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From the Editor

I have moved to the Institute for Astronomy in Honolulu. Please note my new e-mail address *reipurth@ifa.hawaii.edu* for future submissions. Once I have set up a web site here, I will communicate the new URL for the online archive of the Star Formation Newsletter.

Abstracts of recently accepted papers

Massive molecular outflows

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With the aim of understanding the role of massive outflows in high-mass star formation, we mapped in the ^{12}CO $J = 2-1$ transition 26 high-mass star-forming regions at very early stages of their evolution. At a spatial resolution of $11''$ bipolar molecular outflows were found in 21 of them. The other five sources show confusing morphology but strong line wings. This high detection rate of bipolar structure proves that outflows common in low-mass sources are also ubiquitous phenomena in the formation process of massive stars. The flows are large, very massive and energetic, and the data indicate stronger collimation than previously thought. The dynamical timescales of the flows correspond well to the free-fall timescales of the associated cores. Comparing with correlations known for low-mass flows, we find continuity up to the high-mass regime suggesting similar flow-formation scenarios for all masses and luminosities. Accretion rate estimates in the 10^4 L$_\odot$ range are around 10^{-4} M$_\odot$yr^{-1}, higher than required for low-mass star formation, but consistent with high-mass star formation scenarios. Additionally, we find a tight correlation between the outflow mass and the core mass over many orders of magnitude. The strong correlation between those two quantities implies that the product of the accretion efficiency $f_{\rm acc} = \dot{M}_{\rm acc}/(M_{\rm core}/t_{\rm ff})$ and $f_{\rm r}$ (the ratio between jet mass loss rate and accretion rate), which equals the ratio between jet and core mass ($f_{\rm acc}f_{\rm r} = M_{\rm jet}/M_{\rm core}$), is roughly constant for all core masses. This again indicates that the flow-formation processes are similar over a large range of masses. Additionally, we estimate median $f_{\rm r}$ and $f_{\rm acc}$ values of approximately 0.2 and 0.01, respectively, which is consistent with current jet-entrainment models.
To summarize, the analysis of the bipolar outflow data strongly supports theories which explain massive star formation by scaled up, but otherwise similar physical processes – mainly accretion – to their low-mass counterparts.

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preprints available at http://www.mpifr-bonn.mpg.de/staff/beuther/

Collapse and Fragmentation of Molecular Cloud Cores. VII. Magnetic Fields and Multiple Protostar Formation

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Recent observations of star-forming regions suggest that binary and multiple young stars are the rule rather than the exception, and implicate fragmentation as the likely mechanism for their formation. Most numerical hydrodynamical calculations of fragmentation have neglected the possibly deleterious effects of magnetic fields, in spite of ample evidence for the importance of magnetic support of pre-collapse clouds. We present here the first numerical hydrodynamical survey of the collapse and fragmentation of initially magnetically-supported clouds which takes into account several magnetic field effects in an approximate manner. The models are calculated with a three dimensional, finite differences code which solves the equations of hydrodynamics, gravitation, and radiative transfer in the Eddington and diffusion approximations. Magnetic field effects are included through two simple approximations: magnetic pressure is added to the gas pressure, and magnetic tension is approximated by gravity dilution once collapse is well underway. Ambipolar diffusion of the magnetic field leading to cloud collapse is treated approximately as well. Models are calculated for a variety of initial cloud density profiles, shapes, and rotation rates. We find that in spite of the inclusion of magnetic field effects, dense cloud cores are capable of fragmenting into binary and multiple protostar systems. Initially prolate clouds tend to fragment into binary protostars, while initially oblate clouds tend to fragment into multiple protostar systems containing a small number (of order four) of fragments. The latter are likely to be subject to rapid orbital evolution, with close encounters possibly leading to the ejection of fragments. Contrary to expectation, magnetic tension effects appear to enhance fragmentation, allowing lower mass fragments to form than would otherwise be possible, because magnetic tension helps to prevent a central density singularity from forming and producing a dominant single object. Magnetically-supported dense cloud cores thus seem to be capable of collapsing and fragmenting into sufficient numbers of binary and multiple protostar systems to be compatible with observations of the relative rarity of single protostars.

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Preprint available at http://www.ciw.edu/boss/ftp/coresvii/

HD 112 μm in absorption and extreme CO depletion in a cold molecular cloud

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We present ISO-LWS observations at high spectral resolution (R $\sim 10^4$) towards a cold molecular cloud in the line of sight of W49. The HD ground state transition at 112 μm is detected, showing the first observation of this line in absorption outside the solar system. The 112 μm absorption depth gives a straightforward measure of the lower limit of the cloud's HD column density, N(HD) $> 8 \times 10^{18}$ cm^{-2}. We also mapped the same line of sight in the ^{12}CO (2-1) and (3-2), and ^{13}CO (2-1) transitions at the CSO, and in the C^{18}O and C^{17}O (1-0) and (2-1) transitions at the IRAM 30-m. From these observations we derive an upper limit to the CO column density, N(CO) $< 7 \times 10^{17}$ cm^{-2}. Assuming a standard CO abundance (1×10^{-4}) would imply a [D]/[H] abundance two orders of magnitude larger than the average [D]/[H] value observed in the solar neighborhood. The alternative explanation that we defend here is that CO is highly depleted (by a factor 100) in this cloud. This is the first measurement of such a depletion factor in a relatively massive cold molecular cloud ($\sim 10^3 M_\odot$).

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Preprints are available at:
http://www.cesr.fr/ maret/publications/HDdetection.pdf

ISO ammonia line absorption reveals a layer of hot gas veiling Sgr B2

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We report the first results of the unbiased spectral high resolution survey obtained towards Sgr B2 with the Long Wavelenght Spectrometer on board ISO. The survey detected more than one hundreds lines from several molecules. Ammonia is the molecule with the largest number (21) of detected lines in the survey. We detected NH_3 transitions from levels with energies from 45 to 500 cm^{-1}. The detected transitions are from both para and ortho ammonia and metastable and non-metastable levels. All the ammonia lines are in absorption against the FIR continuum of Sgr B2. With such a large number of detected lines in such a large range of level energies, we could constrain very efficiently the main parameters of the absorbing gas layer. The gas is at (700 ± 100) K and has a density lower than 10^4 cm^{-3}. The total NH_3 column density in the layer is $(3 \pm 1) \times 10^{16}$ cm^{-2}, equally shared between ortho and para ammonia. Given the derived relatively high gas temperature and ammonia column density, our observations support the hypothesis previously proposed of a layer of shocked gas between us and Sgr B2. We also discuss previous observations of far infrared line absorption from other molecules, like H_2O and HF, in the light of this hot absorbing layer. If the absorption is done by the hot absorbing layer rather than by the warm envelope surrounding Sgr B2, as was previously supposed to interpret the mentioned observations, the derived H_2O and HF abundances are one order of magitude larger than previously estimated. Yet, the present H_2O and HF observations do not allow to disentangle the absorption from the hot layer against the warm envelope. Our conclusions are hence that care should be applied when interpreting the absorption observations in Sgr B2, as the hot layer clearly seen in the ammonia transitions may substantially contribute to the absorption.

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http://www.observ.u-bordeaux.fr/

SO and SiO emission around the young cluster in the CB34 globule

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The globule CB34, which harbors a cluster of Class 0 YSOs protostars, has been investigated through a multiline SO and SiO survey at mm-wavelengths. The SO data reveal that the globule consists of three quiescent high-density ($\sim 10^5$ cm^{-3}) clumps, labeled A, B, and C, with sizes of $\sim$ 0.2-0.3 pc. The SiO data provide evidence for high-velocity gas across the globule. Most likely, the high-velocity gas is distributed in three distinct high-velocity outflows associated with the YSOs in each of the three clumps. High-velocity SO features have been detected only towards the two brightest SiO outflows. These broad SO components exhibit spatial and spectral distributions which are consistent with those of the SiO emission, so they can also be used as tracers of the outflows.

The comparison between the spatial and spectral properties of the SO and SiO emissions in the three clumps suggests

different evolutionary stages for the relative embedded YSOs. In particular, the YSO associated with clump C exhibits some peculiarities, namely: smaller SiO linewidths, lower SiO column densities, lack of extended SiO structure and of SO wings, and presence of a SO spatial distribution which is displaced with respect to the location of the YSO. This behaviour is well explained if the SiO and SO molecules which were produced at high-velocities in the shocked region have been destroyed or slowed down because of the interaction with the ambient medium and the chemistry is dominated again by low-temperature reactions. Thus, our observations strongly suggest that the YSO in clump C is in a more evolved phase than the other members of the cluster.

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Near-infrared Fabry-Perot imaging of Herbig-Haro energy sources: collimated, small-scale H_2 jets and wide-angled winds

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To search for further evidence of H_2 line emission towards the central engines of Herbig-Haro (HH) flows we have obtained near-infrared Fabry-Perot images of eight Class I outflow sources (SVS 13 [HH 7-11], L 1551-IRS5, HH 26-IRS, HH 72-IRS, SSV 63E [HH 24C], SSV 63W [HH 24J], HH 34-IRS and HH 111-IRS) and two Class 0 sources (HH 24-MMS and HH 25-MMS). Elongated H_2 emission (on scales of a few arcseconds) is detected from four of the Class I YSOs. These small-scale "jets" are associated with the base of more extended, parsec-scale HH outflows (and the "Molecular Hydrogen Emission Line" regions, or MHELs, discussed in Davis et al. 2001, MNRAS 326, 524). In L 1551-IRS 5 we detect *two* jet components in H_2; these may be the molecular counterparts of the two known optical jets from this binary protostellar system, or they may represent H_2 excitation along the walls of a narrow, edge-brightened cavity.

In addition to the small-scale MHEL jets, analysis of the data also suggests the presence of discrete molecular shock fronts formed along the jet axes close to the energy sources. In the most clear-cut example, SVS 13, we see an H_2 knot at a distance of about 440 AU from the outflow source; assuming a flow velocity of $\sim 200\,\mathrm{km\ s^{-1}}$, then the dynamical age of this molecular feature is only 10 yrs.

In these data we also see evidence for both collimated jets and wide-angled winds from the same sources. Indeed, even in one of the two Class 0 sources, HH 25MMS, a poorly-collimated flow component seems to be present. A two-component wind model may therefore be appropriate for outflows from Class I (and possibly even Class 0) protostars.

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Preprints available from: http://www.jach.hawaii.edu/~cdavis/

Resolved Near-Infrared Spectroscopy of the Mysterious Pre-Main Sequence Binary System T Tau S

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We obtained new near-infrared images of the prototypical pre-main sequence triple system T Tau, as well as the first resolved medium-resolution spectra of the close pair T Tau S. At the time of our observations, the tight binary had a 13 AU projected separation and showed significant motion since its discovery, three years before. The orbit cannot be strongly constrained yet, but the observed motion of T Tau Sb with respect to T Tau Sa suggests that the system is at least as massive as T Tau N itself. This may indicate that T Tau N is not the most massive star in the system. The spectrum of T Tau Sa, which is totally featureless except for a strong Brγ emission line, identifies this component with the "infrared companion", whose exact nature remains obscure but may be the consequence of it being the most massive component of the system. Contrasting sharply with T Tau Sa, the spectrum of T Tau Sb shows numerous photospheric features consistent with an early-M spectral type. The presence of a strong Brγ emission line and of a

significant veiling continuum classifies this object as a deeply embedded T Tauri star. From these observations, we conclude that both components of T Tau S are embedded in their own dense circumstellar cocoon of material, which are probably fed by a much more extended structure.

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On the infrared void in the Lupus dark clouds

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Strömgren $uvby\beta$ photometry observations obtained for 205 stars in the general direction of a void in the *IRAS* 100 μm emission from the Lupus dark cloud complex are presented and analysed. The colour excess versus distance diagram confirms the existence of a region depleted from interstellar material, which is also seen in the *ROSAT* soft X-ray background emission map. The distance to the surrounding material is estimated as being within the interval from 60 to 100 pc. This result is in disagreement with previous distance estimates to the supposed supernova that has been suggested as responsible for clearing the region from dust. As an alternative, the data presented support the suggestion that the void may have been produced by the detachment of material from the interface between Loop I and the Local Bubble as a consequence of hydromagnetic instabilities. Moreover, the distribution of colour excess as a function of distance supports a value of ~ 150 pc as the most probable distance to the dark cloud known as Lupus 1.

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A Near-Infrared Survey of Radio-Selected Ultra-Compact HII Regions

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A near-infrared (NIR) survey of 63 radio-selected, ultra-compact HII (UC HII) regions representing 47 different star forming sites has been completed. The survey was obtained using H-band imaging and moderate resolution, $R = 1200$, K-band spectroscopy, centered on the radio emission peak of the UC HII regions. The goal of this survey was to determine the fraction of radio-selected UC HII regions that can be studied with NIR observations and analysis. Approximately 50% of the 63 radio-selected UC HII regions appear to be detected at NIR wavelengths in Brγ emission (10^7 ergs s^{-1} cm^{-2} sr^{-1}). Typical line of sight extinction towards the detected UC HII regions ranged from $A_V = 30 - 50$, though one source was measured to have $A_V = 80$. For a few of these UC HII regions, the central ionizing sources are detected through high signal-to-noise NIR spectra of photospheric transitions. This preliminary survey suggests that perhaps 5 to 10% of UC HII regions showing NIR counterparts will have directly detectable central ionizing sources. Using the ratio of HeI 2.11 to Brγ, the effective temperatures of the central ionizing stars in 25 UC HII regions have been estimated. While HeI is not always detected in UC HII regions, when it was found or a meaningful upper limit determined, the spectral type implied by the ratio of HeI 2.11 to Brγ closely matched similar estimates of spectral type derived from radio. Model predictions based on mid-infrared measurements appear to underestimate the temperature of the central ionizing stars for which we have directly detected spectral types. The line ratios of H_2 2-1 S(1) and 1-0 S(0) relative to the 1-0 S(1) line in our sample of UC HII regions are generally indicative of dense photo-dissociation regions rather than shocks, similar to what is seen in the Orion Bar. This was true even for UC HII regions showing very weak Brγ emission. While Brγ was generally found to be spatially correlated with the radio emission, H_2 showed little correlation with the UC HII regions, typically lying $\sim 10''$ from the central radio emission. A discussion of each UC HII region studied is included in an extensive Appendix.

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Preprints are available on the WWW at:

http://www.physics.uc.edu/~hanson/ABSTRACTS/hanson12.html

Annealing of Silicate Dust by Nebular Shocks at 10 AU

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Silicate dust grains in the interstellar medium are known to be mostly amorphous, yet crystalline silicate grains have been observed in many long-period comets and in protoplanetary disks. Annealing of amorphous silicate grains into crystalline grains requires temperatures $\geq 1000\,\mathrm{K}$, but exposure of dust grains in comets to such high temperatures is incompatible with the generally low temperatures experienced by comets. This has led to the proposal of models in which dust grains were thermally processed near the protoSun, then underwent considerable radial transport until they reached the gas giant planet region where the long-period comets originated. We hypothesize instead that silicate dust grains were annealed *in situ*, by shock waves triggered by gravitational instabilities. We assume a shock speed of $5\,\mathrm{km\,s^{-1}}$, a plausible value for shocks driven by gravitational instabilities. We calculate the peak temperatures of micron and submicron amorphous pyroxene grains of chondritic composition under conditions typical in protoplanetary disks at 5 – 10 AU. Our results also apply to chondritic amorphous olivine grains. We show that *in situ* thermal annealing of submicron and micron-sized silicate dust grains can occur, obviating the need for large-scale radial transport.

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http://arXiv.org/abs/astro-ph/0112494

On Disk Braking of T Tauri Rotation

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The rotation of T Tauri stars is thought to be slowed by coupling between the stellar magnetosphere and the circumstellar disk. Stassun and collaborators have recently questioned this picture, based on their observations of young stars in and near the Orion Nebula Cluster (ONC) which indicate little evidence for disk-mediated spindown. However, stellar spindown can occur no faster than the rate at which angular momentum is removed from the inner disk, either through viscous processes associated with accretion or by a wind. Observational estimates of these processes suggest that the timescales for angular momentum loss may be comparable to the ages of the ONC stars, so that disk braking may not be completely effective, at least among the lowest-mass stars. Testing this hypothesis will require further measurements of mass accretion and mass loss rates as well as determinations of rotational periods as a function of age.

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

Gravitationally bound cores in a molecular cirrus cloud

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Using MAMBO at the IRAM 30 m telescope we have observed a dense core in the cirrus cloud MCLD123.5+24.9 in the dust continuum emission at 250 GHz. The core is detected as an elongated filament with an extent of $4\farcm2 \times 0\farcm7$, corresponding to $0.18\,\mathrm{pc}\times0.03\,\mathrm{pc}$ at an adopted distance of 150 pc. We find a close correlation between the continuum emission and previously observed $C^{18}O$ ($1\rightarrow0$) line emission. Using standard dust models we derive hydrogen column

densities of up to $10^{22}\,cm^{-2}$. The total mass for the filament is about $0.66\,M_\odot$.
We also present observations of the HC_3N (3→2), (4→3), and (10→9) emission lines obtained with the MPIfR 100 m and the IRAM 30 m telescopes. The distribution is very different from the dust continuum and the $C^{18}O$ (1→0) line emission. HC_3N is concentrated in two distinct clumps located at the ends of the filament seen in the other tracers. Based on a LVG analysis of the HC_3N transitions we derive column densities of $N(HC_3N)/\Delta v \approx 10^{13} cm^{-2}/km/s$ and volume densities of $n(H_2) \approx 10^5\,cm^{-3}$. We find that the HC_3N clumps have masses of 0.13 and $0.19\,M_\odot$. Our data demonstrate that the cirrus cloud cores are gravitationally bound, and that they show chemical structure indicating different evolutionary stages within the cloud.

Accepted by Astronomy & Astrophysics

On the Measurement of the Magnitude and Orientation of the Magnetic Field in Molecular Clouds.

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We demonstrate that the combination of Zeeman, polarimetry and ion-to-neutral molecular line width ratio measurements permits the determination of the magnitude and orientation of the magnetic field in the weakly ionized parts of molecular clouds. Zeeman measurements provide the strength of the magnetic field along the line of sight, polarimetry measurements give the field orientation in the plane of the sky and the ion-to-neutral molecular line width ratio determines the angle between the magnetic field and the line of sight. We apply the technique to the M17 star-forming region using a HERTZ 350 μm polarimetry map and HCO^+-to-HCN molecular line width ratios to provide the first three-dimensional view of the magnetic field in M17.

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Preprint available at http://www.submm.caltech.edu/papers/

The Intrinsic Shapes of Molecular Cloud Fragments over a Range of Length Scales

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We decipher intrinsic three-dimensional shape distributions of molecular clouds, cloud cores, Bok globules, and condensations using recently compiled catalogues of observed axis ratios for these objects mapped in carbon monoxide, ammonia, through optical selection, or in continuum dust emission. We apply statistical techniques to compare assumed intrinsic axis ratio distributions with observed projected axis ratio distributions. Intrinsically triaxial shapes produce projected distributions which agree with observations. Molecular clouds mapped in ^{12}CO are intrinsically triaxial but more nearly prolate than oblate, while the smaller cloud cores, Bok globules, and condensations are also intrinsically triaxial but more nearly oblate than prolate.

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http://phobos.astro.uwo.ca/∼cjones/

Planet Formation in the Outer Solar System

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This paper reviews coagulation models for planet formation in the Kuiper Belt, emphasizing links to recent observations of our and other solar systems. At heliocentric distances of 35–50 AU, single annulus and multiannulus planetesimal accretion calculations produce several 1000 km or larger planets and many 50–500 km objects on timescales of 10–30 Myr in a Minimum Mass Solar Nebula. Planets form more rapidly in more massive nebulae. All models yield two power law cumulative size distributions, $N_C \propto r^{-q}$ with $q = 3.0$–3.5 for radii $r \geq 10$ km and $N_C \propto r^{-2.5}$ for radii $r \leq 1$ km. These size distributions are consistent with observations of Kuiper Belt objects acquired during the past decade. Once large objects form at 35–50 AU, gravitational stirring leads to a collisional cascade where 0.1–10 km objects are ground to dust. The collisional cascade removes 80% to 90% of the initial mass in the nebula in ~ 1 Gyr. This dust production rate is comparable to rates inferred for α Lyr, β Pic, and other extrasolar debris disk systems.

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preprints: http://xxx.lanl.gov/abs/astro-ph/0112120

The Role of Tidal Interactions in Star Formation

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Nearly all of the initial angular momentum of the matter that goes into each forming star must somehow be removed or redistributed during the formation process. The possible transport mechanisms and the possible fates of the excess angular momentum are discussed, and it is argued that transport processes in disks are probably not sufficient by themselves to solve the angular momentum problem, while tidal interactions with other stars in forming binary or multiple systems are likely to be of very general importance in redistributing angular momentum during the star formation process. Most, if not all, stars probably form in binary or multiple systems, and tidal torques in these systems can transfer much of the angular momentum from the gas around each forming star to the orbital motions of the companion stars. Tidally generated waves in circumstellar disks may contribute to the overall redistribution of angular momentum. Stars may gain much of their mass by tidally triggered bursts of rapid accretion, and these bursts could account for some of the most energetic phenomena of the earliest stages of stellar evolution, such as jet-like outflows. If tidal interactions are indeed of general importance, planet-forming disks may often have a more chaotic and violent early evolution than in standard models, and shock heating events may be common. Interactions in a hierarchy of subgroups may play a role in building up massive stars in clusters and in determining the form of the upper IMF. Many of the processes discussed here have analogs on galactic scales, and there may be similarities between the formation of massive stars by interaction-driven accretion processes in clusters and the buildup of massive black holes in galactic nuclei.

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Available at http://aps.arxiv.org/abs/astro-ph/0108471

ECHA J0843.3–7905: Discovery of an ‘old’ classical T Tauri star in the η Chamaeleontis cluster

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A limited-area survey of the η Chamaeleontis cluster has identified 2 new late-type members. The more significant of these is ECHA J0843.3–7905 (= *IRAS* F08450–7854), a slowly-rotating (P = 12 d) M2 classical T Tauri (CTT) star with a spectrum dominated by Balmer emission. At a distance of 97 pc and cluster age of $\approx$ 9 Myr, the star is a nearby rare example of an 'old' CTT star and promises to be a rewarding laboratory for the study of disk structure and evolution in pre-main sequence (PMS) stars. The other new member is the M4 weak-lined T Tauri (WTT) star ECHA J0841.5–7853, which is the lowest mass ($M \approx 0.2$ $M_\odot$) primary known in the cluster.

Accepted by MNRAS

Preprints available at `www.ph.adfa.edu.au/w-lawson/press/CTT2001.pdf`

Photon Dominated Regions in Low UV Fields: A Study of The Peripheral Region of L1204/S140

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We have carried out an in-depth study of the peripheral region of the molecular cloud L1204/S140, where the far ultraviolet radiation and the density are relatively low. Our observations test theories of photon-dominated regions (PDRs) in a regime that has been little explored. Knowledge of such regions will also help to test theories of photoionization-regulated star formation. CII 158 micron and OI 63 micron lines are detected by ISO at all 16 positions along a 1-dimensional cut in right ascension. Emission from molecular hydrogen rotational transitions, at 28 and 17 micron, was also detected at several positions. The CII, OI, and molecular hydrogen intensities along the cut show much less spatial variation than do the rotational lines of CO and other CO isotopes. The average CII and OI intensities and their ratio are consistent with models of PDRs with low FUV radiation (Go) and density. The best-fitting model has Go about 15 and density, n about 1000 per cubic cm. Standard PDR models underpredict the intensity in the H2 rotational lines by up to an order of magnitude. This problem has also been seen in bright PDRs and attributed to factors, such as geometry and gas-grain drift, that should be much less important in the regime studied here. The fact that we see the same problem in our data suggests that more fundamental solutions, such as higher H2 formation rates, are needed. Also, in this regime of low density and small line width, the OI line is sensitive to the radiative transfer and geometry. Using the ionization structure of the models, a quantitative analysis of timescales for ambipolar diffusion in the peripheral regions of the S140 cloud is consistent with a theory of photoionization-regulated star formation. Observations of CII in other galaxies differ both from those of high Go PDRs in our galaxy and from the low Go regions we have studied. The extragalactic results are not easily reproduced with mixtures of high and low Go regions.

Accepted by Ap. J.

Preprints are available at: http://arXiv.org/abs/astro-ph/0112248

A Coupled Dynamical and Chemical Model of Starless Cores of Magnetized Molecular Clouds: I. Formulation and Initial Results

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We develop a detailed chemical model for the starless cores of strongly magnetized molecular clouds, with the ambipolar diffusion-driven dynamic evolution of the clouds coupled to the chemistry through ion abundances. We concentrate on two representative model clouds in this initial study, one with magnetic fields and the other without. The model predictions on the peak values and spatial distributions of the column densities of CO, CCS, N_2H^+ and HCO^+ are compared with those observationally inferred for the well-studied starless core L1544, which is thought to be on the verge of star formation. We find that the magnetic model, in which the cloud is magnetically supported for several million years before collapsing dynamically, provides a reasonable overall fit to the available data on L1544; the fit is significantly worse for the non-magnetic model, in which the cloud collapses promptly. The observed large peak column density for N_2H^+ and clear central depression for CCS favor the magnetically-retarded collapse over the free-fall collapse. A relatively high abundance of CCS is found in the magnetic model, resulting most likely from an interplay of depletion and late-time hydrocarbon chemistry enhanced by CO depletion. These initial results lend some support to the standard picture of dense core formation in strongly magnetized clouds through ambipolar diffusion. They are at variance with those of Aikawa et al. (2001) who considered a set of models somewhat different from ours and preferred one in which the cloud collapses more or less freely for L1544.

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preprint available at astro-ph/0201019

Discovery of the first young brown dwarf in the Serpens cluster

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In this letter, we report the discovery of the first young early L-dwarf in the Serpens cloud. It is obscured by more than ten magnitudes of visual absorption and was found during a near infrared (NIR) photometric survey of a 50 square arcminutes area in the Serpens cloud, deep enough to probe the substellar domain. After selection from NIR colour-magnitude and colour-colour diagrams, its substellar nature has been confirmed by NIR spectroscopy at the VLT. We estimate the mass of this brown dwarf to be $M \sim 0.05\,M_\odot$ and its age to be ~ 3.5 Myr. From its NIR indices, we estimate its present spectral type to be L0-L3, and using a model its future spectral type to be T. This is the first young brown dwarf ever found deeply embedded in a star formation region.

Accepted by Astronomy & Astrophysiscs Letters

Preprints are available at:
http://www-laog.obs.ujf-grenoble.fr/ monin/publis/bdserlet4.pdf

Far Infrared Spectroscopy of the HH 1/2 Outflow

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The HH 1/2 system has been observed with the two spectrometers on board the Infrared Space Observatory. Diffuse [[C II]158μm emission indicate the presence of a Photo-Dissociation Region (PDR) which is only in part due to the external Far-UV irradiation from the nearby Orion Nebula. Additional irradiation must be originated locally and we show that the FUV field produced in the recombination regions behind the shocks traced by the HH objects is sufficient to induce a PDR at the flow cavity walls.

The analysis of [OI], [SiII]34.8μm and [NeII]12.8μm lines suggests shock velocities $v_s \sim 100 \div 140$ km s^{-1} with pre-shock densities between 100 and 1000 cm^{-3}. H_2 pure rotational lines trace a T$\sim$600 K gas which is likely to be warmed up in slow, planar, molecular shocks. The coexistence in the areas subtended by the instrumental beamsizes of shocks at different velocities is consistent with the bow-shock morphology of the HH 1 and, to a lesser extent, HH 2 as traced by optical images.

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Astro-ph/0112400

No disks around low-mass stars and brown dwarfs in the young σ Orionis cluster?

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We report on the analysis of 2MASS near-infrared data of a sample of low-mass stars and brown dwarfs in the σ Orionis cluster. Youth and cluster membership have been spectroscopically confirmed using the Li I spectral line. We find little evidence in the JHK_s colour-colour diagram for near-infrared excess emission for these cluster members. By comparison with model expectations, at most 2 out of 34 stars show $(H - K_s)$ colour consistent with a near-infrared excess. This scarcity of near-infrared signatures of circumstellar disks in the lower-mass and substellar regimes of this cluster contrasts with findings in younger clusters, hinting at an age dependence of the disk frequency. Taking into account the apparent cluster age, our result supports the idea of a relatively fast (few Myr) disk dissipation and extends this conclusion to the substellar regime. We also find some evidence that, in this cluster, the disk frequency as measured by the K_s-band excess may be mass dependent.

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Preprints available at http://arXiv.org/abs/astro-ph/0112319

Massive core parameters from spatially unresolved multi-line observations

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We present observations of 15 massive cores in three different CS transitions from the FCRAO 14m and the KOSMA 3m telescope. We derive physical parameters of these cores using different approaches to the line radiative transfer problem. The local radiative transfer approximations fail to provide reliable values except for the column densities. A self-consistent explanation of the observed line profiles is only possible when taking density gradients and an internal turbulent structure of the cores into account. The observational data can be fitted by a spherically symmetric radiative transfer model including such gradients and a turbulent clumping. We find that the observed massive cores are approximately virialised with a clumpy density profile that decays with a radial exponent of about -1.6 down to a relatively sharp outer boundary.
We show that a careful analysis of spatially unresolved multi-line observations using a physical radiative transfer model can provide values for physical parameters that could be obtained otherwise only by direct observations with much higher spatial resolution. This applies to all quantities directly affecting the line excitation, like the mass and size of dense cores. Information on the exact location or number of clumps, of course, always has to rely on high-resolution observations e.g. from interferometers.

Accepted by Astron. Astrophys.

On the structure of self-gravitating molecular clouds

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To study the interaction of star-formation and turbulent molecular cloud structuring, we analyse numerical models and observations of self-gravitating clouds using the Δ-variance as statistical measure for structural characteristics. In the models we resolve the transition from purely hydrodynamic turbulence to gravitational collapse associated with the formation and mass growth of protostellar cores. We compare models of driven and freely decaying turbulence with and without magnetic fields. Self-gravitating supersonic turbulence always produces a density structure that contains most power on the smallest scales provided by collapsed cores as soon as local collapse sets in. This is in

contrast to non-self-gravitating hydrodynamic turbulence where the Δ-variance is dominated by large scale structures.

To detect this effect in star-forming regions observations have to resolve the high density contrast of protostellar cores with respect to their ambient molecular cloud. Using the 3mm continuum map of a star-forming cluster in Serpens we show that the dust emission traces the full density evolution. On the contrary, the density range accessible by molecular line observations is insufficient for this analysis. Only dust emission and dust extinction observations are able to to determine the structural parameters of star-forming clouds following the density evolution during the gravitational collapse.

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The outflow activity of the protostars in S140 IRS

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The S140/L1204 cloud contains a deeply embedded region of star formation and a powerful molecular outflow. In this paper, we present images of the S140 region obtained in the light of the 2.12 μm molecular hydrogen emission line and adjacent continuum. Our images reveal several knots of H_2 line emission originating from shocked material close to IRS 1 as well as further out. Strong H_2 shock emission is found north-east of IRS1 (at position angles of $\sim 20° - 30°$), as well as to the south-west of IRS1 (at position angles around $\sim 190° - 220°$), clearly demonstrating the presence of outflow activity in the north-east/south-west direction. We also find patches of H_2 emission several arcminutes away from IRS1 at a position angles of $\sim 150°$ and 340°, i.e. in directions consistent with the previously known north-west/south-east molecular outflow. Our results therefore provide evidence for the existence of two distinct bipolar outflow systems originating simultaneously from IRS 1. We also discuss general aspects of the star formation process in the S140 region. An inferred high ratio of stellar to gas mass suggests that the outflows have dispersed most of the cloud mass.

Accepted by: Astronomy & Astrophysics

Preprints are available at http://www.mpifr-bonn.mpg.de/staff/tpreibis/publications.html (paper # 28)

Near-Infrared Study of M16: Star Formation in the Elephant Trunks

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We present combined JH & Ks images of M16 which were obtained with SIRIUS (Simultaneous three-color InfraRed Imager for Unbiased Surveys; http://www.z.phys.nagoya-u.ac.jp/~sirius/index_e.html) on the UH 2.2m telescope. In contrast to optical images, the infrared images show that the Eagle Nebula's "pillars" have head-tail structures with the heads faced toward the central part of the star cluster NGC 6611 and the tails trailed toward the opposite side. We have found a number of previously unreported YSO candidates associated with these head-tail pillars. In particular, the youngest YSOs are located at the tips of the pillars or globules, facing toward the central part of NGC 6611. Some are associated with near-infrared jets or cometary reflection nebulae with indications of a circumstellar disk. This YSO distribution and the cloud structures suggest that the most recent star formation is taking place following the interaction with UV light from the OB stars in NGC 6611.

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Preprints are available at: http://www.nsc.nagoya-cu.ac.jp/∼sugitani/ preprints/M16.pdf

Systematic Molecular Differentiation in Starless Cores

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We present evidence that low-mass starless cores, the simplest units of star formation, are systematically differentiated in their chemical composition. Molecules including CO and CS almost vanish near the core centers, where the abundance decreases by at least one or two orders of magnitude with respect to the value in the outer core. At the same time, the N_2H^+ molecule has a constant abundance, and the fraction of NH_3 increases toward the core center. Our conclusions are based on a systematic study of 5 mostly-round starless cores (L1498, L1495, L1400K, L1517B, and L1544), which we have mapped in $C^{18}O$(1–0), CS(2–1), N_2H^+(1–0), NH_3(1,1) and (2,2) and the 1.2 mm continuum (complemented with $C^{17}O$(1–0) and $C^{34}S$(2–1) data for some systems). For each core we have built a spherically symmetric model in which the density is derived from the 1.2 mm continuum, the kinetic temperature from NH_3, and the abundance of each molecule is derived using a Monte Carlo radiative transfer code which simultaneously fits the shape of the central spectrum and the radial profile of integrated intensity. Regarding the cores for which we have $C^{17}O$(1–0) and $C^{34}S$(2–1) data, the model fits these observations automatically when the standard isotopomer ratio is assumed.

As a result of this modeling, we also find that the gas kinetic temperature in each core is constant at approximately 10 K. In agreement with previous work, we find that if the dust temperature is also constant, then the density profiles are centrally flattened, and we can model them with a single analytic expression. We also find that for each core the turbulent linewidth seems constant in the inner 0.1 pc.

The very strong abundance drop of CO and CS toward the center of each core is naturally explained by the depletion of these molecules onto dust grains at densities of 2-6 $\times 10^4$ cm^{-3}. N_2H^+ seems unaffected by this process up to densities of several 10^5 or even 10^6 cm^{-3}, while the NH_3 abundance may be enhanced by its lack of depletion and reactions triggered by the disappearance of CO from the gas phase.

With the help of the Monte Carlo modeling, we show that chemical differentiation automatically explains the discrepancy between the sizes of CS and NH_3 maps, a problem which has remained unexplained for more than a decade. Our models, in addition, show that a combination of radiative transfer effects can give rise to the previously observed discrepancy in the linewidth of these two tracers. Although this discrepancy has been traditionally interpreted as resulting from a systematic increase of the turbulent linewidth with radius, our models show that it can arise in conditions of constant gas turbulence.

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http://arXiv.org/abs/astro-ph/0112487

Nanodiamonds around HD 97048 and Elias 1

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We present an analysis of ISO-SWS observations of the Herbig Ae/Be stars HD 97048 and Elias 1. Besides the well-known family of IR emission bands at 3.3, 6.2, “7.7”, 8.6 and 11.2 μm these objects show strong, peculiar emission features at 3.43 and 3.53 μm. The latter two features show pronounced substructure which is very similar in the two

sources.
Comparison of the spectra of HD 97048 and Elias 1 with laboratory spectra of H–terminated diamond surfaces show excellent and very convincing agreement in peak position and spectral detail (Guillois et al. 1999).
The position of the 3.53 μm band indicates a temperature of $\sim$ 1000 K. An analysis of the radiative energy budget makes us conclude that the diamond carrier of the 3.53 μm feature has typical sizes of 1–10 nm for HD 97048. A fit of the 3.53 μm feature with a theoretical, calculated profile indicates that the emitting diamonds in HD 97048 see a FUV flux of 5.8 10^{-3} [W/cm^2]. The derived diamond mass, 1.5 10^{-10} $M_\odot$, is only a tiny fraction of the total circumstellar dust mass and corresponds to only about 1 parts per billion relative to hydrogen.
We discuss the origin of the diamond around these Herbig Ae/Be stars and conclude that most likely they are formed in situ. The implications for the nanodiamonds discovered in meteorites are also discussed.

Accepted by A&A

Herbig-Haro Objects in the Off-core Regions of the ρ Oph Dark Cl oud

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A wide-field survey for Herbig-Haro (HH) objects has been carried out in the ρ Oph dark cloud, which extends the previous HH-surveyed area in this cloud from 1 deg^2 to 11 deg^2. Besides the confirmation of all the 10 known HH objects in the ρ Oph cloud core (Reipurth 1999), seven groups of HH objects, including HH 548, HH 549A-C, HH 550, HH 551, HH 552, HH 553A-E, and HH 554, are newly discovered in the off-core regions. The newly found HH objects concentrate in three regions, which are 2-3 pc away from the ρ Oph dark cloud core. Among these, the three brightest objects, HH 549, HH 550 and HH 551, show characteristic HH morphologies of shock or knot with tail. HH 553 and HH 554 are located in the L1689N region, but they are unlikely driven by the well known protostar IRAS 16293-2422. HH 550 and HH 551 are located more than 1 pc away from the cloud and possibly form a pc-scale HH flow in Ophiuchus.

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Preprints are available at http://jets.pmo.ac.cn/starfm/preprints.html

On the formation of massive stars

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We calculate numerically the collapse of slowly rotating, non-magnetic, massive molecular clumps of masses 30 $M_\odot$, 60 $M_\odot$, and 120 $M_\odot$, which conceivably could lead to the formation of massive stars. Because radiative acceleration on dust grains plays a critical role in the clump's dynamical evolution, we have improved the module for continuum radiation transfer in an existing 2D (axial symmetry assumed) radiation hydrodynamic code. In particular, rather than using "grey" dust opacities and "grey" radiation transfer, we calculate the dust's wavelength-dependent absorption and emission simultaneously with the radiation density at each wavelength and the equilibrium temperatures of three grain components: amorphous carbon particles, silicates, and "dirty ice"-coated silicates. Because our simulations cannot spatially resolve the innermost regions of the molecular clump, however, we cannot distinguish between the formation of a dense central cluster or a single massive object. Furthermore, we cannot exclude significant mass loss from the central object(s) which may interact with the inflow into the central grid cell. Thus, with our basic assumption that all material in the innermost grid cell accretes onto a single object, we are only able to provide an

upper limit to the mass of stars which could possibly be formed.

We introduce a semi-analytical scheme for augmenting existing evolutionary tracks of pre-main sequence protostars by including the effects of accretion. By considering an open outermost boundary, an arbitrary amount of material could, in principal, be accreted onto this central star. However, for the three cases considered (30 $M_\odot$, 60 $M_\odot$, and 120 $M_\odot$ originally within the computation grid), radiation acceleration limited the final masses to 31.6 $M_\odot$, 33.6 $M_\odot$, and 42.9 $M_\odot$, respectively, for wavelength-dependent radiation transfer and to 19.1 $M_\odot$, 20.1 $M_\odot$, and 22.9 $M_\odot$ for the corresponding simulations with grey radiation transfer. Our calculations demonstrate that massive stars can in principle be formed via accretion through a disk. The accretion rate onto the central source increases rapidly after one initial free-fall time and decreases monotonically afterwards. By enhancing the non-isotropic character of the radiation field the accretion disk reduces the effects of radiative acceleration in the radial direction — a process we denote the "flashlight effect". The flashlight effect is further amplified in our case by including the effects of frequency dependent radiation transfer. We conclude with the warning that a careful treatment of radiation transfer is a mandatory requirement for realistic simulations of the formation of massive stars.

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http://arXiv.org/abs/astro-ph/0201041

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CHEMISTRY AS A DIAGNOSTIC OF STAR FORMATION

21–23 August 2002
University of Waterloo, Ontario, Canada
Conference Web-site: http://astro.uwaterloo.ca/sfchem2002

Registration opens February 1, 2001

Aim of the conference

An understanding of the microphysics underlying spectral line and continuum observations is essential to most areas of astronomy. In star formation, where optical measurements are often lacking, our dependence on these diagnostics is particularly acute. Improvements in single-dish and interferometer (sub-)millimeter facilities, both ground- and space-based, continue to provide a wealth of new data. These observations reveal a wide range of physical conditions ranging from the cold, pre-collapse stage, where key molecules are depleted onto grains, to warmer, more evolved phases where ices evaporate and drive a rich chemistry. As our only window onto the gas and solid-state composition of star-forming regions, interpretation of these data is critical to many important problems in the field.

The aim of the meeting is to forge a synthesis between the different domains of star formation research via the unifying concept of astrochemistry. This should help turn spectroscopy and broadband photometry into even more powerful probes of the physical transformation of gas and dust into stars. By concentrating on the role of dust and gas, we hope to provide a more focussed forum for discussion of the critical problems and directions of progress, while maintaining an informal, workshop environment.

Scientific Program

I. Fundamental processes
II. Chemistry, physical conditions, and structure of dark clouds
III. Chemical diagnostics of infall, outflow, and disks
IV. High-mass star formation
V. The role of dust continuum observations
VI. Issues of ongoing and future interest

Scientific Organizing Committee

M. Fich (Waterloo, Chair), C. Curry (Waterloo), E. van Dishoeck (Leiden), D. Williams (UC London), A. Tielens (Kapteyn Inst.), N. Evans (Texas), E. Bergin (CfA)

Local Organizing Committee

C. Curry (Chair), M. Fich, W. Duley, P. Bernath (all at Waterloo)

A more detailed announcement may be found at the conference website:

http://astro.uwaterloo.ca/sfchem2002/

At this time, we would like to hear from those interested in participating. If you would like to receive future mailings. Please send a short message to:

sfchem@astro.uwaterloo.ca

FIRST ANNOUNCEMENT

Workshop Jets 2002: Theory and Observations in YSOs

3 - 6 September, Porto, Portugal

PRE-REGISTRATION: http://www.sp-astronomia.pt/jenam2002/ws-jets/

Workshop Scientific Organising Committee:

R. Bachiller (Spain), A. Fernandes (Portugal) - Convener, P. Garcia (Portugal) - Convener, P. Hartigan (USA), T. Kudoh (Japan), J. Lima (Portugal) - Convener, A. Natta (Italy), G. Pelletier (France), A. Raga (Mexico), K. Tsinganos (Greece), D. Williams (UK), H. Zinnecker (Germany).

[To contact the Conveners send an email to ws-jets@sp-astronomia.pt]

Scientific Rationale:

The ubiquity of jet phenomena in YSOs, AGNs, symbiotic stars, planetary nebulae and x-ray binaries has driven a broad literature on the astrophysics of collimated mass ejection. Indeed, ADS shows that over the past few years around 500 refereed papers per year have been published with the word jet on the abstract!

One of the fundamental open problems in star formation is the understanding of the physical mechanisms by which mass is ejected from the proto-stellar system and collimated into jets. Locally jets will regulate the system angular momentum and therefore its evolution during the first 10^6 years. At large scale jets inject momentum into the cloud thus affecting its star formation efficiency and evolution.

In this workshop we'll address both theory and observations of jet phenomena with special emphasis in YSOs.

The main topics of this conference are:

a) steady state jet models including X-winds, disk winds and stellar winds;

b) time dependent simulations of episodic outflows and star-disk interact ion;

c) observations of atomic jet excitation, morphology, dynamics and proper -motions;

d) simulations for jet (pulsed) propagation and interaction with (magneti zed/side wind) interstellar medium including cooling and chemistry;

e) observations of molecular jets chemistry, dynamics, excitation and mor phology;

f) models for jet energetics including shocks, ambipolar diffusion, turbulent dissipation and photoionization;

g) jets in other objects as AGNs, PNs, GRBs, symbiotic stars and ... the lab.

We hope this workshop will be a magnetizing experience full of supersonic/superluminal new ideas for the serious jet researcher.