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Abstracts of recently accepted papers

Warm Molecular Layers in Protoplanetary Disks

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We have investigated molecular distributions in protoplanetary disks, adopting a disk model with a temperature gradient in the vertical direction. The model produces sufficiently high abundances of gaseous CO and HCO^+ to account for line observations of T Tauri stars using a sticking probability of unity and without assuming any non-thermal desorption. In regions of radius $R \gtrsim 10$ AU, with which we are concerned, the temperature increases with increasing height from the midplane. In a warm intermediate layer, there are significant amounts of gaseous molecules owing to thermal desorption and efficient shielding of ultraviolet radiation by the flared disk. The column densities of HCN, CN, CS, H_2CO, HNC and HCO^+ obtained from our model are in good agreement with the observations of DM Tau, but are smaller than those of LkCa15. Molecular line profiles from our disk models are calculated using a 2-dimensional non-local-thermal-equilibrium (NLTE) molecular-line radiative transfer code for a direct comparison with observations. Deuterated species are included in our chemical model. The molecular D/H ratios in the model are in reasonable agreement with those observed in protoplanetary disks.

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http://nova.planet.sci.kobe-u.ac.jp/~aikawa/paper_list.html

Characterization of low-mass pre-main sequence stars in the Southern Cross

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We report high-resolution spectroscopic observations, as well as high-resolution near infrared (IR) imaging of six stars previously identified in a ROSAT pointed observation in the direction of the B-type star β Cru, and classified as low-mass pre-main sequence (PMS) stars. Four of the stars are confirmed to be low-mass PMS stars, associated with the Lower Centaurus-Crux group, while the other two are unrelated to the Sco-Cen association. The confirmed PMS stars are most likely in their post-T Tauri evolutionary phase. Although future deep X-ray observations with high-resolution imagers might detect more new PMS stars, the possibility that the Crux PMS stars are part of a small aggregate, with β Crux itself approximately at the center, is rather unlikely, given the high velocity dispersion and the low spatial density of the confirmed PMS stars. Instead, these stars may be part of a moving group in a more dispersed and numerous population of low-mass PMS stars, distributed in the Lower Centaurus-Crux subgroup. New PMS binaries and multiple systems were also discovered among the stars in the sample namely, a close visual pair and a hierarchical triple system in which one of the components is a double-lined spectroscopic binary (SB2). The

detailed orbital solution is reported for the inner short-period (P_{orb}=58.3 days) SB2. A preliminary orbital solution for the hierarchical triple system yields a systemic orbital period of about 4.6 years, which makes this object a very suitable target for follow-up observations with the Very-Large Telescope Interferometer (VLTI) in the coming years.

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Variability of Southern T Tauri Stars II: The Spectral Variability of the Classical T Tauri Star TW Hya

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We present the analysis of 42 spectra of the Classical T Tauri star TW Hya observed with the FEROS echelle spectrograph over 2 years. We determined the rotational and radial velocities of TW Hya, obtaining $v \sin i = 5 \pm 2$ km s^{-1} and $v_{rad} = 12.5 \pm 0.5$ km s^{-1}. The star exhibits strong emission lines that show substantial variety and variability in their profile shapes. Emission lines such as Hα, Hβ and HeI show both outflow and infall signatures, which change on different timescales.

The system displays periodic variations in line and veiling intensities, but the stellar rotation period remains uncertain. We see evidence of a variation in the mass accretion rate over a 1 year period from the NaD line profiles that are well fitted by magnetospheric accretion models with moderate mass accretion rates (10^{-9} up to 10^{-8} $M_{\odot}yr^{-1}$). The lower values inferred from the models are close to the average mass accretion rate obtained from the veiling estimates ($\sim 2 \times 10^{-9}$ $M_{\odot}yr^{-1}$), but the veiling results are consistent with a constant a mass accretion rate within the errors of the calculations.

The Hα, HeI, NaD and Hβ emission line equivalent widths corrected from veiling correlate well with each other and are correlated with the veiling, indicating the same mechanism should be powering them and suggesting an origin related to the accretion process. The wings of the main emission lines are generally correlated, except when the Balmer lines exhibit properties suggesting a strong contribution from a wind. The blueward absorption components of the Balmer lines, most likely from awind, are not correlated with veiling.

The spectroscopic analysis allows us to infer the inclination of the stellar rotation axis ($i = 18° \pm 10°$) that matches the current estimations of the disk orientation ($0° < i < 15°$). A magnetospheric dipole axis that is misaligned with the stellar/disk rotation axis could produce the observed photometric variability and we tend to favor a low inclination but not a totally face-on geometry for the system. TW Hya exhibits typical spectral characteristics of many classical T Tauri stars in Taurus, despite its older age, indicating that active accretion disks can readily survive up to 10 Myr.

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preprints available at http://www.iagusp.usp.br/~alencar/twhya/twhya1.html

Physical vs. Observational Properties of Clouds in Turbulent Molecular Cloud Models

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We examine the question of how well the physical properties of clumps in turbulent molecular clouds can be determined by measurements of observed clump structures. To do this, we compare simulated observations of three-dimensional numerical models of isothermal, magnetized, supersonic turbulence to the actual physical structure of the models. We begin by determining how changing the parameters of the turbulence changes the structure of the simulations. Stronger driving produces greater density fluctuations, and longer wavelength driving produces larger structures. Magnetic fields have a less pronounced effect on structure, and one that is not monotonic with field strength. Aligned structures are seen only with low-density tracers, and when the intensity of the field is large. Comparing different regions with the same tracers (or conversely, the same region with different tracers) can give information about the physical conditions of the region. In particular, different density tracers can help determine the size of the density fluctuations and thus the strength of the driving. Nevertheless, velocity superposition of multiple physical clumps can fully obscure the physical properties of those clumps, and short wavelength (compared to the size of the region under analysis) driving worsens this effect. We then compare Larson's relationships and mass spectra in physical and observational space for the same structure dataset. We confirm previous claims that the mean density-size relationship is an observational artifact due to limited dynamical range in column density: it is the inevitable consequence presence of a lower cutoff in column density. The velocity dispersion-size relationship, on the other hand, is reproduced in both physical and observed clumps, although with substantial scatter in the derived slope, consistent with observations. Finally, we compute the mass spectra for the models and compare them to mass spectra derived from simulated observations of the models. We show that, when we look for clumps with high enough resolution, they both converge to the same shape. This shape appears to be log-normal, however, rather than the power-law function usually used in the literature.

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Preprint available at `ftp://ftp.astrosmo.unam.mx/pub/j.ballesteros/Papers`

Velocity Structure of the ISM as Seen by the Spectral Correlation Function

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We use the statistical tool known as the "Spectral Correlation Function" [SCF] to intercompare simulations and observations of the atomic interstellar medium. The simulations considered, which mimic three distinct sets of physical conditions, are each calculated for a 300 pc^3 box centered at the Galactic plane. Run "ISM" is intended to represent a mixture of cool and warm atomic gas, and includes self-gravity and magnetic fields in the calculations. Run "ISM-IT" is more representative of molecular clouds, where the gas is presumed isothermal. The third run, "IT" is for purely isothermal gas, with zero magnetic field, and no self-gravity. Forcing in the three cases is accomplished by including simulated effects of stellar heating (for ISM), stellar winds (ISM-IT), or random compressible fluctuations (IT).

For each simulation, H I spectral-line maps are simulated, and it is these maps which are intercompared, both with each other, and with observations, using the SCF. For runs where the separation of velocty features is much greater than the "thermal" width of a line, density-weighted velocity histograms are decent estimates of H I spectra. When thermal broadening is large in comparison with fine-scale turbulent velocity structure, this broadening masks sub-thermal velocity sub-structure in observed spectra. So, simulated spectra for runs where thermal broadening is important must be calculated by convolving density-weighted histograms with gaussians whose width represents the thermal broadening.

The H I observations we use here for comparison are of the North Celestial Pole Loop, a region chosen to minimize line-of-sight confusion on scales > 100 pc. *None* of the simulations match the NCP Loop data very well, for a variety of reasons described in the paper. Most of the reasons for simulation/observation discrepancy are predictable and understandble, but one is particularly curious: the most realistic "simulation" comes from *artifically expanding* the velocity axis of run ISM by a factor of six. Without rescaling, the high temperature associated with much of the gas in run ISM causes almost all of the spectra to appear as virtually identical gaussians whose width is deterimined solely by the temperature–all velocity structure is smeared out by thermal broadening. However, if the velocity axis is expanded $\times 6$, the SCF distributions of run ISM an the NCP Loop match up fairly well. This means that the ratio of thermal to turbulent pressure in run ISM is much too large in the simulation as it stands, and that either the temperature is much (~ 36 times) lower, and/or that the turbulent energy in the simulation is much too small. Run ISM does not include the effects of supernovae, which means that the turbulent energy (and hence velocity scale) is likely to be dramatically underestimated.

The paper concludes that the SCF is a useful tool for understanding and fine-tuning simulations of interstellar gas, and in particular that a realistic simulation of the atomic ISM needs to include the effects of energetic stellar winds

(e.g. supernovae) before the ratio of thermal-to-turbulent pressure will give spectra representative of the observed interstellar medium in our Galaxy.

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Hubble Space Telescope Observations of Proper Motions in Herbig-Haro Objects 1 and 2

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Hubble Space Telescope observations obtained in 1994 and 1997 are used to measure proper motions in the HH 1/2 protostellar outflow in Orion. Since the HH 1/2 system lies within 10^o of the plane of the sky, proper motions provide accurate measures of true space velocities. Comparison of the 1994 and 1997 images reveal a variety of changes such as the emergence of new knots from the driving source embedded in the HH 1/2 cloud core and the fading or brightening of some features. However, such brightness changes affect a small fraction ($< 10\%$) of the total emission. Proper motion measurements reveal complex velocity variations along the flow axis and pronounced velocity shear orthogonal to it. Along the extension of the HH 1 jet axis, speeds vary from under 100 km/s near the tip of HH 2, range from 255 to 345 km/s in the HH 1 jet itself, and reach peak values of more than 400 km/s near the leading edge of HH 1 and in parts of the brightest knot complexes in the center of HH 2. While the velocity dispersion within the low-excitation HH 1 jet is less than 30 km/s, high-excitation features in HH 1 and HH 2 exhibit local velocity variations in excess of 150 km/s. Both the internal velocity dispersion and the angular width of the emitting fluid as seen from the source, VLA 1, increase with distance. HH 1 and HH 2 contain complex substructures having chaotic internal motions, proper motions that decline rapidly orthogonal to the jet axis, and both downstream and upstream facing (reverse) bow shocks. Downstream facing bow features tend to have high velocities while reverse bow shocks have low speeds. The complex texture and flow field indicate that both the fast and slow fluid elements now colliding in shocks were clumped and had chaotic velocity field prior to entering the currently active shocks. Both fluids may have been processed by prior generations of shocks and been processed by instabilities. Indeed, transverse motions in HH 1 and HH 2 indicate that expansion started well after the material was ejected from VLA 1, possibly as a result of having been processed through now extinct shocks. A second outflow from the HH 1/2 cloud core, HH 501, which consists of two knots located about $1''$ west of the base of the HH 1 jet, also has proper motions directly away from VLA 1, but with a speed of only about 180 km/s. The lack of interactions between the nearby high speed HH 1 and slower HH 501 jets may indicate that the density of the medium surrounding each jet is at least an order of magnitude below that of the visible knots. Thus, the visible jet components probably transport the bulk of the energy and momentum in these outflows. Finally, the Cohen-Schwartz star is found to be a $0.2''$ separation binary.

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The Excitation, Propagation and Dissipation of Waves in Accretion Discs: The Non-linear Axisymmetric Case

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We analyse the non-linear propagation and dissipation of axisymmetric waves in accretion discs using the ZEUS-2D hydrodynamics code. The waves are numerically resolved in the vertical and radial directions. Both vertically isothermal and thermally stratified accretion discs are considered. The waves are generated by means of resonant forcing and several forms of forcing are considered. Compressional motions are taken to be locally adiabatic ($\gamma = 5/3$). Prior to non-linear dissipation, the numerical results are in excellent agreement with the linear theory of wave channelling in predicting the types of modes that are excited, the energy flux by carried by each mode, and the vertical wave energy distribution as a function of radius. In all cases, waves are excited that propagate on both sides of the resonance (inwards and outwards). For vertically isothermal discs, non-linear dissipation occurs primarily through shocks that result from the classical steepening of acoustic waves. For discs that are substantially thermally stratified, wave channelling is the primary mechanism for shock generation. Wave channelling boosts the Mach number of the wave by vertically confining the wave to a small cool region at the base of the disc atmosphere. In general, outwardly propagating waves with Mach numbers near resonance $\mathcal{M}_{\rm r} \gtrsim 0.01$ undergo shocks within a distance of order the resonance radius.

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http://www.astro.ex.ac.uk/people/mbate

The Environment and Nature of the Class I Protostar Elias 29: Molecular Gas Observations and the Location of Ices

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A (sub-)millimeter line and continuum study of the class I protostar Elias 29 in the ρ Ophiuchi molecular cloud is presented, whose goals are to understand the nature of this source, and to locate the ices that are abundantly present along this line of sight. Within 15–60″ beams, several different components contribute to the line emission. Two different foreground clouds are detected, an envelope/disk system and a dense ridge of HCO^+–rich material. The latter two components are spatially separated in millimeter interferometer maps. We analyze the envelope/disk system by using inside-out collapse and flared disk models. The disk is in a relatively face-on orientation ($< 60^o$), which explains many of the remarkable observational features of Elias 29, such as its flat SED, its brightness in the near infrared, the extended components found in speckle interferometry observations, and its high velocity molecular outflow. It cannot account for the ices seen along the line of sight, however. A small fraction of the ices is present in a (remnant) envelope of mass 0.12–0.33 $M_\odot$, but most of the ices ($\sim$70%) are present in cool (T <40 K) quiescent foreground clouds. This explains the observed absence of thermally processed ices (crystallized H_2O) toward Elias 29. Nevertheless, the temperatures could be sufficiently high to account for the low abundance of apolar (CO, N_2, O_2) ices. This work shows that it is crucial to obtain spectrally and spatially resolved information from single-dish and interferometric molecular gas observations in order to determine the nature of protostars and to interpret infrared ISO satellite observations of ices and silicates along a pencil beam.

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Evidence for a developing gap in a 10 Myr old protoplanetary disk

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We have developed a physically self-consistent model of the disk around the nearby 10 Myr old star TW Hya which matches the observed spectral energy distribution and 7mm images of the disk. The model requires both significant dust size evolution and a partially-evacuated inner disk region, as predicted by theories of planet formation. The outer disk, which extends to at least 140 AU in radius, is very optically thick at infrared wavelengths and quite massive ($\sim 0.06 M_{\odot}$) for the relatively advanced age of this T Tauri star. This implies long viscous and dust evolution timescales, although dust must have grown to sizes of order ~ 1 cm to explain the sub-mm and mm spectral slopes. In contrast, the negligible near-infrared excess emission of this system requires that the disk be optically thin inside 4 AU. This inner region cannot be completely evacuated; we need ~ 0.5 lunar mass of ~ 1 μm particles remaining to produce the observed 10μm silicate emission. Our model requires a distinct transition in disk properties at ~ 4 AU, separating the inner and outer disk. The inner edge of the optically-thick outer disk must be heated almost frontally by the star to account for the excess flux at mid-infrared wavelengths. We speculate that this truncation of the outer disk may be the signpost of a developing gap due to the effects of a growing protoplanet; the gap is still presumably evolving because material still resides in it, as indicated by the silicate emission, the molecular hydrogen emission, and by the continued accretion onto the central star (albeit at a much lower rate than typical of younger T Tauri stars). TW Hya thus may become the Rosetta stone for our understanding of the evolution and dissipation of protoplanetary disks.

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http://cfa-www.harvard.edu/cfa/youngstars/index.html

Extinction with 2MASS: star counts and reddening toward the North America and the Pelican Nebulae

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We propose a general method for mapping the extinction in dense molecular clouds using 2MASS near-infrared data. The technique is based on the simultaneous utilization of star counts and colors. These two techniques provide independent estimations of the extinction and each method reacts differently to foreground star contamination and to star clustering. We take advantage of both methods to build a large scale extinction map ($2.5° \times 2.5°$) of the North America-Pelican nebulae complex. With K_s star counts and $H - K_s$ color analysis the visual extinction is mapped up to 35 mag. Regions with visual extinction greater than 20 mag account for less than 3% of the total mass of the cloud. Color is generally a better estimator for the extinction than star counts. Nine star clusters are identified in the area, seven of which were previously unknown.

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http://spider.ipac.caltech.edu/staff/laurent/NAN/nan.ps.gz

The Magnetic Field Structure of W51A

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We present 850 μm imaging polarimetry of the W51A massive star forming region performed with SCUBA on the JCMT. From the polarimetry we infer the column-averaged magnetic field direction, projected onto the plane of the sky. We find that the magnetic field geometry in the region is complicated. We compare the field geometry with 6 cm and CS J=7-6 emission and determine that the magnetic field must be relatively weak and plays a passive role, allowing itself to be shaped by pressure forces and dynamics in the ionised and neutral gases. Comparisons are drawn between our data and 1.3 mm BIMA interferometric polarimetry data, from which we conclude that the magnetic field must increase in importance as we move to smaller scales and closer to sites of active star formation.

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ISO LWS Spectra of T Tauri and Herbig AeBe Stars

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We present an analysis of ISO-LWS spectra of eight T Tauri and Herbig AeBe young stellar objects. Some of the objects are in the embedded phase of star-formation, whereas others have cleared their environs but are still surrounded by a circumstellar disk. Fine-structure lines of [OI] and [CII] are most likely excited by far-ultraviolet photons in the circumstellar environment rather than high-velocity outflows, based on comparisons of observed line strengths with predictions of photon-dominated and shock chemistry models. A subset of our stars and their ISO spectra are adequately explained by models constructed by Chiang & Goldreich (1997) and Chiang et al. (2001) of isolated, passively heated, flared circumstellar disks. For these sources, the bulk of the LWS flux at wavelengths longward of 55μm arises from the disk interior which is heated diffusively by reprocessed radiation from the disk surface. At 45μm, water ice emission bands appear in spectra of two of the coolest stars, and are thought to arise from icy grains irradiated by central starlight in optically thin disk surface layers.

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A search for 4750- and 4765-MHz OH masers in Southern Star Forming Regions

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We have used the Australia Telescope Compact Array (ATCA) to make a sensitive (5-$\sigma \simeq$ 100 mJy) search for maser emission from the 4765-MHz $^2\Pi_{1/2}$ F=1$\rightarrow$0 transition of OH. Fifty five star formation regions were searched and maser emission with a peak flux density in excess of 100 mJy was detected toward fourteen sites, with ten of these being new discoveries. In addition we observed the 4750-MHz $^2\Pi_{1/2}$ F=1$\rightarrow$1 transition towards a sample of star formation regions known to contain 1720-MHz OH masers, detecting marginal maser emission from G348.550-0.979. If confirmed this would be only the second maser discovered from this transition.

The occurrence of 4765-MHz OH maser emission accompanying 1720-MHz OH masers in a small number of well studied star formation regions has lead to a general perception in the literature that the two transitions favour similar physical conditions. Our search has found that the presence of the excited-state 6035-MHz OH transition is a much better predictor of 4765-MHz OH maser emission from the same region than is 1720-MHz OH maser emission. Combining our results with those of previous high resolution observations of other OH transitions we have examined the published theoretical models of OH masers and find that none of them predict any conditions in which the 1665-, 6035- and 4765-MHz transitions are simultaneously inverted.

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Magnetic Aggregation I: Aggregation Dynamics and Numerical Modelling

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Focussing on preplanetary grains growth, we discuss the properties of dust aggregation driven by magnetic dipole forces. While there is no direct evidence for the existence of magnetic grains present in the solar nebula, there are reasons to assume they may have been present. We derive analytical expressions for the cross-section of two interacting dipoles. The effective cross section depends upon the strength of the magnetic dipoles and the initial velocities. For typical conditions the magnetic cross section is between 2 and 3 orders of magnitude larger than the geometric cross section. We study the growth dynamics of magnetic grains and find that the mass of the aggregates should increase with time like $t^{3.2}$ whereas Brownian motion growth behaves like t^2. A numerical tool is introduced which can be used to model dust aggregation in great detail, including the treatment of contact forces, aggregate restructuring processes and long-range forces. This tool is used to simulate collisions between magnetic grains or clusters and to validate the analytical cross-sections. The numerically derived cross section is in excellent agreement with the analytical expression. The numerical tool is also used to demonstrate that structural changes in the aggregates during collisions can be significant.

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Enhancement of Ambipolar Diffusion Rates through Field Fluctuations

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Previous treatments of ambipolar diffusion in star-forming molecular clouds do not consider the effects of fluctuations in the fluid fields about their mean values. This paper generalizes the ambipolar diffusion problem in molecular cloud layers to include such fluctuations. Because magnetic diffusion is a nonlinear process, fluctuations can lead to an enhancement of the ambipolar diffusionrate. In addition, the stochastic nature of the process makes the ambipolar diffusion time take on a distribution of different values. In this paper, we focus on the case of long wavelength fluctuations and find that the rate of ambipolar diffusion increases by a significant factor $\Lambda \sim 1-10$. The corresponding decrease in the magnetic diffusion time helps make ambipolar diffusion more consistent with observations.

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Magnetic flaring in the pre-main sequence Sun and implications for the early solar system

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To address the role of energetic processes in the solar nebula, we provide a detailed characterization of magnetic flaring in stellar analogs of the pre-main sequence Sun based on two 0.5-day observations of analogs of the young Sun in the Orion Nebula Cluster obtained with the *Chandra X-ray Observatory*. The sample consists of 43 stars with

masses 0.7-1.4 $M_\odot$ and ages < 0.3 to $\simeq 10$ My. We find the X-ray luminosities measured in the $0.5 - 8$ keV band are strongly elevated over main sequence levels with average $< \log L_x >= 30.3$ erg s^{-1} and $< \log L_x/L_\star >= -3.9$. The X-ray emission is strongly variable within our exposures in nearly all solar analogs; about 30 flares with $29.0 < \log L_x(peak) < 31.5$ erg s^{-1} on timescales from 0.5 to > 12 hours are seen during the Chandra observations. Analogs of the ≤ 1 My old pre-main sequence Sun exhibited X-ray flares that are $10^{1.5}$ times more powerful and $10^{2.5}$ times more frequent than the most powerful flares seen on the contemporary Sun.

Radio observations indicate that acceleration of particles to relativistic energies is efficient in young stellar flares. Extrapolating the solar relationship between X-ray luminosity and proton fluence, we infer that the young Sun exhibited a 10^5-fold enhancement in energetic protons compared to contemporary levels. Unless the flare geometries are unfavorable, this inferred proton flux on the disk is sufficient to produce the observed meteoritic abundances of several important short-lived radioactive isotopes. Our study thus strengthens the astronomical foundation for local proton spallation models of isotopic anomalies in carbonaceous chondritic meteorites. The radiation, particles and shocks produced by the magnetic reconnection flares seen with *Chandra* may also have flash melted meteoritic chondrules and produced excess ^{21}Ne seen in meteoritic grains.

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Available by anon ftp at: ftp://ftp.astro.psu.edu/pub/edf/ONC_solar.pdf

Far–infrared spectroscopy across the asymmetric bipolar outflows from Cepheus A and L 1448

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Bipolar outflows are driven from protostars within molecular cores. They drive into molecular clouds, generating shock waves whose molecular emission lines have been observed in the infrared with ISO. We present spectroscopic data for seven locations within two asymmetric outflows, Cepheus A and L 1448, in order to test the shock physics and shock dynamics. Here, we simultaneously interpret the CO and H_2 data sets which are generated by shocked gas, radiating at temperatures from 300 to 2000 K. We find that large-scale spatial variations in the excitation are absent across both outflows and that the excitation is low everywhere.
Planar shock models are inconsistent with the data sets. Models with configurations or ensembles of shocks, in the form of bow shocks or supersonic turbulence, are consistent. This solves the previously reported problem that the CO abundances were anomalously high. Cool gas is dominant, from which we infer bow shocks with flanks more extended than for paraboloids. As a consequence, the atomic oxygen abundances must be quite low. J-type bow models require implausibly long wings. C-type physics is thus favoured.
The density and the ratio of molecules to atoms are constrained by the CO/H_2 flux levels as well as the H_2 vibrational level distributions. Other C-shock parameters, such as the magnetic field strength, ion fraction and speed, are not tightly constrained. The total shock powers are derived and are comparable to the mechanical outflow luminosities for both outflows, consistent with the outflows being momentum-driven.

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Preprints are available at http://www.tls-tautenburg.de/research/research.html

The FUV spectrum of TW Hya. I. Observations of H_2 Fluorescence

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We observed the classical T Tauri star TW Hya with *HST*/STIS using the E140M grating, from 1150–1700 Å, with the E230M grating, from 2200–2900 Å, and with FUSE from 900–1180 Å. Emission in 143 Lyman-band H_2 lines representing 19 progressions dominates the spectral region from 1250–1650 Å. The total H_2 emission line flux is 1.94×10^{-12} erg cm^{-2} s^{-1}, which corresponds to 1.90×10^{-4} $L_\odot$ at TW Hya's distance of 56 pc. A broad stellar Lyα line photoexcites the H_2 from excited rovibrational levels of the ground electronic state to excited electronic states. The C II 1335 Å doublet, C III 1175 Å multiplet, and C IV 1550 Å doublet also electronically excite H_2. The velocity shift of the H_2 lines is consistent with the photospheric radial velocity of TW Hya, and the emission is not spatially extended beyond the $0.05''$ resolution of *HST*. The H_2 lines have an intrinsic FWHM of 11.91 ± 0.16 km s^{-1}. One H_2 line is significantly weaker than predicted by this model because of C II wind absorption. We also do not observe any H_2 absorption against the stellar Lyα profile. From these results, we conclude that the H_2 emission is more consistent with an origin in a disk rather than in an outflow or circumstellar shell. We also analyze the hot accretion-region lines (e.g., C IV, Si IV, O VI) of TW Hya, which are formed at the accretion shock, and discuss some reasons why Si lines appear significantly weaker than other TR region lines.

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Discovery of Reflection Nebulosity Around Five Vega-like Stars

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Coronagraphic optical observations of six Vega-like stars reveal reflection nebulosities, five of which were previously unknown. The nebulosities illuminated by HD 4881, HD 23362, HD 23680, HD 26676, and HD 49662 resemble that of the Pleiades, indicating an interstellar origin for dust grains. The reflection nebulosity around HD 123160 has a double-arm morphology, but no disk-like feature is seen as close as 2.5 arcseconds from the star in K-band adaptive optics data. We demonstrate that uniform density dust clouds surrounding HD 23362, HD 23680 and HD 123160 can account for the observed $12-100$ μm spectral energy distributions. For HD 4881, HD 26676, and HD 49662 an additional emission source, such as from a circumstellar disk or non-equilibrium grain heating, is required to fit the $12-25$ μm data. These results indicate that in some cases, particularly for Vega-like stars located beyond the Local Bubble (>100 pc), the dust responsible for excess thermal emission may originate from the interstellar medium rather than from a planetary debris system.

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The Initial Mass Function of Stars: Evidence for Uniformity in Variable Systems

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The distribution of stellar masses that form in one star-formation event in a given volume of space is called the initial mass function (IMF). The IMF has been estimated from low-mass brown dwarfs to very massive stars. Combining IMF estimates for different populations in which the stars can be observed individually unveils an extraordinary uniformity of the IMF. This general insight appears to hold for populations including present-day star formation in small molecular clouds, rich and dense massive star-clusters forming in giant clouds, through to ancient and metal-poor exotic stellar populations that may be dominated by dark matter. This apparent universality of the IMF is a challenge for star formation theory because elementary considerations suggest that the IMF ought to systematically vary with star-forming conditions.

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Thickening of galactic disks through clustered star formation

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The building blocks of galaxies are star clusters. These form with low-star formation efficiencies and, consequently, loose a large part of their stars that expand outwards once the residual gas is expelled by the action of the massive stars. Massive star clusters may thus add kinematically hot components to galactic field populations. This kinematical imprint on the stellar distribution function is estimated here by calculating the velocity distribution function for ensembles of star-clusters distributed as power-law or log-normal initial cluster mass functions (ICMFs). The resulting stellar velocity distribution function is non-Gaussian and may be interpreted as being composed of multiple kinematical sub-populations.

The velocity-dispersion of solar-neighbourhood stars increases more rapidly with stellar age than theoretical calculations of orbital diffusion predict. Interpreting this difference to arise from star formation characterised by larger cluster masses, rather than as yet unknown stellar-dynamical heating mechanisms, suggests that the star formation rate in the MW disk has been quietening down, or at least shifting towards less-massive star-forming units. Thin-disk stars with ages 3–7 Gyr may have formed from an ICMF extending to very rich Galactic clusters. Stars appear to be forming preferentially in modest embedded clusters during the past 3 Gyr.

Applying this approach to the ancient thick disk of the Milky Way, it follows that its large velocity dispersion may have been produced through a high star formation rate and thus an ICMF extending to massive embedded clusters ($\approx 10^{5-6}\,M_\odot$), even under the extreme assumption that early star formation occurred in a thin gas-rich disk. This enhanced star-formation episode in an early thin Galactic disk could have been triggered by passing satellite galaxies, but direct satellite infall into the disk may not be required for disk heating.

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Ongoing Star Formation Activity in the L 1340 Dark Cloud

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We present a study of the L 1340 molecular cloud that is known to be actively forming low and intermediate mass stars in three independent cores. We present optical and NIR images of the central regions of the three cores of this cloud, better known as RNO 7, RNO 8 and RNO 9. We show that RNO 7 is a Herbig Be cluster. We have discovered three Herbig-Haro flows in core A (south western part) of the cloud that are named HH 487, HH 488 and HH 489. HH 487 is a spectacular set of bowshocks that appear to be driven by IRAS 02224+7227. HH 488a is a $\sim 3.4'$ long flow possibly overlaping with a second flow(HH 488b)in the line of sight. HH 489 is a flow extending to $\sim 1'$ on either side of the driving source IRAS 02249+7230. Most of these HH objects are found to be high excitation objects.

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The ISO-LWS map of the Serpens cloud core. II. The line spectra

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We present spectrophotometric ISO imaging with the LWS and the CAM-CVF of the Serpens molecular cloud core. The LWS map is centred on the far infrared and submillimetre sourceFIRS 1/SMM 1 and its size is $8' \times 8'$. The fine structure line emission in [O I] 63 μm and [C II] 157 μm is extended on the arcminute scale and can be successfully modelled to originate in a PDR with $G_0 = 15 \pm 10$ and $n(H_2)$ in the range of $(10^4 - 10^5)\,\mathrm{cm}^{-3}$. Extended emission

might also be observed in the rotational line emission of H_2O and high-J CO. However, lack of sufficient angular resolution prevents us from excluding the possibility that the emssion regions of these lines are point like, which could be linked to the embedded objects SMM 9/S 68 and SMM 4. Toward the Class 0 source SMM 1, the LWS observations reveal, in addition to fine structure line emission, a rich spectrum of molecular lines, superposed onto a strong, optically thick dust continuum (Larsson et al. 2000). The sub-thermally excited and optically thick CO, H_2O and OH lines are tracing an about 10^3 AU source with temperatures higher than 300 K and densities above $10^6\,\mathrm{cm}^{-3}$ ($M = 0.01\,\mathrm{M}_\odot$). The molecular abundances, $X = N(\mathrm{mol})/N(\mathrm{H}_2)$, are $X = (1,\ 0.1,\ 0.02,\ \geq 0.025) \times 10^{-4}$ for CO, H_2O, OH and ^{13}CO, respectively. Our data are consistent with an ortho-to-para ratio of 3 for H_2O. OH appears highly overabundant, which we tentatively ascribe to an enhanced (X-ray) ionisation rate in the Serpens cloud core ($\zeta \gg 10^{-18}\,\mathrm{s}^{-1}$). We show that geometry is of concern for the correct interpretation of the data and based on 2D-radiative transfer modelling of the disk/torus around SMM 1, which successfully reproduces the entire observed SED and the observed line profiles of low-to-mid-J CO isotopomers, we can exclude the disk to be the source of the LWS-molecular line emission. The same conclusion applies to models of dynamical collapse ('inside-out' infall). The 6″ pixel resolution of the CAM-CVF permits us to see that the region of rotational H_2 emission is offset from SMM 1 by 30″, at position angle 340°, which is along the known jet flow from the Class 0 object. This H_2 gas is extinguished by $A_\mathrm{V} = 4.5$ mag and at a temperature of 10^3 K, which suggests that the heating of the gas is achieved through relatively slow shocks. This is also in agreement with the deduced low ortho-to-para ratio of H_2-$o/p = 1$. Although we are not able to establish any firm conclusion regarding the detailed nature of the shock waves, our observations of the molecular line emission from SMM 1 are to a limited extent explainable in terms of an admixture of J-shocks and of C-shocks, the latter with speeds of about (15–20) km s^{-1} , whereas dynamical infall is not directly revealed by our data.

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New determinations of the critical velocities for C-type shock waves in dense molecular clouds: application to the outflow source in Orion

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We report calculations of the intensities of rovibrational transitions of H_2 emitted from C-type shock waves propagating in molecular gas. Attention was paid to the thermal balance of the gas and to the rates of collisional dissociation and ionization of H_2. We found that the maximum shock speeds which can be attained, prior to the collisional dissociation of H_2 (which results in a sonic point in the flow and hence a J-type shock wave), can be much higher than had previously been believed. Thus, adopting the "standard" scaling of the transverse magnetic induction with the gas density, $\mathrm{B}/\mu\mathrm{G} = \sqrt{\mathrm{nH/cm^{-3}}}$, we established that the maximum shock speed increased from 20-30 km s^{-1} at high pre-shock densities (nH $\geq 10^6$ cm^{-3}) to 70-80 km s^{-1} at low densities (nH $\leq 10^4$ cm^{-3}). The critical shock speed, Vcrit, also increases significantly with the transverse magnetic induction, B, at a given preshock gas density nH.

By way of an application of these results, we demonstrate that a two-component model, comprising shock waves with nH = 10^4 cm^{-3} and velocities vs = 60 km s^{-1} and 40 km s^{-1}, reproduces the column densities of H_2 observed by ISO-SWS (Rosenthal et al. 2000) up to the highest level (possibly) detected, v = 0, J = 27, which lies 42 515 K above the ground state. We find no necessity to invoke mechanisms other than thermal collisional excitation in the gas phase; but the v = 1 vibrational band remains less completely thermalized than is indicated by the observations. Fine structure transitions of atoms and ions were also considered. The intensity of the [Si I] 68.5 μm transition, observed by Gry et al. (1999) using ISO-LWS, is satisfactorily reproduced by the same model and may also originate in OMC-1, rather than Orion-KL as originally believed. The transitions of [Fe II] and [S I], observed by Rosenthal et al. (2000), may also arise in the shock-heated gas.

Predicted level populations of H_2 for our full grid of C-shock models (densities of $10^3, 10^4, 10^5, 10^6, 10^7$ cm^{-3} and shock speeds ranging from 10 km s^{-1} to Vcrit) are made available on the WWW at `http://ccp7.dur.ac.uk/pubs.html`.

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`http://ccp7.dur.ac.uk/pubs.html`

Crossing the Brown Dwarf Desert Using Adaptive Optics: A Very Close L-Dwarf Companion to the Nearby Solar Analog HR 7672

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We have found a very faint companion to the active solar analog HR 7672 (HD 190406; GJ 779; 15 Sge). Three epochs of high resolution imaging using adaptive optics (AO) at the Gemini-North and Keck II Telescopes demonstrate that HR 7672B is a common proper motion companion, with a separation of $0\farcs79$ (14 AU) and a 2.16 μm flux ratio of 8.6 mags. Using follow-up K-band spectroscopy from Keck AO+NIRSPEC, we measure a spectral type of L4.5±1.5. This is the closest ultracool companion around a main sequence star found to date by direct imaging. We estimate the primary has an age of 1–3 Gyr. Assuming coevality, the companion is most likely substellar, with a mass of 55–78 M_{Jup} based on theoretical models. The primary star shows a long-term radial velocity trend, and we combine the radial velocity data and AO imaging to set a firm (model-independent) lower limit of 48 M_{Jup}. In contrast to the paucity of brown dwarf companions at $\lesssim$4 AU around FGK dwarfs, HR 7672B implies that brown dwarf companions do exist at separations comparable to those of the giant planets in our own solar system. Its presence is at variance with scenarios where brown dwarfs form as ejected stellar embryos. Moreover, since HR 7672B is likely too massive to have formed in a circumstellar disk as planets are believed to, its discovery suggests that a diversity of physical processes act to populate the outer regions of exoplanetary systems.

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Herbig-Haro jets from orbiting sources

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The origin of the wiggles detected in the trajectory of HH jets, microjets and radio continuum jets from YSOs is investigated. We propose that the orbital motion of a binary stellar system is the cause of these outflow morphologies. The analytical trajectories of a ballistic jet ejected by a source moving along a circular orbit have been derived, and their validity has been checked through a comparison with 3D gasdynamic simulations. We propose a simple method to calculate the mass of the outflow source and the orbital parameters using observational measurements (i. e., the opening angle of the wiggling jet pattern, the separation between successive wiggles, the jet velocity and the orientation of the outflow with respect to the plane of the sky), and we apply it to the DG Tauri microjet, HH 47 and the Serpens radio continuum jet. For these three objects we obtain orbital parameters and masses that are reasonable for pre-main sequence binaries. From this result we conclude that the observed wiggles (of these three outflows) can indeed be interpreted in terms of a model of an outflow ejected from a source with an orbital motion.

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Magnetic Fields in Star-Forming Molecular Clouds III. Submillimeter Polarimetry of Intermediate Mass Cores and Filaments in Orion B

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Using the imaging polarimeter for the Submillimeter Common User Bolometric Array at the James Clerk Maxwell Telescope, we have detected polarized thermal emission at 850 μm from dust toward three star-forming core systems in the Orion B molecular cloud: NGC 2071, NGC 2024 and LBS 23N (HH 24). The polarization patterns are not indicative of those expected for magnetic fields dominated by a single field direction, and all exhibit diminished polarization percentages toward the highest intensity peaks. NGC 2024 has the most organized polarization pattern which is centered consistently along the length of a chain of 7 far-infrared sources. We have modeled NGC 2024 using a helical field geometry threading a curved filament and also as a magnetic field swept up by the ionization front of the expanding HII region. In the latter case, the field is bent by the dense ridge, which accounts for both the polarization pattern and existing measurements of the line-of-sight field strength toward the northern cores FIR 1 to FIR 4. The direction of the net magnetic field direction within NGC 2071 is perpendicular to the dominant outflow in that region. Despite evidence that line contamination exists in the 850 μm continuum, the levels of polarization measured indicate that the polarized emission is dominated by dust.

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Magnetic Fields in Star-Forming Molecular Clouds. IV. Polarimetry of the Filamentary NGC 2068 Cloud in Orion B

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We present submillimeter polarimetry at 850 μm toward the filamentary star-forming region associated with the reflection nebulosity NGC 2068 in Orion B. These data were obtained using the James Clerk Maxwell Telescope's SCUBA polarimeter. The polarization pattern observed is not consistent with that expected for a field geometry defined by a single mean field direction. There are three distinct distributions of polarization angle, which could represent regions of differing inclination and/or field geometry within the filamentary gas. In general, the polarization pattern does not correlate with the underlying total dust emission. The presence of varying inclinations against the plane of the sky is consistent with the comparison of the 850 μm continuum emission to the optical emission from the Palomar Optical Sky Survey, which shows that the western dust emission lies in the foreground of the optical nebula while the eastern dust emission originates in the background. Percentage polarizations are high, particularly toward the north-east region of the cloud. The mean polarization percentage in the region is 5.0% with a standard deviation of 3.1%. Depolarization toward high intensities is identified in all parts of the filament.

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The Eagle's EGGs: fertile or sterile?

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We present a deep, high spatial resolution (0.35 arcsec FWHM), near-infrared (1–2.5 μm) imaging survey of the Eagle Nebula, M 16, made with the VLT, centred on the famous elephant trunks. We compare these data with the existing HST optical images to search for evidence of ongoing or recent star formation in the trunks, and in particular in the 73 small evaporating gaseous globules (EGGs) on their surface. We find that two of the three HST trunks have relatively massive YSOs in their tips. Most of the EGGs appear to be empty, but some 15% of them do show evidence for associated young low-mass stars or brown dwarfs: in particular, there is a small cluster of such sources seen at the head of the largest trunk.

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The Formation of Massive Stars. I. High Resolution Millimeter and Radio Studies of High-Mass Protostellar Candidates

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We used the Owens Valley Millimeter Array and the Very Large Array to obtain interferometric maps at millimeter and centimeter wavelengths, both in the continuum and in various lines (HCO^+(1-0), $H^{13}CO^+$(1-0), SiO(v=3D0, J=3D2-1) and $H^{13}CN$(1-0)), toward a sample of 11 high-mass protostellar candidates. These sources are known from a previous study to be associated with dense gas and dust, and not associated with HII regions.

All 11 sources were detected in HCO^+(1-0), 9 in mm-continuum and 5 (out of 8 observed) in cm-continuum. The derived physical parameters confirm the high mass nature of these molecular clumps and suggest they are gravitationally bound. Molecular outflows were detected toward 6 sources, with flow masses and momenta much higher than in low-mass Young Stellar Objects. In many of the sources the molecular emission is organized in sub-structures, resolved both spatially and in velocity. We find that the sources may be characterized by their degree of fragmentation, turbulence and outflow activity, with the sample dividing into two groups: group 1 cores have multiple peaks but with a clearly dominant component, larger linewidths, and are systematically associated with outflows, while group 2 cores have several, comparable sub-entities, smaller linewidths, and no association with outflows. We speculate that more massive *cores* may form from smaller cores via coalescence or competitive accretion. Even conservative estimates of outflow mass loss rates, however, indicate that accretion is the dominant process in the later formation of massive *protostars* from such cores.

We find a flattening of the outflow mass spectra with increasing flow velocities, at variance with previous studies that suggest a steepening with increasing flow velocities. In the light of this result we suggest a re-evaluation of the wide-angle wind momentum-driven flow models to describe the acceleration of outflows in the earliest stages of massive star formation.

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Nonaxisymmetric Evolution of Magnetically Subcritical Clouds: Bar Growth, Core Elongation, and Binary Formation

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We have begun a systematic numerical study of the nonlinear growth of nonaxisymmetric perturbations during the ambipolar diffusion-driven evolution of initially magnetically subcritical molecular clouds, with an eye on the formation of binaries, multiple stellar systems and small clusters. In this initial study, we focus on the $m = 2$ (or bar) mode, which is shown to be unstable during the dynamic collapse phase of cloud evolution after the central region has become magnetically supercritical. We find that, despite the presence of a strong magnetic field, the bar can grow fast enough that for a modest initial perturbation (at 5% level) a large aspect ratio is obtained during the isothermal phase of cloud collapse. The highly elongated bar is expected to fragment into small pieces during the subsequent adiabatic phase. Our calculations suggest that the strong magnetic fields observed in some star-forming clouds and envisioned

in the standard picture of single star formation do not necessarily suppress bar growth and fragmentation; on the contrary, they may actually promote these processes, by allowing the clouds to have more than one (thermal) Jeans mass to begin with without collapsing promptly. Nonlinear growth of the bar mode in a direction perpendicular to the magnetic field, coupled with flattening along field lines, leads to the formation of supercritical cores that are triaxial in general. It removes a longstanding objection to the standard scenario of isolated star formation involving subcritical magnetic field and ambipolar diffusion based on the likely prolate shape inferred for dense cores. Continuted growth of the bar mode in already elongated starless cores, such as L1544, may lead to future binary and multiple star formation.

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The Smallest Mass Ratio Young Star Spectroscopic Binaries

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Using high resolution near-infrared spectroscopy with the Keck telescope, we have detected the radial velocity signatures of the cool secondary components in four optically identified pre−main-sequence, single-lined spectroscopic binaries. All are weak-lined T Tauri stars with well-defined center of mass velocities. The mass ratio for one young binary, NTTS 160905−1859, is $M_2/M_1 = 0.18\pm0.01$, the smallest yet measured dynamically for a pre−main-sequence spectroscopic binary. These new results demonstrate the power of infrared spectroscopy for the dynamical identification of cool secondaries. Visible light spectroscopy, to date, has not revealed any pre−main-sequence secondary stars with masses $<0.5\ M_\odot$, while two of the young systems reported here are in that range. We compare our targets with a compilation of the published young double-lined spectroscopic binaries and discuss our unique contribution to this sample.

Accepted by Astroph. J.

Preprint at astro-ph

Velocity Resolved [Fe II] Line Spectroscopy of L1551 IRS 5: A Partially Ionized Wind under Collimation around an Ionized Fast Jet

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We present a new [Fe II] λ 1.644 μm emission line image of the L1551 IRS 5 jets and a velocity-resolved spectrum obtained with the Subaru Telescope. In the [Fe II] line image showing two separate jetlike features, a strong and spatially wide [Fe II] emission feature was found elongated along the northern jet at its base. The echelle spectrum taken along this feature shows two prominent velocity components together with underlying pedestal and wing emissions. The entire emission range is blueshifted with respect to the systemic velocity, and this shows that the emission originates from an outflow. The high-velocity component (HVC) at $V_{LSR} = -300$ km s^{-1}, which has a corresponding Hα emission, consistently shows a narrow linewidth of $\sim$40 km s^{-1} (deconvolved FWHM value). The low-velocity component (LVC) at $V_{LSR} = -100$ km s^{-1}, on the other hand, has no corresponding Hα feature and is located spatially closer to the IRS 5 VLA sources (IRS 5 VLA) than is the HVC. The LVC shows broad linewidths of 130–160 km s^{-1} (FWHM) near IRS 5 VLA, while its linewidth decreases with increasing distance from it. We interpret from these characteristics that the HVC is a spatially narrow, well-collimated ionized stellar jet and the LVC is a widely opened, partially ionized disk wind that is being collimated as it travels away from the origin. The inclination corrected velocity of the HVC, 440 km s^{-1}, may imply that the accreting protostar driving the jet is rotating at almost its breakup

speed. The LVC has an inclination-corrected wind velocity of $\sim$200 km s^{-1}, suggesting that it is accelerated at the region where the accretion disk is interacting with the stellar magnetic field. The pedestal and red wing features may represent the LVC gas entrained and accelerated by the HVC. It is possible that the two apparently parallel jetlike features seen more than 6$''$ away from the IRS 5 VLA sources are the brightened edges of the partially ionized wind.

Accepted by Astroph. J. (scheduled for May 10, 2002 issue)

Preprint available at http://www.subarutelescope.org/staff/pyo/L1551paper/ms.pdf
or http://www.subarutelescope.org/staff/pyo/L1551paper/ms.ps

The Effect of the Hall Term on the Nonlinear Evolution of the Magnetorotational Instability: I. Local Axisymmetric Simulations

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The effect of the Hall term on the evolution of the magnetorotational instability (MRI) in weakly ionized accretion disks is investigated using local axisymmetric simulations. First, we show that the Hall term has important effects on the MRI when the temperature and density in the disk is below a few thousand K and between 10^{13} and 10^{18} cm^{-3} respectively. Such conditions can occur in the quiescent phase of dwarf nova disks, or in the inner part (inside 10 – 100 AU) of protoplanetary disks. When the Hall term is important, the properties of the MRI are dependent on the direction of the magnetic field with respect to the angular velocity vector $\mathbf{\Omega}$. If the disk is threaded by a uniform vertical field oriented in the same sense as $\mathbf{\Omega}$, the axisymmetric evolution of the MRI is an exponentially growing two-channel flow without saturation. When the field is oppositely directed to $\mathbf{\Omega}$, however, small scale fluctuations prevent the nonlinear growth of the channel flow and the MRI evolves into MHD turbulence. These results are anticipated from the characteristics of the linear dispersion relation. In axisymmetry on a field with zero-net flux, the evolution of the MRI is independent of the size of the Hall term relative to the inductive term. The evolution in this case is determined mostly by the effect of ohmic dissipation.

Accepted by Astrophys. J.

Preprint available at http://arXiv.org/abs/astro-ph/0201179

A Multiwavelength Study of the S106 Region
I. Structure and dynamics of the molecular gas

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The molecular cloud associated with Sharpless 106 has been studied in a variety of (sub)millimeter CO rotational lines on angular resolution scales from 11$''$ to 80$''$. We used the KOSMA 3m telescope to obtain an extended ^{12}CO J=3→2 map, from which we calculate a total mass of 2000 M$_\odot$ and an average density of 1.4×10^3 cm^{-3} for the molecular cloud. The peak intensity region around the massive young star S106 IR was observed in ^{13}CO J=6→5 and 3→2 with KOSMA and in isotopomeric low-J CO lines with the IRAM 30m telescope. A clump decomposition made for several lines yields a common clump-mass spectral index of α=1.7, illustrating the self-similarity of the detected structures for length-scales from 0.06 to 0.9 parsec.
All ^{12}CO and ^{13}CO line profiles within approximately 2$'$ around S106 IR show blue wing emission and less prominent red wing emission, partly affected by self-absorption in colder foreground material. We attribute this high-velocity emission to the ionized wind of S106 IR driving a shock into the inhomogeneous molecular cloud. We do not find evidence for a smooth or fragmented disk around S106 IR and/or an *expanding* ring in the observed CO emission distribution.
The excitation conditions along a cut through the molecular cloud/HII region are studied with an LTE analysis (and

an Escape Probability model at the position of S106 IR), using the observed CO line intensities and ratios. The kinetic gas temperature is typically 40 K, the average density of the cloud in the core region is 9×10^3 cm^{-3}, and the local density within the clumps is 9×10^4 cm^{-3}. The ^{13}CO/C^{18}O line and column density ratios away from S106 IR reflect the natural isotopic abundance but optical lobes and the cavity walls, we see enhanced ^{13}CO emission and abundance with respect to C^{18}O. This shows that selective photo-dissociation is only important close to S106 IR and in a thin layer of the cavity walls. In combination with the results from the excitation analysis we conclude that the molecular line emission arises from two different gas phases: (i) rather homogeneous, low- to medium-density, spatially extended clumps and (ii) embedded, small ($\ll$0.2 pc), high-density clumps with a low volume filling factor.

Accepted by Astronomy and Astrophysics

Preprint available : http://www.observ.u-bordeaux.fr/public/aeronomie/pages_web_aero/web_schneider/publications.html

Relative orientation of orbits in triple stars

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Statistical analysis of the relative alignment of inner and outer orbits in triple systems resulting from a dynamical decay of small-N clusters (N$\leq$ 10) is presented and compared to the statistics of real multiple stars. The distribution of the relative angle Φ between the angular momentum vectors of inner and outer orbits in triple stars formed by decay is shown to depend on the initial cluster conditions like geometry, mass function, rotational and thermal energy. For a realistic set of initial conditions, a modest alignment of orbital momentum vectors is found, in good agreement with the latest observational data on visual multiple stars exhibiting an average $\langle\Phi\rangle$ between 67° and 79°. The relation between eccentricities of outer orbits and period ratios for both simulated and real triples is consistent with a slightly adjusted formulation of the stability criterium by Mardling & Aarseth (2001). Dynamical decay can therefore explain the weak correlation of orbital orientations observed in multiple stars. Using modern high-resolution techniques, the observed statistics of Φ should be extended as it will allow to sensitively constrain properties of initial clusters.

Accepted by A&A

preprint: http://www.sc.eso.org/ msterzik/TripleOrbits/triple_acc.ps

Statistical study of C^{18}O dense cloud cores and star formation

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Dense molecular cloud cores are studied statistically in nearby ($d \leq 200$ pc) star-forming regions (SFRs) that show various modes of star formation. As a result of the C^{18}O survey of NANTEN and the 4m radio telescopes of Nagoya University, 179 cores have been collected in the SFRs of Taurus, the ρ Oph cloud, the Ophiuchus north region, the Lupus clouds, L1333, the Corona Australis cloud, Southern Coalsack, and the Pipe nebula, and their physical properties investigated. According to their star-formation activities, the cores are divided into 3 categories as 136 starless, 36 star-forming, and 7 cluster-forming cores. It is found that cores with active star formation tend to have larger $N(\mathrm{H}_2)$, $n(\mathrm{H}_2)$, and M. The mass function of the cores does not appear to follow a single power-law function, but the power-law index is subject to change with the mass range. The average star-formation efficiency (SFE) of the cores is roughly $\sim$ 10%, and the expected stellar mass function from the SFE approximates the stellar initial-mass function (IMF). Virial analysis shows that the star-forming cores are gravitationally more bound, with smaller virial ratios than the starless cores, while cluster-forming cores are marginally bound with moderate virial ratios. We found that turbulent decay is indicated by diminishing ΔV from the starless to the star-forming cores. It is suggested that the turbulent decay is necessary for star formation, while formed star clusters provide the turbulence and make the cores unbound. Molecular clouds associated with the clusters tend to have head-tail structures and the cluster

formation takes place at the head. This implies that the clouds are affected by external shocks, which have triggered cluster formation. We suggest that star and cluster formation are strongly controlled by the initial amount of internal turbulence and the interaction with the external shocks.

Accepted by A&A

http://www.xray.mpe.mpg.de/~tatihara/research.html

Detection of FeO towards SgrB2

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We have observed the J=5-4 ground state transition of FeO at a frequency of 153 GHz towards a selection of galactic sources. Towards the galactic center source SgrB2, we see weak absorption at approximately the velocity of other features towards this source (62 km s^{-1} LSR). Towards other sources, the results were negative as they were also for MgOH(3-2) and FeC(6-5). We tentatively conclude that the absorption seen toward SgrB2 is due to FeO in the hot ($\sim$ 500 K) relatively low density absorbing gas known to be present in this line of sight. This is the first (albeit tentative) detection of FeO or any iron–containing molecule in the interstellar gas. Assuming the observed absorption to be due to FeO, we estimate [FeO]/[SiO] to be of order or less than 0.002 and [FeO]/[H_2] of order $3\,10^{-11}$. This is compatible with our negative results in other sources. Our results suggest that the iron liberated from grains in the shocks associated with SgrB2 remains atomic and is not processed into molecular form.

Accepted by Ap. J. Letters

The Relationship Between Gas Content and Star Formation in Molecule-Rich Spiral Galaxies

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We investigate the relationship between HI, H_2, and the star formation rate (SFR) using azimuthally averaged data for seven CO-bright spiral galaxies. Contrary to some earlier studies based on global fluxes, we find that $\Sigma_{\rm SFR}$ exhibits a much stronger correlation with $\Sigma_{\rm H_2}$ than with $\Sigma_{\rm HI}$, as $\Sigma_{\rm HI}$ saturates at a value of $\sim$ 10 $M_\odot$ $\rm pc^{-2}$ or even declines for large $\Sigma_{\rm SFR}$. Hence the good correlation between $\Sigma_{\rm SFR}$ and the total (HI+H_2) gas surface density $\Sigma_{\rm gas}$ is driven by the molecular component in these galaxies, with the observed relation between $\Sigma_{\rm SFR}$ and $\Sigma_{\rm H_2}$ following a Schmidt-type law of index $n_{\rm mol}\approx0.8$ if a uniform extinction correction is applied or $n_{\rm mol}\approx1.4$ for a radially varying correction dependent on gas density. The corresponding Schmidt law indices for $\Sigma_{\rm gas}$ vs. $\Sigma_{\rm SFR}$ are 1.1 and 1.7 for the two extinction models, in rough agreement with previous studies of the disk-averaged star formation law. An alternative to the Schmidt law, in which the gas depletion timescale is proportional to the orbital timescale, is also consistent with the data if radially varying extinction corrections are applied. We find no clear evidence for a link between the gravitational instability parameter for the gas disk (Q_g) and the SFR, and suggest that Q_g be considered a measure of the gas fraction. This implies that for a state of marginal gravitational stability to exist in galaxies with low gas fractions, it must be enforced by the stellar component. In regions where we have both HI and CO measurements, the ratio of HI to H_2 surface density scales with radius as roughly $R^{1.5}$, and we suggest that the balance between HI and H_2 is determined primarily by the midplane interstellar pressure. These results favor a "law" of star formation in quiescent disks in which the ambient pressure and metallicity control the formation of molecular clouds from HI, with star formation then occurring at a roughly constant rate per unit H_2 mass.

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Preprints at http://www.atnf.csiro.au/people/twong/preprints or astro-ph/0112204

A Large-Scale Molecular Line Survey for Cold IRAS Sources in the Galaxy: I. The CO (J=1-0) Data

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We conducted a large-scale survey for the cold infrared sourcesalong the northern galactic plane in CO (J=1-0) line. There are 1912 IRAS sources selected on the basis of their color indices over the 12μ, 25μ, and 60μ wave bands and their association with regions of recent star formation. A quick single-point survey was made toward all of the sources, which results in a detection of 1331 sources with significant CO emission above the detection limit of 0.9 K, inferring a CO detection rate of 70%. Located over a wide range of the galactocentric distances, the CO sources show high concentration toward the spiral arms.

Among the detected sources, there are 351 sources found to have high-velocity CO wing emission. A search for the latest catalog of high-velocity CO flows (HVFs) from young stellar objects indicates that 289 sources are beyond the present lists of HVFs. These high-velocity wing sources provide us a comprehensive database for the study of HVFs from young stellar objects. Using the known outflow sources as an effective indicator, we found the detectio n rate for high-velocity wings during the quick survey is 62%, moderately sensiti ve in searching for new outflow sources. The CO detection rate of the IRAS sources, combined with the ratio of high-velocity wing, suggests that 41% of the CO sources are undergoing the HVF phase. In this paper, the CO spectra are presented along with the preliminary statistics of the data.

Accepted by Astrophys. J. Suppl. (v141, n1)

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Dissertation Abstracts

The Impact of Giant Stellar Outflows on Molecular Clouds

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Ph.D dissertation directed by: Alyssa A. Goodman

Ph.D degree awarded: October 2001

We use new millimeter wavelength observations to reveal the important effects that giant (parsec-scale) outflows from young stars have on their surroundings. We find that giant outflows have the potential to disrupt their host cloud, and/or drive turbulence there. In addition, our study confirms that episodicity and a time-varying ejection axis are common characteristics of giant outflows.

We carried out our study by mapping, in great detail, the surrounding molecular gas and parent cloud of two giant Herbig-Haro (HH) flows. The HH flows studied were HH 300 from the young star IRAS 04239+2436, at a distance of 140 pc, and HH 315 from the young star PV Ceph, at a distance of 500 pc. These outflows were thoroughly mapped in the ^{12}CO(2-1) line, with a beam size of 27″. These observations were aimed at mapping the giant outflows and investigating their morphology and velocity distribution.

Also, larger maps of the region surrounding each outflow were obtained in the ^{12}CO(1-0) and ^{13}CO(1-0) lines, with 45″ and 47″ beam sizes, respectively. By observing a large extent of the gas surrounding each outflow we were able to study each outflow in the context of its surrounding medium. The ^{13}CO(1-0) observations also helped us assess the effects the outflows have on the surrounding medium-density ($n \sim 10^3$ cm^{-3}) gas structure and kinematics. Moreover, the combined ^{12}CO(1-0) and ^{13}CO(1-0) line observations enabled us to properly estimate the mass of the outflow by correcting for the velocity-dependent opacity of the ^{12}CO(1-0) line.

We performed higher spatial ($\sim 11 - 22''$) and velocity (~ 0.1 km s^{-1}) resolution observations of the molecular gas surrounding several HH knots of the HH 315 flow. These high-resolution observations were aimed at studying the entrainment mechanism of the outflow from PV Ceph.

Our study shows that these giant HH flows have been able to entrain large amounts of molecular gas, as the molecular outflows they have produced have masses of 4 to 7 M$_\odot$ —which is approximately 5 to 10% of the total quiescent gas mass in their parent clouds. These outflows have injected substantial amounts of momentum and kinetic energy on their parent cloud, in the order of 10 M$_\odot$ km s^{-1} and 10^{44} erg, respectively. We find that both molecular outflows have energies comparable to their parent clouds' turbulent and gravitationally binding energies. In addition, these outflows have been able to redistribute large amounts of their surrounding medium-density ($n \sim 10^3$ cm^{-3}) gas, thereby sculpting their parent cloud and affecting its density and velocity distribution at distances as large as 1 to 1.5 pc from the outflow source.

Our study, in combination with other outflow studies, indicate that a single giant molecular outflow in a molecular cloud of less than about 80 M$_\odot$ has the potential to seriously disrupt its parent cloud. We, therefore, conclude that the cumulative action of many giant outflows will certainly have a profound effect on their cloud's evolution and fate.

Our detailed study of the outflow morphology, velocity structure, and momentum distribution —among other properties of both outflows— lead us to suggest that they are predominantly formed by bow-shock prompt entrainment, from an episodic wind with a time-varying axis. Close to PV Ceph (the source of HH 315), though, the coexistence of a jet-like wind *and* a wide-angle wind explains better the observed outflow properties.

Thesis available at: `http://www.astro.caltech.edu/~harce`

New Books

Science with the Atacama Large Millimeter Array (ALMA)

Editor: Alwyn Wootten

ASP Conference Series Volume 235

Proceedings of a Workshop held at the Carnegie Institution of Washington 6-8 October 1999

The Conference on *Science with the Atacama Large Millimeter Array* took place on 6-8 October 1999 under sponsorship of Associated Universities, Inc. (AUI) and the National Radio Astronomy Observatory (NRAO). The venue was the historic neo-classical auditorium at the Carnegie Institution of Washington at 16th and P Streets, NW, Washington, D.C., across the street from the AUI offices and just a few blocks from the White House and DuPont Circle.

The Atacama Large Millimeter Array, or ALMA, is an international telescope project which will be built over the coming decade in Northern Chile. With over 7000 m^2 of collecting area comprised of 64 12m antennas arrayed over baselines up to 14 km in extent, ALMA will provide images of unprecedented clarity and detail. One revolutionary feature of ALMA will be its ability to combine interferometric and single telescope data, providing complete flux recovery. ALMA will cover a spectral wavelength range from 7mm to 0.3 mm or shorter wavelengths, providing astronomy with its first detailed look at the structures which emit millimeter and submillimeter photons, the most abundant photons in the Universe.

The theme of the conference was 'Imaging Cosmic Dawn'. Topics covered included:

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From Darkness To Light:
Origin and Evolution of Young Stellar Clusters

Edited by Thierry Montmerle and Philippe Andr

ASP Conference Series Volume 243

These are the proceedings of a Euroconference held in Cargse, Corsica, France 3-8 April 2000. The conference focused on the initial conditions for clustered-mode star formation in molecular clouds and on the evolution of low-mass stars in young clusters, from prestellar cores to protostars, on to T Tauri stars and advanced pre-main sequence stages. Special attention was also paid to feedback effects, from the small scale (accretion disks, outflows) to the large scale (winds and SN explosions from massive stars). The following lists the various topics covered and the introductory review articles. The book contains more than thirty other invited papers.

Part 1. Interstellar Medium Structure and Magnetic Fields

Clustered Star Formation R.E. Pudritz

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Part 3. Collapse and Protostars

Collapse Models A.P. Whitworth

Part 4. Origin of the Initial Mass Function

The Origin of the Stellar Initial Mass Function B.G. Elmegreen

Part 5. Cluster Properties & Evolution

Overview of Cluster Properties B.A. Wilking

Part 6. Pre-Main Sequence Evolution

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New Book on the World Wide Web

Star Formation and the Physics of Young Stars

Edited by J. Bouvier & J.-P. Zahn

How do stars form in molecular clouds ? When and how are planetary systems assembled in circumstellar disks ? How has the star formation rate varied over cosmological timescales ? In the last decade, considerable progress has been made on these fundamental issues, thanks to advances in both observations and theory.

The chapters in this book provide a critical and up-to-date review of current results and concepts in various aspects of star formation, from local to cosmological scales. They are based on a series of tutorial review lectures given at the *Xth Aussois School on Stellar Physics*, which took place on September 18-22, 2000 in the alpine village of Aussois, France. The level is meant to be accessible to graduate and post-graduate students, and to researchers from neighbouring astrophysical fields. The list of chapters and authors is the following:

- The initial conditions for protostellar collapse: Observational constraints (Philippe Andr)
- The star formation process (Jean-Pierre Chize)
- The physics of pre-main sequence evolution (Francesco Palla)
- Accretion disks around young stars: An observational perspective (Francois Mnard, Claude Bertout)
- Theory of turbulent accretion disks (Caroline Terquem)
- Constraints on accretion-ejection structures in young stars (Sylvie Cabrit)
- Theory of magnetized accretion discs driving jets (Jonathan Ferreira)
- The physics of young stellar objects: X-rays, magnetism, and high-energy phenomena (Thierry Montmerle)
- Massive pre-main sequence stars in the Magellanic clouds (Jean-Philippe Beaulieu, W.J. de Wit)
- Massive star forming regions from the local Universe to high redshift (Daniel Schaerer)
- Cosmological star formation history (Franois Hammer)

While this book is in press, preprints of individual chapters are accessible on the WWW at

`http://wwwrc.obs-azur.fr/fresnel/pnps/Aussois2000/aussois.html`.

Reference to this material should mention: Star Formation and the Physics of Young Stars, Xth Aussois School, eds. J. Bouvier & J.P. Zahn 2002, EAS Pub. Ser., Vol.3, in press.

Winds, Bubbles and Explosions: a conference to honour John Dyson
Pátzcuaro, Michoacán, México, 9-13 September, 2002

This meeting aims to discuss the dynamical effects that mass loss and radiation from astrophysical objects have on their environment in the light of recent observational results and theoretical models.

The topics of the meeting include:

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- Post Main Sequence Winds (PNe, WR stars, LBV)
- Supernovae and their Remnants
- Line Forming Regions of AGN
- Starburst Superwinds

The conference also has the aim of honouring John Dyson, who has madeimportant contributions to our understanding of the dynamics of the interstellar medium.

Format
The scientific programme of the meeting will consist of invited talks, contributed talks selected by the Scientific Organizing Committee, and poster contributions.

Organization
The conference is organized by the Instituto de Astronomia, UNAM, Mexico, where John Dyson has many friends.

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We would like all interested participants to register for the conference using our web page:
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Scientific Frontiers in Research on Extrasolar Planets

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We call your attention to the call for contributed talks and posters at "Scientific Frontiers in Research on Extrasolar Planets," to be held 18-21 June 2002, at the Carnegie Institution in Washington, D.C. The Conference is sponsored by NASA and the Carnegie Institution.

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The contributed talks can be up to 15-minutes, plus discussion time. The Conference format will be arranged to provide for maximum discussion time. The abstract deadline is April 15, 2002. However, we encourage submission of titles well before the abstract deadline, especially for those who wish to give 15-minute talks.

The call-for-papers is linked from the Conference web site at:

http://lep694.gsfc.nasa.gov/code693/planetsconf.html

We look forward to seeing you in Washington in June!

Drake Deming, Conference Chair
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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, not reviews nor conference notes), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star formation and interstellar medium community), *New Books* (giving details of books relevant for the same community), *New Jobs* (advertising jobs specifically aimed towards persons within our specialty), and *Short Announcements* (where you can inform or request information from the community).

Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter.

The Star Formation Newsletter is available on the World Wide Web at http://casa.colorado.edu/reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .