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Abstracts of recently accepted papers

The TW Hya Disk at 870 μm: Comparison of CO and Dust Radial Structures

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We present high resolution ($0.3'' = 16$ AU), high signal-to-noise ratio Submillimeter Array observations of the 870 μm (345 GHz) continuum and CO J=3−2 line emission from the protoplanetary disk around TW Hya. Using continuum and line radiative transfer calculations, those data and the multiwavelength spectral energy distribution are analyzed together in the context of simple two-dimensional parametric disk structure models. Under the assumptions of a radially invariant dust population and (vertically integrated) gas-to-dust mass ratio, we are unable to simultaneously reproduce the CO and dust observations with model structures that employ either a single, distinct outer boundary or a smooth (exponential) taper at large radii. Instead, we find that the distribution of millimeter-sized dust grains in the TW Hya disk has a relatively sharp edge near 60 AU, contrary to the CO emission (and optical/infrared scattered light) that extends to a much larger radius of at least 215 AU. We discuss some possible explanations for the observed radial distribution of millimeter-sized dust grains and the apparent CO-dust size discrepancy, and suggest that they may be hallmarks of substructure in the dust disk or natural signatures of the growth and radial drift of solids that might be expected for disks around older pre-main sequence stars like TW Hya.

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Runaway massive stars from R136: VFTS 682 is very likely a 'slow runaway'

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We conduct a theoretical study on the ejection of runaway massive stars from R136 — the central massive, star-burst cluster in the 30 Doradus complex of the Large Mag- ellanic Cloud. Specifically, we investigate the possibility of the very massive star (VMS) VFTS 682 being a runaway member of R136. Recent observations of the above VMS, by virtue of its isolated location and its moderate peculiar motion, have raised the fundamental question whether isolated massive star formation is indeed possible. We perform the first realistic N-body computations of fully mass-segregated R136-type star clusters in which all the massive stars are in primordial binary systems. These calculations confirm that the dynamical ejection of a VMS from a R136-like cluster, with kinematic properties similar to those of VFTS

682, is common. Hence the conjecture of isolated massive star formation is unnecessary to account for this VMS. Our results are also quite consistent with the ejection of 30 Dor 016, another suspected runaway VMS from R136. We further note that during the clusters? evolution, mergers of massive binaries produce a few single stars per cluster with masses significantly exceeding the canonical upper-limit of $150M_\odot$. The observations of such single super-canonical stars in R136, therefore, do not imply an IMF with an upper limit greatly exceeding the accepted canonical $150M_\odot$ limit, as has been suggested recently, and they are consistent with the canonical upper limit.

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EX Lupi from Quiescence to Outburst: Exploring the LTE Approach in Modelling Blended H_2O and OH Mid-Infrared Emission

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We present a comparison of archival *Spitzer* spectra of the strongly variable T Tauri EX Lupi, observed before and during its 2008 outburst. We analyze the mid-infrared emission from gas-phase molecules thought to originate in a circumstellar disk. In quiescence the emission shows a forest of H_2O lines, highly excited OH lines, and the Q branches of the organics C_2H_2, HCN, and CO_2, similar to the emission observed toward several T Tauri systems. The outburst emission shows instead remarkable changes: H_2O and OH line fluxes increase, new OH, H_2, and HI transitions are detected, and organics are no longer seen. We adopt a simple model of a single-temperature slab of gas in local thermal equilibrium, a common approach for molecular analyses of *Spitzer* spectra, and derive the excitation temperature, column density, and emitting area of H_2O and OH. We show how model results strongly depend on the selection of emission lines fitted, and that spectrally-resolved observations are essential for a correct interpretation of the molecular emission from disks, particularly in the case of water. Using H_2O lines that can be approximated as thermalized to a single temperature, our results are consistent with a column density decrease in outburst while the emitting area of warm gas increases. A rotation diagram analysis suggests that the OH emission can be explained with two temperature components, which remarkably increase in column density in outburst. The relative change of H_2O and OH emission suggests a key role for UV radiation in the disk surface chemistry.

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X-ray Emission From Protostellar Jet HH 154: The First Evidence Of A Diamond Shock?

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X-ray emission from about 10 protostellar jets has been discovered and it appears as a feature common to the most energetic jets. Although X-ray emission seems to originate from shocks internal to jets, the mechanism forming these shocks remains controversial. One of the best-studied X-ray jets is HH 154, which has been observed by Chandra over a time base of about 10 years. We analyze the Chandra observations of HH 154 by investigating the evolution of its X-ray source. We show that the X-ray emission consists of a bright stationary component and a faint elongated component. We interpret the observations by developing a hydrodynamic model describing a protostellar jet originating from a nozzle and compare the X-ray emission synthesized from the model with the X-ray observations. The model takes into account the thermal conduction and radiative losses and shows that the jet/nozzle leads to the formation of a diamond shock at the nozzle exit. The shock is stationary over the period covered by our simulations and generates an X-ray source with luminosity and spectral characteristics in excellent agreement with the observations. We conclude that the X-ray emission from HH 154 is consistent with a diamond shock originating from a nozzle through which the jet is launched into the ambient medium. We suggest that the physical origin of the nozzle could be related to the dense gas in which the HH 154 driving source is embedded and/or to the magnetic field at the jet launching/collimation region.

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POISSON project – II – A multi-wavelength spectroscopic and photometric survey of young protostars in L 1641

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Characterising stellar and circumstellar properties of embedded young stellar objects (YSOs) is mandatory for understanding the early stages of the stellar evolution. This task requires the combination of both spectroscopy and photometry, covering the widest possible wavelength range, to disentangle the various protostellar components and activities.
As part of the POISSON project (Protostellar Optical-Infrared Spectral Survey On NTT), we present a multi-wavelength spectroscopic and photometric investigation of embedded YSOs in L 1641, aimed to derive the stellar parameters and evolutionary stages and to infer their accretion properties.
Our multi-wavelength database includes low-resolution optical-IR spectra from the NTT and Spitzer (0.6-40 μm) and photometric data covering a spectral range from 0.4 to 1100 μm, which allow us to construct the YSOs spectral energy distributions (SEDs) and to infer the main stellar parameters (visual extinction, spectral type, accretion, stellar, bolometric luminosity, mass accretion and ejection rates).
The NTT optical-NIR spectra are rich in emission lines, which are mostly associated with YSO accretion, ejection, and chromospheric activities. A few emission lines, prominent ice (H_2O and CO_2), and amorphous silicate absorption features have also been detected in the Spitzer spectra. The SED analysis allows us to group our 27 YSOs into nine Class I, eleven Flat, and seven Class II objects. However, on the basis of the derived stellar properties, only six Class I YSOs have an age of $\sim 10^5$ yr, while the others are older (5×10^5–10^6 yr), and, among the Flat sources, three out of eleven are more evolved objects (5×10^6–10^7 yr), indicating that geometrical effects can significantly modify the SED shapes. Inferred mass accretion rates ($\dot{M}_{acc}$) show a wide range of values (3.6×10^{-9} to $1.2\times10^{-5}\,M_\odot\,yr^{-1}$), which reflects the age spread observed in our sample well. Average values of mass accretion rates, extinction, and spectral indices decrease with the YSO class. The youngest YSOs have the highest $\dot{M}_{acc}$, whereas the oldest YSOs do not show any detectable jet activity in either images and spectra. Apart from the outbursting source # 25 and, marginally, # 20, none of the remaining YSOs is accretion-dominated ($L_{acc} > L_*$). We also observe a clear correlation among the YSO $\dot{M}_{acc}$, M_*, and age. For YSOs with $t > 10^5$ yr and $0.4\,M_\odot \leq M_* \leq 1.2\,M_\odot$, a relationship between $\dot{M}_{acc}$ and t ($\dot{M}_{acc} \propto t^{-1.2}$) has been inferred, consistent with mass accretion evolution in viscous disc models and indicating that the mass accretion decay is slower than previously assumed. Finally, our results suggest that episodic outbursts are required for Class I YSOs to reach typical classical T Tauri stars stellar masses.

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Multiplicity, Disks, and Jets in the NGC 2071 Star-Forming Region

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We present centimeter and millimeter observations of the NGC 2071 star-forming region performed with the VLA and CARMA. We detected counterparts at 3.6 cm and 3 mm for the previously known sources IRS 1, IRS 2, IRS 3, and VLA 1. All these sources show SEDs dominated by free-free thermal emission at cm wavelengths, and thermal dust emission at mm wavelengths, suggesting that all of them are associated with YSOs. IRS 1 shows a complex morphology at 3.6 cm, with changes in the direction of its elongation. We discuss two possible explanations to this morphology: the result of changes in the direction of a jet due to interactions with a dense ambient medium, or that we are actually observing the superposition of two jets arising from two components of a binary system. Higher angular resolution observations at 1.3 cm support the second possibility, since a double source is inferred at this wavelength. IRS 3 shows a clear jet-like morphology at 3.6 cm. Over a time-span of four years, we observed changes in the morphology of this source that we interpret as due to ejection of ionized material in a jet. The emission at 3 mm of IRS 3 is angularly resolved, with a deconvolved size (FWHM) of ∼120 AU, and seems to be tracing a dusty circumstellar disk perpendicular to the radio jet. An irradiated accretion disk model around an intermediate-mass YSO can account for the observed SED and spatial intensity profile at 3 mm, supporting this interpretation.

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Transition disk chemistry and future prospects with ALMA

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We explore the chemical structure of a disk that contains a large central gap of R ∼ 45 AU, as is commonly seen in transitional disk systems. In our chemical model of a disk with a cleared inner void, the midplane becomes revealed to the central star so that it is directly irradiated. The midplane material at the truncation radius is permissive to reprocessed optical heating radiation, but opaque to the photo-dissociating ultraviolet, creating an environment abundant in gas-phase molecules. Thus the disk midplane, which would otherwise for a full disk be dominated by near complete heavy element freeze-out, should become observable in molecular emission. If this prediction is correct this has exciting prospects for observations with the Atacama Large Millimeter/Submillimeter Array (ALMA), as the inner transition region should thus be readily detected and resolved, especially using high-J rotational transitions excited in the high density midplane gas. Therefore such observations will potentially provide us with a direct probe of the physics and chemistry at this actively evolving interface.

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Discarded candidate companions to low-mass members of Chamaeleon I

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Direct detections of brown dwarfs and planetary-mass companions to members of nearby star forming regions provide important clues on the process of star formation, core fragmentation, and protoplanetary disk evolution. The nature of two faint objects that appear at a very small angular distance of the low-mass star ESO-Hα-558 and the possible massive brown dwarf ESO-Hα-566, both of which are members of the Chamaeleon I star forming region, is investigated with the goal of establishing whether or not they are physical companions to those sources. If they were, their low luminosities would lead to the expectation of clearly detectable spectral features distinctive of the L or T spectral types. Adaptive optics-assisted imaging and spectroscopy of both faint candidate companions has been obtained with the NACO instrument at the Very Large Telescope (VLT). Photometry shows that the colors of both objects are compatible with them being moderately reddened, normal stars in the background of the Chamaeleon I clouds. This interpretation is definitely confirmed spectroscopically, as the spectrum between 1.4 and 2.4 μm of both objects has a featureless, monotonic slope lacking the strong H_2O absorption features that dominate cool stellar and substellar spectra in that domain. It is conclusively demonstrated that the two faint sources seen very close to ESO-Hα-558 and ESO-Hα-566 are actually unrelated background stars, rather than giant planetary-mass companions as might be suspected from their faintness and angular proximity.

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http://www.eso.org/~fcomeron/cham_companions.pdf

The Absorption and Emission Spectrum of the Herbig Ae Star HD 190073

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We determine abundances from the absorption spectrum of the Herbig Ae star HD 190073 (V1295 Aql). The observations are primarily from HARPS spectra obtained at a single epoch. We accept arguments that the presence of numerous emission lines does not vitiate a classical abundance analysis, though it likely reduces the achievable accuracy. Most abundances are closely solar, but several elements show departures of a factor of two to three, as an earlier study has also shown. We present quantitative measurements of more than 60 emission lines, peak intensities, equivalent widths, and FWHM's. The latter range from over 200 km s^{-1} (Hα, He D_3) down to 10-20 km s^{-1} (forbidden lines). Metallic emission lines have intermediate widths. We eschew modeling, and content ourselves with a presentation of the observations a successful model must explain. Low-excitation features such as the Na I D-lines and [O I] appear with He I D_3, suggesting proximate regions with widely differing T_e and N_e as found in the solar chromosphere. The [O I] and [Ca II] lines show sharp, violet-shifted features. Additionally, [Fe II] lines appear to be weakly present in emission.

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Nitrogen hydrides and the H_2 ortho-to-para ratio in dark clouds

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Nitrogen bearing species are common tracers of the physical conditions in a wide variety of objects, and most remarkably in dark clouds. The reservoir of gaseous nitrogen is expected to be atomic or molecular, but none of the two species are observable in the dark gas. Their abundances therefore derive indirectly from those of N-bearing species through chemical modelling. The recent years have accumulated data which stress our incomplete understanding of the nitrogen chemistry in dark cloud conditions. To tackle this problem of the nitrogen chemistry in cold gas, we have revised the formation of nitrogen hydrides, which is initiated by the key reaction $N^+ + H_2 \rightarrow NH^+ + H$. We propose a new rate for this reaction which depends on the ortho-to-para ratio of H_2. This new rate allows to reproduce the abundance ratios of the three nitrogen hydrides, NH, NH_2, and NH_3, observed towards IRAS 16293–2422, pro-

vided that the channel leading to NH from the dissociative recombination of N_2H^+ is not closed at low temperature. The ortho-to-para ratio of H_2 is constrained to o/p=10^{-3} by the abundance ratio NH/NH_2, which provides a new method to measure O/P. This work stresses the need for reaction rates at the low temperatures of dark clouds, and for branching ratios of critical dissociative recombination reactions.

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http://ipag.osug.fr/∼philybla/data/nitrogen-paperII.pdf
http://arxiv.org/pdf/1111.1572

Magnetic field of young star RW Aur

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Results of longitudinal magnetic field B_z measurements for young star RW Aur A are presented. We found that B_z in the formation region of He I 5876 line's narrow component varies from -1.47 ± 0.15 kG to $+1.10 \pm 0.15$ kG. Our data are consistent with a stellar rotational period of $\simeq 5.6^d$ and with a model of two hotspots with an opposite polarity of magnetic field and with a difference in a longitude about 180^o. The spot with $B_z < 0$ is located at the hemisphere above the midplane of RW Aur's accretion disc and the spot with $B_z > 0$ is below the midplane.

The following upper limits for B_z (at 3σ level) were found after averaging of all our observations: 180 G for photospheric lines, 220 G and 230 G for formation regions of H_α and [OI] 6300 lines respectively. Upper limit 600 G were found in the region where broad components of emission lines form.

For two cases out of 11 we observed the field in a formation region of a blue absorption wing of Na I D lines i.e. in an outflow: $B_z = -180 \pm 50$ G and -810 ± 80 G.

Radial velocity of RW Aur's photospheric lines averaged over all our observations is $\simeq +10.5$ km s^{-1} what is 5.5 km s^{-1} less than value derived ten years earlier by Petrov et al. (2001). In this connection, we discuss a possibility that RW Aur is not a binary but a triple system.

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Molecular clouds under the influence of massive stars in the Galactic HII region G353.2+0.9

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Aims: We investigate the structure of the Galactic HII region G353.2+0.9, by analyzing (sub-)mm molecular-line and -continuum observations. This region is excited by the massive open cluster Pismis-24. We study the detailed morphology, distribution, and physical parameters (column and volume densities, masses, temperatures and opacities) of the molecular gas and dust. We are also interested in the variation in these parameters across the photon-dominated region.
Methods: We observed various molecules and transitions to derive the physical properties of the molecular gas through line ratios, and both LTE and non-LTE analyses. The physical properties of the gas were derived with a Bayesian approach for the non-LTE analysis. Based on the continuum data at 870 μm, we derived the column density of molecular hydrogen from the surface brightness and thus molecular abundances from the molecular column densities. We determined the mass of the dust from the integrated flux. We also carried out the simplest possible analysis to identify the clump candidates for gravitational instability, determining their virial parameter α.
Results: The total mass of the gas in the region is $\sim 2000\,M_\odot$, while that of the dust is $\sim 21\,M_\odot$. The presence

of a velocity gradient in the region, with clumps with redder $V_{\rm LSR}$ nearer Pis-24 suggests that the expansion of the ionized gas is pushing the molecular gas away from the observer. We unambiguously identify the ionization front in G353.2+0.9, at the location of which we detect an increase in gas density and temperature. Its location and position angle is consistent with Pis-24 being the main ionization source. Almost no molecular gas is found south of the ionization front, at the location of the intense, elongated continuum and atomic-line emission, strengthening the hypothesis that Pis-24 is associated with G353.2+0.9. We find at least 14 clumps at different positions and LSR velocities, and we determine their physical conditions. The typical excitation temperatures are in the range of about $10-25\,$K, while H_2 column densities are in the range $\sim 10^{20}-10^{23}\,{\rm cm}^{-2}$. From the non-LTE analysis, we derive kinetic temperatures in the ranges $11-45\,$K (CS) and $20-45\,$K (CN). The H_2 number density is typically around $\sim 10^5\,{\rm cm}^{-3}$ from CS and few $\times\,10^5\,{\rm cm}^{-3}$ from CN, with maxima above $10^6\,{\rm cm}^{-3}$. The abundances of the molecules observed are found to vary across the region, and appear to be higher in regions further away from the ionization front.

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The Supernova Triggered Formation and Enrichment of Our Solar System

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We investigate the enrichment of the pre-solar cloud core with short lived radionuclides (SLRs), especially 26Al. The homogeneity and the surprisingly small spread in the ratio 26Al/27Al observed in the overwhelming majority of calcium-aluminium-rich inclusions (CAIs) in a vast variety of primitive chondritic meteorites places strong constraints on the formation of the the solar system. Freshly synthesized radioactive 26Al has to be included and well mixed within 20kyr. After discussing various scenarios including X-winds, AGB stars and Wolf-Rayet stars, we come to the conclusion that triggering the collapse of a cold cloud core by a nearby supernova is the most promising scenario. We then narrow down the vast parameter space by considering the pre-explosion survivability of such a clump as well as the cross-section necessary for sufficient enrichment. We employ numerical simulations to address the mixing of the radioactively enriched SN gas with the pre-existing gas and the forced collapse within 20kyr. We show that a cold clump of 10Msun at a distance of 5pc can be sufficiently enriched in 26Al and triggered into collapse fast enough - within 18kyr after encountering the supernova shock - for a range of different metallicities and progenitor masses, even if the enriched material is assumed to be distributed homogeneously in the entire supernova bubble. In summary, we envision an environment for the birth place of the Solar System 4.567Gyr ago similar to the situation of the pillars in M16 nowadays, where molecular cloud cores adjacent to an HII region will be hit by a supernova explosion in the future. We show that the triggered collapse and formation of the Solar System as well as the required enrichment with radioactive 26Al are possible in this scenario.

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Luminosity Discrepancy in the Equal-Mass, Pre–Main Sequence Eclipsing Binary Par 1802: Non-Coevality or Tidal Heating?

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Parenago 1802, a member of the ∼1 Myr Orion Nebula Cluster, is a double-lined, detached eclipsing binary in a 4.674 d orbit, with equal-mass components (M_2/M_1=0.985±0.029). Here we present extensive $VI_C JHK_S$ light curves spanning ∼15 yr, as well as a Keck/HIRES optical spectrum. The light curves evince a third light source that is variable with a period of 0.73 d, and is also manifested in the high-resolution spectrum, strongly indicating the presence of a third star in the system, probably a rapidly rotating classical T Tauri star. We incorporate this third light into our radial velocity and light curve modeling of the eclipsing pair, measuring accurate masses (M_1=0.391±0.032, M_2=0.385±0.032 $M_\odot$), radii (R_1=1.73±0.02, R_2=1.62±0.02 $R_\odot$), and temperature ratio ($T_{\rm eff,1}/T_{\rm eff,2}$=1.0924±0.0017). Thus the radii of the eclipsing stars differ by 6.9±0.8%, the temperatures differ by 9.2±0.2%, and consequently the luminosities differ by 62±3%, despite having masses equal to within 3%. This could be indicative of an age difference of $\sim 3 \times 10^5$ yr between the two eclipsing stars, perhaps a vestige of the binary formation history. We find that the eclipsing pair is in an orbit that has not yet fully circularized, e=0.0166±0.003. In addition, we measure the rotation rate of the eclipsing stars to be 4.629±0.006 d; they rotate slightly faster than their 4.674 d orbit. The non-zero eccentricity and super-synchronous rotation suggest that the eclipsing pair should be tidally interacting, so we calculate the tidal history of the system according to different tidal evolution theories. We find that tidal heating effects can explain the observed luminosity difference of the eclipsing pair, providing an alternative to the previously suggested age difference.

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Rapid Star Formation and Global Gravitational Collapse

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Most young stars in nearby molecular clouds have estimated ages of 1-2 Myr, suggesting that star formation is rapid. However, small numbers of stars in these regions with inferred ages of ¿= 5-10 Myr have been cited to argue that star formation is instead a slow, quasi-static process. When considering these alternative pictures it is important to recognize that the age spread in a given star-forming cloud is necessarily an upper limit to the timescales of local collapse, as not all spatially-distinct regions will start contracting at precisely the same instant. Moreover, star-forming clouds may dynamically evolve on timescales of a few Myr; in particular, global gravitational contraction will tend to yield increasing star formation rates with time due to generally increasing local gas densities. We show that two different numerical simulations of dynamic, flow-driven molecular cloud formation and evolution 1) predict age spreads for the main stellar population roughly consistent with observations, and 2) raise the possibility of forming small numbers of stars early in cloud evolution, before global contraction concentrates the gas and the bulk of the stellar population is produced. In general, the existence of a small number of older stars among a generally much-younger population is consistent with the picture of dynamic star formation, and may even provide clues to the time evolution of star-forming clouds.

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Radiation hydrodynamics of triggered star formation: the effect of the diffuse radiation field

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We investigate the effect of including diffuse field radiation when modelling the radiatively driven implosion of a Bonnor-Ebert sphere (BES). Radiation-hydrodynamical calculations are performed by using operator splitting to combine Monte Carlo photoionization with grid-based Eulerian hydrodynamics that includes self-gravity. It is found that the diffuse field has a significant effect on the nature of radiatively driven collapse which is strongly coupled to the strength of the driving shock that is established before impacting the BES. This can result in either slower or more rapid star formation than expected using the on-the-spot approximation depending on the distance of the BES from the source object. As well as directly compressing the BES, stronger shocks increase the thickness and density in the shell of accumulated material, which leads to short, strong, photo-evaporative ejections that reinforce the compression whenever it slows. This happens particularly effectively when the diffuse field is included as rocket motion is induced over a larger area of the shell surface. The formation and evolution of 'elephant trunks' via instability is also found to vary significantly when the diffuse field is included. Since the perturbations that seed instabilities are smeared out elephant trunks form less readily and, once formed, are exposed to enhanced thermal compression.

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Analytical star formation rate from gravoturbulent fragmentation

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We present an analytical determination of the star formation rate (SFR) in molecular clouds, based on a time-dependent extension of our analytical theory of the stellar initial mass function (IMF). The theory yields SFR's in good agreement with observations, suggesting that turbulence *is* the dominant, initial process responsible for star formation. In contrast to previous SFR theories, the present one does not invoke **an ad-hoc** density threshold for star formation; instead, the SFR *continuously* increases with gas density, naturally yielding two different characteristic regimes, thus two different slopes in the SFR vs gas density relationship, in agreement with observational determinations. Besides the complete SFR derivation, we also provide a simplified expression, which reproduces reasonably well the complete calculations and can easily be used for quick determinations of the SFR in cloud environments. A key property at the heart of both our complete and simplified theory is that the SFR involves a *density-dependent dynamical time*, characteristic of each collapsing (prestellar) overdense region in the cloud, instead of one single mean or critical freefall timescale. Unfortunately, the SFR also depends on some ill-determined parameters, such as the core-to-star mass conversion efficiency and the crossing timescale. Although we provide estimates for these parameters, their uncertainty hampers a precise quantitative determination of the SFR, within less than a factor of a few.

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Eruptive Variable Stars and Outflows in Serpens NW

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We study the outflow activity, photometric variability and morphology of three very young stellar objects in the

Serpens NW star forming region: OO Serpentis, EC 37 (V370 Ser) and EC 53 (V371 Ser). High spatial resolution Keck/NIRC2 laser guide star adaptive optics images obtained in 2007 and 2009 in broad-band K and in a narrow-band filter centered on the 1–0 S(1) emission line of H_2 allow us to identify the outflows from all three objects. We also present new, seeing-limited data on the photometric evolution of the OO Ser reflection nebula and re-analyze previously published data. We find that OO Ser declined in brightness from its outburst peak in 1995 to about 2003, but that this decline has recently stopped and actually reversed itself in some areas of the reflection nebula. The morphology and proper motions of the shock fronts MHO 2218 near EC 37 suggest that they all originate in EC 37 and that this is an outflow seen nearly along its axis. We identify an H_2 jet emerging from the cometary nebula EC 53. The star illuminating EC 53 is periodically variable with a period of 543 days, and has a close-by, non-variable companion at a projected distance of 92 AU. We argue that the periodic variability is the result of accretion instabilities triggered by another very close, not directly observable, binary companion and that EC 53 can be understood in the model of a multiple system developing into a hierarchical configuration.

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Protostellar Feedback Halts the Growth of the First Stars in the Universe

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The first stars fundamentally transformed the early Universe by emitting the first light and by producing the first heavy elements. These effects were predetermined by the mass distribution of the first stars, which is thought to have been fixed by a complex interplay of gas accretion and protostellar radiation. We performed radiation-hydrodynamics simulations that followed the growth of a primordial protostar through to the early stages as a star with thermo-nuclear burning. The circumstellar accretion disk was evaporated by ultraviolet radiation from the star when its mass was 43 times that of the Sun. Such massive primordial stars, in contrast to the often postulated extremely massive stars, may help explain the fact that there is no signatures of the pair-instability supernovae in abundance patterns of metal-poor stars in our galaxy.

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Characterising the magnetic fields of the Herbig Ae/Be stars HD97048, HD150193, HD176386, and MWC480

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Our knowledge of the presence and the role of magnetic fields in intermediate-mass pre-main-sequence stars remains very poor.

We present the magnetic properties of four Herbig Ae/Be stars that have not been previously studied in detail.
Our results for the three Herbig Ae/Be stars HD 97048, HD 150193, and HD 176386 are based on multi-epoch low-resolution spectra obtained in spectropolarimetric mode with FORS 2 mounted on the VLT. New high-resolution polarimetric spectra were obtained for MWC 480 with the SOFIN spectrograph installed at the Nordic Optical Telescope.
We discuss 41 FORS 2 low-resolution observations of the Herbig Ae/Be stars HD 97048, HD 150193, and HD 176386 and determine their rotational periods. Using stellar fundamental parameters and the longitudinal magnetic field phase curves, we place constraints on the magnetic field geometry. Three high-resolution circularly polarised SOFIN spectra obtained for MWC 480 were measured using the moment technique where wavelength shifts between right- and left-hand side circularly polarised spectra are interpreted in terms of a longitudinal magnetic field $\langle B_z \rangle$.
Our search for periodicities resulted in $P = 0.693$ d for HD 97048, $P = 1.317$ d for HD 150193, and $P = 0.899$ d for HD 176386. The magnetic field geometry can likely be described by a centred dipole with a polar magnetic field strength $B_{\rm d}$ of several hundred Gauss. The longitudinal magnetic-field measurements of MWC 480 reveal the presence of a strong kG field, which was undetected in our previous low-resolution polarimetric observations with FORS 1. A weak magnetic field was detected in the circumstellar components of the Ca II H&K lines and the Na I D lines, indicating a complex interaction between the stellar magnetic field and the circumstellar environment.

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Far-Infrared Imaging Observations of the Chamaeleon region

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We have carried out far-infrared imaging observations toward the Chamaeleon star forming region by the Far-Infrared Surveyor (FIS) onboard the AKARI satellite. The AKARI images cover a total area of 33.79 degree^2, corresponding to 210 pc^2 at the distance to the source. Using the FIS bands of $65 - 160$ μm and the COBE/DIRBE bands of $60 - 240$ μm, we constructed column density maps of cold (11.7 K) and warm (22.1 K) dust components with a linear resolution of 0.04 pc. On the basis of their spatial distributions and physical properties, we interpret that the cold component corresponds to the molecular clouds and the warm one the cold H I clouds, which are thought to be in a transient phase between atomic and molecular media. The warm component is shown to be uniformly distributed at a large spatial scale of ~ 50 pc, while a several pc-scale gradient along the east-west direction is found in the distribution of the cold component. The former is consistent with a formation scenario of the cold H I clouds through the thermal instability in the warm neutral medium triggered by a 100 pc-scale supernova explosion. This scenario, however, cannot produce the latter, several pc-scale gradient in molecular cloud mass. We conclude that the gravitational fragmentation of the cold H I cloud likely created the molecular clouds with spatial scale as small as several pc.

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http://hibari.isas.jaxa.jp/nikeda/preprints/chass_paper_20111111.pdf

Orbit of the young very low-mass spectroscopic binary CHXR 74

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The pre-main sequence star CHXR 74 (M4.25) in Chamaeleon I was detected a few years ago to be a very low-mass spectroscopic binary. Determination of its mass would provide a valuable dynamical mass measurement at young ages in the poorly constrained mass regime of $< 0.3\,\mathrm{M}_\odot$. We carried out follow-up radial velocity monitoring with UVES/VLT between 2008 and 2011 and high-resolution adaptive optic assisted imaging with NACO/VLT in 2008

with the aim to constrain the binary orbit. We present an orbital solution of the system based on the combined radial velocity data set which spans more than eleven years of UVES monitoring for CHXR 74. The best-fit Kepler model has an orbital period of 13.1 years, zero eccentricity, and a radial velocity semi-amplitude of 2.2 km s^{-1}. A companion mass $M_2 \sin i$ (which is a lower limit due to the unknown orbital inclination i) of 0.08 $M_\odot$ is derived by using a model-dependent mass estimate for the primary of 0.24 $M_\odot$. The binary separation ($a_1 \sin i + a_2$) for an inclination of 90° is 3.8 AU which corresponds to 23 mas. Complementary NACO/VLT images of CHXR 74 were taken with the aim to directly resolve the binary. While there are marginal signs of an extended PSF, we have no convincing companion detected to CHXR 74 in the NACO images. From the non-detection of the companion together with a prediction of the binary separation at the time of the NACO observations, we derive an upper limit for the K-band brightness ratio of the two binary components of 0.5. This allows us to estimate an upper limit of the companion mass of 0.14 $M_\odot$ by applying evolutionary models. Thus, we have confirmed that CHXR 74 is a very low-mass spectroscopic binary and constrained the secondary mass to lie within the range of about 0.08 and 0.14 $M_\odot$. We predict an astrometric signal of the primary between 0.2 and 0.4 mas when taking into account the luminosity of the companion. The GAIA astrometric mission might well be able to solve the astrometric orbit of the primary and in combination with the presented radial velocity data to determine an absolute companion mass.

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http://www.mpia.de/homes/joergens/refpublications.html

The alignment of molecular cloud magnetic fields with the spiral arms in M33

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The formation of molecular clouds, which serve as stellar nurseries in galaxies, is poorly understood. A class of cloud formation models suggests that a large-scale galactic magnetic field is irrelevant at the scale of individual clouds, because the turbulence and rotation of a cloud may randomize the orientation of its magnetic field. Alternatively, galactic fields could be strong enough to impose their direction upon individual clouds, thereby regulating cloud accumulation and fragmentation, and affecting the rate and efficiency of star formation. Our location in the disk of the Galaxy makes an assessment of the situation difficult. Here we report observations of the magnetic field orientation of six giant molecular cloud complexes in the nearby, almost face-on, galaxy M33. The fields are aligned with the spiral arms, suggesting that the large-scale field in M33 anchors the clouds.

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G0.253+0.016: A molecular cloud progenitor of an Arches-like cluster

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Young massive clusters (YMCs) with stellar masses of 10^4 10^5 $M_\odot$ and core stellar densities of 10^4 10^5 stars per cubic pc are thought to be the missing link between open clusters and extreme extragalactic super star clusters and globular clusters. As such, studying the initial conditions of YMCs offers an opportunity to test cluster formation models across the full cluster mass range. G0.253+0.016 is an excellent candidate YMC progenitor. We make use of existing multi-wavelength data including recently available far-IR continuum (Herschel/Hi-GAL) and mm spectral line (HOPS and MALT90) data and present new, deep, multiple-filter, near-IR (VLT/NACO) observations to study G0.253+0.016. These data show G0.253+0.016 is a high mass (1.3×10^5 $M_\odot$), low temperature (T_{dust} ~20 K), high volume and column density ($n \sim 8 \times 10^4$ cm ^{3}; $N_{H2} \sim 4 \times 10^{23}$ cm ^{2}) molecular clump which is close to virial equilibrium ($M_{dust} \sim M_{virial}$) so is likely to be gravitationally-bound. It is almost devoid of star formation and, thus, has exactly the properties expected for the initial conditions of a clump that may form an Arches-like massive cluster. We compare the properties of G0.253+0.016 to typical Galactic cluster-forming molecular clumps and find it is extreme, and possibly unique in the Galaxy. This uniqueness makes detailed studies of G0.253+0.016 extremely important for testing massive cluster formation models.

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The Late Stages of Protoplanetary Disk Evolution: A Millimeter Survey of Upper Scorpius

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We present deep 1.2 millimeter photometry of 37 stars in the young (5 Myr) Upper Scorpius OB association, sensitive to $\sim 4 \times 10^{-3}$ M_{Jup} of cool millimeter dust. Disks around four low- and solar-mass stars are detected, as well as one debris disk around an intermediate mass star, with dust masses ranging from $3.6 \times 10^{-3} - 1.0 \times 10^{-1} M_{Jup}$. The source with the most massive disk exhibits a transition-disk spectral energy distribution. Combining our results with previous studies, we find the millimeter-detection fraction of Class II sources has significantly decreased from younger ages, and comparison with near-infrared and Hα measurements indicates the present disks have undergone significant evolution in composition or structure at all radii. The disks of Upper Scorpius represent the tail-end of the depletion of primordial disks; while a few near-solar mass stars may still sustain giant planet formation, this process has finished around higher mass stars.

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Molecular Gas In Young Debris Disks

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Gas-rich primordial disks and tenuous gas-poor debris disks are usually considered as two distinct evolutionary phases of the circumstellar matter. Interestingly, the debris disk around the young main-sequence star 49 Ceti possesses a substantial amount of molecular gas, and possibly represents the missing link between the two phases. Motivated to understand the evolution of the gas component in circumstellar disks via finding more 49 Ceti-like systems, we carried out a CO J=3-2 survey with Atacama Pathfinder EXperiment, targeting 20 infrared-luminous debris disks. These systems fill the gap between primordial and old tenuous debris disks in terms of fractional luminosity. Here we report on the discovery of a second 49 Ceti-like disk around the 30 Myr old A3-type star HD21997, a member of the Columba Association. This system was also detected in the CO(2-1) transition, and the reliable age determination makes it an even clearer example of an old gas-bearing disk than 49 Ceti. While the fractional luminosities of HD21997 and 49 Ceti are not particularly high, these objects seem to harbor the most extended disks within our sample. The double-peaked profiles of HD21997 were reproduced by a Keplerian disk model combined with the LIME radiative transfer code. Based on their similarities, 49 Ceti and HD21997 may be the first representatives of a so far undefined new class of relatively old ($\gtrsim$ 8 Myr), gaseous dust disks. From our results, neither primordial origin nor steady secondary production from icy planetesimals can unequivocally explain the presence of CO gas in the disk of HD21997.

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Evidence For Cloud-Cloud Collision and Parsec-Scale Stellar Feedback Within the L1641-N Region

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We present high spatial resolution ^{12}CO ($J = 1-0$) images taken by the Nobeyama 45m telescope toward a $48' \times 48'$ area including the L1641-N cluster. The effective spatial resolution of the maps is $21''$, corresponding to 0.04 pc at a distance of 400 pc. A recent 1.1 mm dust continuum map reveals that the dense gas is concentrated in several thin filaments. We find that a few dust filaments are located at the parts where ^{12}CO ($J = 1-0$) emission drops sharply. Furthermore, the filaments have two-components with different velocities. The velocity difference between the two-components is about 3 km s^{-1}, corresponding to a Mach number of 10, significantly larger than the local turbulent velocity in the cloud. These facts imply that the collision of the two components (hereafter, the cloud-cloud collision) possibly contributed to the formation of these filaments. Since the two components appear to overlap toward the filaments on the plane of the sky, the collision may have occurred almost along the line of sight. Star formation in the L1641-N cluster was probably triggered by such a collision. We also find several parsec-scale CO shells whose centers are close to either the L1641-N cluster or V 380 Ori cluster. We propose that these shells were created by multiple winds and/or outflows from cluster YSOs, i.e., "protocluster winds." One exceptional dust filament located at the western cloud edge lies along a shell; it is presumably a part of the expanding shell. Both the cloud-cloud collision and protocluster winds are likely to influence the cloud structure and kinematics in this region.

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First firm spectral classification of an early-B pre-main-sequence star: B275 in M17

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The optical to near-infrared (300 – 2500 nm) spectrum of the candidate massive young stellar object (YSO) B275, embedded in the star-forming region M17, has been observed with X-shooter on the ESO *Very Large Telescope*. The spectrum includes both photospheric absorption lines and emission features (H and Ca II triplet emission lines, 1st and 2nd overtone CO bandhead emission), as well as an infrared excess indicating the presence of a (flaring) circumstellar disk. The strongest emission lines are double-peaked with a peak separation ranging between 70 and 105 km s^{-1}, and they provide information on the physical structure of the disk. The underlying photospheric spectrum is classified as B6–B7, which is significantly cooler than a previous estimate based on modeling of the spectral energy distribution. This discrepancy is solved by allowing for a larger stellar radius (i.e. a bloated star) and thus positioning the star above the main sequence. This constitutes the first firm spectral classification of an early-B pre-main-sequence (PMS) star. We discuss the position of B275 in the Hertzsprung-Russell diagram in terms of PMS evolution. Although the position is consistent with PMS tracks of heavily accreting protostars ($\dot{\mathrm{M}}_{\mathrm{acc}} \geq 10^{-5}$ M$_{\odot}$ yr^{-1}), the fact that the photosphere of the object is detectable suggests that the current mass-accretion rate is not very high.

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APEX CO (9–8) Mapping of an Extremely High-Velocity and Jet-like Outflow in a High-Mass Star-Forming Region

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Atacama Pathfinder Experiment (APEX) mapping observations in CO (9–8) and (4–3) toward a high-mass star-forming region, NGC 6334 I, are presented. The CO (9–8) map has a 6.″4 resolution, revealing a ∼0.5 pc, jet-like, and bipolar outflow. This is the first map of a molecular outflow in a THz line. The CO (9–8) and (4–3) lines arising from the outflow lobes both show extremely high-velocity line wings, and their ratios indicate a gas temperature greater than 100 K and a density higher than 10^{4} cm^{-3}. The spatial-velocity structure of the CO (9–8) data is typical of a bow-shock-driven flow, which is consistent with the association between the bipolar outflow and the infrared bow-shaped tips. In short, the observations unveil a highly-excited and collimated component in a bipolar outflow that is powered by a high-mass protostar, and provide insights into the driving mechanism of the outflow. Meanwhile, the observations demonstrate that high-quality mapping observations can be performed with the new THz receiver on APEX.

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Analytic and numerical models for the expansion of a compact HII region

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"Compact" HII regions (embedded in dense molecular clouds) relax to a pressure equilibrium configuration in shorter timescales than the main sequence lifetime of the exciting O stars. This result motivates a re-derivation of the analytic model for the expansion of an HII region into a uniform environment. We have modified the classical model so as to include the breaking of the expansion necessary to reach the correct, final pressure equilibrium configuration. We find that this extended model also has a full analytic solution. A comparison of the analytic solution with a (spherically symmetric) numerical simulation is also presented.

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http://www.nucleares.unam.mx/astroplasmas/

New variable jet models for HH 34

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We consider newly derived proper motions of the HH 34 jet to reconstruct the evolution of this outflow. We first extrapolate ballistic trajectories for the knots (starting from their present day positions and velocities) and find that at ~ 1000 yr in the future most of them will merge to form a larger mass structure. This mass structure will be formed close to the present day position of the HH 34S bow shock. We then carry out a fit to the ejection velocity vs. time reconstructed from the observed proper motions (assuming that the past motion of the knots was ballistic) and use this fit to compute axisymmetric jet simulations. We find that the intensity maps predicted from these simulations do indeed match reasonably well the [S II] structure of HH 34 observed in HST images.

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Radio continuum emission from knots in the DG Tau jet

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Context: HH 158, the jet from the young star DG Tau, is one of the few sources of its type where jet knots have been detected at optical and X-ray wavelengths.
Aims: To search, using Very Large Array observations of this source, radio knots and if detected, compare them with the optical and X-ray knots. To model the emission from the radio knots.
Methods: We analyzed archive data and also obtained new Very Large Array observations of this source, as well as an optical image, to measure the present position of the knots. We also modeled the radio emission from the knots in terms of shocks in a jet with intrinsically time-dependent ejection velocities.

Results: We detected radio knots in the 1996.98 and 2009.62 VLA data. These radio knots are,within error, coincident with optical knots. We also modeled satisfactorily the observed radio flux densities as shock features from a jet with intrinsic variability. All the observed radio, optical, and X-ray knot positions can be intepreted as four successive knots, ejected with a period of 4.80 years and traveling away from the source with a velocity of 198 km s^{-1} in the plane of the sky.
Conclusions: The radio and optical knots are spatially correlated and our model can explain the observed radio flux densities. However, the X-ray knots do not appear to have optical or radio counterparts and their nature remains poorly understood.

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The Magnetic Field of the H II Region NGC 6334A from Faraday Rotation

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We have studied the polarization characteristics and Faraday rotation of the extragalactic radio source J17204−3554, that appears projected on the north lobe of the galactic H II region NGC 6334A. From observations made with the Very Large Array at 6.0 and 3.6 cm in three different epochs (1994, 1997, and 2006), we estimate a rotation measure of $+5100 \pm 900$ rad m^{-2} for the extragalactic source. This large rotation measure implies a line-of-sight average magnetic field of $B_{\|} \simeq +36 \pm 6$ μG, the largest obtained by this method for an H II region. NGC 6334A is significantly denser than other H II regions studied and this larger magnetic field is expected on the grounds of magnetic flux conservation. The ratio of thermal to magnetic pressure is $\sim$5, in the range of values determined for more diffuse H II regions.

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Molecular Line Observations of MCLD 123.5+24.9 in the Polaris Cirrus

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We present results of millimeter-wave observations with various molecular lines made toward MCLD 123.5+24.9 in the Polaris cirrus using the NRO 45 m telescope. MCLD 123.5+24.9 is one of the rare dense cores forming in diffuse cirrus clouds where star formation may rarely take place. In order to investigate the structure, dynamics, and the evolutionary stage of MCLD 123.5+24.9, we observed this core in 17 emission lines from 13 different molecular species. Emission lines of CS, CCS, and HC_3N are strongly detected all over the core, while those of SO and N_2H^+ are weak or remain undetected, indicating that MCLD 123.5+24.9 is in an early stage of core evolution in terms of the chemical compositions. Based on the comparison of the fractional abundances of CCS and HC_3N, which are considered as an indicator of the chemical age, with those of other cores with and without star formation as well as with model calculations in literature, we suggest that MCLD 123.5+24.9 is in a phase prior to star formation. From the $C^{18}O$ data obtained, we derived the total molecular mass of MCLD 123.5+24.9 to be $sim3\ Msun$ at an assumed distance of 150 pc. There are three subcores in MCLD 123.5+24.9, called CS-A, CS-B, and CS-C. We derived their masses to be

0.2–0.6 *Msun*. We also investigated the dynamical stability of MCLD 123.5+24.9 and the subcores by applying the Virial theorem to find that MCLD 123.5+24.9 is not gravitationally bound as a whole, while the individual subcores are in the Virial equilibrium and can turn into collapsing with a small increase of the external pressure imposed on their surfaces.

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Disc-mass distribution in star-disc encounters

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Investigations of stellar encounters in cluster environments have demonstrated their potential influence on the mass and angular momentum of protoplanetary discs around young stars. In this study it is investigated in how far the initial surface density in the disc surrounding a young star influences the outcome of an encounter. The numerical method applied here allows to determine the mass and angular momentum losses in an encounter for any initial disc-mass distribution. Based on a power-law ansatz for the surface density, $\Sigma(r) \propto r^{-p}$, a parameter study of star-disc encounters with different initial disc-mass distributions has been performed using N-body simulations.
It is demonstrated that the shape of the disc-mass distribution has a significant impact on the quantity of the disc-mass and angular momentum losses in star-disc encounters. Most sensitive are the results where the outer parts of the disc are perturbed by high-mass stars. By contrast, disc-penetrating encounters lead more or less independently of the disc-mass distribution always to large losses. However, maximum losses are generally obtained for initially flat distributed disc material. Based on the parameter study a fit formula is derived, describing the relative mass and angular momentum loss dependent on the initial disc-mass distribution index p. Generally encounters lead to a steepening of the density profile of the disc. The resulting profiles can have a r^{-2}-dependence or even steeper independent of the initial distribution of the disc material.
From observations the initial density distribution in discs remains unconstrained, so the here demonstrated strong dependence on the initial density distribution might require a revision of the effect of encounters in young stellar clusters. The steep surface density distributions induced by some encounters might be the prerequisite to form planetary systems similar to our own solar system.

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X-ray view of IC348 in the light of an updated cluster census

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IC348 is a nearby (~ 310 pc), young ($\sim 2-3$ Myr) open cluster with > 300 members identified from optical and infrared observations. We study the properties of the coronae of the young low-mass stars in IC348 combining X-ray and optical/infrared data. The four existing Chandra observations of IC348 are merged, thus providing a deeper and spatially more complete X-ray view than previous X-ray studies of the cluster. We have compiled a comprehensive catalog of IC348 members taking into account recent updates to the cluster census. Our data collection comprises fundamental stellar parameters, infrared excess indicating the presence of disks, Hα emission as a tracer of chromospheric emission or accretion and mass accretion rates. We have detected 290 X-ray sources in four merged

Chandra exposures, of which 187 are associated with known cluster members corresponding to a detection rate of $\sim 60\%$ for the cluster members of IC348 identified in optical/infrared studies. According to the most recent spectral classification of IC348 members only four of the X-ray sources are brown dwarfs (spectral type M6 and later). The detection rate is highest for diskless Class III stars and increases with stellar mass. This may be explained with higher X-ray luminosities for higher mass and later evolutionary stage that is evident in the X-ray luminosity functions. In particular, we find that for the lowest examined masses $(0.1 - 0.25\, M_\odot)$ there is a difference between the X-ray luminosity functions of accreting and non-accreting stars (classified on the basis of their Halpha emission strength) as well as those of disk-bearing and diskless stars (classified on the basis of the slope of the spectral energy distribution). These differences disappear for higher masses. This is related to our finding that the $L_{\rm x}/L_{\rm bol}$ ratio is non-constant across the mass/luminosity sequence of IC348 with a decrease towards lower luminosity stars. Our analysis of an analogous stellar sample in the Orion Nebula Cluster suggests that the decline of $L_{\rm x}/L_{\rm bol}$ for young stars at the low-mass end of the stellar sequence is likely universal.

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Multilayer modeling of porous grain surface chemistry I. The GRAINOBLE model

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Context: Mantles of iced water, mixed with carbon monoxyde, formaldehyde and methanol are formed during the so called prestellar core phase. In addition, radicals are also thought to be formed on the grain surfaces, and to react to form complex organic molecules later on, during the so called warm-up phase of the protostellar evolution.
Aims: The aim of this work is to study the formation of the grain mantles during the prestellar core phase and the abundance of formaldehyde, methanol, and radicals trapped in them.
Methods: We have developed a macroscopic statistic multilayer model that follows the formation of grain mantles with time and that includes two effects that may increase the number of radicals trapped in the mantles: i) at each time of the mantle formation, only the surface layer is chemically active rather than the entire bulk, and ii) the porous structure of grains allows to trap reactive particles. The model considers a network of H, O and CO forming neutral species such as water, CO, formaldehyde, and methanol, plus several radicals. We run a large grid of models to study the impact of the mantle multilayer nature and grain porous structure. In addition, we explored the influence of the uncertainty of other key parameters on the mantle composition.
Results: Our model predicts relatively large abundances of radicals, and more particularly of HCO and CH_3O. In addition, the multilayer approach makes it possible to follow the chemical differentiation within the grain mantle, showing that the mantles are far from being uniform. For example, methanol is mostly present in the outer layers of the mantles whereas CO and other reactive species are trapped in the inner layers. The overall mantle composition depends on the density and age of the prestellar core, as well as on some microscopic parameters, such as the diffusion energy and the hydrogenation reactions activation energy. Comparison with observations allows us to constrain the value of the last two parameters (0.5-0.65 and 1500 K, respectively) and provide some indications on the physical conditions during the formation of the ices.

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Numerical simulations of radiative magnetized Herbig-Haro jets: the influence of pre-ionization from X-rays on emission lines

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We investigate supersonic, axisymmetric magnetohydrodynamic (MHD) jets with a time-dependent injection velocity by numerical simulations with the PLUTO code. Using a comprehensive set of parameters, we explore different jet configurations in the attempt to construct models that can be directly compared to observational data of microjets. In particular, we focus our attention on the emitting properties of traveling knots and construct, at the same time, accurate line intensity ratios and surface brightness maps. Direct comparison of the resulting brightness and line intensity ratios distributions with observational data of microjets shows that a closer match can be obtained only when the jet material is pre-ionized to some degree. A very likely source for a pre-ionized medium is photoionization by X-ray flux coming from the central object.

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Modelling Herschel observations of hot molecular gas emission from embedded low-mass protostars

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Aims: Young stars interact vigorously with their surroundings, as evident from the highly rotationally excited CO (up to $E_{\rm up}/k = 4000$ K) and H_2O emission (up to 600 K) detected by the Herschel Space Observatory in embedded low-mass protostars. Our aim is to construct a model that reproduces the observations quantitatively, to investigate the origin of the emission, and to use the lines as probes of the various heating mechanisms.
Methods: The model consists of a spherical envelope with a power-law density structure and a bipolar outflow cavity. Three heating mechanisms are considered: passive heating by the protostellar luminosity, ultraviolet irradiation of the outflow cavity walls, and small-scale C-type shocks along the cavity walls. Most of the model parameters are constrained from independent observations; the two remaining free parameters considered here are the protostellar UV luminosity and the shock velocity. Line fluxes are calculated for CO and H_2O and compared to Herschel data and complementary ground-based data for the protostars NGC1333 IRAS2A, HH 46 and DK Cha. The three sources are selected to span a range of evolutionary phases (early Stage 0 to late Stage I) and physical characteristics such as luminosity and envelope mass.
Results: The bulk of the gas in the envelope, heated by the protostellar luminosity, accounts for 3–10% of the CO luminosity summed over all rotational lines up to $J = 40$–39; it is best probed by low-J CO isotopologue lines such as $C^{18}O$ 2–1 and 3–2. The UV-heated gas and the C-type shocks, probed by ^{12}CO 10–9 and higher-J lines, contribute 20–80% each. The model fits show a tentative evolutionary trend: the CO emission is dominated by shocks in the youngest source and by UV-heated gas in the oldest one. This trend is mainly driven by the lower envelope density in more evolved sources. The total H_2O line luminosity in all cases is dominated by shocks ($> 99\%$). The exact percentages for both species are uncertain by at least a factor of 2 due to uncertainties in the gas temperature as function of the incident UV flux. However, on a qualitative level and within the context of our model, both UV-heated gas and C-type shocks are needed to reproduce the emission in far-infrared rotational lines of CO and H_2O.

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Millimeter multiplicity in DR21(OH): outflows, molecular cores and envelopes

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We present sensitive high angular resolution ($\sim$ 1") millimeter continuum and line observations from the massive star forming region DR21(OH) located in the Cygnus X molecular cloud. Within the well-known dusty MM1-2 molecular cores, we report the detection of a new cluster of about ten compact continuum millimeter sources with masses between 5 and 24 $M_\odot$, and sizes of a few thousands of astronomical units. These objects are likely to be large dusty envelopes surrounding massive protostars, and some of them most probably drive several of the outflows that emanate from this region. Additionally, we report the detection of strong millimeter emission of formaldehyde (H_2CO) and methanol (CH_3OH) near 218 GHz as well as compact emission from the typical outflow tracers carbon and silicon monoxide (CO and SiO) toward this massive star-forming region. The H_2CO and CH_3OH emission is luminous ($\sim 10^{-4}$ $L_\odot$), well resolved, and found along the collimated methanol maser outflow first identified at centimeter wavelengths and in the sources SMA6 and SMA7. Our observations suggest that this maser outflow might be energized by a millimeter source called SMA4 located in the MM2 dusty core. The CO and SiO emission traces some other collimated outflows that emanate from MM1-2 cores, and are not related with the low velocity maser outflow.

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Disks and outflows in the massive protobinary system W3(OH)TW

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Sensitive and high angular resolution ($\sim 0''.7$) (sub)millimeter line and continuum observations of the massive star forming region W3(OH) made with the Submillimeter Array are presented. We report the first detection of two bipolar outflows emanating from the young and massive "Turner-Welch" [TW] protobinary system detected by the emission of the carbon monoxide. The outflows are massive (10 $M_\odot$), highly-collimated (10°), and seem to be the extended molecular component of the strong radio jets and a 22 GHz maser water outflow energized also by the stars in the W3(OH)TW system. Observations of the 890 μm continuum emission and the thermal emission of the CH_3OH might suggest the presence of two rotating circumstellar disk-like structures associated with the binary system. The disks-like structures have sizes of about 1500 AU, masses of a few $M_\odot$ and appear to energize the molecular outflows and radio jets. We estimate that the young stars feeding the outflows and that are surrounded by the massive disk-like structures maybe are B-type.

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Water in Star and Planet Forming Regions

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In this paper we discuss the astronomical search for water vapor in order to understand the disposition of water in all its phases throughout the process of star and planet formation. Our ability to detect and study water vapor has recently received a tremendous boost with the successful launch and operations of the *Herschel Space Observatory. Herschel* spectroscopic detections of numerous transitions in a variety of astronomical objects, along with previous work by other space-based observatories, will be threaded throughout this contribution. In particular, we present observations of water tracing the earliest stage of star birth where it is predominantly frozen as ice. When a star is born the local energy release by radiation liberates ices in its surrounding envelope and powers energetic outflows that appear to be water factories. In these regions water plays an important role in the gas physics. Finally, we end with an exploration of water in planet forming disks surrounding young stars. The availability of accurate molecular data (frequencies, collisional rate coefficients, and chemical reaction rates) are crucial to analyze the observations at each of these steps.

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Mixing and Transport of Isotopic Heterogeneity in the Early Solar System

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Isotopic abundances of short-lived radioisotopes such as ^{26}Al appear to provide precise chronometers of events in the early Solar System, assuming that they were initially homogeneously distributed. However, both ^{60}Fe and ^{26}Al were likely formed in a supernova and then injected into the solar nebula in a highly heterogeneous manner. On the other hand, the abundances in primitive meteorites of the three stable oxygen isotopes exhibit mass-independent fractionations that somehow survived homogenization in the solar nebula. The presence of refractory particles in Comet 81P/Wild 2, and the anomalously high crystallinity observed in protoplanetary disks, may both require large-scale outward radial transport from the hotter inner disk regions, even as disk gas accretes onto the central protostar. We examine here theoretical efforts to solve these seemingly disparate cosmochemical puzzles, and conclude that the mixing and transport produced by a phase of marginal gravitational instability appears to be able to meet all of these constraints.

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

Theory of Disks and Outflows around Massive Young Stellar Objects

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The inner most regions around massive young stellar objects (YSO) are associated with complex interactions between numerous physical processes. Since the inner few Astronomical Units (AU) are tough to resolve observationally, a theoretical approach is important to create a qualitative picture for these regions around young high-mass stars. This thesis investigates the interplay between important physical processes with respect to the dynamics of jets and inner accretion disks. This thesis provides a bridge between the physical structures of the inner and the outer disk, where the later is observationally easier to access. Above all, the importance of the radiative force in altering the dynamics of a magnetically launched jet is outlined in this thesis.

A thin accretion disk model with proper gas and dust opacities is applied for a luminous young high-mass star. This study has furnished estimates of various physical quantities in the inner few AU of the accretion disk. In particular, I have found that the mid-plane temperature around 0.1 AU could be as high as $10^5\,\mathrm{K}$ for a $10\,\mathrm{M}_\odot$ star. Such high temperatures in the disk destroy most of the dust grains already at large radii from the central star. This in turn reduces the opacity of the accreted matter thereby overcoming the central radiation-pressure from the young massive star. In addition, such disks are stable to gravitational fragmentation inside of 100 AU from the central star. Thus they form an ideal launching base for long-lasting outflows.

Outflows and jets are an ubiquitous phenomenon in young massive star forming regions. Observational surveys have suggested that the outflows become wider as the star grows in luminosity (thus mass) with time. I have performed magneto-hydrodynamical simulations of jet launching in presence of radiative forces from the luminous star and the inner hot accretion disk. The major outcome of this work, is that the radiative force from the *central star* plays a dominating role in accelerating and de-collimating the magnetically launched jet, while the influence of the *disk radiative force* is rather small. In addition, conducting an extensive parameter study, I have found that the outflows become wider as the mass (or luminosity) of the central star increases. The degree of collimation is also affected by the magnetic field strength and optical thickness of the line. This interplay of radiative and magnetic forces provides a physical insight to the trend in degree of collimation suggested by observations.

Finally, a fully three-dimensional simulation is conducted to understand the manner in which the inner accretion disk transports material onto the central massive star. The hydrodynamic flow in the disk is simulated in the presence of radiative transfer and/or self-gravity. The transport of angular momentum is solely due to gravitational torques. My first results indicate that a locally isothermal disk becomes gravitationally instable and fragments in the inner parts as it is fed with matter from the outer massive core with a steady accretion of $10^{-3}\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$. About 10% of the mass added onto the disk is accreted onto the central star in form of clumps. On the other hand, no fragmentation is seen in an adiabatic disk whose initial temperature profile is consistently derived from radiative transfer calculations. This investigation complements the above semi-analytical study of the inner disk to single out the physics of angular momentum transport in massive accretion disks.

http://www.ub.uni-heidelberg.de/archiv/12653

Postdoctoral fellowship and PhD positions
Star- and planet formation with ALMA

A 5-year postdoctoral fellowship and two 4-year PhD positions are available within the Molecular Astrophysics group at Leiden Observatory for observational and modeling studies of star- and planet formation and their astrochemistry with ALMA. The postdoc and PhD students will be part of an international team studying the physical and chemical evolution from collapsing cores to protoplanetary disks centered around ALMA observations. A wide range of complementary data from Herschel (in the context of the WISH and DIGIT key programs) as well as ground-based infrared and submillimeter spectroscopy is available.

The postdoc candidate is expected to co-supervise PhD students and is encouraged to also pursue a personal research program. The postdoc appointment is initially for two years, with the possibility of renewal for up to three years. It can start anytime up to Fall 2012.

Candidates with an observational and/or modeling background in astrochemistry, low-mass star formation, circumstellar disks or submillimeter spectroscopy are encouraged to apply.

Leiden Observatory carries out observational, interpretative and theoretical research in the fields of the star and planet formation, laboratory astrophysics, galactic structure, the formation and cosmology. Leiden is a charming university town, within easy reach of the major European centers.

Applications should include a curriculum vitae, publication list, and a brief statement of research experience and interests, and arrange for at least three letters of reference to be uploaded on the relevant website. Deadline for PhD positions is December 16 2011. Review of applications for the postdoc position will start on January 2 2012.

Web site for submission:

Postdoc: http://jobs.strw.leidenuniv.nl/2012/dishoeckPD/

PhD: http://www.strw.leidenuniv.nl/phd/apply.php

For more information, see

http://www.strw.leidenuniv.nl/~ewine

http://www.strw.leidenuniv.nl/WISH

Post Doctoral Position at IRAP (Toulouse, France):
Properties of Galactic cold sources seen by Planck and Herschel

The National Center for Space Studies (CNES) offers a postdoctoral fellowship at the Research Institute in Astrophysics and Planetology (IRAP[1]) in Toulouse to work on the Herschel key-programme : 'Galactic Cold Cores : A Herschel survey of the source population revealed by Planck' (PI M.Juvela). More than 10000 Galactic cold sources have been detected in the Planck all-sky survey. These cold sources cover a broad range of characteristics and their link to star formation in the Galaxy remains to be established : this is the main goal of our project based on Herschel/SPIRE and PACS observations of a subset of about 350 Planck cold sources distributed in a variety of environments in the Galaxy.
The successful applicant will take an active role in the project working at his/her convenience on the different approaches necessary to characterize the cold sources: their dust and gas properties, their association with young stellar objects, their gravitational stability and kinetic and magnetic support, the influence of the Galactic environment on their properties. This is made possible by the large set of available data from Herschel and Planck (including the

polarized dust emission) combined with AKARI, Spitzer, WISE and dedicated follow-ups on ground-based telescopes in dust continuum emission and gas molecular line tracers. A first set of results has been published : a statistical view of the cold source catalogue in the Planck collaboration paper : http://arxiv.org/abs/1101.2035, and the first follow-ups with Herschel in the Planck collaboration paper : http://arxiv.org/abs/1101.2034, and in Juvela et al. A&A 518, L93, 2010 and A&A 527, A111, 2011.

Applicants should have a PhD in astronomy or a closely related field. Preference will be given to applicants with observational or theoretical experience in one or more of the following domains: interstellar dust, star formation, molecular clouds, submillimetre astronomy, molecular lines, interstellar chemistry. The position will be for 2 years, with the possibility of extension for one additional year, and could start as early as March 2012. Review of applications will begin on January 15th 2012 and until the application is filled. Applications (curriculum vitae, list of publications, and a statement of research interests) should be submitted by e-mail with three reference letters sent separately by their author to the same address. For further information and to submit the application, please contact the co-leader of the project, Dr Isabelle Ristorcelli at IRAP: isabelle.ristorcelli@irap.omp.eu .

(1) IRAP : http://www.irap.omp.eu/index.php/eng/irap , the Research Institute in Astrophysics and Planetology (IRAP) has been recently created by merging the former LATT and CESR research institutes and teams of Planetology. With about 300 researchers, it has become one of the main poles of space astrophysics in France, and benefits from laboratory experiments on dust and theoretical expertise.

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

Protostars and Planets VI

15 - 20 July 2013, Heidelberg Germany
http://www.ppvi.org

The Protostars and Planets series for more than three decades has served the community with state of the art compilations of the current knowledge in the fields of star and planet formation. The previous volume PPV is published in 2007, but the contents is based on the year of the corresponding conference in 2005 in Hawaii. Since then, the field of protostars and planets has advanced tremendously, from a theoretical as well as observational point of view. To give a few examples:

Regarding observational studies of star formation, the launch of the Herschel Space Observatory opened up a new window to investigate the peak of the spectral energy distribution of young star-forming regions, and SOFIA will continue exploring that wavelength regime. While previous investigations about the initial conditions of star formation often relied on more indirect approaches, we can now study the onset of star formation and the associated physical/chemical processes in unprecedented detail.

The exoplanet searching and characterization has progressed enormously. More than 700 extra-solar planets have been detected, and thanks to the Kepler mission more and more super-earth like objects are among these planets. Having large samples is important for deriving statistical characteristics of exoplanets and exoplanetary systems, and since PPV the population synthesis models to explain these systems have also progressed dramatically. Furthermore, the field of transit spectroscopy rises to adulthood, and we start obtaining spectra from extrasolar planetary atmospheres.

As for the planetary birth places: The amount of observational data of protoplanetary disks has multiplied: large quantities of Spitzer data are already there and published, Herschel data are currently streaming in and the first results of the Atacama Large Millimeter Array (ALMA) are expected. Also our knowledge about the underlying disk physics e.g. the role of the turbulence driving mechanisms has revolutionized. Our better numerical simulations of disks in combination with radiation transport lead currently to a breakthrough in the migration problem of planets.

Also in our theoretical (in particular numeric) understanding of how planets form there has been tremendous progress since PPV. For instance, there has been a clear paradigm shift in how planetesimals are formed from cosmic dust: The new buzz words are "gravoturbulent planetesimal formation" and "particle growth in pressure traps". It is now feasible to engage in a multi-scale and multi-physics approach to modeling the birth of stars and planets. Furthermore, 3-dimensional magnetohydrodynamic simulations combined with time-dependent chemistry and radiative transfer calculations allow for the self-consistent treatment of such diverse physical processes as molecular cloud formation in the turbulent multi-phase interstellar medium or studying the influence of ionizing feedback from the central high-mass star on the fragmentation and star-formation properties of the infalling envelope.

All in all it is high time for a new Protostars and Planets conference and a corresponding book. The Protostars and Planets conference will take place in Heidelberg, Germany, 15-20 July 2013. A call to the community for review chapters and their corresponding review talks will be posted in due time. The call will allow free suggestions of topics, but the SAC and the editors found it useful to compile a strawman's topic/chapter list as a guideline as to what we think the PPVI chapters might look like. This is by no means final. The list is:

<u>Star Formation</u>
- Formation of molecular clouds and global conditions for star formation
e.g., converging flows, turbulence, HI to H2 conversion, magnetic fields, filamentary structures
- Formation of individual stars and clusters
e.g., low- and high-mass star formation, core fragmentation, origin of IMF, magnetic fields
- Origin of stellar multiplicity
e.g., binaries and higher order systems, core fragmentation
- Importance of stellar feedback
e.g., winds, outflows, radiation

- Collapse and formation of protostellar disks
e.g., chemical evolution, main protostellar accretion phase (class 0), outflows, accretion rates, episodic accretion, magnetic fields, environmental conditions
- Formation of very low-mass stars, brown dwarfs and free-floating planets
- A unified picture from low- to high-mass and "isolated" to clustered" star formation?

<u>Formation and evolution of protoplanetary disks</u>
- Physical characteristics of disks
e.g., disk sizes, masses, structure, characteristics, transition disks, environmental conditions
- Gas evolution in disks
e.g., initial conditions
- Dust evolution in disks
- Protoplanetary disks in cluster environment
e.g., radiation from O stars, dynamic interaction
- Cosmochemical constraints on disk evolution
e.g., isotopes in solar system, crystals, mixing, stardust
- Disk dynamics
e.g. dead zone, viscosity, stability, turbulence, instabilities
- Disk dissipation
e.g., photoevaporation, disk winds, transition disks

<u>Planet formation and planetary systems</u>
- Planetesimal formation
e.g., dust growth, gravoturbulence
- Terrestrial planet formation
- Giant planet formation
e.g., core accretion and disk instabilities
- Planet-disk interaction
e.g., migration, gaps
- Structure and evolution of debris disks
- Long term dynamical evolution of planetary systems
e.g., isolated and in clusters
- Chemical evolution of planetary systems
e.g., primitive matter in the solar system (refractory, ices, vapor), meteoritics
- Planetary system architecture
e.g. observations, size, mass, composition, orbits, resonances, misalignement
- The solar system in context of planet formation
e.g., asteroids, comets, KBOs, planets: orbits, masses
- Dating of major events in the solar system by isotope studies
- Planetary internal structures
e.g., terrestrial and giants, bloated, core masses, envelope structures
- Planetary atmospheres
e.g., terrestrial and giants
- Population synthesis

<u>Astrophysical conditions for life</u>
- Habitability
e.g., stellar distance to get water, moon, UV/X-rays
- Geochemical landscape for the formation of life
e.g., geochemical cycles, techtonics
- Formation of life
e.g., formation of cells and astrophysical signatures, left-right amino-acids

Scientific Advisory Committee (SAC): Philippe Andre, Javier Ballesteros-Paredes, Isabelle Baraffe, Alan Boss, John Bradley, Nuria Calvet, Gael Chauvin, Therese Encrenaz, Guido Garay, Tristan Guillot, Nader Haghighipour, Shigeru Ida, Ray Jayawardhana, Willy Kley, Alexander Krot, Katharina Lodders, Karl Menten, Michael Meyer, Alessandro Morbidelli, Ralph Pudritz, Bo Reipurth, Dimitar Sasselov, Motohide Tamura, Ewine van Dishoeck, Stephane Udry, Alycia Weinberger

We are looking forward to see you in Heidelberg in July 2013!

Henrik Beuther, Ralf Klessen, Kees Dullemond, Thomas Henning

42nd Saas-Fee Winter Course: Dynamics of Young Star Clusters and Associations

March 25-31, 2012, Villars-sur-Ollon, Switzerland

We are pleased to announce the program for the 2012 Saas-Fee Course with a series of lectures concerning the theory and observational constraints on the dynamics of young star clusters and associations. With the proliferation of large area photometric, radial velocity, and astrometric surveys from ground-based telescopes, the launch of Gaia planned for 2013, and the explosive increase in our capacity to simulate the dynamics of these complex systems, the time is right to visit this topic. The school will attempt to address such questions as:

1) How common are star-forming events of varying richness?

2) What are the dynamical states of these events?

3) In what sort of star-forming event did the Sun form?

4) How can we use answers to these questions to constrain predictive theories of star formation?

These questions will be addressed by the following distinguished international faculty:

Prof. Cathie Clarke, Institute of Astronomy, U. Cambridge

Prof. Robert Mathieu, Dept. of Astronomy, U. Wisconsin

Dr. Neill Reid, Space Telescope Science Institute

These schools, which began over 40 years ago, are intended for graduate students, post-doctoral fellows, and senior researchers interested in learning more about the topic. Registration is now open with early registration discount deadline 15 January, 2012. The school is limited to 100 participants. Villars-sur-Ollon, Switzerland is located in the heart of the Alpes Vaudoises provides a range of winter sport and other activities. It should provide an excellent setting for this school. Travel grants are available for students who also plan to attend 'From Atoms to Pebbles: Herschel's view of Star and Planet Formation'. More information is available on the website:

http://www.astro.phys.ethz.ch/sf2012/