram*, E.F. van Dishoeck, L.E. Kristensen and the WISH team
Abstract: Water is an extremely sensitive probe of the temperature and kinematics of the dense gas in star forming regions. The "Water in star-forming regions with Herschel" (WISH) survey has observed multiple transitions of water and related species with HIFI for a sample of ∼80 sources ranging from low to high mass and from prestellar cores to disks. I will present recent WISH results which reveal that embedded YSOs have diverse and complex water line profiles, often containing multiple components tracing different dynamical processes within a single beam. For example, inverse P-Cygni profiles, indicative of an infalling envelope, are detected in water observations towards 6 of 15 low-mass Class 0 YSOs, while 3 of 15 Class I YSOs exhibit regular P-Cygni profiles, indicative of envelope expansion. 1-D radiative transfer models of the observed water profiles are used to self-consistently quantify the infall velocities and envelope physical properties. Comparing these results with those for other WISH sources, we constrain how the dynamics in the envelope vary as a function of evolutionary stage and mass. These are the first steps in creating an empirical dynamical evolutionary model for star formation.

Name: Scott Schnee
Affiliation: NRAO
Email: sschnee@nrao.edu
Presentation: Contributed Talk
Title: **An Observed Lack of Substructure in Starless Cores**
Author(s): Scott Schnee*, James Di Francesco, Doug Johnstone, Stella Offner, Sarah Sadavoy, Lisa Wei
Abstract: We present the results of recent CARMA and SMA surveys of starless cores. We find that up to 20% of "starless" cores actually host hidden protostars and/or first hydrostatic cores. Furthermore, we find that there is no observational evidence for fragmentation within true starless cores. The lack of substructure may imply that the origin of binary (and higher order) systems occurs only after the formation of a protostar within a dense core. Alternatively, we test whether turbulent fragmentation models of star formation may be consistent with our observations. We conclude with future prospects for identifying the earliest hint of multiplicity in low-mass star formation, focusing on the revolutionary capabilities of ALMA.

Name: Shu-Ichiro Inutsuka
Affiliation: Nagoya University
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Presentation: Keynote
Title: **From Cloud Cores to Protostars and Protoplanetary Disks**
Author(s): Shu-ichiro Inutsuka
Abstract: Essential physical processes in the formation of protostars and protoplanetary disks are described with special emphasis on the importance of radiative heating/cooling and non-ideal magnetohydrodynamics. Recent advances in the resistive magnetohydrodynamical simulations have enabled our understanding of 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 initial condition and 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.

Name: Benoît Commerçon
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Presentation: Contributed Talk
Title: **Theoretical and observational predictions of collapsing dense cores using 3D radiation-magneto-hydrodynamics**
Author(s): Commerçon*, Hennebelle, Levrier, Henning, Launhardt & Dullemond
Abstract: We will present radiation-magneto-hydrodynamics calculations of low-mass and massive dense core collapse, focusing on the first collapse and the first hydrostatic core (first Larson core) formation. In the first part reporting low mass dense core collapse calculations, synthetic observations of spectral energy distributions will be derived, as well as classical observational (e.g. bolometric temperature and luminosity). We will show how the dust continuum emission can help to target first hydrostatic cores and to state about the nature of VeLLOs. Last, we will present synthetic ALMA observation predictions which may give an answer to the fragmentation controversy at the early Class 0 stage. In the second part, we will report the results of the first self-consistent radiation-magneto-hydrodynamics calculations in the context of high mass star formation. We identify a new mechanism that inhibits initial fragmentation of massive, turbulent, and massive dense cores, where magnetic field and radiative transfer interplay. We speculate that highly magnetized massive dense cores are good candidates for isolated massive star formation, while moderately magnetized massive dense cores are more appropriate to form OB associations or small star clusters. Finally we will also present synthetic observations of these collapsing massive dense cores.

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Session 7: Planet Formation - Early Stages in Disks

Name: Christian Gräfe
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Presentation: Contributed Talk
Title: **Constraints on the early stages of planet formation from multi-wavelength observations and modeling of the circumstellar disk of the Butterfly Star**
Author(s): Ch. Gräfe*, S. Wolf, S. Guilloteau, A. Dutrey, K.R. Stapelfeldt, D.L. Padgett, and J. Sauter
Abstract: The Butterfly Star in Taurus is a showcase-like Class I young stellar object surrounded by a perfectly edge-on orientated circumstellar disk. Based on high angular resolution studies at near-infrared to millimeter wavelengths, the Butterfly Star is an ideal target to study the change of the opacity structure due to disk evolution and early planet-forming processes, such as dust grain growth and settling. We present results of self-consistent multi-wavelength modeling of this unique circumstellar disk. Spatially resolved images in the range from $1 mu$m to 2.7mm as well as the continuum spectral energy distribution of the disk and envelope around this young stellar object are taken into account. Besides general conclusions about the global disk structure, we also provide evidence for dust grain growth as well as vertical settling and radial segregation of the dust. Furthermore, we present detailed constraints for the disk structure and the dust grain properties in the inner (<100AU), potential planet-forming region of this disk which provide new insights into the evolution of dust in circumstellar disks. Finally, we compare our results with theoretical models for growth and migration of solids in protostellar disks.

Name: Kees Dullemond
Affiliation: University of Heidelberg
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Presentation: Review
Title: **From dust to planetary embryos**
Abstract: In this review I give an overview of developments in our understanding of how planetary embryos (1 to 1000 km size bodies) form from cosmic dust ($\sim$ 1 micron size grains). The main problem is to understand how the growth process can overcome the so-called "meter-size barrier": the size range where bodies acquire such large velocities that any collisions among them lead to fragmentation rather than growth. There have been two major developments in this field over the last decade or so. One is the increasingly realistic laboratory experiments of colliding dust aggregates, as well as advances in numerical modeling of these processes. The other is the discovery and appreciation of the fundamental role of streaming instabilities in the macroscopic clumping of dust aggregates. I will review both developments, and speculate how a combination of both may be leading us to a full picture. I will also highlight a few methods of testing such scenarios, including comparison with mm-wave observations of protoplanetary disks (in particular ALMA) and comparisons to our own solar system, such as the asteroid belt and the Kuiper belt.

Name: Farzana Meru
Affiliation: ETH Zurich
Email: farzana@phys.ethz.ch
Presentation: Contributed Talk
Title: **SPH simulations of dust aggregate collisions: the effects of aggregate porosity and mass on the threshold velocities for fragmentation**
Author(s): Farzana Meru*, Ralf J. Geretshauser, Roland Speith, Wilhelm Kley
Abstract: We carry out high resolution Smoothed Particle Hydrodynamics simulations to determine the collision velocities that SiO2 dust aggregates can withstand before fragmenting. Earlier laboratory experiments showed that these threshold velocities were approximately 1-4 m/s (Blum and Munch 1993) whereas recent laboratory results showed that for particular dust conditions, aggregates can coagulate when collision velocities are as much as approximately 55 m/s (Teiser & Wurm 2009). However, a detailed parameter study of pre-planetesimal collisions is not possible in the laboratory. We perform a comprehensive study into the outcome of such collisions by considering the aggregate mass and porosity to determine the conditions that allow dust aggregates to coagulate and grow into planets. We find threshold velocities to be higher than the often used value of 1m/s - a promising result for aggregate growth in protoplanetary discs. In addition, we find that both the aggregate mass and porosity significantly affect the threshold velocities. Very porous and highly compact objects are more prone to destruction, while intermediate porosity objects are more resistant to fragmentation. In addition, collisions between objects with very different sizes allow growth of dust aggregates to occur over a larger velocity range, to at least as much as 27.5m/s.

Name: Jean-Philippe Berger
Affiliation: European Southern Observatory
Email: jpberger@eso.org
Presentation: Contributed Talk
Title: **First PIONIER-VLTI images of protoplanetary disks inner dusty rim.**
Author(s): J.-P. Berger, B. Lazareff, J. Kluska, M. Benisty,W.-F,Thi, F. Malbet, J.B Lebouquin, R. Milan-Gabet, W. Traub
Abstract: PIONIER is the first instrument capable of combining 4 VLTI telescopes in order to generate aperture synthesis images with milli-arcsecond resolution. We have used it to map the inner rim of 10 Herbig AeBe stars in the H band. In all cases we resolve the emission and reveal the asymmetry of the emission. At the astronomical unit resolutions reached we are capable of constraining the disk properties in the planet forming and migrating regions. We discuss the our new constraints on the inner dust properties, in particular signs for dust processing and evolution, and on the disk surface density. Moreover we find clear hints of extended emission for which we explore possible interpretations including the first direct evidence of a self-shadowed disk. We present a preliminary trend for the disk inner properties with stellar central properties and discuss the implications on planet forming disks around intermediate mass young stars.

Name: Paola Pinilla
Affiliation: Institute of Theoretical Astrophysics/ Heidelberg University
Email: pinilla@uni-heidelberg.de
Presentation: Contributed Talk
Title: **Trapping dust particles in the outer regions of protoplanetary and transitional disks**
Author(s): Pinilla*, P.; Birnstiel, T.; Benisty, M.; Ricci, L.; Dullemond C. P
Abstract: Abstract: Planet formation via core accretion implies the growth from micron size particles to planetesimals. This process which covers more than forty order of magnitude in mass, contains different physical challenges. Theoretically, pebbles cannot grow due to destructive collisions and radial drift because of their interaction with the gas. However, large grains are observed in the outer regions of the disk at sub-mm and mm wavelengths. Different works tried to solve this issue, without a conclusive answer. We introduce how the presence of long-lived pressure bumps moderate the rapid inward drift using a disk model that includes dust coagulation and fragmentation. These pressure inhomogeneities allow the retainment of large dust particles on million years time scales, leading to a better agreement between observations and theory (Pinilla et al. 2012, A&A, 538, A114). We apply this idea to transitional disks that reveal gaps that can result from the presence of a massive planet, making them potentially interesting laboratories for studying processes related to planet formation. Combining hydrodynamical simulations for the gas with the mentioned dust evolution code, we find that the outer edge of the gap is actually a planetesimal factory where the dust has been trapped, in agreement with the ring like emission imaged in the millimeter (Pinilla et al. 2012, submitted to A&A).

Name: Anders Johansen
Affiliation: Lund University
Email: anders@astro.lu.se
Presentation: Keynote
Title: **From pebbles to planetesimals and beyond**
Author(s): Anders Johansen*, Michiel Lambrechts, Katrin Ros, Andrew Youdin, Yoram Lithwick
Abstract: The formation of km-sized planetesimals from smaller cm-dm sized pebbles faces major difficulties in the traditional coagulation scenario. Such particles do not stick well and very quickly drift towards the star to sublimate in the inner nebula. I will present the alternative scenario where overdense regions of particles collapse under their own gravity to form massive 1000-km-scale planetesimals. The overdensities are seeded by hydrodynamical streaming instabilities arising in the coupled motion of gas and particles. New computer simulations that include particle collisions show the perseverance of planetesimal formation by this route. Planetesimal masses are relatively independent of the computational resolution and the simulations reveal a characteristic planetesimal size that increases with distance from the sun, agreeing well with the observed largest bodies residing in the asteroid and Kuiper belts. I will also present new results showing that very large planetesimals can continue to accrete pebbles extremely efficiently. Formation of gas-giant cores by pebble accretion is 1,000-10,000 times faster than traditional core formation by run-away planetesimal accretion, explaining the presence of giant planets in the solar system as well as extrasolar planets in wide orbits.

Name: Fredrik Windmark
Affiliation: Institute of Theoretical Astrophysics, Heidelberg University
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Presentation: Contributed Talk
Title: **Planetesimal formation by sweep-up: How the bouncing barrier can aid growth**
Author(s): Windmark*, Fredrik; Birnstiel, Til; Güttler, Carsten; Blum, Jürgen; Dullemond, Cornelis P.; Henning, Thomas
Abstract: The formation of planetesimals is often accredited to collisional sticking of dust grains. The exact process is however unknown, as collisions between larger aggregates tend to lead to fragmentation or bouncing rather than sticking. To study this, we have created a new dust collision model based on the latest laboratory experiments, and have used it together with a dust-size evolution code capable of resolving all grain interactions in the protoplanetary disk. We find that for the general dust population, bouncing collisions prevent the growth above millimeter-sizes. However, if a small number of cm-sized particles are introduced, they can act as a catalyst and start to sweep up the smaller particles. At a distance of 3 AU, 100-meter-sized bodies are formed on a timescale of 1 Myr. The bouncing barrier is here even beneficial, as it prevents the growth of too many large particles that would otherwise only fragment among each other, and creates a reservoir of small particles that can be swept up by larger bodies. However, for this process to work, a few seeds of cm-size or larger have to be introduced.

Name: Wladimir Lyra
Affiliation: Jet Propulsion Laboratory
Email: wlyra@amnh.org
Presentation: Contributed Talk
Title: **Vortex excitation at dead zone boundaries in 3D resistive magnetohydrodynamical global models of protoplanetary disks**
Author(s): Wladimir Lyra*
Abstract: Vortices have long been considered as a route for fast planet formation. Though common-place in planetary atmospheres, great theoretical and numerical obstacles have been through the years found on achieving their excitation and self-sustainance in Keplerian disks. In this contribution I present results from 3D resistive MHD high resolution numerical simulations that demonstrate that vortices are excited in the boundary between the turbulent and non-turbulent (aka "dead") zones. Vortices exist only in the non-magnetized boundary, in accordance with recent numerical and analytical work that preclude their existence in magnetized regions. The solid material accumulating between the turbulent active and dead regions would be trapped into these vortices to effective form planetary embryos of Moon to Mars mass. Once the planets are formed, we follow the multi-million year N-body evolution of the ensemble, showing that they eventually coallesce into bodies of the order of tens of Earth masses, in effect a core of a giant planet.

Name: Ralf Klessen
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Presentation: Discussion

Name: Jarrett Johnson
Affiliation: Los Alamos National Laboratory
Email: jlj@lanl.gov
Presentation: Contributed Talk
Title: **The First Planets: the Critical Metallicity for Planet Formation**
Author(s): Jarrett L. Johnson* and Hui Li
Abstract: A rapidly growing body of observational results suggests that planet formation takes place preferentially at high metallicity. In the core accretion model of planet formation this is expected because heavy elements are needed to form the dust grains which settle into the midplane of the protoplanetary disk and coagulate to form the planetesimals from which planetary cores are assembled. As well, there is observational evidence that the lifetimes of circumstellar disks are shorter at lower metallicities, likely due to greater susceptibility to photoevaporation. Here we estimate the minimum metallicity for planet formation, by comparing the timescale for dust grain growth and settling to that for disk photoevaporation. For a wide range of circumstellar disk models and dust grain properties, we find that the critical metallicity above which planets can form is a function of the distance r at which the planet orbits its host star. With the iron abundance relative to that of the Sun [Fe/H] as a proxy for the metallicity, we estimate a lower limit for the critical abundance for planet formation of $[\mathrm{Fe/H}]_{\mathrm{crit}} \sim -1.5 + \log(r/1\ \mathrm{AU})$, where an astronomical unit (AU) is the distance between the Earth and the Sun. This prediction is in agreement with the available observational data, and carries implications for the properties of the first planets and for the emergence of life in the early Universe. In particular, it implies that the first Earth-like planets likely formed from circumstellar disks with metallicities $Z > 0.1\ Z_{\mathrm{Sun}}$. If planets are found to orbit stars with metallicities below the critical metallicity, this may be a strong challenge to the core accretion model.

Name: Zhaohuan Zhu
Affiliation: Princeton University
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Presentation: Contributed Talk
Title: **Transitional Disks: multiple planets, dust filtration or dust growth?**
Author(s): Zhaohuan Zhu*, Richard Nelson, Ruobing Dong, Catherine Espaillat, Lee Hartmann
Abstract: Transitional disks may provide us the first chance to study young planet(s) in birth. Near-IR spectroscopy, scattered light images, and sub-mm interferometry put stringent constraints on the disk properties. In this work, we studied the structure of protoplanetary disks with gap opening by planet(s) using a newly developed two-fluid hydrodynamic code which can simulate the dust dynamics separately from the gaseous disk. This treatment is essential for comparison with observations since most observations are only sensitive to dust in disks. Our simulations suggest the planet-induced gap in disks have a significant effect on dust particles at the gap edge - the so called "dust filtration". This effect successfully explains the discrepancy between near-IR scattered light images and sub-mm interferometry. Then we translate these hydrodynamic results to observations using Monte-Carlo radiative transfer models. However, by comparing with transitional disk observations (e.g. GM Aur), we have found that dust filtration alone has difficulties to deplete small particles sufficiently enough to explain the near-IR deficit of transitional disks. The scenario of gap opening by multiple planets studied previously suffers the same difficulty. We suggest one possible solution by invoking both dust filtration and dust growth in the inner disk. We will also discuss how simulations can imply the planet properties in transitional disks.

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Session 8: Planet Formation - Late Stages

Name: Andrew Shannon
Affiliation: Institute of Astronomy
Email: shannon@ast.cam.ac.uk
Presentation: Contributed Talk
Title: **Growth of Debris Disks**
Author(s): Andrew Shannon*, Yanqin Wu, and Yoram Lithwick
Abstract: Bright debris disks with fractional luminosity greater than ∼0.01% of their host stars are found around roughly one in six Sun-like stars. This fraction decays slowly, by no more than half over their 10 Gyrs of evolution. To continuously supply such a large quantity of dust for a few Gyrs, the brightest disks must have massive parent planetesimals populations, with roughly ten Earth masses of ∼100 km planetesimals undergoing collisional destruction (Shannon & Wu, 2012). Such a population stands at odds with the standard model of planetesimal coagulation, which predicts that the runaway growth of large bodies should result in merely ∼0.1% of the primordial mass ending up in ∼100 km bodies (Kenyon & Luu 1998, Schlichting & Sari 2011). This low growth efficiency predicts impossibly high masses for the corresponding primordial disks. In the standard model, this low growth efficiency has two causes. One, at sub-escape, but super-Hill velocities dispersions, larger bodies double in mass faster than small bodies. Consequently, the largest bodies run away from the group, and only a few bodies grow to large sizes. Two, those large bodies viscously stir the other planetesimals more efficiently than they can accrete them, and starve themselves. We propose a new model that overcomes these two barriers. Where previous models have begun by assuming all of the solids have aggregated in large (typically kilometer) bodies, we begin with most of the solids in small, centimeter sized grains. Collisional cooling between the small grains keeps their velocity dispersions sub-Hill, where large bodies grow in an orderly fashion, all sizes growing at the same pace, rather than in a runaway fashion. Consequently many bodies end up at large sizes, rather than just a few. The collisional cooling also balances the viscous stirring, with the resulting lower velocity dispersions allowing for effective accretion. In this way, roughly half of the primordial mass can end up in large planetesimals, allowing bright debris disks to be produced from observed protostellar nebulae.

Name: Wilhelm Kley
Affiliation: University of Tuebingen
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Presentation: Review
Title: **Planet-disk interaction and orbital evolution**
Author(s): Wilhelm Kley
Abstract: As planets form and grow within gaseous protoplanetary disks, the mutual gravitational interaction between the disk and planet leads to the exchange of angular momentum, and migration of the planet. I review the current understanding of disk-planet interactions, focussing in particular on physical processes that determine the speed and direction of migration. The role of Lindblad and corotation torques as a function of the disk properties will be discussed,as well as the evolution of eccentricities and inclinations. Finally, I address the question of how well global models of planetary formation that include migration are able to match observations of extrasolar planets.

Name: Bertram Bitsch
Affiliation: OCA
Email: bertram.bitsch@oca.eu
Presentation: Contributed Talk
Title: **Implications of the disc structure on planetary migration**
Author(s): B. Bitsch*, A. Crida, A. Morbidelli, W. Kley & I. Dobbs-Dixon
Abstract: Recent research has shown that the direction of migration for low mass planets in isothermal accretion discs (type-I-migration) can change from inwards to outwards, when taking non-isothermal effects into account (Paardekooper & Mellema, 2006). This change in the direction of migration can prevent newly formed planets from falling into the star at an early time of the disc evolution. This effect strongly depends on the gradient of entropy in the disc, which is determined by the disc structure. In previous studies the disc structure was given by viscous heating and radiative cooling. In a real disc around a young star, the disc structure is also determined by stellar irradiation (e.g. Chiang & Goldreich, 1997). I will present a disc model including viscous heating, radiative cooling and stellar irradiation and explain its implications for the migration of planets in gas discs. I will focus especially on the location of the zero-torque radius, where planets and planetary embryos can accumulate and grow further in mass (Bitsch & Kley, 2011b).

Name: Cristobal Petrovich
Affiliation: Princeton University
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Presentation: Contributed Talk
Title: **New developments in the old problem: revisiting disk-planet tidal interaction**
Author(s): Cristobal Petrovich* & Roman R. Rafikov
Abstract: I will present some recent theoretical results from a detailed study of the gravitational coupling between a circumstellar gaseous disk and a planet.rnFirst, a new linear calculation of the torque density excited by a planet in a uniform disk will be presented. Interestingly, we find that our results differ (sometimes substantially) from the widely used theory based on the classical theory of Goldreich & Tremaine. Most remarkably, we find that in uniform density disks the excitation torque density changes sign at around 3.2 scale heights as a result of superposition of Lindblad resonances close to the planet - a result qualitatively different from the conventional wisdom.rnSecond, we investigate the tidal coupling between a planet and a non-uniform disk (namely a disk with a gap around planetary orbit) in the linear approximation. By self-consistently including the density gradients in the fluid equations we found that the excited torque is more concentrated towards the gap edge, compared to what the existing theories predict. We understand this as a result of accumulation of Lindblad resonances in regions with large density gradients. Finally, I discuss the implications of our results for the gap opening and type II migration of planets in disks.

Name: Brenda Matthews
Affiliation: National Research Council of Canada
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Presentation: Keynote
Title: **Herschel surveys of debris disks: incidences, outcomes and surprises**
Abstract: Debris disks are second generation disks around main sequence stars, continually populated by ongoing collisions between large unseen bodies in orbit around the host stars. Their presence indicates that rocky bodies of significant sizes must have been created during or soon after star formation. They also have the capacity to reveal information about planetary bodies through resonance effects, observed offsets of disks from stars and the presence of narrow rings rather than broad disks. The Herschel Space Observatory launched with the capacity to greatly enhance our understanding of debris disk systems around nearby stars owing to its unprecedented sensitivity, wavelength coverage and resolution in the far-infrared. Three key programs focused on debris disks: the GT program, the DEBRIS (Disc Emission via a Bias-free Reconnaissance in the Infrared/Submillimetre) survey, and the DUNES (DUst around NEarby Stars) survey. All the data are now in hand, and I will present the main findings of the survey teams thus far. In particular, I will focus on the results of for resolved disks, from which we are able to place the best constraints on the disk and other objects within those systems.

Name: Geoffrey Bryden
Affiliation: NASA-JPL
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Presentation: Contributed Talk
Title: **SKARPS: The Search for Kuiper belts Around Radial-velocity Planet Stars**
Author(s): Geoffrey Bryden*, David Ardila, Charles Beichman, Carlos Eiroa, Debra Fischer, Grant Kennedy, Agnes Kospal, John Krist, Jonathan Marshall, Benjamin Montesinos, Amaya Moro-Martin, George Rieke, Kate Su, Karl Stapelfeldt, Mark Wyatt
Abstract: The Fomalhaut, beta Pic, and HR 8799 systems each have directly imaged planets and prominent debris disks, suggesting a direct link between the two phenomena. Unbiased surveys with Spitzer, however, failed to find a statistically significant correlation. We present here new results from SKARPS, a Herschel search for debris disks around solar-type stars known to have orbiting planets. The disks identified by this program tend to be cold (∼50 K) and distant (∼100 AU) - well separated from the radial-velocity-discovered planets. Nevertheless, we find a strong correlation between the inner planets and outer disks, with disks around planet-bearing stars tending to be much brighter than those not known to have planets.

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Session 9: Brown Dwarfs and Lower Mass End of IMF

Name: Matthew Bate
Affiliation: University of Exeter
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Presentation: Keynote
Title: **The formation and properties of stars and brown dwarfs**
Author(s): Matthew Bate
Abstract: I will present results from numerical simulations of star cluster formation. I will discuss the formation mechanisms of the stars and brown dwarfs as determined from the numerical simulations, and the origins of the statistical properties of the stars and brown dwarfs and their dependence on physical processes and initial conditions.

Name: Patrick Rogers
Affiliation: McMaster University
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Presentation: Contributed Talk
Title: **Forming Gas-Giants Through Gravitational Instability: 3D Radiation Hydrodynamics Simulations and the Hill Criterion**
Author(s): Patrick D. Rogers*, James Wadsley
Abstract: The fragmentation of protostellar discs through gravitational instability is a possible formation mechanism for gas-giant planets and brown dwarfs. Previous work has demonstrated that there exists a cooling criterion for fragmentation: for a gravitationally unstable disc to fragment, it must cool faster than a critical rate. We present a detailed physical model that explains the link between cooling and fragmentation in protostellar discs. In this model, the characteristic width of a spiral arm is determined by a balance between heating from gravitational instability and cooling. A section of spiral arm fragments if its characteristic thickness is less than its Hill thickness. This model of fragmentation is consistent with the cooling criterion, but is more physically detailed. For the first time, we are able to calculate the critical cooling time, with results that are consistent with previous studies. In addition, the model is consistent with our suite of 3D radiation hydrodynamics simulations of an irradiated protostellar disc that is unstable near 100 AU.

Name: Gilles Chabrier
Affiliation: Ecole Normale Supérieure de Lyon
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Presentation: Review
Title: **Brown dwarf and star formation and the bottom of the IMF: a critical look**
Abstract: In this review, I will first examine the present determination of the IMF down to the brown dwarf regime, in light of the most recent observational results. Then, I will examine the main scenarios suggested for star and brown dwarf formation, again considering existing observational constraints, and address the different issues raised by these scenarios.

Name: Shantanu Basu
Affiliation: Western University
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Presentation: Contributed Talk
Title: **A Hybrid Scenario for the Formation of Brown Dwarfs and Very Low Mass Stars**
Author(s): Shantanu Basu*, Eduard I. Vorobyov
Abstract: We present a calculation of protostellar disk formation and evolution in which gaseous clumps are ejected from the disk during the early stage of evolution. This is a universal process related to the phenomenon of ejection in multiple systems of point masses. However, it occurs in our model entirely due to the interaction of compact, gravitationally-bound gaseous clumps and is free from the smoothing-length uncertainty that is characteristic of models using sink particles. Clumps that survive ejection span a mass range of 0.08–0.35 $M_{\odot}$, and have ejection velocities 0.8 ± 0.35 km s^{-1}, which are several times greater than the escape spee d. We suggest that, upon contraction, these clumps can form substellar or low-mass stellar objects with notable disks, or even close-separation very-low-mass binaries. In this hybrid scenario, disk formation and the low velocity dispersion of low-mass objects are naturally explained, while it is also consistent with the observation of isolated low-mass clumps that are ejection products. We conclude that clump ejection and the formation of isolated low mass stellar and substellar objects is a common occurrence, with important implications for understanding the initial mass function, the brown dwarf desert, and the formation of stars in all environments and epochs.

Name: Luca Ricci
Affiliation: Caltech
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Presentation: Contributed Talk
Title: **Testing the models of early evolution of solids in disks through sub-mm interferometry**
Author(s): Luca Ricci*, L. Testi, A. Natta, A. Isella, J. Carpenter
Abstract: Observations of protoplanetary disks at sub-mm wavelengths trace mm-sized pebbles in the disk outer regions. Models of dust evolution including grain growth and radial migration in the disk can therefore be tested through these data. I will outline the state-of-the-art of this field by presenting old and new data obtained with CARMA, PdBI, ATCA and EVLA interferometers for a sample of about 100 young disks, and compare observational results with predictions by models of solids evolution in disks. I will also show how very-low mass disks are particularly suitable to test the model predictions and investigate the physics of solids evolution in disks. This is currently being investigated through undergoingrnobservations with ALMA of four disks around brown dwarfs and very low mass young stars, and I will present the preliminary results from thisrnproject.

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Posters

Star Formation in Clusters

Name:	Mohaddesseh Azimlu
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Poster Number:	1-1
Title:	**Massive star formation in a small stellar association?**
Author(s):	Mohaddesseh Azimlu*

Abstract: We have found a young star forming region within an isolated, 550 solar mass molecular cloud at a distance of 1.1 kpc associated with IRAS 00232+6437 point source. The ring shape cloud contains two major condensations, S175A associated with S175 small (0.6 pc) HII region and S175B at a distance of >3 pc from the HII region and likely not being affected by the expanding ionized gas. We found a 30 solar mass, high velocity ($\sim$20 km/s) stellar outflow within S175B. We identified at least six red, embedded objects within the outflow region in 2MASS images and many others in Spitzer data, but the power source of the outflow is too embedded to be detectable even in 22 micron WISE data. Spitzer 3.6 and 4.5 micron images clearly reveals the existence of at least two outflows at this position which describes why the red and blue CO(3-2) lobes are not collimated. This is an interesting case of forming high mass proto-stars in an isolated cloud and a small association rather than a large cluster.

Name: Mary Barsony
Affiliation: SETI Institute
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Poster Number: 1-2
Title: **A Significant Population of Candidate New Members of the Rho Ophiuchi Cluster**
Author(s): Mary Barsony, Karl E. Haisch, Jr., Ken Marsh, Chris McCarthy
Abstract: We present a general method for identifying the pre-main-sequence population of any star-forming region, unbiased with respect to the presence or absence of disks, in contrast to samples selected primarily via their mid-infrared emission from Spitzer surveys. This method relies on the availability of deep, near-infrared (NIR) photometry, in conjunction with equally sensitive Spitzer IRAC (InfraRed Array Camera) photometry. Extinction values to individual objects are inferred from de-reddening, as appropriate, to either the main-sequence or to the classical T-Tauri star (CTTS) loci from their positions in the J-H vs. H-K color-color diagram. Least-squares fits of the complete spectral energy distributions (SEDs) to model spectra (COND, DUSTY, NextGen, and blackbody) are produced. Given the distance to the cloud and the inferred extinction values, background sources can be distinguished from cloud members, based on their locations in a plot of de-reddened absolute K magnitude vs. best-fit effective temperature. We have applied this technique to a new, deep, wide-field, near-infrared imaging survey of the ρ Ophiuchi cloud core, mostly in the extinction interval 5-15, to search for candidate low-mass members. We have identified 948 candidate cloud members within our 90% completeness limits of J = 20.0, H = 20.0, and Ks = 18.50 in a 920 sq. arcmin region. This population represents a factor of $\sim$3 increase in the number of known young stellar objects in the ρ Ophiuchi cloud. A large fraction of the candidate cluster members (81% $\pm$ 3%) exhibit infrared excess emission consistent with the presence of disks, thus strengthening the possibility of their being bona fide cloud members. The additional number of substellar candidates ranges between 83-359, depending on assumed intrinsic spectral type (ranging from M7 through L0). Spectroscopic follow-up will confirm the nature of individual objects, better constrain their parameters, and allow an initial mass function to be derived.

Name: Samantha Benincasa
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Poster Number: 1-3
Title: **Simulating the Formation of Giant Molecular Clouds**
Author(s): Samantha Benincasa*, Ralph Pudritz, Elizabeth Tasker, James Wadsley
Abstract: Stars are born in gaseous dense regions known as molecular clouds. In order to fully understand the processes of star formation we must understand the process of molecular cloud formation. We will present the results of a study of simulated molecular clouds formed in a Milky Way type disk with a flat rotation curve. We find that simulated cloud properties compare well to observed cloud properties. Such clouds can be used to study the initial conditions of both star cluster and massive star formation.

Name: How-Huan Chen
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Poster Number: 1-4
Title: **Shells in the Ophiuchus Cloud: How They Support the Turbulence**
Author(s): How-Huan Chen & Alyssa A. Goodman
Abstract: The spherical winds (also known as 'shells' or 'bubbles') driven by B-type or later stars and by young stellar objects can be seen across the Milky Way, and most of them are associated with the galactic molecular clouds. However, previous works tended to ignore their roles as the momentum sources to support the turbulence within molecular clouds, by claiming that the energy output of an individual shell is (an order of magnitude) smaller than other possible turbulent energy sources such as supernovae. But considering the fact that the number and the timescale of the shells are larger/longer, the total energy output of shells in a molecular cloud could make up at least to the same order of magnitude of the turbulent energy of the molecular cloud. To further examine this, we propose a more systematic investigation of the momentum feedback of shells in the nearby molecular clouds including the Perseus cloud (250$\pm$50 pc) and the Ophiuchus cloud (130$\pm$35 pc). Recent work by Arce et al. (2011) on stellar feedback in IC348 and other regions in the Perseus cloud has shown that the total energy output of shells and bipolar outflows is sufficient to maintain the turbulence in a molecular cloud. Here we present our new study of the Ophiuchus cloud, using data from the COMPLETE (COordinated Molecular Probe Line Extinction Thermal Emission) Survey of Star Forming Regions, the Spitzer C2D (Core to Disk) Survey, and the Herschel Science Archive. Our study focuses on the feedback of the shell of which the center coincides with the B-type binary ρ Ophiuchi and an exotic source 1RXSJ162554.5-233037, and the feedback of the young cluster close to L1688 (known as the 'ρ Oph' cluster, after the B-type binary, in some works). In order to get a reliable estimate of the turbulent energy, we carry out a detailed study on various tracers of the column densities of the Ophiuchus cloud. A simple comparison of the shell momentum and the total momentum of the cloud between the Perseus cloud and the Ophiuchus cloud is also presented here as a hint of what can be done in the future.

Name: Laura Fissel
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Poster Number: 1-5
Title: **BLASTPol 2010 Observations of Magnetic Fields in Nearby Star Forming Regions**
Author(s): Laura Fissel*, the BLASTPol Collaboration
Abstract: Polarimetry is an important tool for studying the role played by magnetic fields in the star formation process. However, at present there are very few submm/mm polarimetry observations of large scale fields within molecular clouds. BLASTPol, the Balloon-borne Large Aperture Submillimeter Telescope for Polarimetry, maps linearly polarized dust emission at 250, 350 and 500 microns; it has the unique combination of sensitivity to large scale magnetic fields, and arcminute resolution necessary to trace fields into prestellar cores and dense filaments. I will give a brief overview of the data from the first BLASTPol science flight completed in January 2011 and discuss preliminary results from BLASTPol observations of nearby star forming regions in the Vela Molecular Ridge and the Lupus Cloud Complex. These maps will be used to study the relationship between large and small scale magnetic fields in molecular clouds, the degree of order in the field, and the relationship between the magnetic field structure and the morphology of filaments and cores within the clouds.

Name: Rachel Friesen
Affiliation: NRAO
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Poster Number: 1-6
Title: **NH3 in Serpens South: A detailed study of the temperature and kinematics of dense gas in an extremely young protocluster**
Author(s): Rachel Friesen*, Rob Gutermuth, James Di Francesco, Tyler Bourke, Philip Myers
Abstract: The nearby Serpens South cluster (SSC) was recently identified through IRAC mid-infrared imaging as part of the Spitzer Gould Belt Legacy Survey, and consists of a central protocluster embedded in a dense, infrared-dark hub-filament structure. With its extensive network of large-scale gas filaments and clumps, and small-scale dense cores (total M $\sim$ 1100 MSun), the SSC offers an unusual chance to study an extremely young system before gas dispersal and stellar dynamics have dramatically altered the landscape. I will present the results of sensitive, large-scale (0.5 x 0.5 degree) mapping of NH3 (1,1), (2,2) and (3,3) emission with the GBT K-band Focal Plane Array towards the SSC. The gas motions traced by NH3 range from sub- to super-sonic, where the supersonic gas is predominantly found towards the active cluster centre, and at lower column densities between filaments. Sharp transitions between turbulent and quiescent gas are visible towards some of the dense structures. The NH3-derived gas temperatures across the region are consistently lower than dust temperatures based on analysis of Herschel data. Combined with 1.1 mm continuum data (AzTEC), we analyze the importance of Jeans fragmentation over a range of physical scales, and test kinematic predictions of star cluster formation scenarios.

Name: Konstantin Getman
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Poster Number: 1-7
Title: **The Elephant Trunk Nebula and the Trumpler37 cluster: Contribution of triggered star formation to the total population of an HII region**
Author(s): Getman K. V.*, Feigelson E. D., Sicilia-Aguilar A., Broos P. S., Kuhn M. A., Garmire G. P.
Abstract: Rich young stellar clusters produce HII regions whose expansion into the nearby molecular cloud is thought to trigger the formation of new stars. However, the importance of this mode of star formation is uncertain. We seek to quantify the population of triggered star formation (TSF) in IC 1396A (a.k.a., the Elephant Trunk Nebula), a bright rimmed cloud (BRC) on the periphery of the nearby giant HII region IC 1396 produced by the Trumpler 37 cluster. Our combined X-ray/IR/Optical study identifies >250 young stars in/around IC 1396A; this doubles the previously known population. A spatio-temporal gradient of stars from the IC 1396A cloud toward the primary ionizing star HD 206267 is found. We argue that the TSF mechanism in IC 1396A is the radiation-driven implosion process persisting over several million years. Analysis of the X-ray luminosity and initial mass functions indicates that >140 stars down to 0.1Mo were formed by TSF. Considering other BRCs in IC 1396 HII region, we estimate the TSF contribution for the entire HII region exceeds 14-25% today, and may be higher over the lifetime of the HII region. Such triggering on the periphery of HII regions may be a significant mode of star formation in the Galaxy.

Name: Corey Howard
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Poster Number: 1-8
Title: **Simulating star cluster formation in giant molecular clouds**
Author(s): Corey Howard
Abstract: Star clusters form in dense molecular clouds. Radiation from these newly formed clusters can have a significant impact on their natal molecular cloud through heating and ionization. Recent studies suggest that radiative feedback effects from a single cluster may be sufficient to disrupt an entire cloud over a short timescale. We use, for the first time, realistic initial conditions for giant molecular clouds obtained through galactic-scale simulations of molecular cloud formation. These were performed using the ENZO adaptive grid code with fixed galactic potentials and included heating and cooling of the ISM. To examine the degree to which radiative feedback shapes the evolution of our simulated molecular clouds, we use the FLASH hydrodynamics code to simulate cluster formation on an adaptive Eulerian grid coupled with a raytracing scheme to treat radiative feedback. This poster will outline recent progress made in implementing these clouds in FLASH and following their subsequent evolution.

Name: Erin Kryukova
Affiliation: University of Toledo
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Title: **Protostellar Luminosity and Clustering in nearby Star-Forming Regions**
Abstract: Stars form in a diverse range of environments, from crowded massive clusters (i.e., Orion) to cold, isolated dark clouds (i.e. Taurus). The role that environment plays in determining properties of protostars, such as mass or luminosity, is not yet well-understood. This poster incorporates Spitzer-identified protostar samples from nine diverse nearby star forming regions, including Taurus, Lupus, Chamaeleon, Ophiuchus, Perseus, Serpens, Orion, Cep OB3, and Mon R2, as well as the more distant, massive Cygnus-X molecular cloud complex. We examine the effect of clustering environment on protostellar luminosity through a comparison of luminosity with the distance to the fourth nearest young stellar object (nn4 distance). We find that in regions which form massive stars, the largest nn4 distance for a given luminosity tends to decrease with increasing luminosity. We also discuss the environments of the most luminous protostars in Cygnus-X, particularly focusing on the Cygnus North and Cygnus South regions.

Name: Aaron Maxwell
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Poster Number: 1-9
Title: **Building the Stellar Halo Through Feedback in Dwarf Galaxies**
Author(s): Aaron Maxwell*, James Wadsley, Hugh Couchman, & Sergey Mashchenko
Abstract: We present a new perspective on the formation of stellar halos in galaxies. We demonstrate that stars and star clusters that form naturally in the inner regions of dwarf galaxies can be expected to migrate outside the gas rich, star forming centre to join the stellar spheroid. For dwarf galaxies, this process could dominate the production of halo stars. It can build a stellar spheroid with a radial progression toward larger ages and lower metallicities without requiring an outside-in formation model. Globular cluster-type star clusters can be created in the galactic ISM and then migrate to the spheroid on 100 Myr timescales. Once outside the inner regions they are less susceptible to tidal disruption and thus long lived. On these wider orbits, the clusters may be easily unbound from the dwarf to join the halo of a larger galaxy during a merger. This new insight arises from the way gas, acted upon by strong stellar feedback, gravitationally couples to the collisionless components. This coupling has been demonstrated to dramatically rearrange the dark component in the inner regions of galaxies and produce cored dark matter profiles. This process is particularly active in dwarf galaxies.

Name: Carolyn McCoey
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Poster Number: 1-10
Title: **Wet in the Middle**
Author(s): McCoey*, Tisi, Johnstone, Fich and the WISH IM team
Abstract: Herschel-HIFI observations of six Intermediate Mass YSOs have yielded detections of up to 14 isotopologues of water in each source. The profiles of the H2O lines in all six sources can be decomposed into three distinct Gaussian components: a 'broad' (> 20 km/s) feature, attributable to an outflow; a less well defined medium component (5 - 20 km/s); and, a narrow (< 5 km/s) feature that is associated with the pre-stellar envelope. Both the narrow and medium components can appear in absorption or emission and in some cases form a P-Cygni profile, indicating expansion of the proto-stellar envelope. The properties of the ground state emission are correlated with a set of outflow and envelope parameters and compared with the same correlations from low mass YSOs. These trends, when also tied in with results from high mass YSOs, yield insight into how star formation evolves with mass. Early results indicate that the same correlation is seen for low and intermediate mass YSOs for global properties, such as bolometric luminosity.

Planets - Statistical Properties

Name: Philippe Delorme
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Poster Number: 2-1
Title: **High-resolution imaging of young M-type stars of the solar neighbourhood: probing for companions down to the mass of Jupiter**
Author(s): Delorme*, P.; Lagrange, A. M.; Chauvin, G.; Bonavita, M.; Lacour, S.; Bonnefoy, M.; Ehrenreich, D.; Beust, H.
Abstract: We present a AO survey for gas giant planets orbiting late-type stars and brown dwarfs of the solar neighbourhood. Around solar-type stars, giant planets are expected to form by core accretion or by gravitational instability, but since core accretion is increasingly difficult as the primary star becomes lighter, gravitational instability would be a probable formation scenario for still-to-find distant giant planets around a low-mass star. Methods: We obtained deep high-resolution images of 16 targets with the adaptive optic system of VLT-NACO in the L' band, using direct imaging and angular differential imaging. The typical contrast achieved is about 9 mag at 0.5" and 11 mag beyond 1". For each target we also determine the probability of detecting a planet of a given mass at a given separation in our images. The resulting detection probabilities of a 3 MJup companion at 10 AU and a 1.5 MJup companion at 20 AUfor planetary companion are in average more than 50%, bringing strong constraints on the existence of Jupiter-mass planets around this sample of young M-dwarfs.

Planets in Cluster Context

Name: Guillaume Belanger
Affiliation: European Space Agency
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Title: **Our Place in the Universe**
Author(s): G. Belanger
Abstract: We will take the audience on a visually stimulating voyage through the Galaxy from the Earth to the Galactic nucleus. During this journey, we will explore the structure of our Galaxy, its contents, the life cycle of stars and their different types. We will talk about star clusters, massive stars, supernovae. About how planets form and what conditions are required for life to arise and sustain itself for prolonged periods of time. We will talk about magnetic fields, particle acceleration, compact objects, extreme orbital dynamics and Sgr A*, our very own supermassive black hole.

Name: Ronny Errmann
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Poster Number: 3-1
Title: **The search for young transiting planets with the YETI network**
Author(s): Ronny Errmann*, Ralph Neuhäuser, Stefanie Rätz, Gracjan Maciejewski, YETI Team
Abstract: The transit method is the only method to determine the radius of a planet and inclination of the orbit directly. Radial velocity follow up results the true mass. So far only transiting exoplanets older than several hundred Myr are known. To close the gap at young ages, the YETI network (Young Exoplanet Transit Initiative) was established. The network consists of ground based telescopes with mirror sizes of 0.4 to 2m, located at different longitudes all over the world. With the telescopes it is possible to observe continuously for 24h a day without gaps in the light curves and therefor not missing a transit.rnThe targets are young clusters, which provide a large number of young stars with similar properties. The cluster is observed with YETI in three runs per year with length of one to two weeks each and over three years. The first target was Trumpler 37 with an age of 4 Myr. The monitoring started 2009. We reach a precision better than 30 milli-mag for 5500 out of the 17,000 field stars. Data processing of 55,000 images from 12 telescopes is still in progress, but we found already 2 transiting candidates, for which follow up is partly done and planed.

Name: Soyoung Youn
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Poster Number: 3-2
Title: **Antartic Submillimeter Telescope Observations of the 30 Doradus Complex in the Large Magellanic Cloud**
Author(s): H. Kim, S. Kim, J.-Y. Park, M. Garcia, B. Brandl, K. Xiao, A. Lane, W. Walsh, R.C. Smith, & S. Youn
Abstract: We present CO J=1-2 observations of the giant shell complex 30 Doradus in the Large Magellanic Cloud (LMC) using the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO). This is the one of the largest HII complexes in the Local Group. We compare the CO J=2-1 observations against CO J=4-3 observations and analyze the spatial distribution of young stellar objects (YSOs) within the cloud observed with the Spitzer space telescope. The YSOs are clustered in the southern ridge of the warm and dense molecular gas clouds traced by CO J=4-3, indicating a filamentary structure of star formation throughout 30 Doradus. We also find an excess of Class I YSOs candidates close to the clouds, which likely represent the most recent phase of star formation in this region. This is a region where the triggered star formation has actually occurred, and newly formed stars have produced such a high-velocity outflow through interacting with the surrounding molecular cloud material.

Young, Gas-Rich Disks

Name: Ines Brott
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Poster Number: 4-1
Title: **Chemical modeling of proto-planetary discs with PHOENIX/3D**
Author(s): Ines Brott, Christian Rab, Manuel Guedel
Abstract: Progress in observation techniques is revealing gas emission from proto-planetary disks. This requires a new approach to disk modeling with simultaneous and self consistent modeling of dust and gas. The models need to be extended into the dense and warm regions of the inner mid-planes to examine planet-forming regions and the hot gas inside the dust sublimation radius. Current disk models are not capable of modeling gas in these regions properly, where the RT is nearly diffusive and near-to-mid IR molecular gas opacities are important. These regions require a new modeling approach, similar to stellar atmospheres. In Vienna we have started an major effort to adapt the stellar atmosphere code PHOENIX/3D for applications to proto-planetary discs. We use especially its ability for detailed NLTE line transfer. The ultimate goal is to extend PHOENIX/3D such that modeling of a self consistent 3D structure with all relevant heating and cooling processes, detailed line and continuum transfer and chemical networks is possible. Here we present the first benchmark tests for chemical modeling in PHOENIX with 3D-RT.

Name: Andres Carmona
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Poster Number: 4-2
Title: **Understanding the gas and dust structure of protoplanetary disks: a synergy of multi-instrument observations and advanced modeling, the case of HD 135344B**
Author(s): A. Carmona*, C. Pinte, W.F, Thi, M. Benisty, J. Olofsson, F. Menard,
Abstract: Protoplanetary disks are composed by gas and dust. They display a gradient of temperature and density in the vertical and radial direction. In consequence, disks are studied employing multi-wavelength and multi-instrument observations of gas and dust. Although there is large variety of disk diagnostics, relatively few studies have tried to derive the disk structure from multi-instrument data in a unified way. This partly due to the fact that the thermo-chemical radiative transfer disk models needed to interpret multiwavelength observations became just recently available. In this contribution, we present a study that we are carrying on HD 135344B, a well known Herbig Fe star which displays a gap in its disk. We use the radiative transfer codes MCFOST and ProDiMo, to derive the disk structure by simultaneous modeling of the SED, IRS-Spitzer spectra, VLTI near-IR interferometry data, VLT-CRIRES CO 4.7 micron spectra, Herschel [OI] 63 micron emission, and JCMT CO J=3-2 spectra. We describe the emitting regions of each tracer and discuss the iterative process of modeling the disk, and how a diversity of multi-instrument data is used to break model degeneracies.

Name: German Chaparro
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Poster Number: 4-3
Title: **Chemical modeling of the cosmic-ray dominated region of protoplanetary disks**
Author(s): German Chaparro
Abstract: We present a method for including gas extinction of cosmic ray generated UV photons in chemical models of the midplane of protoplanetary disks, focusing on its implications on ice formation and chemical evolution. Our goal is to improve on previous chemical models by treating cosmic rays, the main source of ionization in the midplane of the disk, in a way that is consistent with current knowledge of the gas and grain environment present in those regions. We find that the gas opacity is up to 40% of the dust opacity and is highly variable in time, which means that its effect is not negligible in the 1-8 AU region of the disk midplane. The most important species that contribute to the gas opacity are O_2, SiO, Si, CO and CO_2. Full 2D protoplanetary disk models should include the gas opacity of these species in the calculation of cosmic ray induced photoprocesses, specially for the disk midplane.

Name: Ilse Cleeves
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Poster Number: 4-4
Title: **Exploring the T-Tauriosphere: Implications for cosmic ray ionization in protoplanetary disks and the MRI**
Author(s): L. Ilsedore Cleeves*, Edwin A. Bergin, Fred C. Adams
Abstract: A number of physical processes (e.g. accretion, planet-formation) in protoplanetary disks depend crucially on the ability of disks to transport their angular momentum. The leading transport theory is magnetorotational instability (MRI). This mechanism, however, requires the disk to be sufficiently ionized for efficient neutral-ion coupling. Of the main ionization sources available cosmic rays dominate both the X-ray and UV for the bulk of the disk mass. This presents an interesting puzzle, since within our own Solar System the solar wind creates a “bubble,” a.k.a. the heliopause, which acts as a magnetic shield against low energy CRs. Young stars likewise have strong winds and are highly magnetic, and it would thus not be surprising to find a similar T-Tauriopause at the boundary between the stellar wind pressure and the natal cloud magnetic environment. If this exists, the absence of CRs will have significant implications regarding MRI’s ability to drive accretion, as well as the prevalence and extent of dead zones. Such theories will be readily testable by ALMA, and in this presentation we make predictions regarding the geometry and observability of such an effect, using molecular ions as probes of the degree of disk ionization.

Name: Bartek Ewertowski
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Poster Number: 4-5
Title: **Mathematical Model for Hourglass Magnetic Fields**
Author(s): Bartek Ewertowski*, Shantanu Basu
Abstract: Hourglass magnetic fields occur during the process of star formation in molecular clouds due to the phenomenon of flux freezing. The magnetic field lines are locked to the motion of the plasma, forcing them to pinch inwards as the cloud collapses. The shape of the field lines can be inferred from polarization data, but measurements of the field strength are difficult. This study presents a cylindrically symmetric mathematical model for these hourglass magnetic fields. A partial differential equation and associated boundary value problem for the magnetic vector potential is derived. A general solution given any arbitrary current distribution is found by the method of Green's functions. An infinitesimally thin disk model is developed from the Green's function and fitted to observations of G31.41 from Girart et al. as well as simulation data from Kudoh and Basu.

Name: Duncan Forgan
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Poster Number: 4-6
Title: **Turbulent Linewidths as a Diagnostic of Self-Gravity in Protostellar Discs**
Author(s): Duncan Forgan*, Philip J. Armitage, Jacob B. Simon
Abstract: We investigate the possibility that self-gravity driven processes in protostellar discs may be detected by the turbulent broadening of emission lines. Self-gravitating disc turbulence produces angular momentum transport that can be non-local, and may therefore be distinguishable from other sources of turbulence, such as the magnetorotational instability (MRI). This could potentially provide a probe of self-gravity that is independent of disc mass, thus sidestepping current debates on possible systematic errors in observations. To establish the probability distribution of line broadening as a function of the local Mach number, we perform raytracing on smoothed particle hydrodynamics disc simulations with radiative transfer. These linewidth probability distributions (LPDs) are calculated for motion in the disc plane and normal to it. While the simulations are low resolution, this work is offered as a proof of concept - the results provide a basic understanding of the underlying physics, with more detailed and high-resolution work required. In relatively low mass self-gravitating discs, we find that the mode of the LPD has a Mach number in agreement with standard alpha-disc theory. The LPDs for motion in the disc plane and its normal tend to maintain a systematic separation in Mach number, distinguishing it from MRI turbulence. As the disc mass is increased, this relationship begins to break down. The LPD also becomes increasingly sensitive to low-m spiral modes induced as a result of non-local angular momentum transport.

Name: Manuel Guedel
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Poster Number: 4-7
Title: **X-ray jets from young stellar objects**
Author(s): M. Guedel* (Vienna), M. Audard (Geneva), H.M. Guenther (CfA), Ch. Lynch (Iowa), R.L. Mutel (Iowa), Ch. Schneider (Hamburg), S.L. Skinner (Colorado), et al.
Abstract: A growing sample of young stellar objects, including protostars and accreting T Tauri stars, reveals soft X-ray jets in images and spectra. Source temperatures of up to several million degrees have been measured, challenging the shock heating scenario while suggesting a role for magnetic heating. We present an overview of results from an outstanding example of this class of YSO jets, namely the bipolar jet of DG Tau observed with Chandra and XMM-Newton. This X-ray jet reveals a strong, slightly extended source (LX $\sim$ 2E29 erg/s) located at $\sim$30AU from the star. This feature can be resolved down to scales of $\sim$0.1", corresponding to about 20 AU, and represents a standing structure beyond which plasma seems to cool rapidly. Analysis of cooling times suggests high plasma densities, high pressures but very low volume filling factors for the hot plasma. We discuss these findings in the context of jet models and compare the DG Tau jet with other recently studied X-ray jets. We also emphasize the role X-ray jets may play in the processing of material in protoplanetary disks, and thus in the way planets form in these disks.

Name: Robert Harris
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Poster Number: 4-8
Title: **A Resolved Census of Millimeter Emission from Taurus Multiple Star Systems**
Author(s): Robert J. Harris*, Sean M. Andrews, David J. Wilner, Adam L. Kraus
Abstract: We present a high resolution millimeter-wave dust continuum imaging survey of circumstellar disks around components of 23 multiple systems in Taurus-Auriga. These data permit a comprehensive look at how millimeter luminosity (a tracer of disk mass) relates to properties of stellar companions. Stellar pairings' luminosity and projected separation (a_p) are strongly correlated. Wide pairs (a_p>300 AU) are as bright as single stars, medium pairs ($a_p \sim$30-300 AU) are $\sim$5 times fainter, and close pairs (a_p<30 AU) are $\sim$5 times fainter yet (except for a few bright circumbinary disks). Circumprimary disks (or circumtertiary disks in triples) usually dominate the emission. Tests of tidal truncation models yield mixed results: some disk sizes exceed expectations. Approximately one-third of stars in multiples have detectable millimeter emission, a rate half that for single stars. We suggest companions impact disk properties at a level comparable to the internal evolution mechanisms operating in isolated systems, with both the multiple formation process and star-disk interactions playing important roles. From the perspective of disk masses, we expect that giant planet formation is inhibited in close pairs or around secondaries, but should be as likely as for single stars around the primaries (or tertiaries in hierarchical triples) in more widely-separated multiples.

Name: Joel Kastner
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Poster Number: 4-9
Title: **Radio Molecular Line Surveys of Evolved, Irradiated Protoplanetary Disks**
Author(s): Joel Kastner*, David Rodriguez, Valerie Rapson, Pierre Hily-Blant, G. Germano Sacco, Thierry Forveille, B. Zuckerman
Abstract: We present early results from our ongoing, unbiased (broad-band) molecular emission line surveys of evolved, circumstellar disks orbiting nearby (D $<\sim$ 150 pc) pre-main sequence (pre-MS) stars. Our initial focus is on the well-studied protoplanetary disks orbiting LkCa 15, TW Hya, V4046 Sgr. All three stars have relatively advanced pre-MS ages ($\sim$5-10 Myr); nevertheless, their disks are known to retain significant residual gaseous components, as evidenced by previous (radio and IR) detections of molecular and atomic lines. Our goal is to perform a census of the molecular species within each disk, paying special attention to potential tracers of the effects of high-energy radiation from pre-MS stars on disk gas chemistry and physical conditions. In the case of V4046 Sgr, the radio line survey results are presented alongside gaseous emission line detections obtained from Spitzer mid-infrared spectroscopy.

Name: Shigeo Kimura
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Poster Number: 4-10
Title: **Conditions for Gravitational Instability in Protoplanetary Disks**
Author(s): Kimura Shigeo*, Tsuribe Toru
Abstract: Gravitational instability is one of considerable mechanisms to explain the formation of giant planets. We study the gravitational stability in the protoplanetary disks around a protostar. The temperature and Toomre's Q-value are calculated by assuming local equilibrium between viscous heating and radiative cooling. Then, we derive the critical surface density that is necessary for a disk to become gravitationally unstable as a function of radius. At the radius where ices form, the value of critical surface density changes discontinuously by one order of magnitude. By comparing a given surface density profile to the critical surface density, one can discuss the gravitational instability in protoplanetary disks. As an example, we discuss the gravitational instability by using a semi-analytic model for protoplanetary disks in the framework of the steady state accretion disk, which is realized after the viscous evolution. As a result, it is found that the disks tend to become gravitationally unstable in the farther region than the snow line because ices enable the disks to become low temperature.

Name: Stefan Kraus
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Poster Number: 4-11
Title: **Spatially resolved constraints on protoplanetary disk geometry & kinematics**
Author(s): Stefan Kraus*
Abstract: Many of the open questions in star- and planet-formation research are related to the structure and physics of the innermost regions of protoplanetary disks, where disk material is transported onto the forming star, ejected in powerful jets & outflows, or interacts with newly-formed planets. In this talk I will present recent studies, in which we employed near-infrared interferometry to study the AU-scale inner regions of these disks. For instance, using VLTI interferometric imaging, we resolved the disk around the Herbig B[e]-star V921 Scorpii and found indications for a radial temperature gradient and a central opacity depression, as expected for an irradiated dust disk. In addition our images reveal a previously unknown, close (0.025") companion, which shows signs of orbital motion. The polar axis of the circumprimary disk is aligned with an arcminute-scale bipolar nebula, in which we detect multi-layered arc-shaped substructure, likely tracing episodic mass-loss events triggered by the companion. Combining VLTI/AMBER spectro-interferometry with high spectral dispersion (R=12,000) and VLT/CRIRES spectro-astrometry (R=100,000) allows us to resolve the distribution and motion of hot hydrogen gas, providing direct constraints on the gas-velocity field on a sub-AU scale.

Name: Koen Maaskant
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Poster Number: 4-12
Title: **The transitional disk of HD169142, measuring the gap size**
Author(s): Koen Maaskant
Abstract: The disk around the Herbig Ae star HD169142 was imaged and resolved at 18.8 and 24.5 micron using Subaru/COMICS. We interpret the observations using a 2D radiative transfer model and find evidence for the presence of a large gap. The MIR images trace dust that emits at the onset of the strong rise in the spectral energy distribution (SED) at 20 micron, therefore are very sensitive to the location and characteristics of the inner wall of the outer disk and its dust. We determine the location of the wall to be 23 AU from the star. An extra component of hot dust must exist close to the star. We find that a hydrostatic optically thick inner disk does not produce enough flux in the NIR and an optically thin geometrically thick component is our solution to fit the SED. Considering the recent findings of gaps and holes in a number of Herbig Ae/Be group I disks, we suggest that such disk structures may be common in group I sources. Classification as group I should be considered a support for classification as a transitional disk, improved imaging surveys are needed to support this speculation. (ApJ accepted)

Name: Francesco Marzari
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Poster Number: 4-13
Title: **Dynamical evolution of circumbinary disks.**
Author(s): A. Nelson & F. Marzari*
Abstract: We present 2-dimensional hydrodynamic simulations using the Smoothed Particle Hydrodynamic (SPH) code VINE to model a self-gravitating binary system similar to that observed for the GG Tau system. Our scenario includes the circumbinary torus+disk that surrounds the binary and circumstellar disks around each star. We implement simple and approximate prescriptions for heating and cooling via dynamical processes in the disk and radiative heating from the stars. We explore the morphology of the 'torus/disk' structure evolves, to test whether the stirring action of the binary on the surrounding material can explain the disk as an excretion of the torus, if a significant amount of mass is accreted by the circumstellar disks, extending their lifetime, and how all these phenomena depend on the assumed orbital parameters of the binary. We also calculate the eccentricity of the inner border of the circumstellar disk since this parameter is important when estimating from observations the inclination of the system.

Name: Takuya Ohtani
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Poster Number: 4-14
Title: **Simultaneous Growth of a Protostar and a Young Circumstellar Disk in the Early Phase of Disk Formation**
Author(s): Ohtani Takuya* and Tsuribe Toru
Abstract: Protoplanetary disks are the birthplace of planets. The appropriate model for the formation and the evolution of the disk is desirable. In this conference, we will present the simultaneous growth model of both the protostar and the circumstellar disk. We study the origin of surface density distribution and the disk to star mass ratio by numerically solving unsteady evolution of one-dimensional axisymmetric model for viscous accretion disk. We find that the radial profile of surface density of the disk approaches the "quasi-steady state". This state is determined mainly by the process of angular momentum transport rather than the original distribution of angular momentum of the cloud core. We also find that the disk mass tends to be larger than the star mass as long as the constant dynamical flow onto the disk is assumed. Finally, we will show the P-V diagram of the disk in our model to compare to the observations of the star-forming region.

Name: Jon Ramsey
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Poster Number: 4-15
Title: **Simulating magnetic outflows from young disks at both launching and observational length scales**
Author(s): Jon P. Ramsey*, David A. Clarke
Abstract: It has become generally accepted that magnetic fields are required to launch and collimate large-scale outflows from disks and young stars. Although there has been substantial discussion in the literature regarding the launching and collimation of protostellar jets, simulations which explicitly include the launching mechanism have previously not extended very far beyond the small launching region (< 1 AU). In this talk, I will present adaptive mesh refinement simulations of protostellar jets that include both the launching region and much larger observational scales ($> 10^3$ AU). By varying only the initial magnetic field strength, I find that two physical mechanisms work to launch jets, and this affects the resulting observable properties of jets. I also find that these jet simulations reasonably match observations, demonstrating that magnetic outflows from discs, by themselves, are capable of producing realistic jets.

Name: Benjamin Sargent
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Poster Number: 4-16
Title: **Water Vapor Emission and Absorption at 5-7.5 Microns Wavelength in Spitzer-IRS Spectra of Protoplanetary Disks**
Author(s): Benjamin Sargent*, William Forrest, Dan Watson, Paola d'Alessio, Nuria Calvet, Elise Furlan, Kyoung-Hee Kim, Joel Green, Klaus Pontoppidan
Abstract: We present spectra of T Tauri stars in the Taurus-Auriga star-forming region showing emission and absorption in Spitzer Space Telescope Infrared Spectrograph (IRS) 5-7.5 micron spectra from water vapor in these stars' protoplanetary disks. Emission from water vapor in protoplanetary disks has been seen in spectra at near-infrared wavelengths (< 3 microns) and longer mid-infrared (> 10 microns) wavelengths. Water vapor absorption in 5-7.5 micron FU Orionis star Spitzer-IRS spectra has been reported previously. Our finding water vapor spectral signatures in 5-7.5 micron spectra of protoplanetary disks around low-mass stars is noteworthy and complementary to studies at other wavelengths. Some of the stars' spectra show an emission feature at 6.6 microns, likely a blend of many lines, suggesting emission from warm ($>$500K) water vapor. Other stars' spectra show an absorption band peaking in strength at 5.6-5.7 microns, possibly due to water vapor. We present spectral models of these molecular features. The water vapor suggested by these spectra likely originates in the inner regions of these protoplanetary disks and hence is relevant to studies of the origin of water on planets in the habitable zones of stars.

Name: Sanemichi Takahashi
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Poster Number: 4-17
Title: **Formation and Self-Regulated Evolution of Massive Protoplanetary disks**
Author(s): Sanemichi Takahashi, Shu-ichiro Inutsuka, and Masahiro N. Machida
Abstract: We investigate the formation process of self-gravitating protoplanetary disks. The angular momentum in the disk is redistributed by the action of gravitational torque in the massive disk in its early formation stage. We develop a simplified one-dimensional accretion disk models that take into account the infalling gas from the envelope onto the disk and the transfer of angular momentum within the disk in terms of effective viscosity. We find characteristic property in the evolution that does not depend on the detail of modeling for effective viscosity. The resultant disks have structures that are in agreement with the results of three dimensional simulations. Out model will be a useful tool for further modeling of chemistry, radiative transfer and planet formation in the protoplanetary disks.

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Poster Number: 4-18
Title: **Photodissociation of CO isotopologues by T-Tauri stars**
Author(s): Mo Yu*, Sarah Dodson-Robinson, Karen Willacy
Abstract: The nearly equal fractionation of 17O and 18O in calcium-aluminum inclusions shows that oxygen fractionation in the most refractory solar system material was independent of nuclear mass. Lyons and Young (2005) proposed that photodissociation of CO isopologues at the disk surface near 30 AU may count for the isotopic anomalies. The success of their model relies on a background UV radiation field of at least 1000 times the local interstellar value (LISM) shining perpendicular to the disk midline. However, the intensity of UV radiation from the central star can be greater than 1000 LISM in the planet-forming regions of T-Tauri disks. Furthermore, the radiation field decreases with distance from the central star, introducing a radially dependent dissociation efficiency. In order to obtain a more accurate CO isotopologue abuncance profile for a T-Tauri disk as a function of time, we construct a 2-d chemical model of a disk irradiated by a G0 star including photochemical reactions for C and O isotopologues. We see photodissociation at the surface of the disk from 0.3 AU to about 30 AU. We also see an interesting CO depletion at about 3AU due to production of CO2, which may suggest a possible pathway for CO2 formation in the inner solar system.

Atmospheres and Evolutionary Models

Name: John Burton
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Poster Number: 5-1
Title: **Probable z'-band Ground-based Detection of the Secondary Eclipse of WASP-19b**
Author(s): Burton*, John; Watson, C. A.; Littlefair, S. P.
Abstract: We present the probable ground-based detection of the secondary eclipse of the transiting exoplanet WASP-19b. The observations were made in the Sloan z'-band using the ULTRACAM triple-beam CCD camera mounted on the NTT. The measurement shows a 1±0.2mmag eclipse depth, consistent with a dayside temperature of 2900K, matching previous predictions based on H- and K-band measurements. However, since this is based on a single observation, the eclipse depth - at the moment - is not particularly well constrained, and would benefit from additional observations at similar wavelengths. Our technique for the data reduction and analysis is described, along with our approach to dealing with systematic errors associated with ground-based secondary eclipse observations.

Name: Darren Fernandes
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Poster Number: 5-2
Title: **Amino Acid Synthesis in Parent Bodies**
Author(s): Darren Fernandes*, Ralph Pudritz
Abstract: Carbonaceous meteorites have been shown to have significant quantities of amino acids, which are the building blocks of proteins. In light of these discoveries, it is widely believed that carbonaceous meteorites brought biological compounds to early Earth and played a major role in the development of life. Nevertheless, the mechanisms behind amino acid synthesis in meteorites is still not fully understood. Using equilibrium thermodynamics, we show that the amino acids present in carbonaceous meteorites are consistent with the Strecker synthesis mechanism in meteoritic parent bodies. Parent bodies in the early solar system would have gathered large amounts of water, HCN, ammonia and aldehydes - all of which were abundant in the early solar media. These chemicals would have then reacted via the Strecker mechanisms to create the amino acids we see in meteorites today. This has various implications to the development of early life and the genetic code.

Name: Colin Folsom
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Poster Number: 5-3
Title: **Metal-depleted atmospheres of newly formed A and B stars: a tracer of planet formation?**
Author(s): C. P. Folsom*, S. Bagnulo, G. A. Wade, J. D. Landstreet, E. Alecian
Abstract: Herbig Ae and Be stars are young pre-main sequence stars with masses from 1.5 to 8 times that of the sun. We have performed a detailed abundance analysis of the atmospheres of 20 such stars, detecting the depletion of Fe peak elements while at the same time finding solar abundances of light elements such as C, N, and O (the so-called Lambda Bootis chemical peculiarity) in half the sample. Such heavy element depletion is thought to result from selective accretion onto the star of metal-depleted gas. This metal depletion is likely due to metals being bound into dust grains which may be driven away from the star by radiation pressure. The formation of large amounts of dust suggests we may be seeing stars accreting material that is also starting to form rocky planets.

Name: Renyu Hu
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Poster Number: 5-4
Title: **Identification of Rocky Exoplanets and Characterization of Their Surfaces**
Author(s): Renyu Hu, Bethany L. Ehlmann, Sara Seager
Abstract: The Kepler mission and other observations are detecting exoplanets that could have rocky surfaces. Unambiguous identification of a rocky exoplanet, however, has been limited in many cases due to the mass-radius degeneracy between rocks and volatiles. We here propose that identification of rocky exoplanets is possible via observing the wavelength-dependent thermal emissivity of their surfaces at the mid-infrared. With a theoretical framework that self-consistently treats reflection and thermal emission of airless rocky exoplanets, we find that a silicate surface on an exoplanet is spectroscopically detectable via prominent Si-O features in the thermal emission bands of 7 - 13 μm and 15 - 25 μm. The variation of brightness temperature due to the silicate features can be up to 20 K for an airless Earth analog, and the silicate features are wide enough to be distinguished from atmospheric features with relatively high-resolution spectra. Furthermore, characterization of specific rocky surface types, including mafic minerals, water ice, and hydrated silicates, is possible with the planet's reflectance spectrum at the near-infrared. Detection and characterization of rocky surfaces on exoplanets would greatly improve our understanding of the interior and the evolution history of low-mass exoplanets.

Name: Kenji Kurosaki
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Poster Number: 5-5
Title: **Thermal Evolution and Mass Loss of Water-Rich Exoplanets**
Author(s): K. Kurosaki*, M. Ikoma, Y. Hori and S. Ida
Abstract: Recent progress in transit photometry has enabled us to find relatively small, short-period exoplanets with radii of a few to several Earth radii. To constrain the compositions of the planets, we have derived the mass-radius relationship for water-rich planets, including the effects of the thermal contraction and mass loss of the planets. We have found that without mass loss, the radii of the 10-Gyr-old water-rich planets are 5-7 Earth radii, regardless of their masses, which seems to be inconsistent with the observational trend for transiting low mass planets. Considering the mass loss, the planet's radius is found to decrease, as the planet's mass decreases, and its values are calculated to be 2-7 Earth radii, which is consistent with the observational trend. The gradient in radius with respect to mass is due to that in the rock/water ratio in the planets. This study demonstrates that the mass loss has a crucial impact on the fate of low mass planets with short orbital periods, and the fate strongly depends on their initial temperatures. This means that the mass-radius relationship for low mass planets is able to give constraints on the accretion and impact history of short-period low mass planets.

Name: John Landstreet
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Poster Number: 5-6
Title: **A search for magnetic fields in Herbig AeBe stars**
Author(s): E. Alecian, G. A. Wade, C. Catala, J. H. Grunhut, J. D. Landstreet*, S. Bagnulo, T. Boehm, C. P. Folsom, S. Marsden, I. Waite
Abstract: Using ESPaDOnS at CFHT and Narval at Pic-du-Midi, a search for magnetic fields in 70 known and candidate Herbig AeBe stars has been carried out. The data from many spectral lines in each star have been combined with least squares deconvolution (LSD), allowing very precise field measurements. A hybrid technique has been developed for field measurement in stars with strong line emission. The typical field strength uncertainty achieved is of order 100 G. This survey has led to the discovery of fields in five Herbig stars.

Name: Giovanni Rosotti
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Poster Number: 5-7
Title: **The interaction of photoevaporation and giant planet formation**
Author(s): Giovanni Rosotti
Abstract: Observations reveal that some (if not all) discs goes through the "transitional disc" evolutionary phase. Among the possible physical mechanisms to explain this process, we considered photoevaporation and giant planet formation. We have investigated the interplay between them through the use of a 1D viscous evolution code. We studied the dependence of the observable features of the system, namely planet distance from the star, mass accretion rate on the star and hole size, from the different flavors of photoevaporation (UV, X-ray). In addition, we will show preliminary results from 3D hydrodynamical simulations of a X-ray photoevaporating disc with an embedded planet.

Cores and Small Scale Collapse

Name: Che-Yu Chen
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Poster Number: 6-1
Title: **Ambipolar Diffusion and Prestellar Core Formation**
Author(s): Che-Yu Chen & Eve C. Ostriker
Abstract: We studied the dependence of turbulence-enhanced ambipolar diffusion on environment through a numerical parameter study, and obtained the shock thickness mediated by ambipolar diffusion as a function of density, inflow velocity, magnetic field, and ionization fraction in the background cloud. Our formula also agrees with an analytic estimate based on ion-neutral momentum exchange. Using time-dependent numerical simulations, we discovered and characterized a transient stage of ambipolar diffusion during compression of magnetized gas by supersonic turbulence, before the ion-neutral drift reaches equilibrium and the neutrals are compressed much more strongly than the magnetic field. The transient stage has a duration set by the neutral-ion collision time, $t_{AD} \sim L_{shock/v_{drift}} \sim 0.1$ - 1 Myr, creating post-shock regions with relatively high mass-to-flux ratio which may represent the birth sites of prestellar cores. We also examined the transient behavior of ambipolar diffusion in shocked layers using three-dimensional MHD simulations with self-gravity and a perturbed velocity field in the convergent flow. Based on our results to date, we found that with ambipolar diffusion, varying the ionization fraction leads to behavior between pure hydrodynamics and ideal MHD. We are working on a more complete parameter study to investigate how the physical factors can affect the forming process of gravitationally-bounded cores during the transient stage of ambipolar diffusion, which will provide insight into the environment where circumstellar disks form.

Name: Hsin-Fang Chiang
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Poster Number: 6-2
Title: **Interferometric Observations and Modeling of the Envelope around Class 0 Protostars**
Author(s): Hsin-Fang Chiang*, Leslie Looney, John Tobin
Abstract: We present dual-wavelength modeling of the circumstellar envelope around nearby Class 0 protostars using multi-configuration observations of the Combined Array for Research in Millimeter-wave Astronomy. Radiative transfer modeling is performed to compare the dust continuum data at 1 and 3 mm with theoretical envelope models; Bayesian inference and information criteria are applied for parameter estimation and model selection. In particular, we focus on the edge-on Class 0 object L1157-mm, and consider a power-law envelope model and the Terebey-Shu-Cassen model. The results infer a steep density profile for the envelope, and prefer the power-law envelope model against the Terebey-Shu-Cassen model. Moreover, the dust opacity spectral index (beta) is estimated to be ∼0.9, implying that grain growth has started at L1157-mm. Also, the unresolved disk component is constrained to be smaller than ∼40 AU in radius and ∼4-25 Jupiter mass. However, the estimate of the embedded disk component heavily relies on the assumed envelope model as well as the assumed disk characteristics.

Name: Simon Coudé
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Poster Number: 6-3
Title: **The Effects of Molecular Line Contamination on the Emissivity Spectral Index in Orion A**
Author(s): Simon Coudé, Pierre Bastien, Emily Drabek, Doug Johnstone, Jennifer Hatchell, and the JCMT Gould Belt Survey Team
Abstract: The emissivity spectral index is a critical component for studying the physical properties of dust grains in cold and optically thin interstellar star forming regions. Since the sub-millimeter continuum bands are an ideal regime for the observation of interstellar dust emission, they can be used to determine this important parameter. We present two maps from the SCUBA-2 shared risks observations obtained at the James-Clerk-Maxwell telescope. However, some molecular emission lines can also contribute significantly to the measured fluxes in those bands. This could lead to serious errors in the determination of the spectral index in highly contaminated areas by underestimating its value. For the Orion A molecular cloud complex, we have used HARP 12CO 3-2 maps to characterize the molecular line contamination. With the corrected fluxes at 450 μm and 850 μm, we have obtained new spectral index maps for different regions of the well-known integral-shaped filament. We then compare these results and their temperature dependence with previous studies. This work is part of an ongoing effort to characterize the properties of star forming regions in the Gould belt with the new instruments available at the JCMT.

Name: James Di Francesco
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Poster Number: 6-4
Title: **Herschel Observations of a Potential Core Forming Clump: Perseus B1-E**
Author(s): James Di Francesco*, Sarah Sadavoy, the Herschel Gould Belt Survey Team
Abstract: We present continuum observations of the Perseus B1-E region from the Herschel Gould Belt Survey. These Herschel data reveal a loose grouping of substructures at 160 - 500 microns not seen in previous submillimetre observations. We measure temperature and column density from these data and select the nine densest and coolest substructures for follow-up spectral line observations with the Green Bank Telescope. We find that the B1-E clump has a mass of about 100 solar masses and appears to be gravitationally bound. Furthermore, of the nine substructures examined here, one substructure (B1-E2) appears to be itself bound. The substructures are typically less than a Jeans length from their nearest neighbour and thus, may interact on a timescale of ~ 1 Myr. We propose that B1-E may be forming a first generation of dense cores, which could provide important constraints on the initial conditions of prestellar core formation. Our results suggest that B1-E may be influenced by a strong, localized magnetic field, but further observations are still required.

Name: Dennis Duffin
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Poster Number: 6-5
Title: **Formation of warped, magnetised discs**
Author(s): Dennis Duffin*, Ralph Pudritz, Daniel Seifried, Robi Banerjee, Ralf Klessen
Abstract: Protostellar discs are needed to drive molecular outflows and jets observed in star forming regions, but there has been some debate to how they form. We have performed 3D ideal magnetohydrodynamic (MHD) simulations of collapsing Bonnor–Ebert spheres, employing sink particles alongside an AMR grid and using a cooling function to model radiative cooling of the gas. We form a rotationally dominated disc with a radius of 100 AU embedded inside a transient, unstable, flattened, rotating structure extending out to 2000 AU. The inner disc becomes unstable to a warping instability due to the magnetic structure of the outflow, warping 30° with respect to the rotation–axis by the end of the simulation. The disc sheds magnetic loops, degrading the orientation of the mean threading field. This reduces and even reverses the magnetic braking torque of the large scale field back upon the disc. The reduction of magnetic braking allows the disc to form, and may be the key way in which low mass stellar systems produce rotationally dominated discs. We discuss the relevance of our disc misalignment concerning the formation of mis–aligned hot Jupiters.

Name: Hao Gong
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Poster Number: 6-6
Title: **Implementing Sink Particles in Athena**
Author(s): Gong*, H., Eve C. Ostriker
Abstract: We embed lagarangian sink particles in the Eulerian grid code – Athena. Gravitational collapse in numerical simulations creates high density regions causing tiny time step and numerical instabilities. Introducing lagrangian sink particles avoids this difficulty by removing material from the high density to sinks; and the accretion to these sink particles could be tracked. Particle-Mesh algorithm is adopted to calculate the gravitational interaction between the gas and the sink particles. We test the methodology with problems against their analytical solutions or accurate numerical solutions. We also present a application of this new method: stuyding the protostar formation inside a planar supersonic converging flow.

Name: Sungeun Kim
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Title: **Structural Determination of OMC1 in the Orion A Molecular Cloud**
Abstract: We present a 1.1 mm emission map of the OMC1 region observed with AzTEC, a new large-format array composed of 144 silicon-nitride micromesh bolometers that was in use at the James Clerk Maxwell Telescope (JCMT). The AzTEC observations of the OMC1 region at 1.1 mm reveal dozens of cloud cores and a tail of filaments in a manner that is almost identical to the submillimeter continuum emission of the entire OMC1 region at 450 and 850 micronm. The power spectrum was measured from the Fourier transform of the image with the nonparametric periodogram estimator. The expected value of the periodogram converges to the resulting power spectrum in the mean squared sense. From the present analysis of the OMC1 filaments at 1.1 mm emission, the power spectrum steepens at relatively smaller scales. At largest scales, the power spectrum flattens and the large scale power law becomes shallower. The power spectra of the 1.1 mm emission show clear deviations from a single power law. The effects of beam size and the noise spectrum on the shape and slope of the power spectrum are also included in the present analysis.

Name: Jacques Masson
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Poster Number: 6-7
Title: **Non Ideal MHD in low-mass star formation**
Author(s): Masson*
Abstract: The story of how stars form is a very interesting and complex subject. The broad aspects have been understood for many years, but many unanswered issues remain such as the microphysics at stake (grains, chemistry), the importance of magnetic fields (and the fragmentation crisis, the impact of radiation feedback, or the limit of brown dwarfs formation. A major issue in the field of star formation is that we are yet unable to see the first stages of the collapse of dense cores (Class 0 objects): the Herschel program will help to probe deeper into the dense cores up to the protostar! In order to understand better the formation of low-mass stars, we have implemented resistive MHD in the 3D AMR code RAMSES, along with detailed microphysics to compute accurately the various diffusivities. 3D simulations are equired to assess non-symmetrical effects, such as the efficiency of magnetic braking in non-aligned cases.

Name: Neil Vaytet
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Poster Number: 6-8
Title: **Simulations of low-mass protostellar collapse using multigroup radiation hydrodynamics**
Author(s): Neil Vaytet*, Gilles Chabrier, Edouard Audit, Benoit Commercon, Jacques Masson
Abstract: Radiative transfer plays a major role in the process of star formation, the details of which are still not entirely understood. Many previous simulations of gravitational collapse of a cold gas cloud followed by the formation of a protostellar core have used a grey treatment of radiative transfer coupled to the hydrodynamics. However, dust opacities which dominate circumstellar extinction show large variations as a function of frequency. In this work, we used a frequency-dependent formalism for the radiative transfer in order to investigate the influence of the opacity variations on the properties of Larson's first and second cores. I will present the details of the multigroup M1 moment model for the radiative transfer we have developed, and illustrate its strengths by showing test results of simulations of radiative shocks. I will then present its application to the spherically symmetric collapse of 10, 1, 0.1 and 0.01 solar mass cold cloud cores. Monochromatic dust and gas opacities were used to compute Planck and Rosseland means inside each frequency group. I will discuss the differences between the grey and frequency-dependent simulations for both first and second Larson cores (size, mass, entropy,...), and their implications on observations.

Name: Rachel Ward
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Poster Number: 6-9
Title: **Analyzing Synthetic Observations of Star-forming Clumps in Molecular Clouds**
Author(s): Rachel L. Ward*, James Wadsley, Alison Sills, and Nicolas Petitclerc
Abstract: The gravitational collapse of a giant molecular cloud produces localized dense regions, called clumps, within which low-mass star formation is believed to occur. Recent studies have shown that limitations of current observing techniques make it difficult to correctly identify and measure properties of these clumps that reflect the true nature of the star-forming regions. While the Herschel and ALMA observations will disentangle some of the issues, the most self-consistent way to understand the observational biases is by using large-scale simulations to model the collapse of a molecular cloud. In order to make a direct comparison with observations, we produced a synthetic column density map and a synthetic spectral-line data cube from the simulated collapse of a 5000 solar mass molecular cloud. By correlating the clumps found in the simulation to those found in the synthetic observations, we find that 'observed' clump masses derived from the column density map are on order a factor of three larger than their true masses, due to the projection of low-density material along the line of sight.

Planet Formation - Early Stages in Disks

Name: Tilman Birnstiel
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Poster Number: 7-1
Title: **Can grain growth explain transition disks?**
Author(s): T. Birnstiel*, S. Andrews, H. Klahr, B. Ercolano
Abstract: The global size and spatial distribution of dust is an important ingredient to the structure and evolution of protoplanetary disks and the formation of larger bodies, such as planetesimals. We developed a toy model for the evolution of the dust surface density profile, taking growth, fragmentation as well as drift, gas drag, and radial mixing of dust into account and find very good agreement with a full dust evolution code. We derive analytical profiles which describe the dust surface density and the dust-to-gas ratio in protoplanetary disks. We show that dust grain fragmentation is the dominating effect in the inner regions of the disk leading to a dust surface density exponent of -1.5 while the outer regions at later times can become drift dominated yielding a dust surface density exponent of -0.75. The latter exponent is expected for old disks and found to be in agreement with recent observations of TW Hya (Andrews et al., ApJ (2012) vol. 744 pp. 162). We also discuss the ability of grain growth and transport to produce the observational signatrues of transition disks.

Name: Alex Dunhill
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Poster Number: 7-2
Title: **Eccentricity growth of embedded giant planets**
Author(s): Alex Dunhill*, Richard Alexander
Abstract: Most extra-solar planets have eccentric orbits around their host stars. This is in stark contrast to Solar System planets, which are all in near-circular orbits, and it is unclear how exoplanets attain their eccentricities. One possible mechanism for exciting eccentricity is by resonant interactions between a young planet and its parent protoplanetary disc. We present high-resolution 3-D numerical simulations of this planet-disc interaction. We find that eccentricity is only excited in discs that have very high surface densities with shallow radial profiles; in more realistic discs the excitation is very weak, and is further damped by other resonant torques. We conclude that disc-planet interactions cannot explain a significant fraction of observed exoplanet eccentricities, and discuss the consequences of our results for future exoplanet studies.

Name: Yuri Fujii
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Poster Number: 7-3
Title: **Can Circumplanetary Disks Sustain the MRI?**
Author(s): Yuri I. Fujii*, Satoshi Okuzumi, and Shu-ichiro Inutsuka
Abstract: During the formation of gas giant planets, gaseous disks are formed around them. These disks are called circumplanetary disks. Circumplanetary disks are supposed to be the formation sites of satellites. Although an understanding of disk evolution is required for developing the theory of satellite formation, gas accretion rates of circumplanetary disks are very uncertain. The most promising mechanism of gas accretion is thought to be magnetic turbulence which is driven by the magnetorotational instability (MRI), and we can estimate the efficiency of MRI by the Elsseser number. To evaluate the value of the Elsseser number, we need to know the ionization degree of the disk gas. We can calculate the ionization degree with dust grains using the method developed by Fujii et al. (2011). We investigate the value of the Elssesser number in circumplanetary disks of various surface densities, and find that only disks with very small surface densities can sustain MRI.

Name: Marina Galvagni
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Poster Number: 7-4
Title: **Simulations of clump collapse in a protoplanetary disc: pre-dissociation phase**
Author(s): Galvagni*, Hayfield, Boley, Mayer, Saha
Abstract: Working in the context of gas giant planets formation via gravitational instability (GI), we present the first tridimensional (3D) high resolution simulations for the collapse of clumps formed in the outer, GI unstable protoplanetary disk ($R > 50$ AU) spanning over several orders of magnitude in density towards planetary sizes. We adopt an improved equation of state with a variable adiabatic index and dissociation of molecular hydrogen, which takes into account the gas microphysics in the various temperature and density regimes that we model. We study the effect of initial asymmetries and rotation on the clump evolution by comparing with idealized models of non-rotating spherical clumps, finding that realist clumps are marginally unstable to the growth of non-axisymmetric modes in the outer, extended envelope. These developed spiral modes transport angular momentum outwards rapidly, leading to a collapse timescale in the pre-dissociation phase an order of magnitude faster than in published one dimensional calculations. Owing to their rapid contraction towards planetary densities we argue, contrary to recent claims, that even clumps migrating inward in the disk on orbital timescales will survive stellar tides even interior to 1 AU, perhaps producing some of the observed Hot Jupiters and Hot Neptunes.

Name: Yukihiko Hasegawa
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Poster Number: 7-5
Title: **Dust density at the onset of the Kelvin-Helmholtz Instability**
Author(s): Yukihiko Hasegawa*, Toru Tsuribe
Abstract: We reexamine sedimentation of dust grains and the possibility of turbulence in the protoplanetary disk for the both cases without and with dust growth. Dust density in the midplane at the onset of KHI increases with an increase of the dust abundance for the case without dust growth. In the case with dust growth, it is found that the Kelvin-Helmholtz Instability tends to occur before the gravitational instability even in the case with large abundance of dust grains. It is suggested that the difference between the case without dust growth and that with dust growth arises from the change of stopping time of dust grains due to dust growth.

Name: Andrea Isella
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Poster Number: 7-6
Title: **The signature of young planetary systems in LkCa 15 and LkHa 330 disks**
Author(s): Andrea Isella*, Laura Perez, John Carpenter
Abstract: In this poster we present recent millimeter wave observations of the transitional disks around LkCa 15 and LkHa 330 that reveal the signature of young planetary systems in the act of the formation. From comparison with hydrodynamic and radiative transfer models we constrain the properties of the embedded planetary system and of disk structure. We find that both disks might host multiple giant planets and suggest that LkCa 15 system might be more evolved than LkHa 330.

Name: Attila Juhasz
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Poster Number: 7-7
Title: **Detectability of warps in protoplanetary disks**
Author(s): Attila Juhasz*, Zsolt Regaly, Cornelis Dullemond
Abstract: One of the striking discoveries of the recent years was the detection of temporal variability in the emission of protoplanetary disks from optical to infrared wavelengths. In some cases the observed variability was attributed to a warp caused by e.g. a (sub)stellar companion in the disk on an inclined orbit. The warp casts a shadow on the disk behind it and due to its precession can cause variation in the observed flux. The emission of such warped disks was usually modeled assuming that the disk is geometrically infinitely thin and optically thick. We took the next step and used the full 3D radiative transfer code RADMC-3D to study the observability of warps in protoplanetary disks. Our results show that the general trends in the wavelength dependence of the flux variation are similar to those derived from simpler models, however the amplitude of the variability depends on the vertical density structure and on the amount of perturbation in the optical depth. We also make predictions for the detectability of warped protoplanetary disks with ALMA both in the continuum and in low-J CO lines.

Name: Akimasa Kataoka
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Poster Number: 7-8
Title: **Settling Process of Dust Aggregates in Protoplanetary disks with Porosity Evolution**
Author(s): Akimasa Kataoka*, Hideko Nomura, Satoshi Okuzumi
Abstract: How micron-sized dust aggregates evolve to kilo-meter-sized planetesimals in protoplanetary disks is one of the most important problems of the planet formation. Some previous studies using BPCA and/or BCCA models have shown that porosity has strong effects on coagulation and settling of dust aggregates. However, effects of the porosity evolution have not been taken into account before. We simulate coagulation of dust aggregates settling to an equatorial plane in a protoplanetary disk, using QBCCA model, in which the porosity evolution depends on the volume ratio of colliding two aggregates. We show that porous aggregates grow slowly and settle in longer timescale compared to compact grains. We also calculate wavelength-dependent optical depth and find that the 10 μm silicate feature remains in the case of porous aggregates even after they grow in the disk. Moreover, we find that compaction of dust aggregates affects optical depth in (sub)mm wavelength, which would be detected by ALMA.

Name: Joseph Liskowsky
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Poster Number: 7-9
Title: **HD100546: Asymmetric Emission Modeling from an Eccentric Disk**
Author(s): Joseph Liskowsky*, Sean Brittain, Joan Najita, John Carr, Greg Doppmann, Matthew Troutman
Abstract: We present averaged line profile observations of ro-vibrational OH and CO emission from the Herbig Be star HD 100546. The emission from both molecules arises from the outer portion of the disk extending approximately 13 AU from the central star. The velocity profiles of the OH lines are narrower than the velocity profile of the OI 6300Åline indicating that the OH in the disk is not co-spatial with the OI ion. This suggests that the inner optically thin region of the disk is largely devoid of molecular gas. Unlike the ro-vibrational CO emission lines, the OH lines are highly asymmetric. We show that the CO and OH line profiles can be simultaneously fit with an eccentric inner wall and a circular outer disk where the OH emission arises mainly from the inner wall and the CO emission arises mostly from the outer disk. Eccentric inner disks are predicted by hydrodynamic simulations of circumstellar disks containing an embedded giant planet. We discuss the implications of such a disk geometry in light of models of planet disk tidal interactions.

Name: Gijs Mulders
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Poster Number: 7-10
Title: **Stellar-mass-independent disk structure**
Author(s): Gijs Mulders* and Carsten Dominik
Abstract: Do planets form in the same way around stars of different masses? We examine this question by looking at the first steps of planet formation in protoplanetary disks, namely dust setting and grain growth. With the legacy of Spitzer, it has become clear that the vertical structure – and hence the amount of dust settling – can be derived from unresolved Spectral Energy Distributions (SEDs) using radiative transfer codes. I will present a grid of hydrostatic disk models with realistic dust settling, that takes into account the dust-gas coupling of sub-micron to millimeter sized particles using the turbulent mixing strength. These models are fitted to median SEDs of Herbig stars, T Tauri stars and brown dwarfs, and directly constrain the turbulent mixing strength in the mid-infrared emitting region. We find no evidence for significant variations in the vertical structure or the degree of settling across the stellar mass range, contrary to previous results. In addition, we predict that the grain size distributions are independent of the mass of the central star for turbulent-driven grain growth and fragmentation. This implies that the first steps of planet formation are the same around stars of different masses.

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Poster Number: 7-11
Title: **3-D radiative disks in binary star systems and migration of embedded planets**
Author(s): G. Picogna*, F. Marzari
Abstract: We model the evolution of 3D circumstellar disks in binary star systems using the SPH code VINE. Different prescriptions are adopted for the disk cooling. In the first model the cooling term is defined as the ratio between the gas specific internal energy and a cooling time which depends on the local temperature and density in various opacity regimes (Cossins et al., 2010). The second model uses a complete set of equations of radiation transport in the flux-limited diffusion approximation (Whitehouse & Bate, 2004). The disk cooling is in this case obtained by defining vertical and radial boundary particles which radiate away thermal energy to infinity (Monaghan, 2012). We also explore the dynamical evolution of a planet embedded in the disk around the primary star. The planet-disk interaction is described by a modified gravitational potential that allows the gas to pile up on the planet surface in a realistic way (Ayliffe & Bate, 2009).

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Poster Number: 7-12
Title: **Evolution of Protoplanetary Disks with Dead Zones**
Author(s): Taku Takeuchi*, Satoshi Okuzumi, Takayuki Muto
Abstract: We study viscous evolution of protoplanetary disks via MHD turbulence. The main focus of our study is to determine the surface density structure of the dead zone of disks. Recent simulations on MHD turbulence have shown that the mass accretion rate in the dead zone is proportional to the net vertical flux of the magnetic fields threading the disk, B_z. Thus, the surface density structure in the dead zone depends on the radial profile of B_z. We show that for a steady accretion state the radial profile of B_z is uniquely determined for a given value of the mass accretion rate. On the other hand, any surface density profile can be a solution for the steady accretion state, meaning that considering only steady solutions cannot determine the density profile of the disk. The time evolutions of both the surface density and the net vertical flux must be considered simultaneously. In this study, we consider the simplest model in which the evolution of B_z is assumed a priori. The disk gas piles up in the dead zone only if B_z is less than a certain required value to maintain the steady state.

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Poster Number: 7-13
Title: **Radial accumulation of dust particles and their maximum density by non-uniform gas density distribution in protoplanetary disks**
Author(s): Tetsuo Taki*, Masaki Fujimoto, Shigeru Ida
Abstract: One of the ideas to solve the problem of falling dusts in the process of planetesimal formation is that, if there are local quasi-steady gas high density regions in protoplanetary disks, super/sub-Keplerian flow boundary exists, then dusts accumulate on that boundary (Haghighipour & Boss, 2003). It is showed that, however, dust frictional force is effective in dusts accumulated region, thus gas density profile changes (Kato et al. , 2012). In our study, we investigated the evolutional process of dusts and gas interacting each other by friction when there are quasi-steady non-uniform gas density distribution in protoplanetary disks using local 1-D model. We conduct numerical hydrodynamics simulations with dusts as super particles. We solve the interaction between gas and dusts self-consistently. We find that a maximum dust-to-gas mass ratio gets up to only $\sim$1, then gas density distribution uniformized by effect of dust friction. Additionally, We show that dust and gas velocity fields follow steady solutions derived by Nakagawa et al. (1986), and including effects of local pressure gradient. And, we discuss a mechanism of stopping the increase of dust density using that solutions.

Name: Nienke van der Marel
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Poster Number: 7-14
Title: **The transition from disks to planetary systems: revealing dust and gas with ALMA**
Author(s): Nienke van der Marel*, Ewine F. van Dishoeck, Simon Bruderer, Bruno Merin, and collaborators.
Abstract: The best test of planet formation scenarios comes from observing systems that are actively forming planets, the transitional disks with large inner dust holes or gaps. A statistical study of dust and gas properties of a large sample of transitional disks is required to compare with exoplanet studies. Therefore, a sample of bright transitional disk candidates was constructed by using selection criteria based on infrared fluxes in the Spitzer c2d and Gould Belt catalogs. From the SEDs (including submillimeter fluxes) dust properties and hole sizes have been derived with the radiative transfer model RADMC-3D. However, gas is a better diagnostic of planet formation and the mechanism of disk clearing. The huge leap in sensitivity from ALMA allows the measurement of the gas distribution, so the origin of the hole can be determined: substellar or planetary mass companions versus photoevaporation versus grain growth. The derived disk properties will help to select a robust sample for ALMA molecular line observations in future ALMA cycles. The transitional disk Oph-IRS48 from our sample has already been scheduled in ALMA Cycle 0. The combination of gas and dust observations will provide a much better understanding of planet formation processes and disk evolution.

Planet Formation - Late Stages

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Title: **Platinum Group Elements (PGEs) in Chondrites**
Author(s): Narendra Kumar Agrawal, Ravi Agrawal*, Priti Agrawal
Abstract: The platinum-group elements (PGEs) comprise a group of six rare metals – Os, Ir, Ru, Rh, Pt and Pd with similar physical and chemical properties. All six PGEs are distinguished by their refractory nature (except for Pd) and siderophile character. The behaviour of PGEs remains poorly understood, due large to paucity of quality data. In most samples, the PGEs occur at sub-parts per billion concentrations, posing a significant challenge for their analysis. For a long time, analysis of the PGEs was carried out mostly by neutron activation analysis (NAA) which has been particularly effective for Ir, with sensitivity in the parts per trillion ranges. The other PGEs are more than a factor of 10 less sensitive by the NAA and their analysis requires lengthy radiochemical procedures. During recent times, the development of inductively coupled plasma-mass spectrometry (ICP-MS) technique showed a great progress in trace and ultra-trace analysis of samples. In the PLANEX Program at PRL, we have initiated the measurement of PGEs by ICP-MS, with the aim of applications in meteorite studies and planetary processes. We have worked out procedures to analyse about ≤ 50 mg sample of a bulk chondritic and iron meteorite. For comparison, the samples were prepared separately by conventional acid digestion and alkali fusion procedures. Measurements were made using a Thermo X-Series II Quadrupole ICP-MS. The PGEs along with some other siderophile elements were analysed in about a dozen chondritic, iron and ureilite meteorites. Some meteorites with known PGE concentrations were also analysed for cross-verification. Some of these results and their implications will be presented.

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Title: **Rotational evolution of stars hosting planets**
Author(s): *Damiani, C. & Lanza, A.F.
Abstract: Several studies suggest that hot hot Jupiters spin-up their companion stars (Pont 2009, Lanza 2010). We present a model of angular momentum evolution of late-type stars hosting hot Jupiters starting from the pre-main sequence phase. Using stellar evolution models to reproduce the global contraction and internal structural variations, radial differential rotation is modeled by core-envelope decoupling (Allain 1998). Wind braking is described by a Skumanich-type braking law (Kawaler 1988) limited by saturation. Tidal evolution is computed using a constant time-lag model, modified to allow two different tidal quality factors in the core and the envelope. The evolution starts after the evaporation of the disk, around 5 Myr from the birth-line, assuming anterior disk-locking. We ran the model for several masses of star and planets, initial orbital and rotational periods. In the case of a solar-like star, both rotation period and radial differential rotation during the main-sequence are significantly changed by the presence of a hot-Jupiter. For a 10 Jupiter-mass planet, the differential rotation is increased by a factor 3/2. Those results could be confirmed by asteroseismology or activity measurement of host stars on a large sample.

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Poster Number: 8-3
Title: **Magnetic Fields in Giant Planet Formation**
Author(s): Sarah L. Keith & Mark Wardle
Abstract: Current theories of accretion in giant planet formation rely on magnetically induced turbulence (caused by the magnetorotational instability) as the source of viscosity within circumplanetary disks. However, whether the magnetic field and disk interact sufficiently to produce this turbulence remains a key question. Although significant headway has been made in understanding the impact of magnetic coupling in protoplanetary disks, little of this knowledge has been transferred to circumplanetary disks. Here I examine the nature and effectiveness of magnetic coupling in circumplanetary disks. I present model radial profiles of the midplane temperature, ionisation, and magnetic diffusivity calculated assuming a standard alpha-disk model, and incorporating the effects of dust grains. I demonstrate that the inner 20 Jupiter radii of the disk is coupled to the field, with Ohmic diffusivity dominating over Hall and Ambipolar. However, the field exerts no influence over the majority of the disk midplane. No magnetic viscosity is produced in these regions and accretion cannot proceed through the midplane. I discuss alternative scenarios, such as inflow occurring in layers above the midplane, and explore the influence of cosmic rays as an additional ionising source.

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Title: **Coupled migration of Jupiter and Saturn in evolved disks.**
Author(s): G. D'Angelo & F. Marzari*
Abstract: We study the outward migration of Jupiter and Saturn once they get trapped in resonance during the early stage of the solar system evolution, when gas is still present. Self-consistent density profiles for the disk are derived at the time of Saturn resonance trapping by taking properly into account viscous evolution and photo-evaporation. The inward/outward migration rates are computed, under appropriate conditions of viscosity and temperature, on the basis of 2D and 3D disk-planet interaction calculations. The goal is to evaluate the extent of outward migration of the two planets until the disk's gas is completely dissipated. We intend to estimate the probability that Jupiter, once reached a distance of ∼1 AU from the star, can migrate out to its present orbit at 5.2 AU.

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Poster Number: 8-5
Title: **Trapping of resonantly interacting objects near the disk inner edge: origin of orbital configuration of the Galilean moons**
Author(s): Masahiro Ogihara*, Shigeru Ida
Abstract: Recent work on dynamical behavior of close-in planets shows that planets on eccentric orbits near the disk inner edge gain angular momentum from the gaseous disk, which results in halting type I migration of resonant convoys (Ogihara et al. 2010). This trapping mechanism, which is called an "eccentricity trap", can be responsible for the formation of non-resonant, multiple, close-in super-Earth systems. Applying the same approach, in this study, we have investigated formation of satellite systems around giant planets using N-body simulations that includes gravitational interactions with a circumplanetary gas disk. Our main aim is to reproduce the observable properties of the Galilean satellites around Jupiter, as previous N-body simulations have not explained the origin of the resonant configuration. Through numerical experiments and semianalytical arguments, we have found that several satellites are formed and captured in mutual mean motion resonances outside the disk inner edge and are stable after rapid disk gas dissipation, which explains the characteristics of the Galilean satellites.

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Poster Number: 8-6
Title: **LBT Adaptive Optics High-Contrast Imaging of Young Exoplanets and Debris Disks: New Results on HR 8799 and HD 15115**
Author(s): Timothy J. Rodigas*, Phil Hinz, Andy Skemer
Abstract: This past fall we obtained the first LBT AO science images. We imaged all four HR 8799 planets, with the first detection of "e" at H band and at 3.3 microns, and the first conclusive detections of "b" and "d" at 3.3 microns. These new results reveal that all four planets are unexpectedly bright at 3.3 microns, compared to the equilibrium chemistry models used for field brown dwarfs, which predict that planets should be faint at 3.3 microns due to CH4 opacity. We also obtained the first detections of the HD 15115 edge-on debris disk at Ks band and L'. The disk is asymmetric at Ks, but symmetric at L', suggesting a changing disk structure with wavelength. The disk appears grey from 2-4 microns, implying large dust grains 1-10 microns in size. We also find evidence for a gap in the disk near 45 AU, potentially indicative of a planet. However no companions were detected, adding to our understanding of the complex interactions between young forming planets and disk gaps. These first results together show the potential for unprecedented high-resolution near- to mid-infrared imaging with the LBT adaptive optics system.

Brown Dwarfs and Lower Mass End of IMF

Name: Andreas Bleuler
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Poster Number: 9-1
Title: **A new sink particle implementation for star formation simulations**
Author(s): Andreas Bleuler*, Romain Teyssier, Ben Moore
Abstract: Sink particles are a commonly used tool in star formation simulations. We present the implementation of a new sink particle algorithm for the Adaptive Mesh Refinement code RAMSES. The main difference to existing sink implementations is that we let the creation of new sinks depend on a clump finding algorithm which identifies density peaks and their associated regions. We describe the sink particle algorithm and the clump finder and show first results of simulations that follow the collapse of a turbulent molecular cloud.

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Title: **X-ray Spectroscopy of the Nearby cTTS Binary TWA 30**
Author(s): Dave Principe*, Joel Kastner, Giuseppe Sacco, Juan Alcala, Beate Stelzer, David Huenemoerder, Benjamin Zuckerman
Abstract: The recently discovered binary system TWA 30 consists of two of the nearest known examples of actively accreting, pre-MS star systems. Both components of TWA 30 have masses just above the brown dwarf regime and are orbited by circumstellar disks viewed nearly edge-on, with evidence for collimated stellar outflows. TWA 30A, a known X-ray source, exhibits large, variable optical/IR extinction that is evidently due to variable disk absorption. We present preliminary results obtained from XMM Newton spectroscopy of TWA 30 A and B. We explore whether X-ray emission from accretion shocks and/or jets is observable in such low-mass stars, and we compare the effects of X-ray and optical/IR extinction due to the disks in these systems.

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Poster Number: 9-3
Title: **Optical images of the young brown dwarf-planet system 2M1207**
Author(s): Nikoletta Sipos, Paul Kalas, Ansgar Reiners
Abstract: We present Hubble Space Telescope WFC3/UVIS imaging observations of the young nearby brown dwarf 2MASS 1207-3932A and its planetary mass companion (2M1207b). The system is part of the ∼8 Myr old TW Hydra association, and shows signs of active accretion (Mohanty et al., 2005). We examine accretion signatures of the components of the system through narrow-band filter observations centered on H_α, determine the accretion rate of the brown dwarf and give an upper limit for that of the planet. Our deep optical images provide constraints for the luminosity of the circumstellar disk. Based on our optical photometry, we also revisit the problem of the underluminosity of 2M1207b.

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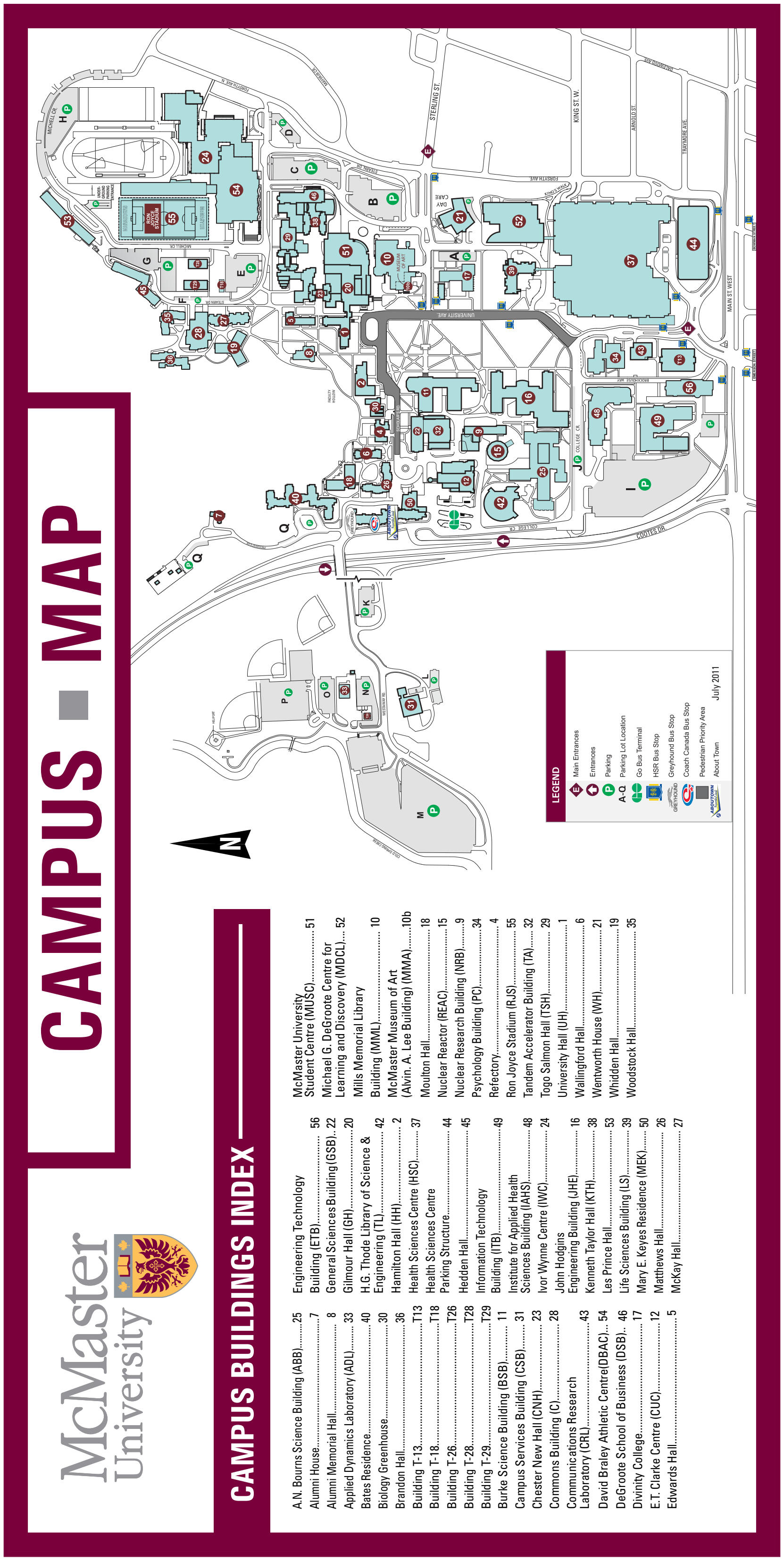
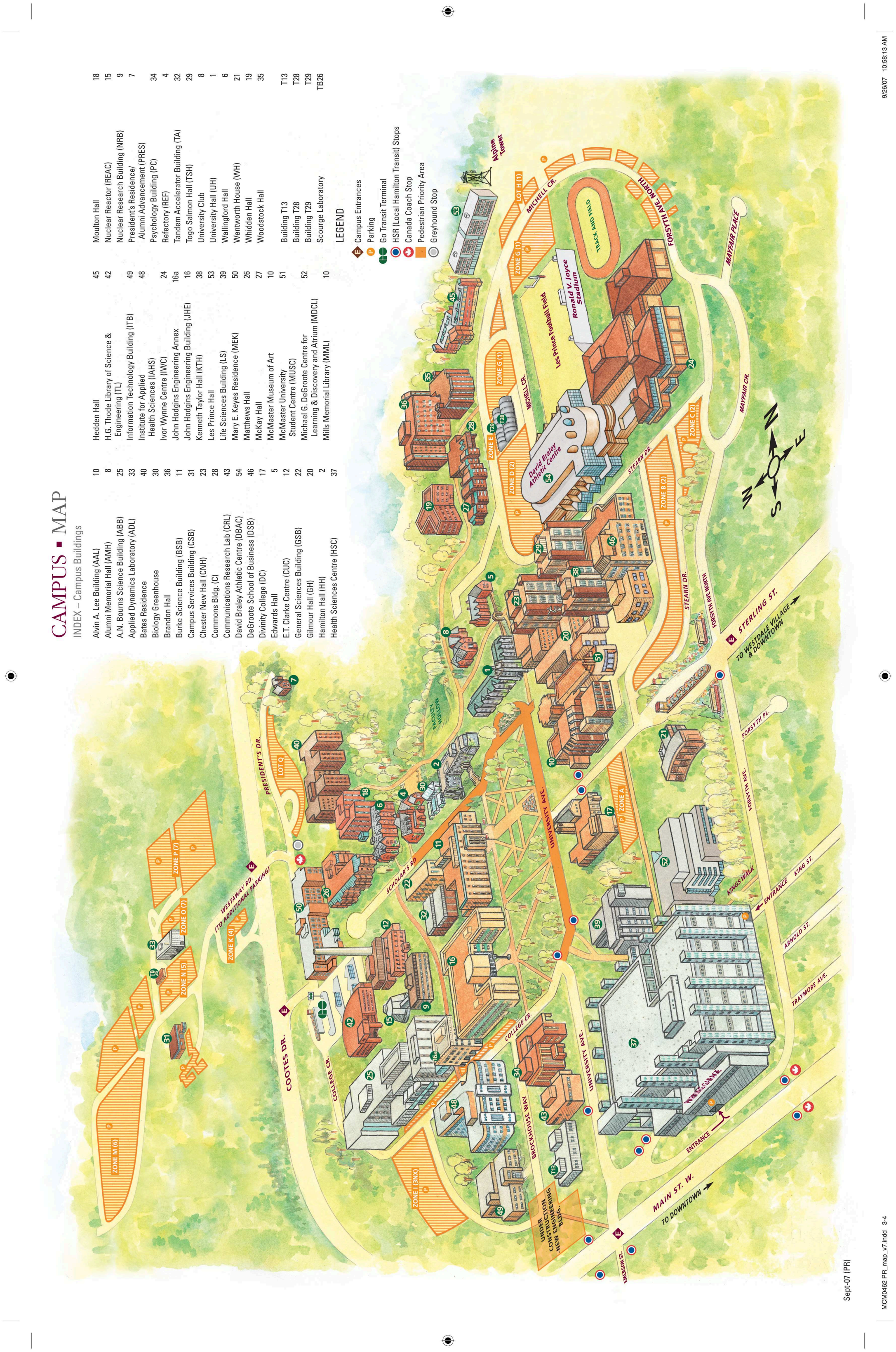
Maps

West Hamilton and Downtown

McMaster University Campus 1



McMaster University Campus 2



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