THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 223 — 22 July 2011 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

Thermal Structure of a Protoplanetary Disk around HD163296: A Study of Vertical Temperature Distribution by CO Emission Lines

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This paper presents observations of a protoplanetary disk around Herbig Ae star HD163296 in ^{12}CO (J=1–0), ^{12}CO (J=3–2), ^{13}CO (J=1–0), and ^{13}CO (J=3–2) emission lines. Double-peaked emission profiles originating from the rotating circumstellar disk were detected in all the lines. The disk parameters were estimated from model calculation in which the radial distribution of temperature or surface density inside the disk has a power-law form. The surface density should be sufficiently high so that the disk is optically thick for all the CO lines, as discussed in previous studies based on interferometric observations. The temperature and outer radius of the disk were also confirmed to be consistent with the previous results. Taking advantage of difference in position of the photosphere among the CO lines, we revealed temperature distribution in vertical direction. The temperature of ^{12}CO (J=3–2) emitting region is about twice higher than that of any other CO emitting region; the former is 58.5 ± 9.5 K while the latter is 31 ± 15 K at 100 AU from the central star, suggesting that there are at least two distinct temperature regions. The best fit temperature for ^{13}CO (J=1–0) that should trace the deepest region of the disk is even lower, implying that there is also a different temperature region in deep inside of the disk. Such vertical temperature distribution in a disk was identified both in T Tauri and Herbig Ae stars (e.g., DM Tau, AB Aur, and HD31648), and this should be a common feature in protoplanetary disks.

Accepted by PASJ

Rapid inward migration of planets formed by gravitational instability

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The observation of massive exoplanets at large separation ($\geq$ 10 AU) from their host star, like in the HR 8799 system, challenges theories of planet formation. A possible formation mechanism involves the fragmentation of massive self-gravitating discs into clumps. While the conditions for fragmentation have been extensively studied, little is known of the subsequent evolution of these giant planet embryos, in particular their expected orbital migration. Assuming a single planet has formed by fragmentation, we investigate its interaction with the gravitoturbulent disc it is embedded in. Two-dimensional hydrodynamical simulations are used with a simple prescription for the disc cooling. A steady gravitoturbulent disc is first set up, after which simulations are restarted including a planet with a range of masses approximately equal to the clump's initial mass expected in fragmenting discs. Planets rapidly migrate inwards, despite the stochastic kicks due to the turbulent density fluctuations. We show that the migration timescale is essentially that of type I migration, with the planets having no time to open a gap. In discs with aspect ratio ~ 0.1 at their forming location, planets with a mass comparable to, or larger than Jupiter's can migrate in as short as 10^4 years, that is, about 10 orbits at 100 AU. Massive planets formed at large separation from their star by gravitational instability are thus unlikely to stay in place, and should rapidly migrate towards the inner parts of protoplanetary discs, regardless of the planet mass.

Accepted by Monthly Notices of the Royal Astronomical Society

http://arxiv.org/abs/1106.0487

Will the starless cores in Chamaeleon I and III turn prestellar?

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Context. The nearby Chamaeleon molecular cloud complex is a good laboratory for studying the process of low-mass star formation because it consists of three clouds with very different properties. Chamaeleon III does not show any sign of star formation, while star formation has been very active in Chamaeleon I and may already be finishing.

Aims. Our goal is to determine whether star formation can proceed in Cha III by searching for prestellar cores, and to compare the results to our recent survey of Cha I.
Methods. We used the Large APEX Bolometer Array (LABOCA) to map Cha III in dust continuum emission at 870 μm. The map is compared with a 2MASS extinction map and decomposed with a multiresolution algorithm. The extracted sources are analyzed by carefully taking into account the spatial filtering inherent in the data reduction process.
Results. Twenty-nine sources are extracted from the 870 μm map, all of them starless. The estimated 90% completeness limit is 0.18 $M_\odot$. The starless cores are found down to a visual extinction of 1.9 mag, in marked contrast with other molecular clouds, including Cha I. Apart from this difference, the Cha III starless cores share very similar properties with those found in Cha I. They are less dense than those detected in continuum emission in other clouds by a factor of a few. At most two sources ($< 7\%$) have a mass larger than the critical Bonnor-Ebert mass, which suggests that the fraction of prestellar cores is very low, even lower than in Cha I ($< 17\%$). Only the most massive sources are candidate prestellar cores, in agreement with the correlation found earlier in the Pipe nebula. The mass distribution of the 85 starless cores of Cha I and III that are not candidate prestellar cores is consistent with a single power law down to the 90% completeness limit, with an exponent close to the Salpeter value. A fraction of the starless cores detected with LABOCA in Cha I and III may still grow in mass and become gravitationally unstable. Based on predictions of numerical simulations of turbulent molecular clouds, we estimate that at most 50% and 20% of the starless cores of Cha I and III, respectively, may form stars.
Conclusions. The LABOCA survey reveals that Cha III, and Cha I to some extent too, is a prime target to study the *formation* of prestellar cores, and thus the onset of star formation. Obtaining observational constraints on the duration of the core-building phase prior to gravitational collapse will be necessary to make further progress.

Accepted by Astronomy and Astrophysics

http://de.arxiv.org/abs/1106.5064

Molecular outflows and hot molecular cores in G24.78+0.08 at sub-arcsecond angular resolution

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Context. This study is part of a large project to study the physics of accretion and molecular outflows towards a selected sample of high-mass star-forming regions that show evidence of infall and rotation from previous studies.
Aims. We wish to make a thorough study at high-angular resolution of the structure and kinematics of the HMCs and corresponding molecular outflows in the high-mass star-forming region G24.78+0.08.
Methods. We carried out SMA and IRAM PdBI observations at 1.3 and 1.4 mm, respectively, of dust and of typical high-density and molecular outflow tracers with resolutions of $<1''$. Complementary IRAM 30-m ^{12}CO and ^{13}CO observations were carried out to recover the short spacing information of the molecular outflows.
Results. The millimeter continuum emission towards cores G24 A1 and A2 has been resolved into three and two cores, respectively, and named A1, A1b, A1c, A2, and A2b. All these cores are aligned in a southeast-northwest direction coincident with that of the molecular outflows detected in the region, which suggests a preferential direction for star formation in this region. The masses of the cores range from 7 to 22 $M_\odot$, and the rotational temperatures from 128 to 180 K. The high-density tracers have revealed the existence of two velocity components towards A1. One of them peaks close to the position of the millimeter continuum peak and of the HC HII region and is associated with the velocity gradient seen in CH_3CN towards this core, while the other one peaks southwest of core A1 and is not associated with any millimeter continuum emission peak. The position-velocity plots along outflow A and the ^{13}CO (2–1) averaged blueshifted and redshifted emission indicate that this outflow is driven by core A2. Core A1 apparently does not drive any outflow. The knotty appearance of the highly collimated outflow C and the ^{12}CO position-velocity plot suggest an episodic outflow, where the knots are made of swept-up ambient gas.

Accepted by A&A

http://arxiv.org/abs/1107.0314

Photoelectric cross-sections in protoplanetary disks

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We provide simple polynomial fits to the X-ray photoelectric cross-sections ($0.03 < E < 10$keV) for mixtures of gas and dust found in protoplanetary disks. Using the solar elemental abundances of Asplund et al. (2009) we treat the gas and dust components separately, facilitating the further exploration evolutionary processes such as grain settling and gain growth. We find that blanketing due to advanced grain-growth ($a_{max} > 1\mu m$) can reduce the X-ray opacity of dust appreciably at $E_X \sim 1$keV, coincident with the peak of typical T Tauri X-ray spectra. However, the reduction of dust opacity by dust settling, which is known to occur in protoplanetary disks, is probably a more significant effect. The absorption of 1-10keV X-rays is dominated by gas opacity once the dust abundance has been reduced to about 1% of its diffuse interstellar value. The gas disk establishes a floor to the opacity at which point X-ray transport becomes insensitive to further dust evolution. Our choice of fitting function follows that of Morrison & McCammon (1983), providing a degree of backward-compatibility.

Accepted by ApJ

Propagation of Ly-α in protoplanetary disks

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We study the role resonant scattering plays in the transport of Ly-α photons in accreting protoplanetary disk systems subject to varying degrees of dust settling. While the intrinsic stellar FUV spectrum of accreting T Tauri systems may already be dominated by a strong, broad Ly-α line (∼80% of the FUV luminosity), we find that resonant scattering further enhances the Ly-α density in the deep molecular layers of the disk. Ly-α is scattered downwards efficiently by the photodissociated atomic hydrogen layer that exists above the molecular disk. In contrast, FUV-continuum photons pass unimpeded through the photodissociation layer, and (forward-)scatter inefficiently off dust grains. Using detailed, adaptive grid Monte Carlo radiative transfer simulations we show that the resulting Ly-α/FUV-continuum photon density ratio is strongly stratified; FUV-continuum dominated in the photodissociation layer, and Ly-α dominated field in the molecular disk. The enhancement is greatest in the interior of the disk ($r \sim$ 1AU) but is also observed in the outer disk ($r \sim$ 100AU). The majority of the total disk mass is shown to be increasingly Ly-α dominated as dust settles towards the midplane.

Accepted by ApJ

The Coalsack near and far

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Context: The large Coalsack dark cloud is one of the most prominent southern starless clouds, which is even visible to the naked eye. Furthermore, it is one of the rare molecular clouds without clear signs of star formation.
Aims: We investigate the dynamical properties of the gas within the Coalsack.
Methods: The two highest extinction regions were mapped with the APEX telescope in ^{13}CO(2–1) comprising a region of ∼1 square degree.
Results: In addition to the well-known, nearby gas component around $-4\,\mathrm{km\,s^{-1}}$, we identified additional molecular gas components – in particular a second extended molecular cloud at a velocity of $\sim -30\,\mathrm{km\,s^{-1}}$ and an estimated distance of ∼3.1 kpc – that dominate the column density and visual extinction distributions in the northeastern part of the Coalsack. Although comprising $\sim 2600\,\mathrm{M_\odot}$, the mass of this distant cloud is distributed over an extent of ∼73 pc, much larger than typical high-mass infrared dark clouds. Its filamentary structure is consistent with a compressible gaseous self-gravitating cylinder, and its low mass per length indicates that it may be stable against gravitational collapse. We find barely any mid-infrared emission in archival MSX data, which is indicative of almost no star-formation activity in the near and far cloud complexes. The nearby clouds have narrow, almost thermal velocity dispersions with median values between 0.2 and $0.4\,\mathrm{km\,s^{-1}}$, which is also consistent with low star-formation activity. Only Tapia's Globule 2 exhibits a velocity dispersion increase toward the extinction peak and peak-velocity gradients over the core, which is indicative of a state of elevated dynamical properties.
Conclusions: The Coalsack is not one single coherent structure, but consists of several cloud complexes nearby as well as at several kpc distance. All studied clouds appear as starless low-turbulence regions that may not even collapse in the future. Only one globule exhibits more dynamical signatures and is a good candidate for present/future star formation.

Accepted by Astronomy & Astrophysics

http://www.mpia-hd.mpg.de/homes/beuther/papers.html

Herschel observations of the Herbig-Haro objects HH52-54

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Context. The emission from Herbig-Haro objects and supersonic molecular outflows is understood as cooling radiation behind shocks, initiated by a (proto-)stellar wind or jet. Within a given object, one often observes the occurrence of both dissociative (J-type) and non-dissociative (C-type) shocks, owing to the collective effects of internally varying shock velocities.
Aims. We are aiming at the observational estimation of the relative contribution to the cooling by CO and H_2O, as this provides decisive information for the understanding of the oxygen chemistry behind interstellar shock waves.
Methods. The high sensitivity of HIFI, in combination with its high spectral resolution capability, allows us to trace the H_2O outflow wings at unprecedented signal-to-noise. From the observation of spectrally resolved H_2O and CO lines in the HH52-54 system, both from space and from ground, we arrive at the spatial and velocity distribution of the molecular outflow gas. Solving the statistical equilibrium and non-LTE radiative transfer equations provides us with estimates of the physical parameters of this gas, including the cooling rate ratios of the species. The radiative transfer is based on an Accelerated Lambda Iteration code, where we use the fact that variable shock strengths, distributed along the front, are naturally implied by a curved surface.
Results. Based on observations of CO and H_2O spectral lines, we conclude that the emission is confined to the HH54 region. The quantitative analysis of our observations favours a ratio of the CO-to-H_2O-cooling-rate $\gg 1$. Formally, we derive the ratio $\Lambda(\mathrm{CO})/\Lambda(o\text{-}\mathrm{H_2O}) = 10$, which is in good agreement with earlier determination of 7 based on ISO-LWS observations. From the best-fit model to the CO emission, we arrive at an H_2O abundance close to 1×10^{-5}. The line profiles exhibit two components, one of which is triangular and another, which is a superposed, additional feature. This additional feature likely originates from a region smaller than the beam where the *ortho*-water abundance is smaller than in the quiescent gas.
Conclusions. Comparison with recent shock models indicate that a planar shock can not easily explain the observed line strengths and triangular line profiles. We conclude that the geometry can play an important role. Although abundances support a scenario where J-type shocks are present, higher cooling rate ratios than predicted by these type of shocks are derived.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/1106.5440

Evolution of the Solar Nebula. IX. Gradients in the Spatial Heterogeneity of the Short-Lived Radioisotopes ^{60}Fe and ^{26}Al and the Stable Oxygen Isotopes

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Short-lived radioisotopes (SLRI) such as ^{60}Fe and ^{26}Al were likely injected into the solar nebula in a spatially and temporally heterogeneous manner. Marginally gravitationally unstable (MGU) disks, of the type required to form gas giant planets, are capable of rapid homogenization of isotopic heterogeneity as well as of rapid radial transport of dust grains and gases throughout a protoplanetary disk. Two different types of new models of a MGU disk in orbit around a solar-mass protostar are presented. The first set has variations in the number of terms in the spherical harmonic solution for the gravitational potential, effectively studying the effect of varying the spatial resolution of the gravitational torques responsible for MGU disk evolution. The second set explores the effects of varying the initial minimum value of the Toomre Q stability parameter, from values of 1.4 to 2.5, i.e., toward increasingly less unstable disks. The new models show that the basic results are largely independent of both sets of variations. MGU disk models robustly result in rapid mixing of initially highly heterogeneous distributions of SLRIs to levels of $\sim 10\%$ in both the inner (< 5 AU) and outer (> 10 AU) disk regions, and to even lower levels ($\sim 2\%$) in intermediate regions, where gravitational torques are most effective at mixing. These gradients should have cosmochemical implications

for the distribution of SLRIs and stable oxygen isotopes contained in planetesimals (e.g., comets) formed in the giant planet region (~ 5 to ~ 10 AU) compared to those formed elsewhere.

Accepted by ApJ

http://www.dtm.ciw.edu/users/boss/ftp/nebulaix.pdf

A survey for near-infrared H_2 emission in Herbig Ae/Be stars: emission from the outer disks of HD 97048 and HD 100546

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We report on a sensitive search for H_2 1-0 S(1), 1-0 S(0) and 2-1 S(1) ro-vibrational emission at 2.12, 2.22 and 2.25 μm in a sample of 15 Herbig Ae/Be stars employing CRIRES, the ESO-VLT near-infrared high-resolution spectrograph, at R$\sim$90,000. We report the detection of the H_2 1-0 S(1) line toward HD 100546 and HD 97048. In the other 13 targets, the line is not detected. The H_2 1-0 S(0) and 2-1 S(1) lines are undetected in all sources. These observations are the first detection of near-IR H_2 emission in HD 100546. The H_2 1-0 S(1) lines observed in HD 100546 and HD 97048 are observed at a velocity consistent with the rest velocity of both stars, suggesting that they are produced in the circumstellar disk. In HD 97048, the emission is spatially resolved and it is observed to extend at least up to 200 AU from the star. We report an increase of one order of magnitude in the H_2 1-0 S(1) line flux with respect to previous measurements taken in 2003 for this star, which suggests line variability. In HD 100546 the emission is tentatively spatially resolved and may extend at least up to 50 AU from the star. Modeling of the H_2 1-0 S(1) line profiles and their spatial extent with flat keplerian disks shows that most of the emission is produced at a radius larger than 5 AU. Upper limits to the H_2 1-0 S(0)/ 1-0 S(1) and H_2 2-1 S(1)/1-0 S(1) line ratios in HD 97048 are consistent with H_2 gas at T>2000 K and suggest that the emission observed may be produced by X-ray excitation. The upper limits for the line ratios for HD 100546 are inconclusive. Because the H_2 emission is located at large radii, for both sources a thermal emission scenario (i.e., gas heated by collisions with dust) is implausible. We argue that the observation of H_2 emission at large radii may be indicative of an extended disk atmosphere at radii > 5 AU. This may be explained by a hydrostatic disk in which gas and dust are thermally decoupled or by a disk wind caused by photoevaporation.

Accepted by A&A.

http://arxiv.org/abs/1107.1994

Dissecting a hot molecular core: The case of G31.41+0.31

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Context The role of disks in the formation of high-mass stars is still a matter of debate but the detection of circumstellar disks around O-type stars would have a profound impact on high-mass star formation theories.
Aims We made a detailed observational analysis of a well known hot molecular core lying in the high-mass star-forming

region G31.41+0.31. This core is believed to contain deeply embedded massive stars and presents a velocity gradient that has been interpreted either as rotation or as expansion, depending on the authors. Our aim was to shed light on this question and possibly prepare the ground for higher resolution ALMA observations which could directly detect circumstellar disks around the embedded massive stars.
Methods Observations at sub-arcsecond resolution were performed with the Submillimeter Array in methyl cyanide, a typical hot molecular core tracer, and ^{12}CO and ^{13}CO, well known outflow tracers. We also obtained sensitive continuum maps at 1.3 mm.
Results Our findings confirm the existence of a sharp velocity gradient across the core, but cannot confirm the existence of a bipolar outflow perpendicular to it. The improved angular resolution and sampling of the uv plane allow us to attain higher quality channel maps of the CH_3CN lines with respect to previous studies and thus significantly improve our knowledge of the structure and kinematics of the hot molecular core.
Conclusions While no conclusive argument can rule out any of the two interpretations (rotation or expansion) proposed to explain the velocity gradient observed in the core, in our opinion the observational evidence collected so far indicates the rotating toroid as the most likely scenario. The outflow hypothesis appears less plausible, because the dynamical time scale is too short compared to that needed to form species such as CH_3CN, and the mass loss and momentum rates estimated from our measurements appear too high.

Accepted by Astron. Astrophys.

http://www.arcetri.astro.it/~starform/preprints/cesa_22.pdf

Radio Imaging of the NGC 1333 IRAS 4A Region: Envelope, Disks, and Outflows of a Protostellar Binary System

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The NGC 1333 IRAS 4A protobinary was observed in the 1.3 cm and 6.9 mm continuum and the ammonia and SiO lines, with an angular resolution of about 0.4 arcseconds. The continuum maps show the circumstellar structures of the two protostars, A1 and A2. The A1 system is brighter and more massive than the A2 system. The ratio of mass, including dense gas and protostar, is about 6. The properties of the circumstellar disks and outflows suggest that A1 may be younger than A2. The deflected part of the northeastern jet of A2 is bright in the SiO line, and the distance between the brightest peak and deflection point suggests that the enhancement of SiO takes about 100 yr after the collision with a dense core. The ammonia maps show a small structure that seems to be a part of the obstructing core. The outflow properties were studied by comparing interferometric maps of SiO, ammonia, formaldehyde, and HCN lines. Their overall structures agree well, suggesting that these species are excited by the same mechanism. However, the intensity distributions show that SiO is chemically unique. SiO may be directly linked to the primary jet while the other species may be tracing the entrained ambient gas.

Accepted by PASJ

http://arxiv.org/abs/1107.3877

Clues to the star formation in NGC 346 across time and space

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We have studied the properties of the stellar populations in the field of the NGC 346 cluster in the Small Magellanic

Cloud, using the results of a novel self-consistent method that provides a reliable identification of pre-main sequence (PMS) objects actively undergoing mass accretion, regardless of their age. The 680 identified bona-fide PMS stars show a bimodal age distribution, with two roughly equally numerous populations peaked respectively at $\sim 1\,$Myr, and $\sim 20\,$Myr. We use the age and other physical properties of these PMS stars to study how star formation has proceeded across time and space in NGC 346. We find no correlation between the locations of young and old PMS stars, nor do we find a correspondence between the positions of young PMS stars and those of massive OB stars of similar age. Furthermore, the mass distribution of stars with similar age shows large variations throughout the region. We conclude that, while on a global scale it makes sense to talk about an initial mass function, this concept is not meaningful for individual star-forming regions. An interesting implication of the separation between regions where massive stars and low-mass objects appear to form is that high-mass stars might not be "perfect" indicators of star formation and hence a large number of low-mass stars formed elsewhere might have so far remained unnoticed. For certain low surface density galaxies this way of preferential low-mass star formation may be the predominant mechanism, with the consequence that their total mass as derived from the luminosity may be severely underestimated and that their evolution is not correctly understood.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/1106.5780

Photometric determination of the mass accretion rates of pre-main sequence stars. II. NGC346 in the Small Magellanic Cloud

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We have studied the properties of the stellar populations in the field of the NGC 346 cluster in the Small Magellanic Cloud, using a novel self-consistent method that allows us to reliably identify pre-main sequence (PMS) objects actively undergoing mass accretion, regardless of their age. The method does not require spectroscopy and combines broad-band V and I photometry with narrow-band $H\alpha$ imaging to identify all stars with excess Hα emission and derive the accretion luminosity $L_{\rm acc}$ and mass accretion rate $\dot{M}_{\rm acc}$ for all of them. The application of this method to existing HST/ACS photometry of the NGC 346 field has allowed us to identify and study 680 bona-fide PMS stars with masses from $\sim 0.4\,{\rm M}_\odot$ to $\sim 4\,{\rm M}_\odot$ and ages in the range from $\sim 1\,$Myr to $\sim 30\,$Myr. Previous investigations of this region, based on the same data, had identified young ($\sim 3\,$Myr old) candidate PMS stars on the basis of their broad-band colours. In this study we show that there are at least two, almost equally numerous, young populations with distinct ages of respectively ~ 1 and ~ 20 Myr. We provide for all of them accurate physical parameters.

We take advantage of the unprecedented size of our PMS sample and of its spread in mass and age to study the evolution of the mass accretion rate as a function of stellar parameters. We find that, regardless of stellar mass, the mass accretion rate decreases with roughly the square root of the age, or about three times slower than predicted by current models of viscous disc evolution, and that more massive stars have systematically higher mass accretion rate in proportion to their mass. A multivariate linear regression fit reveals that $\log \dot{M}_{\rm acc} \simeq -0.6 \log t + \log m + c$, where t is the age of the star, m its mass and c a quantity that is higher at lower metallicity. This result is consistent with measurements of the mass accretion rate in the 30 Dor region and in the Milky Way and suggests that longer duration for mass accretion could be related to lower metallicity. The high mass accretion rates that we find suggest that a considerable amount of mass is accreted during the PMS phase, of order $\sim 0.2\,{\rm M}_\odot$ or possibly $\sim 20\,\%$ of the final mass for stars with mass $m < 1\,{\rm M}_\odot$ if their discs are eroded by $20\,$Myr, i.e. before they reach the main sequence. Therefore, PMS evolutionary models that do not account for this effect will systematically underestimate the true age when compared with the observations.

Accepted by The Astrophysical Journal
http://arxiv.org/abs/1106.1738

Star formation in 30 Doradus

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Using observations obtained with the Wide Field Camera 3 (WFC3) on board the *Hubble Space Telescope* (HST), we have studied the properties of the stellar populations in the central regions of 30 Dor, in the Large Magellanic Cloud. The observations clearly reveal the presence of considerable differential extinction across the field. We characterise and quantify this effect using young massive main sequence stars to derive a statistical reddening correction for most objects in the field. We then search for pre-main sequence (PMS) stars by looking for objects with a strong ($> 4\,\sigma$) Hα excess emission and find about 1 150 of them over the entire field. Comparison of their location in the Hertzsprung–Russell diagram with theoretical PMS evolutionary tracks for the appropriate metallicity reveals that about one third of these objects are younger than ~ 4 Myr, compatible with the age of the massive stars in the central ionising cluster R 136, whereas the rest have ages up to ~ 30 Myr, with a median of ~ 12 Myr. This indicates that star formation has proceeded over an extended period of time, although we cannot discriminate between an extended episode and a series of short and frequent bursts that are not resolved in time. While the younger PMS population preferentially occupies the central regions of the cluster, older PMS objects are more uniformly distributed across the field and are remarkably few at the very centre of the cluster. We attribute this latter effect to photoevaporation of the older circumstellar discs caused by the massive ionising members of R 136.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/1106.2801

Feedback Regulated Star Formation: Implications for the Kennicutt-Schmidt Law

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We derive a metallicity dependent relation between the surface density of the star formation rate (Σ_{SFR}) and the gas surface density (Σ_g) in a feedback regulated model of star formation in galactic disks. In this model, star formation occurs in gravitationally bound protocluster clumps embedded in larger giant molecular clouds with the protocluster clump mass function following a power law function with a slope of -2. Metallicity dependent feedback is generated by the winds of OB stars ($M \gtrsim 5$ M$_\odot$) that form in the clumps. The quenching of star formation in clumps of decreasing metallicity occurs at later epochs due to weaker wind luminosities, thus resulting in higher final star formation efficiencies (SFE_{exp}). By combining SFE_{exp} with the timescales on which gas expulsion occurs, we derive the metallicity dependent star formation rate per unit time in this model as a function of Σ_g. This is combined with the molecular gas fraction in order to derive the global dependence of Σ_{SFR} on Σ_g. The model reproduces very well the observed star formation laws extending from low gas surface densities up to the starburst regime. Furthermore, our results show a dependence of Σ_{SFR} on metallicity over the entire range of gas surface densities in contrast to other models, and can also explain part of the scatter in the observations. We provide a tabulated form of the star formation laws that can be easily incorporated into numerical simulations or semi-analytical models of galaxy formation and evolution.

Accepted by Astrophysical Journal Letters

http://arxiv.org/abs/1106.3282

Warm H_2O and OH disk emission in V1331 Cyg

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We present high resolution ($R = 24,000$) L-band spectra of the young intermediate mass star V1331 Cyg obtained with NIRSPEC on the Keck II telescope. The spectra show strong, rich emission from water and OH that likely arises from the warm surface region of the circumstellar disk. We explore the use of the new BT2 (Barber et al. 2006) water line list in fitting the spectra, and we find that it does a much better job than the well-known HITRAN (Rothman et al. 1998) water line list in the observed wavelength range and for the warm temperatures probed by our data. By comparing the observed spectra with synthetic disk emission models, we find that the water and OH emission lines have similar widths (FWHM $\simeq 18\,\mathrm{km\,s^{-1}}$). If the line widths are set by disk rotation, the OH and water emission lines probe a similar range of disk radii in this source. The water and OH emission are consistent with thermal emission for both components at a temperature $\sim 1500\,$K. The column densities of the emitting water and OH are large, $\sim 10^{21}$ cm^{-2} and $\sim 10^{20}$ cm^{-2}, respectively. Such a high column density of water is more than adequate to shield the disk midplane from external UV irradiation in the event of complete dust settling out of the disk atmosphere, enabling chemical synthesis to continue in the midplane despite a harsh external UV environment. The large OH-to-water ratio is similar to expectations for UV irradiated disks (e.g., Bethell and Bergin 2009), although the large OH column density is less easily accounted for.

Accepted by ApJ

http://arxiv.org/abs/1106.5173

Multi-wavelength modeling of the spatially resolved debris disk of HD 107146

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Aims: We aim to constrain the location, composition, and dynamical state of planetesimal populations and dust around the young, sun-like (G2 V) star HD 107146.
Methods: We consider coronagraphic observations obtained with the Advanced Camera for Surveys (*HST*/ACS) onboard the *Hubble Space Telescope* (*HST*) in broad V ($\lambda_c \approx 0.6\,\mu$m) and broad I ($\lambda_c \approx 0.8\,\mu$m) filters, a resolved 1.3 mm map obtained with the *Combined Array for Research in Millimeter-Wave Astronomy* (*CARMA*), *Spitzer*/IRS low resolution spectra in the range of $7.6\,\mu$m to $37.0\,\mu$m, and the spectral energy distribution (SED) of the object at wavelengths ranging from $3.5\,\mu$m to 3.1 mm. We complement these data with new coronagraphic high resolution observations of the debris disk using the Near Infrared Camera and Multi-Object Spectrometer (*HST*/NICMOS) aboard the *HST* in the F110W filter ($\lambda_c \approx 1.1\,\mu$m). The SED and images of the disk in scattered light as well as in thermal reemission are combined in our modeling using a parameterized model for the disk density distribution and optical properties of the dust.
Results: A detailed analytical model of the debris disk around HD 107146 is presented that allows us to reproduce the almost entire set of spatially resolved and unresolved multi-wavelength observations. Considering the variety of complementary observational data, we are able to break the degeneracies produced by modeling SED data alone. We find the disk to be an extended ring with a peak surface density at 131 AU. Furthermore, we find evidence for an additional, inner disk probably composed of small grains released at the inner edge of the outer disk and moving inwards due to Poynting-Robertson drag. A birth ring scenario (i.e., a more or less broad ring of planetesimals creating the dust disk trough collisions) is found to be the most likely explanation of the ringlike shape of the disk.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/1107.1057

A rotating molecular disk toward IRAS 18162-2048, the exciting source of HH 80-81

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We present several molecular line emission arcsec and subarcsec observations obtained with the Submillimeter Array (SMA) in the direction of the massive protostar IRAS 18162–2048, the exciting source of HH 80–81.
The data clearly indicates the presence of a compact (radius∼425–850 AU) SO_2 structure, enveloping the more compact (radius<150 AU) 1.4 millimeter dust emission (reported in a previous paper). The emission spatially coincides with the position of the prominent thermal radio jet which terminates at the HH 80–81 and HH 80N Herbig–Haro objects.

Furthermore, the molecular emission is elongated in the direction perpendicular to the axis of the thermal radio jet, suggesting a disk–like structure. We derive a total dynamic mass (disk–like structure and protostar) of 11–15 $M_\odot$. The SO_2 spectral line data also allow us to constrain the structure temperature between 120–160 K and the volume density $> 2 \times 10^9$ cm^{-3}. We also find that such a rotating flattened system could be unstable due to gravitational disturbances.
The data from $C^{17}O$ line emission show a dense core within this star–forming region. Additionally, the H_2CO and the SO emissions appear clumpy and trace the disk–like structure, a possible interaction between a molecular core and the outflows, and in part, the cavity walls excavated by the thermal radio jet.

Accepted by AJ, 07-15-2011

Unveiling Sources of Heating in the Vicinity of the Orion BN/KL Hot Core as Traced by Highly Excited Inversion Transitions of Ammonia

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Using the Expanded Very Large Array, we have mapped the vicinity of the Orion BN/KL Hot Core with sub-arcsecond angular resolution in seven metastable inversion transitions of ammonia (NH_3): (J,K)=(6,6) to (12,12). This emission comes from levels up to 1500 K above the ground state, enabling identification of source(s) responsible for heating the region. We used this multi-transition dataset to produce images of the rotational/kinetic temperature (T_{rot}/T_{kin}) and the column density N_{col} of NH_3 for ortho and para species separately and on a position-by-position basis. We find T_{rot} and N_{col} in the range 160−490 K and $(1-4)\times10^{17}$ cm^{-2}, respectively. Our spatially-resolved images show that the highest (column) density and hottest gas is found in a northeast-southwest elongated ridge to the southeast of Source I. We have also measured the ortho-para ratio of ammonia, estimated to vary in the range 0.9-1.6. Enhancement of ortho with respect to para and the offset of hot NH_3 emission peaks from known (proto)stellar sources provide evidence that the NH_3 molecules have been released from dust grains into the gas-phase through the passage of shocks and not by stellar radiation. We propose that the combined effect of Source I's proper motion and its low-velocity outflow impinging on a pre-existing dense medium is responsible for the excitation of NH_3 and the Orion Hot Core. Finally, we found for the first time evidence of a slow (~ 5 km s^{-1}) and compact ($\sim$1000 AU) outflow towards IRc7.

Accepted by ApJ Letters (EVLA Special Issue)

http://arxiv.org/abs/1106.4202

Mid-infrared interferometry of the massive young stellar object NGC 2264 IRS 1

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The optically invisible infrared-source NGC 2264 IRS 1 lying north of the Cone Nebula is thought to be a massive young stellar object (10 Msun). Although strong infrared excess clearly shows that the central object is surrounded by large amounts of circumstellar material, no information about the spatial distribution of this circumstellar material has been available until now. We used the ESO Very Large Telescope Interferometer to perform long-baseline interferometric observations of NGC 2264 IRS 1 in the mid-infrared regime. Our observations resolve the circumstellar material around NGC 2264 IRS 1, provide the first direct measurement of the angular size of the mid-infrared emission, and yield direct constraints on the spatial distribution of the dust. We analyze the spectrally dispersed interferometric data taken with MIDI at two different position angles and baseline lengths. We use different approaches (a geometrical model, a

temperature-gradient model, and radiative transfer models) to jointly model the observed interferometric visibilities and the spectral energy distribution. The derived visibility values between 0.02 and 0.3 show that the mid-infrared emission is clearly resolved. The characteristic size of the MIR-emission region is 30-60 AU; this value is typical for other YSOs with similar or somewhat lower luminosities. A comparison of the sizes for the two position angles shows a significant elongation of the dust distribution. Simple spherical envelope models are therefore inconsistent with the data. The radiative transfer modeling of our data suggests that we observe a geometrically thin and optically thick circumstellar disk with a mass of about 0.1 Msun. Our modeling indicates that NGC 2264 IRS 1 is surrounded by a flat circumstellar disk that has properties similar to disks typically found around lower-mass young stellar objects. This result supports the assumption that massive young stellar objects form via accretion from circumstellar disks.

Accepted by A&A

A Correlation Between Surface Densities of Young Stellar Objects and Gas in Eight Nearby Molecular Clouds

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We report the discovery and characterization of a power law correlation between the local surface densities of Spitzer-identified, dusty young stellar objects and the column density of gas (as traced by near-IR extinction) in eight molecular clouds within 1 kpc and with 100 or more known YSOs. This correlation, which appears in data smoothed over size scales of $\sim$1 pc, varies in quality from cloud to cloud; those clouds with tight correlations, MonR2 and Ophiuchus, are fit with power laws of slope 2.67 and 1.87, respectively. The spread in the correlation is attributed primarily to local gas disruption by stars that formed there or to the presence of very young sub-regions at the onset of star formation. We explore the ratio of the number of Class II to Class I sources, a proxy for the star formation age of a region, as a function of gas column density; this analysis reveals a declining Class II to Class I ratio with increasing column density. We show that the observed star-gas correlation is consistent with a star formation law where the star formation rate per area varies with the gas column density squared. We also propose a simple picture of thermal fragmentation of dense gas in an isothermal, self-gravitating layer as an explanation for the power law. Finally, we briefly compare the star gas correlation and its implied star formation law with other recent proposed of star formation laws at similar and larger size scales from nearby star forming regions.

Accepted by ApJ

Resolved Submillimeter Observations of the HR 8799 and HD 107146 Debris Disks

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We present 880 μm Submillimeter Array observations of the debris disks around the young solar analogue HD 107146 and the multiple-planet host star HR 8799, at an angular resolution of 3" and 6", respectively. We spatially resolve the inner edge of the disk around HR 8799 for the first time. While the data are not sensitive enough (with rms noise of 1 mJy) to constrain the system geometry, we demonstrate that a model by Su et al. (2009) based on the spectral energy distribution (SED) with an inner radius of 150 AU predicts well the spatially resolved data. Furthermore, by modeling simultaneously the SED and visibilities, we demonstrate that the dust is distributed in a broad (of order 100 AU) annulus rather than a narrow ring. We also model the observed SED and visibilities for the HD 107146 debris disk and generate a model of the dust emission that extends in a broad band between 50 and 170 AU from the star. We perform an *a posteriori* comparison with existing 1.3 mm CARMA observations and demonstrate that a smooth, axisymmetric model reproduces well all of the available millimeter-wavelength data.

Accepted by The Astrophysical Journal

http://astro.berkeley.edu/∼mhughes/download/hughes_debris.pdf

Variability of the SiO thermal line emission toward the young L1448-mm outflow.

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The detection of narrow SiO thermal emission toward young outflows has been proposed to be a signature of the magnetic precursor of C-shocks. Recent modeling of the SiO emission across C-shocks predicts variations in the SiO line intensity and line shape at the precursor and intermediate-velocity regimes in only few years. We present high-angular resolution ($3.8'' \times 3.3''$) images of the thermal SiO J=2→1 emission toward the L1448-mm outflow in two epochs (November 2004-February 2005, March-April 2009). Several SiO condensations have appeared at intermediate velocities (20-50 $\mathrm{km\,s^{-1}}$) toward the red-shifted lobe of the outflow since 2005. Toward one of the condensations (clump D), systematic differences of the dirty beams between 2005 and 2009 could be responsible for the SiO variability. At higher velocities (50-80 $\mathrm{km\,s^{-1}}$), SiO could also have experienced changes in its intensity. We propose that the SiO variability toward L1448-mm is due to a real SiO enhancement by young C-shocks at the internal working surface between the jet and the ambient gas. For the precursor regime (5.2-9.2 $\mathrm{km\,s^{-1}}$), several narrow and faint SiO components are detected. Narrow SiO tends to be compact, transient and shows elongated (bow-shock) morphologies perpendicular to the jet. We speculate that these features are associated with the precursor of C-shocks appearing at the interface of the new SiO components seen at intermediate velocities.

Accepted by Astrophysical Journal

http://arxiv.org/abs/1107.2067

Confirmation of the VeLLO L1148-IRS: Star Formation at very low (Column) Density

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We report the detection of a compact ($\sim 5''$; about 1800 AU projected size) CO outflow from L1148–IRS. This confirms that this Spitzer source is physically associated with the nearby ($\approx$ 325 pc) L1148 dense core. Radiative transfer modeling suggests an internal luminosity of 0.08 to 0.13 $L_{\odot}$. This validates L1148–IRS as a Very Low Luminosity Object (VeLLO; $L \leq 0.1\,L_{\odot}$). The L1148 dense core has unusually low densities and column densities for a star–forming core. It is difficult to understand how L1148–IRS might have formed under these conditions. Independent of the exact final mass of this VeLLO (which is likely $< 0.24\,M_{\odot}$), L1148–IRS and similar VeLLOs might hold some clues about the isolated formation of brown dwarfs.

Accepted by MNRAS

http://arxiv.org/abs/1106.2545

Dynamical Friction in a Gas: The Subsonic Case

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We study the force of dynamical friction acting on a gravitating point mass that travels through an extended, isothermal gas. This force is well established in the hypersonic limit, but remains less understood in the subsonic regime. Using perturbation theory, we analyze the changes in gas velocity and density far from the mass. We show analytically that the steady-state friction force is Mdot*V, where Mdot is the mass accretion rate onto an object moving at speed V. It follows that the speed of an object experiencing no other forces declines as the inverse square of its mass. Using a modified version of the classic Bondi-Hoyle interpolation formula for Mdot as a function of V, we derive an analytic expression for the friction force. This expression also holds when mass accretion is thwarted, e.g. by a wind, as long as the wind-cloud interaction is sufficiently confined spatially. Our result should find application in a number of astrophysical settings, such as the motion of galaxies through intracluster gas.

Accepted by MNRAS

http://arxiv.org/abs/1106.4820

Massive star formation around I05345+3157 – I. The dense gas

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We present observations of the intermediate to massive star-forming region I05345+3157 using the molecular line tracer CS$(2-1)$ with CARMA to reveal the properties of the dense gas cores. Seven gas cores are identified in the integrated intensity map of CS$(2-1)$. Among these, core 1 and core 3 have counterparts in the $\lambda = 2.7$ mm continuum data. We suggest that core 1 and core 3 are star-forming cores that may already or will very soon harbor young massive protostars. The total masses of core 1 estimated from the LTE method and dust emission by assuming a gas-to-dust ratio are 5 ± 1 $M_\odot$ and 18 ± 6 $M_\odot$, and that of core 3 are 15 ± 7 $M_\odot$ and 11 ± 3 $M_\odot$. The spectrum of core 3 shows blue-skewed self-absorption, which suggests gas infall – a collapsing core. The observed broad linewidths of the seven gas cores indicate non-thermal motions. These non-thermal motions can be interactions with nearby outflows or due to the initial turbulence; the former is observed, while the role of initial turbulence is less certain. Finally, the virial masses of the gas cores are larger than the LTE masses, which for a bound core implies a requirement on the external pressure of $\sim 10^8$ K cm^{-3}. The cores have the potential to further form massive stars.

Accepted by MNRAS

http://arxiv.org/abs/1107.1224

Clustered Star Formation in Magnetic Clouds: Properties of Dense Cores Formed in Outflow-Driven Turbulence

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We investigate the physical properties of dense cores formed in turbulent, magnetized, parsec-scale clumps of molecular clouds, using three-dimensional numerical simulations that include protostellar outflow feedback. The dense cores are identified in the simulated density data cube through a clumpfind algorithm. We find that the core velocity dispersion does not show any clear dependence on the core size, in contrast to Larson's linewidth-size relation, but consistent with recent observations. In the absence of a magnetic field, the majority of the cores have supersonic velocity dispersions. A moderately-strong magnetic field reduces the dispersion to a subsonic or at most transonic value typically. Most of the cores are out of virial equilibrium, with the external pressure dominating the self-gravity. The implication is that the core evolution is largely controlled by the outflow-driven turbulence. Even an initially-weak magnetic field can retard star formation significantly, because the field is amplified by the outflow-driven turbulence to an equipartition strength, with the distorted field component dominating the uniform one. In contrast, for a moderately-strong field, the uniform component remains dominant. Such a difference in the magnetic structure is evident in our simulated polarization maps of dust thermal emission; it provides a handle on the field strength. Recent polarization measurements show that the field lines in cluster-forming clumps are spatially well-ordered. It is indicative of a moderately-strong, dynamically important, field which, in combination with outflow feedback, can keep the rate of star formation in embedded clusters at the observationally-inferred, relatively-slow rate of several percent per free-fall time.

Accepted by Astrophysical Journal

Search of HH Objects and Emission-Line Stars in Star Forming Regions. VII. Herbig-Haro Objects in the Vicinity of GM 2-41 Nebula.

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Five new HH objects (HH 1036 -1040) were revealed in the area 14 x 14 arcmin in the vicinity of GM 2-41 nebula in the central part of the HII region DR 15, located in the southern part of the Cyg OB2 association. Four of them have complex structure, resembling the HH-flows. In HH 1036 on the archival images of Spitzer database the infrared emission of molecular hydrogen was detected. Also two new infrared nebulae, illuminated by very red young stellar objects, were found.

Accepted by Astrophysics

Search of HH Objects and Emission-Line Stars in Star Forming Regions. VIII. Hα emission stars around the GM 2-41 Nebula.

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43 stars with Hα emission in the area 14 x 14 arcmin around the GM 2-41 nebula, located in the HII region DR 15 in the southern part of the Cyg OB2 association, were revealed by the method of slitless spectroscopy. 30 objects are new ones. On the basis of VI and JHK photometric data the majority of these objects are classified as low-mass PMS objects with F7 - M3 spectral type and about 1 Myr age. The distribution of the emission stars is not uniform. They form two main groups which by coordinates coincide with the UCHII G0.79+0.3 and G79.2+0.4 regions.

Accepted by Astrophysics

A highly efficient measure of mass segregation in star clusters

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Investigations of mass segregation are of vital interest for the understanding of the formation and dynamical evolution of stellar systems on a wide range of spatial scales. Our method is based on the minimum spanning tree (MST) that serves as a geometry-independent measure of concentration. Compared to previous such approaches we obtain a significant refinement by using the geometrical mean as an intermediate-pass. It allows the detection of mass segregation with much higher confidence and for much lower degrees of mass segregation than other approaches. The method shows in particular very clear signatures even when applied to small subsets of the entire population. We confirm with high significance strong mass segregation of the five most massive stars in the Orion Nebula Cluster (ONC). Our method is the most sensitive general measure of mass segregation so far and provides robust results for both data from simulations and observations. As such it is ideally suited for tracking mass segregation in young star clusters and to investigate the long standing paradigm of primordial mass segregation by comparison of simulations and observations.

Accepted by A&A

http://arxiv.org/abs/1107.1842

Numerical convergence in self-gravitating disc simulations: initial conditions and edge effects

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We study the numerical convergence of hydrodynamical simulations of self-gravitating accretion discs, in which a simple cooling law is balanced by shock heating. It is well-known that there exists a critical cooling time scale for which shock heating can no longer compensate for the energy losses, at which point the disc fragments. The numerical convergence of previous results of this critical cooling time scale was questioned recently using Smoothed Particle Hydrodynamics (SPH). We employ a two-dimensional grid-based code to study this problem, and find that for smooth initial conditions, fragmentation is possible for slower cooling as the resolution is increased, in agreement with recent SPH results. We show that this non-convergence is at least partly due to the creation of a special location in the disc, the boundary between the turbulent and the laminar region, when cooling towards a gravito-turbulent state. Converged results appear to be obtained in setups where no such sharp edges appear, and we then find a critical cooling time scale of 4 Ω^{-1}, where Ω is the local angular velocity.

Accepted by MNRAS

http://arxiv.org/abs/1106.4425

Probing the initial conditions of high-mass star formation — II. Fragmentation, stability, and chemistry towards high–mass star–forming regions G29.96−0.02 and G35.20−1.74

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Most work on high-mass star formation has focused on observations of young massive stars in protoclusters. Very little is known about the preceding stage. Here, we present a new high-resolution study of pre-protocluster regions in tracers exclusively probing the coldest and dense gas (NH_2D). The two target regions G29.96−0.02 and G35.20−1.74 (W48) are drawn from the SCAMPS project, which searches for pre-protoclusters near known ultracompact HII regions. We used our data to constrain the chemical, thermal, kinematic, and physical conditions (i.e., densities) in G29.96e and G35.20w. NH_3, NH_2D, HCO^+, and continuum emission were mapped using the VLA, PdBI, and BIMA. In particular, NH_2D is a unique tracer of cold, precluster gas at high densities, while NH_3 traces both the cold and warm gas of modest-to-high densities. In G29.96e, Spitzer images reveal two massive filaments, one of them in extinction (infrared dark cloud). Dust and line observations reveal fragmentation into multiple massive cores strung along filamentary structures. Most of these are cold (< 20 K), dense ($> 10^5$ cm^{-3}) and highly deuterated ($[NH_2D/NH_3] > 6\%$). In particular, we observe very low line widths in NH_2D (FWHM ≤ 1 km s^{-1}). These are very narrow lines that are unexpected towards a region forming massive stars. Only one core in the center of each filament appears to be forming massive stars (identified by the presence of masers and massive outflows); however, it appears that only a few such stars are currently forming (i.e., just a single Spitzer source per region). These multi-wavelength, high-resolution observations of high-mass pre-protocluster regions show that the target regions are characterized by (*i*) turbulent Jeans fragmentation of massive clumps into cores (from a Jeans analysis); (*ii*) cores and clumps that are "over-bound/subvirial", i.e. turbulence is too weak to support them against collapse, meaning that (*iii*) some models of monolithic cloud collapse are quantitatively inconsistent with data; (*iv*) accretion from the core onto a massive star, which can (for observed core sizes and velocities) be sustained by accretion of envelope material onto the core, suggesting that (similar to competitive accretion scenarios) the mass reservoir for star formation is not necessarily limited to the natal core; (*v*) high deuteration ratios ($[NH_2D/NH_3] > 6\%$), which make the above discoveries possible; (*vi*) and the destruction of NH_2D toward embedded stars.

Accepted by Astronomy & Astrophysics, Volume 530, article 118

http://adsabs.harvard.edu/abs/2011A%26A...530A.118P

EVLA Observations of the Barnard 5 Star-Forming Core: Embedded Filaments Revealed

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We present a $\sim 6.5' \times 8'$ Expanded Very Large Array (EVLA) mosaic observations of the NH_3(1,1) emission in the Barnard 5 region in Perseus, with an angular resolution of 6 arcsec. This map covers the coherent region, where the dense gas presents subsonic non-thermal motions (as seen from single dish observations with the Green Bank Telescope, GBT). The combined EVLA and GBT observations reveal, for the first time, a striking filamentary structure (20 arcsec 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. 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.

Accepted by The Astrophysical Journal Letters (special issue on EVLA Early Science)

http://arxiv.org/abs/1106.5474

Searching for Gas Giant Planets on Solar System Scales: VLT NACO/APP Observations of the Debris Disk Host Stars HD172555 and HD115892

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Using the APP coronagraph of VLT/NACO we searched for planetary mass companions around HD115892 and HD172555 in the thermal infrared at 4 μm. Both objects harbor unusually luminous debris disks for their age and it has been suggested that small dust grains were produced recently in transient events (e.g., a collision) in these systems. Such a collision of planetesimals or protoplanets could have been dynamically triggered by yet unseen companions. We did not detect any companions in our images but derived the following detection limits: For both objects we would have detected companions with apparent magnitudes between ∼13.2–14.1 mag at angular separations between 0.4–1.0″ at the 5-σ level. For HD115892 we were sensitive to companions with 12.1 mag even at 0.3″. Using theoretical models these magnitudes are converted into mass limits. For HD115892 we would have detected objects with 10–15 $M_{\rm Jup}$ at angular separations between 0.4–1.0″ (7–18 AU). At 0.3″ (∼5.5 AU) the detection limit was $\gtrsim$25 $M_{\rm Jup}$. For HD172555 we reached detection limits between 2–3 $M_{\rm Jup}$ at separations between 0.5–1.0″ (15–29 AU). At 0.4″ (∼11 AU) the detection limit was $\gtrsim$4 $M_{\rm Jup}$. Despite the non-detections our data demonstrate the unprecedented contrast performance of NACO/APP in the thermal infrared at very small inner working angles and we show that our observations are mostly background limited at separations $\gtrsim$0.5″.

Accepted by ApJL

http://xxx.lanl.gov/abs/1106.4528

Variable jets with non-top hat ejection cross sections: a model for the knots of the HH 34 jet

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We compute axisymmetric, single-sinusoidal mode variable ejection models with a non-top hat ejection velocity cross section. We find that for decreasing edge-to-centre velocity ratios one obtains internal working surfaces with progressively more extended bow shock wings. These wings produce [S II] emission which partially fills in the inter-knot regions in predicted intensity maps. We then compute 3-mode models (with parameters appropriate for the HH 34 jet), and compare predicted intensity maps with archival HST images of HH 34. We find that a model with a moderate edge-to-centre velocity ratio produces knot structures with morphologies and time-variabilites with clear similarities to the observations of HH 34.

Accepted by RMxAA

An interpretive ballistic model for quasi-symmetric bipolar jet systems

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We present an analytic, ballistic model for quasi-symmetric jet/counterjet systems, considering both the non-relativistic and the relativistic cases. The model considers the presence of ejection time and velocity asymmetries, which produce offsets between the positions of the knots in jet/counterjet pairs. A fit of the non-relativistic model predictions to observations of two quasi-symmetric HH outflows (HH 34 and HH 111) allows us to obtain the magnitudes of the ejection time and velocity asymmetries of these systems.

Accepted by RMxAA

New Young Star Candidates in the Taurus-Auriga Region as Selected from WISE

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The Taurus Molecular Cloud subtends a large solid angle on the sky, in excess of 250 square degrees. The search for legitimate Taurus members to date has been limited by sky coverage as well as the challenge of distinguishing members from field interlopers. The Wide-field Infrared Survey Explorer (WISE) has recently observed the entire sky, and we take advantage of the opportunity to search for young stellar object (YSO) candidate Taurus members from a ∼260 square degree region designed to encompass previously-identified Taurus members. We use near- and mid-infrared colors to select objects with apparent infrared excesses and incorporate other catalogs of ancillary data to present: a list of rediscovered Taurus YSOs with infrared excesses (taken to be due to circumstellar disks), a list of rejected YSO candidates (largely galaxies), and a list of 94 surviving candidate new YSO-like Taurus members. There is likely to be contamination lingering in this candidate list, and follow-up spectra are warranted.

Accepted by ApJS

http://web.ipac.caltech.edu/staff/rebull/research.html

A natural formation scenario for misaligned and short-period eccentric extrasolar planets

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Recent discoveries of strongly misaligned transiting exoplanets pose a challenge to the established planet formation theory which assumes planetary systems to form and evolve in isolation. However, the fact that the majority of stars actually do form in star clusters raises the question how isolated forming planetary systems really are. Besides radiative and tidal forces the presence of dense gas aggregates in star-forming regions are potential sources for perturbations to protoplanetary discs or systems. Here we show that subsequent capture of gas from large extended accretion envelopes onto a passing star with a typical circumstellar disc can tilt the disc plane to retrograde orientation, naturally explaining the formation of strongly inclined planetary systems. Furthermore, the inner disc regions may become denser, and thus more prone to speedy coagulation and planet formation. Pre-existing planetary systems are compressed by gas inflows leading to a natural occurrence of close-in misaligned hot Jupiters and short-period eccentric planets. The likelihood of such events mainly depends on the gas content of the cluster and is thus expected to be highest in the

youngest star clusters.

Accepted by MNRAS

http://arxiv.org/abs/1107.2113

Chemical abundances in the protoplanetary disk LV 2 (Orion) – II: High dispersion VLT observations and microjet properties

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Integral field spectroscopy of the LV 2 proplyd is presented taken with the VLT/FLAMES Argus array at an angular resolution of 0.31×0.31 arcsec^2 and velocity resolutions down to 2 km s^{-1} per pixel. Following subtraction of the local M42 emission, the spectrum of LV 2 is isolated from the surrounding nebula. We measured the heliocentric velocities and widths of a number of lines detected in the intrinsic spectrum of the proplyd, as well as in the adjacent Orion nebula falling within a 6.6 × 4.2 arcsec^2 field of view. It is found that far-UV to optical collisional lines with critical densities, $N_{\rm cr}$, ranging from 10^3 to 10^9 cm^{-3} suffer collisional de-excitation near the rest velocity of the proplyd correlating tightly with their critical densities. Lines of low $N_{\rm cr}$ are suppressed the most. The bipolar jet arising from LV 2 is spectrally and spatially well-detected in several emission lines. We compute the [O III] electron temperature profile across LV 2 in velocity space and measure steep temperature variations associated with the red-shifted lobe of the jet, possibly being due to a shock discontinuity. From the velocity-resolved analysis the ionized gas near the rest frame of LV 2 has $T_{\rm e} = 9200 \pm 800$ K and $N_{\rm e} \sim 10^6$ cm^{-3}, while the red-shifted jet lobe has $T_{\rm e} \approx 9000 - 10^4$ K and $N_{\rm e} \sim 10^6 - 10^7$ cm^{-3}. The jet flow is highly ionized but contains dense semi-neutral clumps emitting neutral oxygen lines. The abundances of N^+, O^{2+}, Ne^{2+}, Fe^{2+}, S^+, and S^{2+} are measured for the strong red-shifted jet lobe. Iron in the core of LV 2 is depleted by 2.54 dex with respect to solar as a result of sedimentation on dust, whereas the efficient destruction of dust grains in the fast microjet raises its Fe abundance to at least 30 per cent solar. Sulphur does not show evidence of significant depletion on dust, but its abundance both in the core and the jet is only about half solar.

Accepted by Monthly Notices of the Royal Astronomical Society

http://arxiv.org/pdf/1107.1531v1

Ruling out unresolved binaries in five transitional disks

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Context. The presence of unresolved binaries on sub-arsecond scales could explain the existence of optically thin inner holes or gaps in circumstellar disks, which are commonly referred to as “transitional” or “cold” disks, and it is the first scenario to check before making any other assumptions.
Aims. We aim at detecting the presence of companions inside the inner hole/gap region of a sample of five well known transitional disks using spatially-resolved imaging in the near-IR with the VLT/NACO/S13 camera, which probes projected distances from the primary of typically 0.1 to 7 arcsec. The sample includes the stars DoAr 21, HD 135344B (SAO 206462), HR 4796A, T Cha, and TW Hya, spanning ages of less than 1 to 10 Myr, spectral types of A0 to K7,

and hole/gap outer radii of 4 to 100 AU.
Methods. In order to enhance the contrast and to avoid saturation at the core of the point-spread function (PSF), we use narrow-band filters at 1.75 and 2.12 μm. The "locally optimized combination of images" (LOCI) algorithm is applied for an optimal speckle noise removal and PSF subtraction, providing an increase of 0.5-1.5 mag in contrast over the classic method.
Results. With the proviso that we could have missed companions owing to unfavorable projections, the VLT/NACO observations rule out the presence of unresolved companions down to an inner radius of about $0''.1$ from the primary in all five transitional disks and with a detection limit of 2 to 5 mag in contrast. In the disk outer regions the detection limits typically reach 8 to 9 mag in contrast and 4.7 mag for T Cha. Hence, the NACO images resolve part of the inner hole/gap region of all disks with the exception of TW Hya, for which the inner hole is only 4 AU. The 5σ sensitivity profiles, together with a selected evolutionary model, allow to discard *stellar* companions within the inner hole/gap region of T Cha, and down to the *substellar* regime for HD 135344B and HR 4796A. DoAr 21 is the only object from the sample of five disks for which the NACO images are sensitive enough for a detection of objects less massive than ~ 13 M_{Jup} that is, potential giant planets or low-mass brown dwarfs at radii larger than ~ 76 AU ($0''.63$).
Conclusions. These new VLT/NACO observations further constrain the origin of the inner opacity cavities to be owing to closer or lower-mass companions or other mechanisms such as giant planet formation, efficient grain growth, and photoevaporation (for DoAr 21 and HR 4796A).

Accepted by Astronomy & Astrophysics

Morphologically Complex Protostellar Envelopes: Structure and Kinematics

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I present an in-depth study of protostars and their surrounding envelopes of dense gas and dust, using a multitude of observational methods to reveal new details of the star formation process. I use mid-infrared imaging from the *Spitzer Space Telescope*, combined with photometry spanning the near-infrared to millimeter wavelengths, to construct a model of the L1527 protostellar system. I modeled both the spectral energy distribution and resolved scattered light images to determine physical properties of the protostellar system. The nature of the apparent central point source in the *Spitzer* images was uncertain until high-resolution L-band imaging from the Gemini observatory resolved the point source into a disk in scattered light, having a radius of 200 AU. Protostellar envelopes are also often found to cast shadows against the 8 micron Galactic background in *Spitzer* imaging, enabling direct probes of envelope structure. The shadow images show that the dense envelopes around twenty-two Class 0 protostars are generally morphologically complex from 0.1 pc scales down to ∼1000 AU; they are often filamentary, and frequently non-axisymmetric. The observed envelope structure indicates a likely origin in turbulent cloud structure rather than a quasi-static/equilibrium formation. The complex envelope structure also may indicate an increased likelihood of fragmentation during collapse, forming close binaries. To further characterize these envelopes, I have observed them in the dense molecular gas tracers N_2H^+ and NH_3, both of which closely follow the 8 micron extinction morphology. The magnitude of the velocity gradients and envelope complexity on ∼10000 AU scales indicates that the velocity structure may reflect large-scale infall in addition to the often assumed rotation. Comparisons with three-dimensional filamentary and symmetric rotating collapse models reinforce the interpretation of velocities reflecting large-scale infall, showing that the structure of the envelope must be considered when interpreting the velocity field. To more definitively probe rotation, the kinematic structure on sub-1000 AU scales must be studied, where rotation will certainly be a more prominent component of the velocity field.

http://www.astro.lsa.umich.edu/∼jjtobin/dissertation.pdf

Molecular gas and dust influenced by massive protostars - spectral surveys in the far-infrared and submillimeter

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Ph.D dissertation directed by: Marco Spaans & Floris van der Tak

Ph.D degree awarded: May 2011

The interstellar material from which new stars form is crucially influenced by these same protostars: gas and dust particles are excited and heated by the protostar. At the same time, the star formation process depends on the gas reservoir: if gas is too warm or dynamically 'stirred', it will not accumulate and contribute to the final mass of the forming star. This issue is specifically important in the formation of massive stars ($> 8\ M_{\odot}$), emitting the bulk of the $> 10^3\ L_{\odot}$ at UV wavelengths. This radiation impedes mass accretion and alters the chemical composition of the circumstellar material. In this thesis, I study molecular gas and dust in various Galactic star-forming regions.

In chapter 2 I employ mid-infrared *Spitzer Space Telescope* photometry to study MSXDC G048.65. Protostars are identified in this Infrared Dark Cloud (IRDC), using a pre-defined grid of Spectral Energy Distribution models for protostellar systems. Protostars are found in various evolutionary stages, indicating that star formation is an ongoing process in this cloud. The derived stellar masses range from $\sim$1 to $\sim$8 $M_{\odot}$. Hence, in contrast with the popular view that IRDCs are sites of high-mass star formation, I conclude that this particular cloud hosts only low- to intermediate-mass protostars.

The topic of chapters 3 and 4 is the molecular envelope of the high-mass protostar AFGL2591, for which spectral scans have been conducted in two large spectral survey programs: the JCMT Spectral Legacy Survey (SLS, 330–373 GHz) and Chemical *HErschel* Surveys of Star-forming regions (CHESS, 490–1240 GHz). The SLS spectral imaging data yields 35 spatially resolved molecular line maps, showing substructure in CO, N_2H^+, H_2CO, CS, C_2H, and CH_3OH. Radiative transfer modeling, adopting various physical descriptions of the circumstellar envelope, shows that the geometry of the envelope needs to provide low-opacity lines of sight for molecular line radiation to escape. Such a geometry likely includes outflow cavities and clumpy substructure at scales smaller than 10^4 AU. Space-based *Herschel* CHESS data reveals high-J lines of linear rotor molecules, CO, HCN, HNC, CS and HCO^+. From a comparison of the ladder of CO line strengths with a radiative transfer model that includes a cavity geometry, direct UV illumination, shocks, and a self-consistent chemical balance, I conclude that one still probes primarily the quiescent outer envelope, even at energy levels up to 300 K. More distinctive probes of UV photodissociation and shocks are expected to be found in species such as HCO^+ or HCN and in even higher-J lines of CO.

Chapter 5 uses SLS data of the Orion Bar to study chemical stratification in this prototypical photodissociation region (PDR). Emission from the C_2H radical lies close to the ionization front, and H_2CO, SO, CO and HCN are seen progressively deeper into the cloud. A simple gas-phase PDR model reproduces the observed layering, with the exceptions of the placement and abundances of SO and H_2CO. The conclusion is that depletion onto dust grains (of sulfur, for example) and production of H_2CO through grain surface chemistry should be incorporated in the models.

Chapter 6 uses the CH signature toward the luminous high-mass star-forming core NGC6334 I, extracted from *Herschel* CHESS data. A remarkably low CH abundance of $7{\times}10^{-11}$ is derived for the hot core, a factor of several hundred below that in diffuse clouds. In contrast with other molecular tracers, CH gas in the hot cores is inferred to trace quiescent material, not heated or dynamically influenced by outflow activity. Model representations of the CH spectrum indicates the presence of four foreground clouds of cold, absorbing gas. Column densities and line-of-sight velocities are derived for these clouds, two of which are inferred to be related to the NGC6334 complex.

http://irs.ub.rug.nl/ppn/333852478

Confronting FU Orionis outbursts and pre/transitional disks: protostellar/protoplanetary disk structure and evolution

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Ph.D degree awarded: July 2011

The mechanisms and efficiencies of mass transport in accretion disks can be best constrained by studying their time-dependent behavior. For the first part of my thesis work, I studied outbursts of rapid accretion in protostellar disks. This was motivated by observations of the FU Orionis objects, which are young stellar objects with a sudden increase of their brightness. I first constructed disk radiative transfer models to compare with *Spitzer* observations, and found that the outburst disk region extends to scales of an AU or more, with the inferred limits on the viscosity parameter $\alpha\sim$0.02-0.2. I further analyzed the multi-wavelength high resolution spectra to show the outbursting disk follows Keplerian rotation. I next studied the thermal structure of the disk which leads us to propose that the outburst is due to the thermal activation of the magnetorotational instability (MRI) at $\sim$AU scales by the gravitational instability (GI). We carried out both analytic studies and 2-Dimensional radiationhydrodyanmic simulations to study the outbursts and constrain the activation of the MRI. Then I extended this work by constructing simplified 1-dimensional time-dependent simulations with infall from the protostellar envelope to study protostellar disk formation and long term evolution. I found that the outbursting behavior of the protostellar disks during the infall phase alleviates the so called "luminosity problem", and the layered accretion at the later phase leads to a massive 'dead zone' where planet formation is favored.

In the second part of my thesis work, I studied protoplanetary disks with gaps and holes-so called "pretransitional and transitional disks",- to study planet formation in young disks. I have studied gap opening by dynamically-interacting multiple giant planets with two-dimensional hydrodynamic simulations. I found that even with as many as four giant planets, additional substantial dust depletion (e.g. growth) is required to explain these gaps and holes, which sheds light on the early planet formation environment.

http://www.astro.lsa.umich.edu/~zhuzh/

IAU Symposium 287
Cosmic Masers: From OH to Ho
January 29 - February 3 2012, Stellenbosch, South Africa
website: http://iau287.ska.ac.za/ email: iaus287 *at* hartrao.ac.za

Scientific Rationale:

Masers have left their mark across large areas of astrophysical research. They are observed in the interstellar medium near star-forming regions, they can probe the envelopes around dying stars and planetary nebulae and they occur in supernova remnants; they are even observed within the solar system in comets and at cosmological distances in galaxies where water masers have been observed at red shifts, $z>2$.

Due to their brightness and compactness, masers give information on the structure and kinematics of a wide variety of sources on extremely small scales. They have therefore been important targets for high resolution observations with radio interferometers, such as MERLIN in the UK, the European VLBI Network (EVN), the Very Large Array, (VLA) and the Very Long Baseline Array (VLBA) in the US, VERA in Japan, and the Australia Telescope Compact Array (ATCA). VLBI observations of e.g. Galactic water masers give information on the dynamics of star formation regions on scales of less than 0.1 - 1 AU at a distance of 1 kpc, as well as accurate distances to these sources.

We are now contemplating the advent of a new golden age in radio astronomy, with the Sub-millimetre Array (SMA), Herschel, the Korean VLBI Network (KVN), dedicated earlier this year and which will target millimeter wavelength masers, the Atacama Large Millimeter Array (ALMA), upgrades of the Plateau de Bure Interferometer (PdBI), VLA, ATCA and MERLIN and further developments of real-time (e)VLBI and the start of construction of the Square Kilometer Array (SKA) pre-cursors, MeerKAT and ASKAP. Studies of molecular masers are prime goals for these new and improved instruments, so maser research is undergoing a rapid growth and continues to provide answers to many important astrophysical questions.

This meeting will be the fourth international symposium on astrophysical masers. Developments in maser research have accelerated over the past years and will continue to do so while new instruments come online. The first results of ALMA are expected towards the end of 2011. The upgraded EVLA and eMERLIN have already started producing science, while the SKA pre-cursors in Australia (ASKAP) and South Africa (MeerKAT) are on the near horizon, planning their early science. The new capabilities of these instruments for maser research will be highlighted by these early results. By bringing together maser researchers, this meeting aims to lead to the development of new observational programmes intended to answer a range of fundamental astrophysical questions. The meeting will also provide a forum for maser observers to interact with theorists working on the physics that must be understood for a full analysis of the wealth of new data.

Specific focus areas for this symposium will include:

Advances in Maser Theory
Polarisation and magnetic fields
Star formation masers
Stellar masers
Maser Surveys
Astrometry using masers
AGN and Megamasers
Cosmology and the Hubble Constant
New masers and other developments in maser physics
Masers with new mm facilities

Confirmed Review Speakers:

Anna Bartkiewicz, Shuji Deguchi, Christian Henkel, Karl Menten, Mark Reid, Anita Richards, Vladimir Strelnitski, Andrea Tarchi, Dinh Van Trung

Scientific Organizing Committee:

Anna Bartkiewicz (Torun), Athol Kemball (Illinois), Huib van Langevelde (JIVE/Leiden), Jim Moran (Harvard/SAO), Jessica Chapman (CSIRO), Kee-Tae Kim (KASI), Liz Humphreys (ESO) co-Chair, Malcolm Gray (Manchester), Mareki Honma (NAOJ), Moshe Elitzur (Kentucky), Roy Booth (SA SKA) Chair, Simon Ellingsen (Tasmania), Valentin Bujarrabal (OAN), Wouter Vlemmings (Chalmers) co-Chair, Yolanda Gomez (UNAM)

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Travel Grants:

A limited amount of travel support will be available.

Important dates/deadlines:

Pre-Registration Opens: July 15
Registration Opens: August 1
Application for IAU Travel Support Deadline: September 16
Abstract Submission Deadline: November 1
(with a late deadline in January for new results)
Early Registration Closes: December 1
(after that a late registration fee will be applied)

From Atoms to Pebbles: Herschel's View of Star and Planet Formation

How do stars and planets form and evolve in time?

Since mid-2009, the Herschel Space Observatory provides new light on these long-standing astrophysical questions. With its 3.5 m primary mirror, it delivers observations in the 55–671 μm range with unprecedented sensitivity, spatial and spectral resolution, revolutionising our understanding of the star and planet formation processes.

Approaching the three year anniversary of the launch of Herschel, the French Space Agency (CNES) and the Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), are organising an exceptional Symposium: **From Atoms to Pebbles: Herschel's view of Star and Planet Formation**. This event will be held over 3.5 days, from 20th to 23rd of March 2012, in Grenoble (the heart of the French Alps), France.

The scientific themes of the symposium will be centred around the physical and chemical evolution of gas and dust in star and planet forming environments and on the impact of the low-and high-mass star formation processes on the surroundings. Specific sessions will be dedicated to :

- The pre-collapse phase,
- The protostellar phase,
- Planet-forming circumstellar disks,
- Debris disks, together with their connection to extra-solar planets.

Please consider your participation at this event and reserve the week from 20 to 23 March 2012 in your agenda. More details and key dates will be reported in the second announcement, as well as on the Symposium web site.

To receive future announcements, you are welcome to provide your email address by going to:

`http://www.herschel2012.com/newsletter/newsletter.php`

Scientific Committee: P. André (CEA/Saclay), P. Caselli (Leeds), F. Casoli (CNES), E. Caux (IRAP), N. Evans (Austin), T. Henning (MPIA), I. Kamp (Groningen), R. Liseau (Onsala), A. Roberge (NASA Goddard), M. Wyatt (Cambridge), J.-C. Augereau, Chair (IPAG)

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Meeting Website: `http://www.herschel2012.com/information/`

First Announcement

New Quests in Stellar Astrophysics. III.
A Panchromatic View of Solar-Like Stars, With and Without Planets

This is the third meeting of a series aimed at stressing the importance of stellar physics to understand the properties of stars and stellar systems at different scales. In the first meeting, in 2001, we reviewed the impact of stellar physics on global properties of stellar aggregates up to cosmological scales. In the second meeting, held in 2007, we focused on the UV interval to review our current knowledge on the properties of nearby and distant evolved stellar populations. In the proposed event for 2012 we want to bring out the attention to the multi-wavelength analyses of solar like (H-fueled) stars and address some of the important recent findings related to exoplanet search. Solar like stars have been subjects of analyses by their own right over the years. Nevertheless, it is undeniable that the study of these stars has been boosted by the discovery of hundreds of exoplanets orbiting them. This conference would be a timely and unique opportunity to collect an up to date view of the outcomes from various on-going surveys aimed at studying normal main sequence stars from the UV to radio frequencies, as well as to review our current knowledge on the correlation of stellar properties with the presence of (proto) planets. This fresh panorama will undoubtedly help on the preparation of future studies, mainly those related to exoplanet search.

Among the main topics to be discussed are:

Solar Analogues
Surveys of Solar-Like Stars at (sub-)millimeter wavelengths
Protoplanetary and Debris Disks: models and observations
The Age of Intermediate-type Main Sequence Stars
Star-Planet Connection: Chemical Abundances, Stellar Activity, and Interactions
Stellar Noise in Exoplanet Searches
Other Suns Hosting other Earths
Habitability Amongst Exoplanets

Scientific Organizing Committee:

Natalie Batahla (San Jose State University, USA), Emanuele Bertone (INAOE, Mexico), Piercarlo Bonifacio (Observatoire du Paris, France), John M. Carpenter (Caltech, USA), Miguel Chavez (INAOE, Mexico), David Hughes (INAOE, Mexico), Lisa Kaltenegger (MPI für Astronomie-Heidelberg, Germany), Susana Lizano (CRyA-UNAM, Mexico), Alejandro Lara (Instituto de Geofisica-UNAM, Mexico), Pablo Mauas (IAFE, Argentina), Rafael Rebolo (Instituto de Astrofisica de Canarias, Spain), Antigona Segura (Instituto de Ciencias Nucleares-UNAM, Mexico), Nuno C. Santos (Centro de Astrofisica, Universidade do Porto, Portugal), Mark Wyatt (IoA, University of Cambridge, UK)

Local Organizing Committee

Fernando Cruz, Victor de La Luz, Raul Mujica, Ana Maria Ramirez, Gerardo Ramos, Olga Vega

If you are interested to receive further information please fill-out the web-form at

http://www.inaoep.mx/∼puerto12/registration.html.

This conference is sponsored by the Instituto Nacional de Astrofisica, Optica y Electronica (INAOE) and the Universidad de Guadalajara (UdeG), Mexico.

Physics of the Interstellar and Intergalactic Medium

Bruce T. Draine

This is a graduate textbook, written by one of the leading researchers in the field, on the physical properties of gas and dust in between the stars and the galaxies, the radiation and cosmic rays that this medium interacts with, and the effect of gravitation and magnetic fields. The text is clearly written and well illustrated with close to 200 figures. This textbook is likely to be frequently used in graduate courses on the interstellar and intergalactic medium. The book contains the following chapters:

1. Introduction
2. Collisional Processes
3. Statistical Mechanics and Thermodynamic Equilibrium
4. Energy Levels of Atoms and Ions
5. Energy Levels of Molecules
6. Spontaneous Emission, Stimulated Emission, and Absorption
7. Radiative Transfer
8. HI 21-cm Emission and Absorption
9. Absorption Lines: The Curve of Growth
10. Emission and Absorption by a Thermal Plasma
11. Propagation of Radio Waves through the ISM
12. Interstellar Radiation Fields
13. Ionization Processes
14. Recombination of Ions with Electrons
15. Photoionized Gas
16. Ionization in Predominantly Neutral Regions
17. Collisional Excitation
18. Nebular Diagnostics
19. Radiative Trapping
20. Optical Pumping
21. Interstellar Dust: Observed Properties
22. Scattering and Absorption by Small Particles
23. Composition of Interstellar Dust
24. Temperatures of Interstellar Grains
25. Grain Physics: Charging and Sputtering
26. Grain Dynamics
27. Heating and Cooling of HII Regions
28. The Orion HII Region
29. HI Clouds: Observations
30. HI Clouds: Heating and Cooling
31. Molecular Hydrogen
32. Molecular Clouds: Observations
33. Molecular Clouds: Chemistry and Ionization
34. Physical Processes in Hot Gas
35. Fluid Dynamics
36. Shock Waves
37. Ionization/Dissociation Fronts
38. Stellar Winds
39. Effects of Supernovae on the ISM
40. Cosmic Rays and Gamma Rays

41. Gravitational Collapse and Star Formation: Theory
42. Star Formation: Observations

A supplementary Solutions Manual is available for this book. It is restricted to teachers using the text in courses. For information on how to obtain a copy, refer to: http://press.princeton.edu/class_use/solutions.html

Endorsements:

"This is the book that I have been waiting for for twenty years. With exceptional clarity, Draine introduces the underlying physics and brings the basic pieces together to describe the multiphase structure of the interstellar and intergalactic medium. Combined with many useful tables and figures, this book will rapidly become a hit with students and researchers alike. It continues the fine tradition of Princeton professors writing seminal books on this topic."–*Ewine van Dishoeck*, Leiden University

"This book is a comprehensive account of the physical processes that take place in the interstellar medium and that determine its behavior. It is likely to become the bible on the subject."–*Alexander Dalgarno*, Harvard University

Princeton University Press, 2011
Princeton Series in Astrophysics, ISBN 978-0-691-12213-7
540 pages, Hardback US$125.00; Paperback US$65.00
http://press.princeton.edu/titles/9499.html

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals), *Abstracts of recently accepted major reviews* (not standard conference contributions), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star and planet formation and early solar system community), *New Jobs* (advertising jobs specifically aimed towards persons within the areas of the Newsletter), and *Short Announcements* (where you can inform or request information from the community).

Latex macros for submitting abstracts and dissertation abstracts (by e-mail to reipurth@ifa.hawaii.edu) are appended to each issue of the newsletter. You can also submit via the Newsletter web interface at http://www2.ifa.hawaii.edu/star-formation/index.cfm .

The Star Formation Newsletter is available on the World Wide Web at http://www.ifa.hawaii.edu/users/reipurth/newsletter.htm.

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.