THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 191 — 9 Nov 2008 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

A Search for H_2CO 6 cm Emission toward Young Stellar Objects. III. VLA Observations

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We report the results of our third survey for formaldehyde (H_2CO) 6 cm maser emission in the Galaxy. Using the Very Large Array, we detected two new H_2CO maser sources (G23.01-0.41 and G25.83-0.18), thus increasing the sample of known H_2CO maser regions in the Galaxy to seven. We review the characteristics of the G23.01-0.41 and G25.83-0.18 star-forming regions. The H_2CO masers in G23.01-0.41 and G25.83-0.18 share several properties with the other known H_2CO masers, in particular, emission from rich maser environments and close proximity to very young massive stellar objects.

Published by The Astrophysical Journal Supplement Series (Vol. 178, p. 330)

Physical Conditions of Accreting Gas in T Tauri Star Systems

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We present results from a low-resolution (R ≈ 300) near-infrared spectroscopic variability survey of actively accreting T Tauri stars (TTSs) in the Taurus-Auriga star-forming region. Paschen and Brackett series H I recombination lines were detected in 73 spectra of 15 classical T Tauri systems. The values of the $Pa^{n_{up}}/Pa\beta$, $Br^{n_{up}}/Br\gamma$, and $Br\gamma/Pa^{n_{up}}$ H I line ratios for all observations exhibit a scatter of $< \sim 20\%$ about the weighted mean, not only from source to source, but also for epoch-to-epoch variations in the same source. A representative or "global" value was determined for each ratio in both the Paschen and Brackett series, as well as the $Br\gamma/Pa^{n_{up}}$ line ratios. A comparison of observed line ratio values was made to those predicted by the temperature- and electron densitydependent models of case B hydrogen recombination line theory. The measured line ratios are statistically well fit by a tightly constrained range of temperatures ($T < \sim 2000$ K) and electron densities (10^9 cm^{-3} $< n_e < \sim 10^{10}$ cm^{-3}). A comparison of the observed line ratio values to the values predicted by the optically thick and thin local thermodynamic equilibrium cases rules out these conditions for the emitting H I gas. Therefore, the emission is consistent with having an origin in a non-LTE recombining gas. While the range of electron densities is consistent with the gas densities predicted by existing magnetospheric accretion models, the temperature range constrained by the case B comparison is considerably lower than that expected for accreting gas. The cooler gas temperatures will require a nonthermal excitation process (e.g., coronal/accretion-related X-rays and UV photons) to power the observed line emission.

Published by The Astrophysical Journal (Vol. 687, p. 376)

Stellar, brown dwarf, and multiple star properties from hydrodynamical simulations of star cluster formation

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We report the statistical properties of stars, brown dwarfs and multiple systems obtained from the largest hydrodynamical simulation of star cluster formation to date that resolves masses down to the opacity limit for fragmentation (a few Jupiter masses). The simulation is essentially identical to that of Bate, Bonnell & Bromm except that the initial molecular cloud is larger and more massive. It produces more than 1250 stars and brown dwarfs, providing unprecedented statistical information that can be compared with observational surveys. The calculation uses sink particles to model the stars and brown dwarfs. Part of the calculation is re-run with smaller sink particle accretion radii and gravitational softening to investigate the effect of these approximations on the results.

We find that hydrodynamical/sink particle simulations can reproduce many of the observed stellar properties very well. Binarity as a function of primary mass, the frequency of very-low-mass (VLM) binaries, general trends for the separation and mass ratio distributions of binaries, and the relative orbital orientations of triples systems are all in reasonable agreement with observations. We also examine the radial variations of binarity, velocity dispersion, and mass function in the resulting stellar cluster and the distributions of disc truncation radii due to dynamical interactions. For VLM binaries, because their separations are typically close, we find that their frequency is sensitive to the sink particle accretion radii and gravitational softening used in the calcuations. Using small accretion radii and gravitational softening results in a frequency of VLM binaries similar to that expected from observational surveys (≈ 20 percent). We also find that VLM binaries evolve from wide, unequal-mass systems towards close equal-mass systems as they form. The two main deficiencies of the calculations are that they over produce brown dwarfs relative to stars and that there are too few unequal mass binaries with K and G-dwarf primaries. The former of these is likely due to the absence of radiative feedback and/or magnetic fields.

Accepted by MNRAS

Animations and paper available at http://www.astro.ex.ac.uk/people/mbate/Cluster/cluster3d.html
Also available at http://arxiv.org/abs/0811.0163

The importance of radiative feedback for the stellar initial mass function

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We investigate the effect of radiative feedback on the star formation process using radiation hydrodynamical simulations. We repeat the previous hydrodynamical star cluster formation simulations of Bate et al., and Bate & Bonnell, but we use a realistic gas equation of state and radiative transfer in the flux-limited diffusion approximation rather than the original barotropic equation of state.

Whereas star formation in the barotropic simulations continued unabated until the simulation was stopped, we find that radiative feedback, even from low-mass stars, essentially terminates the production of new objects within low-mass dense molecular cloud cores after roughly one local dynamical time. Radiative feedback also dramatically decreases the propensity of massive circumstellar discs to fragment and inhibits fragmentation of other dense gas (e.g. filaments) close to existing protostellar objects. These two effects decrease the numbers of protostars formed by a factor of ≈ 4 compared with the original hydrodynamical simulations using the barotropic equation of state. In particular, whereas the original simulations produced more brown dwarfs than stars, the radiative feedback results in a ratio of stars to brown dwarfs of approximately 5:1, in much better agreement with observations. Most importantly, we find that although the characteristic stellar mass in the original calculations scaled linearly with the initial mean Jeans mass in the clouds, when radiative feedback is included the characteristic stellar mass is indistinguishable for the two calculations, regardless of the initial Jeans mass of the clouds. We thus propose that the reason the observed initial mass function appears to be universal in the local Universe is due to self-regulation of the star formation process by radiative feedback. We present an analytic argument showing how a characteristic mass may be derived that is

relatively independent of initial conditions such as the cloud's density.

Accepted by MNRAS

Animations and paper available at http://www.astro.ex.ac.uk/people/mbate/Cluster/clusterRT.html
Paper also available at http://arxiv.org/abs/0811.1035

Chemical Diversity in High-Mass Star Formation

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Massive star formation exhibits an extremely rich chemistry. However, not much evolutionary details are known yet, especially at high spatial resolution. Therefore, we synthesize previously published Submillimeter Array high-spatial-resolution spectral line observations toward four regions of high-mass star formation that are in various evolutionary stages with a range of luminosities. Estimating column densities and comparing the spatially resolved molecular emission allows us to characterize the chemical evolution in more detail. Furthermore, we model the chemical evolution of massive warm molecular cores to be directly compared with the data. The four regions reveal many different characteristics. While some of them, e.g., the detection rate of CH_3OH, can be explained by variations of the average gas temperatures, other features are attributed to chemical effects. For example, $C^{34}S$ is observed mainly at the core-edges and not toward their centers because of temperature-selective desorption and successive gas-phase chemistry reactions. Most nitrogen-bearing molecules are only found toward the hot molecular cores and not the earlier evolutionary stages, indicating that the formation and excitation of such complex nitrogen-bearing molecules needs significant heating and time to be fully developed. Furthermore, we discuss the observational difficulties to study massive accretion disks in the young deeply embedded phase of massive star formation. The general potential and limitations of such kind of dataset are discussed, and future directions are outlined. The analysis and modeling of this source sample reveals many interesting features toward a chemical evolutionary sequence. However, it is only an early step, and many observational and theoretical challenges in that field lie ahead.

Accepted by Astronomical Journal

http://www.mpia.de/homes/beuther/papers.html

Trigonometric Parallaxes of Massive Star Forming Regions: V. G23.01-0.41 and G23.44-0.18

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We report trigonometric parallaxes for the massive star-forming regions G23.01-0.41 and G23.44-0.18, corresponding to distances of 4.59 [+0.38/-0.33] kpc and 5.88 [+1.37/-0.93] kpc, respectively. The distance to G23.01-0.41 is smaller than its near kinematic distance assuming a standard model of the Milky Way and less than half of its far kinematic distance, which has usually been assumed. This places it in the Crux-Scutum spiral arm. The distance to G23.44-0.18 is close to its near kinematic distance and most likely places it in the Norma spiral arm near the end of the Galactic bar. Combining the distance and proper motions with observed radial velocities gives the location and full space motion of the star forming regions. We find large deviations from circular Galactic orbits for these sources: both sources show peculiar motions of 20 to 30 km/s counter to Galactic rotation and toward the Galactic center. These large peculiar motions might be the result of gravitational perturbations from the Galactic bar.

Accepted by Astron. J.

http://arxiv.org/abs/0811.0713

Formation and Evolution of Planetary Systems (FEPS): Properties of Debris Dust around Solar-type Stars

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We present Spitzer photometric (IRAC and MIPS) and spectroscopic (IRS low resolution) observations for 314 stars in the Formation and Evolution of Planetary Systems (FEPS) Legacy program. These data are used to investigate the properties and evolution of circumstellar dust around solar-type stars spanning ages from approximately 3 Myr to 3 Gyr. We identify 46 sources that exhibit excess infrared emission above the stellar photosphere at 24μm, and 21 sources with excesses at 70μm. Five sources with an infrared excess have characteristics of optically thick primordial disks, while the remaining sources have properties akin to debris systems. The fraction of systems exhibiting a 24μm excess greater than 10.2% above the photosphere is 15% for ages $<$ 300 Myr and declines to 2.7% for older ages. The upper envelope to the 70μm fractional luminosity appears to decline over a similar age range. The characteristic temperature of the debris inferred from the IRS spectra range between 60 and 180 K, with evidence for the presence of cooler dust to account for the strength of the 70μm excess emission. No strong correlation is found between dust temperature and stellar age. Comparison of the observational data with disk models containing a power-law distribution of silicate grains suggest that the typical inner disk radius is $\gtrsim$10 AU. Although the interpretation is not unique, the lack of excess emission shortwards of 16μm and the relatively flat distribution of the 24μm excess for ages $<$ 300 Myr is consistent with steady-state collisional models.

Accepted by ApJS

http://arxiv.org/abs/0810.1003

IRAM-PdBI Observations of Binary Protostars I: The Hierarchical System SVS 13 in NGC 1333

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We present millimeter interferometric observations of the young stellar object SVS 13 in NGC 1333 in the N_2H^+ (1–0) line and at 1.4 and 3 mm dust continuum, using the IRAM Plateau de Bure interferometer. The results are complemented by infrared data from the *Spitzer Space Telescope*. The millimeter dust continuum images resolve four sources (A, B, C, and VLA 3) in SVS 13. With the dust continuum images, we derive gas masses of $0.2 - 1.1\,M_\odot$ for the sources. N_2H^+ (1–0) line emission is detected and spatially associated with the dust continuum sources B and VLA 3. The observed mean line width is $\sim 0.48\,\mathrm{km\,s^{-1}}$ and the estimated virial mass is $\sim 0.7\,M_\odot$. By simultaneously fitting the seven hyperfine line components of N_2H^+, we derive the velocity field and find a symmetric velocity gradient of $\sim 28\,\mathrm{km\,s^{-1}\,pc^{-1}}$ across sources B and VLA 3, which could be explained by core rotation. The velocity field suggests

that sources B and VLA 3 are forming a physically bound protobinary system embedded in a common N_2H^+ core. *Spitzer* images show mid-infrared emission from sources A and C, which is spatially associated with the mm dust continuum emission. No infrared emission is detected from source B, implying that the source is deeply embedded. Based on the morphologies and velocity structure, we propose a hierarchical fragmentation picture for SVS 13 where the three sources (A, B, and C) were formed by initial fragmentation of a filamentary prestellar core, while the protobinary system (sources B and VLA 3) was formed by rotational fragmentation of a single collapsing sub-core.

Accepted by ApJ

http://arXiv.org/abs/0810.1712

The Masses of Transition Circumstellar Disks: Observational Support for Photoevaporation Models

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We report deep Submillimeter Array observations of 26 premain-sequence (PMS) stars with evolved inner disks. These observations measure the mass of the outer disk (r ∼20–100 AU) across every stage of the dissipation of the inner disk ($r < 10$ AU) as determined by the IR spectral energy distributions (SEDs). We find that only targets with high mid-IR excesses are detected and have disk masses in the 1–5 $M_{\rm Jup}$ range, while most of our objects remain undetected to sensitivity levels of $M_{\rm DISK} \sim M_{\rm Jup}$. To put these results in a more general context, we collected publicly available data to construct the optical to millimeter wavelength SEDs of over 120 additional PMS stars. We find that the near-IR and mid-IR emissions remain optically thick in objects whose disk masses span 2 orders of magnitude (∼0.5–50 $M_{\rm Jup}$). Taken together, these results imply that, *in general, inner disks start to dissipate only after the outer disk has been significantly depleted of mass.* This provides strong support for photoevaporation being one of the dominant processes driving disk evolution.

Published by The Astrophysical Journal Letters (Vol. 686, p. L115)

Testing Magnetic Star Formation Theory

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Zeeman observations of molecular clouds yield the line-of-sight component B_{LOS} of the magnetic vector $\mathbf{B}$, which makes it possible to test the two major extreme-case theories of what drives star formation – ambipolar diffusion or turbulence. However, only one of the three components of $\mathbf{B}$ is measurable, so tests have been statistical rather than direct, and they have not been definitive. We report here observations of the Zeeman effect in the 18-cm lines of OH in the envelope regions surrounding four molecular cloud cores toward which detections of B_{LOS} have been achieved in the same lines, and evaluate the *ratio* of mass to magnetic flux, M/Φ, between the cloud core and envelope. This relative M/Φ measurement reduces uncertainties in previous studies, such as the angle between $\mathbf{B}$ and the line of sight and the value of [OH/H]. Our result is that for all four clouds, the ratios $\mathcal{R}$ of the core to the envelope values of M/Φ are less than 1. Stated another way, the ratios $\mathcal{R}'$ of the core to the total cloud M/Φ are less than 1. The extreme case or idealized (no turbulence) ambipolar diffusion theory of core formation requires the ratio of the central to total M/Φ to be approximately equal to the inverse of the original subcritical M/Φ, or $\mathcal{R}' > 1$. The probability that all four of our clouds have $\mathcal{R}' > 1$ is 3×10^{-7}; our results are therefore significantly in contradiction with the hypothesis that these four cores were formed by ambipolar diffusion. Highly super-Alfvénic turbulent simulations yield a wide range of relative M/Φ, but favor a ratio $\mathcal{R} < 1$, as we observe. Our experiment is limited to four clouds, and we can only directly test the predictions of the extreme-case "idealized" models of ambipolar-diffusion driven star formation that have a regular magnetic field morphology. Nonetheless, our experimental results are not consistent with the "idealized" strong field, ambipolar diffusion theory of star formation. Comparisons of our results with more realistic models and simulations that include both ambipolar diffusion and turbulence may help to refine our understanding of

the relative importance of magnetic fields and turbulence in the star formation process.

Accepted by Astrophysical Journal

http://lanl.arxiv.org/abs/0807.2862

Iron 60 Evidence for Early Injection and Efficient Mixing of Stellar Debris in the Protosolar Nebula

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Among extinct radioactivities present in meteorites, ^{60}Fe ($t_{1/2}$ = 1.49 Myr) plays a key role as a high-resolution chronometer, a heat source in planetesimals, and a fingerprint of the astrophysical setting of solar system formation. A critical issue with ^{60}Fe is that it could have been heterogeneously distributed in the protoplanetary disk, calling into question the efficiency of mixing in the solar nebula or the timing of ^{60}Fe injection relative to planetesimal formation. If this were the case, one would expect meteorites that did not incorporate ^{60}Fe (either because of late injection or incomplete mixing) to show ^{60}Ni deficits (from lack of ^{60}Fe decay) and collateral effects on other neutron-rich isotopes of Fe and Ni (coproduced with ^{60}Fe in core-collapse supernovae and AGB stars). Here, we show that measured iron meteorites and chondrites have Fe and Ni isotopic compositions identical to Earth. This demonstrates that ^{60}Fe must have been injected into the protosolar nebula and mixed to less than 10% heterogeneity before formation of planetary bodies.

Published by The Astrophysical Journal (Vol. 686, p. 560)

Atomic jets from class 0 sources detected by Spitzer: the case of L1448-C

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We present Spitzer-IRS spectra obtained along the molecular jet from the Class 0 source L1448-C (or L1448-mm). Atomic lines from the fundamental transitions of [FeII], [SiII] and [SI] have been detected showing, for the first time, the presence of an embedded atomic jet at low excitation. Pure rotational H_2 lines are also detected, and a decrease of the atomic/molecular emission ratio is observed within $1''$ from the driving source. Additional ground based spectra (UKIRT/UIST) were obtained to further constrain the H_2 excitation along the jet axis and, combined with the 0–0 lines, have been compared with bow-shock models. From the different line ratios, we find that the atomic gas is characterized by an electron density $n_e \sim$ 200-1000 cm^{-3}, a temperature $T_e < 2500$ K and an ionization fraction $\lesssim 10^{-2}$; the excitation conditions of the atomic jet are thus very different from those found in more evolved Class I and Class II jets. We also infer that only a fraction (0.05-0.2) of Fe and Si is in gaseous form, indicating that dust still plays a major role in the depletion of refractory elements. A comparison with the SiO abundance recently derived in the jet from an analysis of several SiO sub-mm transitions, shows that the Si/SiO abundance ratio is ∼100, and thus that most of the silicon released from grains by sputtering and grain-grain collisions remains in atomic form. Finally, estimates of the atomic and molecular mass flux rates have been derived: values of the order of $\sim 10^{-6}$ and $\sim 10^{-7}$ $M_\odot$ yr^{-1} are inferred from the [SI]25μm and H_2 line luminosities, respectively. A comparison with the momentum flux of the CO molecular outflow suggests that the detected atomic jet has the power to drive the large scale outflow.

Accepted by ApJ

http://www.mporzio.astro.it/∼bruni/publ.html

A slowly accreting ∼10 Myr old transitional disk in Orion OB1a

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Here we present the *Spitzer* IRS spectrum of CVSO 224, the sole transitional disk located within the ∼10 Myr old 25 Orionis group in Orion OB1a. A model fit to the spectral energy distribution of this object indicates a ∼7 AU inner disk hole that contains a small amount of optically thin dust. In previous studies, CVSO 224 had been classified as a weak-line T Tauri star based on its Hα equivalent width, but here we find an accretion rate of 7×10^{-11} $M_\odot$ yr^{-1} based on high-resolution Hectochelle data. CVSO 224's low $\dot{M}$ is in line with photoevaporative clearing theories. However, the *Spitzer* IRS spectrum of CVSO 224 has a substantial mid-infrared excess beyond 20μm which indicates that it is surrounded by a massive outer disk. Millimeter measurements are necessary to constrain the mass of the outer disk around CVSO 224 in order to confirm that photoevaporation is not the mechanism behind creating its inner disk hole.

Accepted by ApJ Letters

http://arxiv.org/abs/0810.4575

The Density Probability Distribution in Compressible Isothermal Turbulence: Solenoidal versus Compressive Forcing

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The probability density function (PDF) of the gas density in turbulent supersonic flows is investigated with high-resolution numerical simulations. In a systematic study, we compare the density statistics of compressible turbulence driven by the usually adopted solenoidal forcing (divergence-free) and by compressive forcing (curl-free). Our results are in agreement with studies using solenoidal forcing. However, compressive forcing yields a significantly broader density distribution with standard deviation ∼3 times larger at the same rms Mach number. The standard deviation-Mach number relation used in analytical models of star formation is reviewed and a modification of the existing expression is proposed, which takes into account the ratio of solenoidal and compressive modes of the turbulence forcing.

Accepted by ApJ Letters

http://arxiv.org/abs/0808.0605

The Fractal Density Structure in Supersonic Isothermal Turbulence: Solenoidal versus Compressive Energy Injection

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In a systematic study, we compare the density statistics in high resolution numerical experiments of supersonic isothermal turbulence, driven by the usually adopted solenoidal (divergence-free) forcing and by compressive (curl-free) forcing. We find that for the same rms Mach number, compressive forcing produces much stronger density enhancements and larger voids compared to solenoidal forcing. Consequently, the Fourier spectra of density fluctuations are significantly steeper. This result is confirmed using the Δ-variance analysis, which yields power law exponents $\beta \sim 3.4$ for compressive forcing and $\beta \sim 2.8$ for solenoidal forcing. We obtain fractal dimension estimates from the density spectra and Δ-variance scaling, and by using the box counting, mass size and perimeter area methods applied to the volumetric data, projections and slices of our turbulent density fields. Our results suggest that compressive forcing yields fractal dimensions significantly smaller compared to solenoidal forcing. However, the actual values depend sensitively on the adopted method, with the most reliable estimates based on the Δ-variance, or equivalently, on Fourier spectra. Using these methods, we obtain $D \sim 2.3$ for compressive and $D \sim 2.6$ for solenoidal forcing, which is within the range of fractal dimension estimates inferred from observations ($D \sim 2.0 \ldots 2.7$). The velocity dispersion to size relations for both solenoidal and compressive forcing obtained from velocity spectra follow a power law with exponents in the range $0.4 \ldots 0.5$, in good agreement with previous studies.

Accepted by ApJ

http://arxiv.org/abs/0710.1359

Formation of protostellar jets as two-component outflows from star-disk magnetospheres

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Axisymmetric magneto-hydrodynamic (MHD) simulations have been applied to investigate the interrelation of a central stellar magnetosphere and stellar wind with a surrounding magnetized disk outflow and how the overall formation of a large scale jet is affected. The initial magnetic field distribution applied is a superposition of two components - a stellar dipole and a surrounding disk magnetic field, in both either parallel or anti-parallel alignment. Correspondingly, the mass outflow is launched as stellar wind plus a disk wind. Our simulations evolve from an initial state in hydrostatic equilibrium and an initially force-free magnetic field configuration. Due to initial differential rotation and induction of a strong toroidal magnetic field the stellar dipolar field inflates and is disrupted on large scale. Stellar and disk wind may evolve in a pair of collimated outflows. The existence of a reasonably strong disk wind component is essential for collimation. A disk jet as known from previous numerical studies will become de-collimated by the stellar wind. In some simulations we observe the generation of strong flares triggering a sudden change in the outflow mass loss rate by a factor of two and also a re-distribution in the radial profile of momentum flux and jet velocity across the jet. We discuss the hypothesis that these flares may trigger internal shocks in the asymptotic jets which are observed as knots.

Accepted by ApJ

http://www.mpia-hd.mpg.de/homes/fendt/publications.html

http://de.arxiv.org/abs/0810.4154

Observations of the Goldreich-Kylafis effect in star-forming regions with XPOL at the IRAM 30m telescope

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The Goldreich-Kylafis (GK) effect causes certain molecular line emission to be weakly linearly polarized, e.g., in the presence of a magnetic field. Compared to polarized dust emission, the GK effect has the potential to yield additional information along the line of sight through its dependence on velocity in the line profile. Our goal was to detect polarized molecular line emission toward the DR21(OH), W3OH/H2O, G34.3+0.2, and UYSO1 dense molecular cloud cores in transitions of rare CO isotopologues and CS. The feasibility of such observations had to be established by studying the influence of polarized sidelobes, e.g., in the presence of extended emission in the surroundings of compact sources. The observations were carried out with the IRAM 30m telescope employing the correlation polarimeter XPOL and using two orthogonally polarized receivers. We produced beam maps to investigate instrumental polarization. While in nearly all transitions toward all sources a polarized signal is found, its degree of polarization only in one case surpasses the polarization that can be expected due to instrumental effects. It is shown that any emission in the polarized sidelobes of the system can produce instrumental polarization, even if the source is unpolarized. Tentative evidence for astronomically polarized line emission with $p_L < 1.5\%$ was found in the CS(2-1) line toward G34.3+0.2.

Accepted by A&A.

http://arxiv.org/abs/0810.2844

A 42.3-43.6 GHz spectral survey of Orion BN/KL: First detection of the v=0 J=1-0 line from the isotopologues ^{29}SiO and ^{30}SiO

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We have surveyed molecular line emission from Orion BN/KL from 42.3 to 43.6 GHz with the Green Bank Telescope. Sixty-seven lines were identified and ascribed to 13 different molecular species. The spectrum at 7 mm is dominated by SiO, SO_2, CH_3OCH_3, and C_2H_5CN. Five transitions have been detected from the SiO isotopologues ^{28}SiO, ^{29}SiO, and ^{30}SiO. We report here for the first time the spectra of the ^{29}SiO and ^{30}SiO $v = 0$ $J = 1 - 0$ emission in Orion BN/KL, and we show that they have double-peaked profiles with velocity extents similar to the main isotopologue. The main motivation for the survey was the search of high-velocity (100-1000 km s^{-1}) outflows in the BN/KL region as traced by SiO Doppler components. Some of the unidentified lines in principle could be high-velocity SiO features, but without imaging data their location cannot be established. Wings of emission are present in the $v = 0$ ^{28}SiO, ^{29}SiO and ^{30}SiO profiles, and we suggest that the $v = 0$ emission from the three isotopologues might trace a moderately high-velocity ($\sim 30 - 50$ km s^{-1}) component of the flows around the high-mass protostar Source I in the Orion BN/KL region. We also confirm the 7 mm detection of a complex oxygen-bearing species, acetone (CH_3COCH_3), which has been recently observed towards the hot core at 3 mm, and we have found further indications of the presence of long cyanopolyynes (HC_5N and HC_7N) in the quiescent cold gas of the extended ridge.

Accepted by ApJ

http://arXiv.org/abs/0810.1140

The "True" Column Density Distribution in Star-Forming Molecular Clouds

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We use the COMPLETE Survey's observations of the Perseus star-forming region to assess and intercompare three methods for measuring column density in molecular clouds: near-infrared extinction mapping; thermal emission mapping in the far-IR; and mapping the intensity of CO isotopologues. Overall, the structures shown by all three tracers are morphologically similar, but important differences exist amongst the tracers. We find that the dust-based measures (near-IR extinction and thermal emission) give similar, *log-normal*, distributions for the full ($\sim$ 20 pc-scale) Perseus region, once careful calibration corrections are made. We also compare dust- and gas-based column density distributions for physically-meaningful sub-regions of Perseus, and we find significant variations in the distributions for those (smaller, $\sim$few pc-scale) regions. Even though we have used ^{12}CO data to estimate excitation temperatures, and we have corrected for opacity, the ^{13}CO maps seem unable to give column distributions that consistently resemble those from dust measures. We have edited out the effects of the shell around the B-star HD 278942 from the column-density distribution comparisons. In that shell's interior and in the parts where it overlaps the molecular cloud, there appears to be a dearth of ^{13}CO, which is likely due either to ^{13}CO not yet having had time to form in this young structure, and/or destruction of ^{13}CO in the molecular cloud by the HD 278942's wind and/or radiation. We conclude that the use of either dust or gas measures of column density without extreme attention to calibration (e.g. of thermal emission zero-levels) and artifacts (e.g. the shell) is more perilous than even experts might normally admit. And, the use of ^{13}CO data to trace total column density in detail, even after proper calibration, is unavoidably limited in utility due to threshold, depletion, and opacity effects. If one's main aim is to map column density (rather than temperature or kinematics), then dust extinction seems the best probe, up to a limiting extinction caused by a dearth of sufficient background sources. Linear fits amongst all three tracers' estimates of column density are given, allowing us to quantify the inherent uncertainties in using one tracer, in comparison with the others.

Accepted by ApJ

http://arxiv.org/pdf/0806.3441, and for high-resolution figures
http://cfa-www.harvard.edu/COMPLETE/papers/Goodman_ColumnDensity.pdf

NGC 346 in The Small Magellanic Cloud. IV. Triggered Star Formation in the HII Region N66

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Stellar feedback, expanding H II regions, wind-blown bubbles, and supernovae are thought to be important triggering mechanisms of star formation. Stellar associations, being hosts of significant numbers of early-type stars, are the loci where these mechanisms act. In this part of our photometric study of the star-forming region NGC 346/N 66 in the Small Magellanic Cloud, we present evidence based on previous and recent detailed studies, that it hosts at least two different events of triggered star formation and we reveal the complexity of its recent star formation history. In our earlier studies of this region (Papers I, III) we find that besides the central part of N 66, where the bright OB stellar content of the association NGC 346 is concentrated, an arc-like nebular feature, north of the association, hosts recent star formation. This feature is characterized by a high concentration of emission-line stars and Young Stellar Objects, as well as embedded sources seen as IR-emission peaks that coincide with young compact clusters of low-mass pre-main sequence stars. All these objects indicate that the northern arc of N 66 encompasses the most current star formation event in the region. We present evidence that this star formation is the product of a different mechanism than that in the general area of the association, and that it is triggered by a wind-driven expanding H II region (or bubble) blown by a massive supernova progenitor, and possibly other bright stars, a few Myr ago. We propose a scenario according to which this mechanism triggered star formation away from the bar of N 66, while in the bar of N 66 star formation is introduced by the photo-ionizing OB stars of the association itself.

Accepted by the Astrophysical Journal

http://lanl.arxiv.org/abs/0710.1352

Star-Forming Region BBW 36 in Puppis

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Recent studies of the star formation region BBW 36 and associated molecular clouds are presented. The ^{1}2CO (1-0) observations, carried out with the 15-m SEST (Swedish-ESO) telescope (Cerro La Silla, Chile), revealed the existence of cloud a, connected with BBW 36 and of cloud b, having elongation in SE-NW direction. A red-shifted molecular outflow with velocity ∼+5 km/s (with respect to cloud a), having a direction parallel to the line of sight, was also observed. VLA observations showed the presence of a source VLA 2 at 3.6 cm with an elongation in the N-S direction. It is suggested that the VLA 2 source coincides with a dust disc (surrounding the object BBW 36). The star 3, which is one of the YSOs in the star-forming region BBW 36 and is connected with a bright comma-like nebula, can be the source of the molecular outflow. The star 3 has very high IR colors and is associated with an IRAS point source IRAS 07280-1829, which has IR colors, typical for an IRAS point source, connected with a water maser. On the 2MASS K image of BBW 36 we can see the existence of a bright nebula; a group of stars is embedded in that nebula, and among these stars there are stars with dust discs (or envelopes). On the 2MASS K image several spiral jets are also present, some of them with a condensation at the end.

Published by Astrophysics (Vol. 51, p. 469)

A *Spitzer* View of Protoplanetary Disks in the γ Velorum Cluster

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We present new *Spitzer Space Telescope* observations of stars in the young (∼5 Myr) γ Velorum stellar cluster. Combining optical and 2MASS photometry, we have selected 579 stars as candidate members of the cluster. With the addition of the *Spitzer* mid-infrared data, we have identified five debris disks around A-type stars and five to six debris disks around solar-type stars, indicating that the strong radiation field in the cluster does not completely suppress the production of planetesimals in the disks of cluster members. However, we find some evidence that the frequency of circumstellar primordial disks is lower, and the infrared flux excesses are smaller than for disks around stellar populations with similar ages. This could be evidence for a relatively fast dissipation of circumstellar dust by the strong radiation field from the highest mass star(s) in the cluster. Another possibility is that γ Velorum stellar cluster is slightly older than reported ages and the low frequency of primordial disks reflects the fast disk dissipation observed at ∼5 Myr.

Published by The Astrophysical Journal (Vol. 686, p. 1195)

Spectral energy distribution modelling of Southern candidate massive protostars using the Bayesian inference method.

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Concatenating data from the millimetre regime to the infrared, we have performed spectral energy distribution modelling for 227 of the 405 millimetre continuum sources of Hill et al. (2005) which are thought to contain young massive stars in the earliest stages of their formation. Three main parameters are extracted from the fits: temperature, mass and luminosity. The method employed was Bayesian inference, which allows a statistically probable range of suitable values for each parameter to be drawn for each individual protostellar candidate. This is the first application of this method to massive star formation.

The cumulative distribution plots of the SED modelled parameters in this work indicate that collectively, the sources without methanol maser and/or radio continuum associations (MM-only cores) display similar characteristics to those of high mass star formation regions. Attributing significance to the marginal distinctions between the MM-only cores and the high-mass star formation sample we draw hypotheses regarding the nature of the MM-only cores, including the possibility that the population itself is comprised of different types of source, and discuss their role in the formation scenarios of massive star formation. In addition, we discuss the usefulness and limitations of SED modelling and its application to the field. From this work, it is clear that within the valid parameter ranges, SEDs utilising current far-infrared data can not be used to determine the evolution of massive protostars or massive young stellar objects.

Accepted by MNRAS

http://arxiv.org/abs/0810.3158

A Survey of Dense Cores in the Orion B Cloud

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We have carried out an $H^{13}CO^+(J=1-0)$ core survey in a large area of one square degree, covering most of the dense region in the Orion B molecular cloud, using the Nobeyama 45 m radio telescope with the 25-BEam Array Receiver System (BEARS). We cataloged 151 dense cores using the `clumpfind` method. The cores have mean radius, velocity width, and mass of 0.10±0.02 pc, 0.53±0.15 km s^{-1}, and 8.1±6.4 $M_\odot$, respectively, which are very similar to those in the Orion A cloud (Ikeda et al. 2007). We examined the spatial relation between our $H^{13}CO^+$ cores and the 850 μm cores observed by Johnstone et al. (2001; 2006), and found that there are two types of spatial relationships: $H^{13}CO^+$ cores with and without the 850 μm cores. Since the mean density of the 850 μm cores is higher than that of the $H^{13}CO^+$ cores, we can interpret the $H^{13}CO^+$ cores with 850 μm cores as being more centrally concentrated and hence more evolved, compared with those without. Considering the relationship between the masses of the $H^{13}CO^+$ and 850 μm cores, we estimate the 850 μm core mass function (CMF) using the $H^{13}CO^+$ CMF through the generalization of the confusion model proposed by Ikeda et al. (2007). Our predicted 850 μm CMF is found to be quite consistent with that directly derived by Johnstone et al. (2001; 2006). Furthermore, we predict the initial mass function (IMF) by the generalized confusion model assuming a star-formation efficiency of 40 % for the $H^{13}CO^+$ cores, and found that our predicted IMF is consistent with the Galactic field-averaged IMF within uncertainties. This agreement may indicate that the origin of the IMF goes back to the cloud structures with densities of less than 10^4 cm^{-3}.

Accepted by The Astrophysical Journal

http://133.74.151.111/nikeda/preprints/nikeda_20081008_orib.pdf

Dusty Cometary Globules in W5

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We report the discovery of four dusty cometary tails around low-mass stars in two young clusters belonging to the W5 star-forming region. Fits to the observed emission profiles from 24 μm observations with the *Spitzer Space Telescope* give tail lifetimes < 30 Myr, but more likely $< \sim 5$ Myr. This result suggests that the cometary phase is a short lived phenomenon, occurring after photoevaporation by a nearby O star has removed gas from the outer disk of a young low-mass star.

Published by The Astrophysical Journal Letters (Vol. 687, p. L37)

The Atomic to Molecular Transition in Galaxies. II: HI and H_2 Column Densities

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Gas in galactic disks is collected by gravitational instabilities into giant atomic-molecular complexes, but only the inner, molecular parts of these structures are able to collapse to form stars. Determining what controls the ratio of atomic to molecular hydrogen in complexes is therefore a significant problem in star formation and galactic evolution. In this paper we use the model of H_2 formation, dissociation, and shielding developed in the previous paper in this series to make theoretical predictions for atomic to molecular ratios as a function of galactic properties. We find that the molecular fraction in a galaxy is determined primarily by its column density and secondarily by its metallicity, and is to good approximation independent of the strength of the interstellar radiation field. We show that the column of atomic hydrogen required to shield a molecular region against dissociation is ~ 10 $M_\odot$ pc^{-2} at solar metallicity. We compare our model to data from recent surveys of the Milky Way and of nearby galaxies, and show that the both the primary dependence of molecular fraction on column density and the secondary dependence on metallicity that we predict are in good agreement with observed galaxy properties.

Accepted by ApJ

http://arxiv.org/abs/0811.0004
http://www.ucolick.org/∼krumholz/publications.html

Direct Imaging and Spectroscopy of a Planetary Mass Candidate Companion to a Young Solar Analog

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We present Gemini near-infrared adaptive optics imaging and spectroscopy of a planetary mass candidate companion to 1RXS J160929.1-210524, a roughly solar-mass member of the 5 Myr-old Upper Scorpius association. The object, separated by 2.22″ or 330 AU at ∼150 pc, has infrared colors and spectra suggesting a temperature of 1800^{+200}_{-100} K, and spectral type of L4^{+1}_{-2}. The H- and K-band spectra provide clear evidence of low surface gravity, and thus youth. Based on the widely used DUSTY models, we infer a mass of 8^{+4}_{-2} $M_{\rm Jupiter}$. If gravitationally bound, this would be the lowest mass companion imaged around a normal star thus far, and its existence at such a large separation would pose a serious challenge to theories of star and planet formation.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/abs/0809.1424

Mean Motion Resonances in Extrasolar Planetary Systems with Turbulence, Interactions, and Damping

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This paper continues our previous exploration of the effects of turbulence on mean motion resonances in extrasolar planetary systems. Turbulence is expected to be present in the circumstellar disks that give rise to planets, and these fluctuations act to compromise resonant configurations. This paper extends previous work by considering how interactions between the planets and possible damping effects imposed by the disk affect the outcomes. These physical processes are studied using three related approaches: direct numerical integrations of the 3-body problem with additional forcing due to turbulence, model equations that reduce the problem to stochastically driven oscillators, and Fokker-Planck equations that describe the time evolution of an ensemble of such systems. With this combined approach, we elucidate the basic physics of how turbulence can remove extrasolar planetary systems from mean motion resonance. As expected, systems with sufficiently large damping (dissipation) can maintain resonance, in spite of turbulent forcing. In the absence of strong damping, ensembles of these systems exhibit two regimes of behavior, where the fraction of the bound states decreases as a power-law or as an exponential. Both types of behavior can be understood through the model developed herein. For systems that have weak interactions between the planets, the model reduces to that of a stochastic pendulum, and the fraction of bound states decreases as a power-law $P_{\rm b} \propto t^{-1/2}$. For highly interactive systems, however, the dynamics are more complicated and the fraction of bound states decreases exponentially with time. We show how planetary interactions lead to drift terms in the Fokker-Planck equation and account for this exponential behavior. In addition to clarifying the physical processes involved, this paper strengthens our original finding that turbulence implies that mean motions resonances should be rare.

Accepted by The Astrophysical Journal

arXiv:0810.4076v1

Near Infrared Spectroscopic Monitoring of EXor variables: First Results

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We present low resolution ($\mathcal{R} \sim 250$) spectroscopy in the near-IR (0.8 to 2.5 μm) of the EXor variables. These are the initial results (obtained during the period 2007-2008) from a long term photometric and spectroscopic program aimed to study the variability in the accretion processes of pre-Main Sequence (PMS) stars, by correlating the continuum fluctuations with the spectroscopical properties. Eight sources have been observed in different epochs, for a total of 25 acquired spectra. EXor spectra show a wide variety of emission features dominated by HI recombination (Paschen and Brackett series). We have investigated whether line and continuum variability could be due to a variable extinction, but such hypothesis is applicable only to the peculiar source PV Cep. By comparing the observed spectra with a wind model, mass loss rates in the range (2-10) 10^{-8} $M_\odot$ yr^{-1} are derived, along with other wind parameters. Consistent results are also obtained by assuming that HI lines are due to accretion. CO overtone is also detected in the majority of the sources both in absorption and in emission. It appears to come from regions more compact than winds, likely the stellar photosphere (when in absorption) and the circumstellar disk (when in emission). NaI and CaI IR lines behave as the CO does, thus they are thought to arise in the same locations. For some targets multiple spectra correspond to different activity stages of the source. Those exhibiting the largest continuum variation at 2 μm (ΔK $\gtrsim$1 mag) present a significant line flux fading during the continuum declining phases. In particular, CO absorption (emission) appears associated to inactive (active) stages, respectively.

Accepted by ApJ

The Distribution and Properties of Cold Dust in NGC 6334

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NGC 6334 is a galactic star-forming region in Scorpius, heavily obscured by intervening dust. The region consists of several major sites of star formation known previously from far-infrared (IR) and radio-wavelength observations. We present images of NGC 6334 obtained at wavelengths of 850 and 450 μm with the Submillimeter Common-User Bolometric Array at the James Clerk Maxwell Telescope. These data highlight the distribution of dense cold dust, a particularly striking feature of which is a narrow ridge of emission passing between most of the star-forming centers. We use a clump-finding technique to quantify the distribution of dust emission throughout the region, and we obtain estimates of the sizes, masses, and temperatures of the clump ensemble under simple assumptions. Clump masses range from a minimum detectable of about $1M_\odot$, up to almost 3000 $M_\odot$. We find in particular that the ridge feature is characterized by a relatively narrow range of clump parameters as compared with the rest of NGC 6334, and we obtain a clump mass spectral index that lies between $N(M) \propto M^{-1.5}$ and $M^{-1.0}$ for the high-mass clumps. The total mass of dust emitting at submillimeter wavelengths is about 16700 $M_\odot$ for an assumed temperature of 25 K; a significant fraction of this mass is contained within the ridge feature. These data are compared with recently published observations of NGC 6334 obtained at 1.2 mm wavelength using a direct-detection scanning technique, and with images obtained by the GLIMPSE-II and *Mid-course Space Experiment* missions at wavelengths from 3.3 to 21 μm in the near IR (NIR). The most massive compact submillimeter-wavelength regions in the north are invisible at these shorter wavelengths, and the NIR and mid-IR emission generally have little correspondence with the cool dust distribution. In this paper we use these data sets and supplementary millimeter-wavelength spectral line observations to investigate the star-forming sites in NGC 6334 and to speculate on the significance of the ridge of material seen in the submillimeter images.

Published by The Astronomical Journal (Vol. 136, p. 2083)

Trigonometric Parallaxes of Massive Star Forming Regions: II. Cep A & NGC 7538

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We report trigonometric parallaxes for the sources NGC 7538 and Cep A, corresponding to distances of 2.65 [+0.12/-0.11] kpc and 0.70 [+0.04/-0.04] kpc, respectively. The distance to NGC 7538 is considerably smaller than its kinematic distance and places it in the Perseus spiral arm. The distance to Cep A is also smaller than its kinematic distance and places it in the Local arm or spur. Combining the distance and proper motions with observed radial velocities gives the location and full space motion of the star forming regions. We find significant deviations from circular Galactic orbits for these sources: both sources show large peculiar motions (¿ 10 km/s) counter to Galactic rotation and NGC 7538 has a comparable peculiar motion toward the Galactic center.

Accepted by Astron. J.

http://arxiv.org/abs/0811.0679

HK-Band Imaging Polarimetry and Radiative Transfer Modeling of the Massive Young Stellar Object CRL 2136

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Aims. We investigate the physical properties of the dust environment of the massive proto-stellar object CRL 2136 by means of two-dimensional radiative transfer modeling, which combines fitting of the spectral energy distribution, the intensity images, and the polarization images.
Methods. We obtained polarimetric images of CRL 2136 in the H and K bands using the CIAO instrument on the 8 m Subaru telescope. We developed a new Monte Carlo code which can deal with multiple-grain models and computes the SED, the dust temperature, and the Stokes $IQUV$ images. With this code, we performed two-dimensional modeling of CRL 2136's circumstellar disk and envelope.
Results. Our images show a compact infrared source, two bright lobes extending towards the south and east, and two faint lobes extending towards the northwest and west. The polarization images show a polarization disk near the central star with a position angle of $\sim$ -135°, a polarization vector alignment approximately parallel to the polarization disk, and a region with low polarization between the eastern and the southern lobes. In our modeling, we assume three grain models: bare grains, warm grains with a crystalline water ice mantle, and cold grains with an amorphous water ice mantle. We obtained a maximum grain core size of 0.45 μm. We found that the CRL 2136 disk has a low disk mass of 0.007 $M_\odot$, a large radius of 2000 AU, a scale height of 1.0, and a low accretion rate of 2.1×10^{-7} $M_\odot$ yr^{-1} compared to an envelope mass infall rate of 1.0×10^{-4} $M_\odot$ yr^{-1}.
Conclusions. The predicted environment of the disk and the envelope is consistent with a scenario in which the central star forms rapidly ($\sim 2 \times 10^5$ yr), with a high mass infalling rate, and nearly isotropically (large disk scale height) in the early phase. Then, the accretion of the disk matter is prevented by the strong radiation pressure from the luminous central star, resulting in a low disk mass and a low accretion rate.

Published by Astronomy & Astrophysics (Vol. 490, p. 673)

NGC 602 Environment, Kinematics and Origins

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The young star cluster NGC 602 and its associated HII region, N90, formed in a relatively isolated and diffuse environment in the Wing of the Small Magellanic Cloud. Its isolation from other regions of massive star formation and the relatively simple surrounding HI shell structure allows us to constrain the processes that may have led to its formation and to study conditions leading to massive star formation. We use images from the Hubble Space Telescope and high resolution echelle spectrographic data from the Anglo-Australian Telescope, along with 21 cm neutral hydrogen (HI) spectrum survey data and the shell catalog derived from it to establish a likely evolutionary scenario leading to the formation of NGC 602. We identify a distinct HI cloud component that is likely the progenitor cloud of the cluster and HII region, which probably formed in blister fashion from the cloud's periphery. We also find that the past interaction of HI shells can explain the current location and radial velocity of the nebula. The surrounding interstellar medium is diffuse and dust-poor as demonstrated by a low visual optical depth throughout the nebula and an average HI density of the progenitor cloud estimated at 1 cm^{-3}. These conditions suggest that the NGC 602 star formation event was produced by compression and turbulence associated with HI shell interactions. It therefore represents a single star-forming event in a low gas density region.

Published by Publications of the Astronomical Society of the Pacific (Vol. 120, p. 972)

The Three Dimensional Dynamic Structure of the Inner Orion Nebula

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The three dimensional structure of the brightest part of the Orion Nebula is assessed in the light of published and newly established data. We find that the widely accepted model of a concave blister of ionized material needs to be altered in the southwest direction from the Trapezium, where we find that the Orion-S feature is a separate cloud of very optically thick molecules within the body of ionized gas, which is probably the location of the multiple embedded sources that produce the optical and molecular outflows that define the Orion-S star formation region. Evidence for this cloud comes from the presence of H_2CO lines in absorption in the radio continuum and discrepancies in the extinction derived from radio-optical and optical only emission. We present an equilibrium Cloudy model of the Orion-S cloud, which successfully reproduces many observed properties of this feature, including the presence of gas-phase H_2CO in absorption. We also report the discovery of an open-sided shell of [O III] surrounding the Trapezium stars, revealed through emission line ratio images and the onset of radiation shadows beyond some proplyds. We show that the observed properties of the shell are consistent with it being a stationary structure, produced by shock interactions between the ambient nebular gas and the high-velocity wind from θ^1Ori C. We examine the implications of the recently published evidence for a large blueshifted velocity of θ^1Ori C with respect to the Orion Molecular Cloud, which could mean that this star has only recently begun to photoionize the Orion Nebula. We show that current observations of the Nebula do not rule out such a possibility, so long as the ionization front has propagated into a pre-existing low-density region. In addition, a young age for the Nebula would help explain the presence of nearby proplyds with a short mass-loss timescale to photoablation.

Accepted by Astron. J.

http://arxiv.org/abs/0810.4375

Driven and Decaying Turbulence Simulations of Low-Mass Star Formation: From Clumps to Cores to Protostars

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Molecular clouds are observed to be turbulent, but the origin of this turbulence is not well understood. As a result, there are two different approaches to simulating molecular clouds, one in which the turbulence is allowed to decay after it is initialized, and one in which it is driven. We use the adaptive mesh refinement (AMR) code, Orion, to perform high-resolution simulations of molecular cloud cores and protostars in environments with both driven and decaying turbulence. We include self-gravity, use a barotropic equation of state, and represent regions exceeding the maximum grid resolution with sink particles. We analyze the properties of bound cores such as size, shape, line width, and rotational energy, and we find reasonable agreement with observation. At high resolution the different rates of core accretion in the two cases have a significant effect on protostellar system development. Clumps forming in a decaying turbulence environment produce high-multiplicity protostellar systems with Toomre Q unstable disks that exhibit characteristics of the competitive accretion model for star formation. In contrast, cores forming in the context of continuously driven turbulence and virial equilibrium form smaller protostellar systems with fewer low-mass members. Our simulations of driven and decaying turbulence show some statistically significant differences, particularly in the production of brown dwarfs and core rotation, but the uncertainties are large enough that we are not able to conclude

whether observations favor one or the other.

Published by The Astrophysical Journal (Vol. 686, p. 1174)

Optical Characterization of a New Young Stellar Population in the Serpens Molecular Cloud

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We report on the results of an optical spectroscopic survey designed to confirm the youth and determine the spectral types among a sample of young stellar object (YSO) candidates in the Serpens Molecular Cloud. We observed 150 infrared excess objects, previously discovered by the Spitzer Legacy Program "From Molecular Cores to Planet-Forming Disks" (c2d), bright enough for subsequent Spitzer/IRS spectroscopy. We obtained 78 optical spectra of sufficient S/N for analysis. Extinctions, effective temperatures and luminosities are estimated for this sample, and used to construct H-R diagrams for the population. We identified 20 background giants contaminating the sample, based on their relatively high extinction, position in the H-R diagram, the lack of Hα emission and relatively low infrared excess. Such strong background contamination (25%) is consistent with the location of Serpens being close to the Galactic plane (5° Galactic latitude). The remaining 58 stars (75%) were all confirmed to be young, mostly K and M-type stars that are presumed to belong to the cloud. Individual ages and masses for the YSOs are inferred based on theoretical evolutionary models. The models indicate a spread in stellar ages from 1 to 15 Myr, peaking at 2 – 6 Myr, and a mass distribution of 0.2 to 1.2 $M_\odot$ with median value around 0.8 $M_\odot$. Strong Hα emission lines (EW[Hα] > 3 Å) have been detected in more than half of the sample (35 stars). The mass accretion rates as derived from the Hα line widths span a broad distribution over 4 orders of magnitude with median accretion rate of 10^{-8} $M_\odot$ yr^{-1}. Our analysis shows that the majority of the infrared excess objects detected in Serpens are actively accreting, young T-Tauri stars.

Accepted by ApJ

http://adsabs.harvard.edu/abs/2008arXiv0810.0829O

The low-mass Initial Mass Function in the young cluster NGC 6611

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NGC 6611 is the massive young cluster (2−3 Myr) that ionises the Eagle Nebula. We present very deep photometric observations of the central region of NGC 6611 obtained with the Hubble Space Telescope and the following filters: ACS/WFC F775W and F850LP and NIC2 F110W and F160W, loosely equivalent to ground-based $IZJH$ filters. This survey reaches down to $I \sim 26$ mag. We construct the Initial Mass Function (IMF) from $\sim$1.5 $M_\odot$ well into the brown dwarf regime (down to $\sim$0.02 $M_\odot$). We have detected $30 - 35$ brown dwarf candidates in this sample. The low-mass IMF is combined with a higher-mass IMF constructed from the groundbased catalogue from Oliveira et al. (2005). We compare the final IMF with those of well studied star forming regions: we find that the IMF of NGC 6611 more closely resembles that of the low-mass star forming region in Taurus than that of the more massive Orion Nebula Cluster (ONC). We conclude that there seems to be no severe environmental effect in the IMF due to the proximity

of the massive stars in NGC 6611.

Accepted by MNRAS

http://arxiv.org/abs/0810.4444

Chemical modeling of L183 (= L134N) : an estimate of the ortho/para H_2 ratio

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context : The high degree of deuteration observed in some prestellar cores depends on the ortho-to-para H_2 ratio through the H_3^+ fractionation.
aims : We want to constrain the ortho/para H_2 ratio across the L183 prestellar core. This is required to correctly describe the deuteration amplification phenomenon in depleted cores such as L183 and to relate the total (ortho+para) H_2D^+ abundance to the sole ortho–H_2D^+ column density measurement.
methods : To constrain this ortho/para H_2 ratio and derive its profile, we make use of the N_2D^+/N_2H^+ ratio and of the ortho–H_2D^+ observations performed across the prestellar core. We use two simple chemical models limited to an almost totally depleted core description. New dissociative recombination and trihydrogen cation–dihydrogen reaction rates (including all isotopologues) are presented in this paper and included in our models.
results : We estimate the H_2D^+ ortho/para ratio in the L183 cloud, and constrain the H_2 ortho/para ratio : we show that it varies across the prestellar core by at least an order of magnitude, being still very high (≈ 0.1) in most of the cloud. Our time-dependent model indicates that the prestellar core is presumably older than 1.5–2 $\times$ 10^5 years but that it may not be much older. We also show that it has reached its present density only recently and that its contraction from a uniform density cloud can be constrained.
conclusions : A proper understanding of deuteration chemistry cannot be attained without taking into account the whole ortho/para family of molecular hydrogen and trihydrogen cation isotopologues as their relations are of utmost importance in the global scheme. Tracing the ortho/para H_2 ratio should also place useful constrains on the dynamical evolution of prestellar cores.

Accepted by A&A

2008arXiv0810.1861P

The Temperature of Interstellar Clouds from Turbulent Heating

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To evaluate the effect of turbulent heating in the thermal balance of interstellar clouds, we develop an extension of the log-Poisson intermittency model to supersonic turbulence. The model depends on a parameter, d, interpreted as the dimension of the most dissipative structures. By comparing the model with the probability distribution of the turbulent dissipation rate in a simulation of supersonic and super-Alfvénic turbulence, we find a best-fit value of $d = 1.64$. We apply this intermittency model to the computation of the mass-weighted probability distribution of the gas temperature of molecular clouds, high-mass star-forming cores, and cold diffuse HI clouds. Our main results

are: i) The mean gas temperature in molecular clouds can be explained as the effect of turbulent heating alone, while cosmic ray heating may dominate only in regions where the turbulent heating is low; ii) The mean gas temperature in high-mass star-forming cores with typical FWHM of ~ 6 km s^{-1} (corresponding to a 1D rms velocity of 2.5 km s^{-1}) may be completely controlled by turbulent heating, which predicts a mean value of approximately 36 K, two to three times larger than the mean gas temperature in the absence of turbulent heating; iii) The intermittency of the turbulent heating can generate enough hot regions in cold diffuse HI clouds to explain the observed CH^+ abundance, if the rms velocity on a scale of 1 pc is at least 3 km s^{-1}, in agreement with previous results based on incompressible turbulence. Because of its importance in the thermal balance of molecular clouds and high-mass star-forming cores, the process of turbulent heating may be central in setting the characteristic stellar mass and in regulating molecular chemical reactions.

Accepted by ApJ

http://arxiv.org/abs/0806.4970

Dissipative Structures in Supersonic Turbulence

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We show that density-weighted moments of the dissipation rate, ϵ_l, averaged over a scale l, in supersonic turbulence can be successfully explained by the She and Lévêque model [Z-S. She and E. Lévêque Phys. Rev. Lett. **72**, 336 (1994)]. A general method is developed to measure the two parameters of the model, γ and d, based directly on their physical interpretations as the scaling exponent of the dissipation rate in the most intermittent structures (γ) and the dimension of the structures (d). The method provides an important confirmation of the physical interpretation of the parameters and hence of the model. We find that the best-fit parameters ($\gamma = 0.75$ and $d = 1.75$) derived from the ϵ_l scalings in a simulation of supersonic turbulence at Mach 6 agree with their direct measurements, confirming the validity of the model in supersonic turbulence.

Accepted by Phys. Rev. Lett.

http://arxiv.org/abs/0808.1330

The new star forming site NGC 6334 IV (MM3)

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The eastern part of the massive star forming region NGC 6334 IV is characterized by the presence of the millimeter continuum sources MM3, MM4, and the optically thin HII region G351.24+0.65. Here we study the star formation in this part of the cloud. We imaged this region, here named NGC 6334 IV (MM3), at sub-arcsec resolution in Ks, H_2, Br γ, and in the mid-infrared, from 8.9 to 12.7μm. In addition, we used IRAC/*Spitzer* and ISOCAM images. From the analysis of the IRAC color-color and $H - K_s$ versus K_s - [3.6] diagrams, we found 18 embedded very young stellar objects within an area of $75'' \times 75''$. One of these sources, IR-MM3 (IRS 8E), shows a very steep energy distribution with an infrared spectral index of $\alpha_{IR} = 3.5$ and $L_{\rm bol} = 985 L_\odot$. This protostar, which coincides with an OH maser source and with the continuum millimeter source MM3, is the exciting source of two hydrogen molecular knots found in our H_2 image. Two sources (IRS 18, and 19), with infrared excess and a steep SED, are probably associated with the HII region G351.24+0.65. Finally, the IRAC and ISOCAM images indicate the presence of extended PAH emission in the region. We have discovered a new center of massive star formation in the giant molecular cloud complex NGC 6334.

Accepted by A&A

Encounter-driven accretion in young stellar clusters - A connection to FUors?

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Context: The brightness of FUors increases by several magnitudes within one to several years. The currently favoured explanation for this brightness boost is that of dramatically rising accretion from the disc material around a young star. The mechanism leading to this accretion increase is a point of debate.
Aim: Choosing the Orion Nebula Cluster as representative we simulate accretion bursts driven by encounters in dense stellar environments. We investigate whether properties like rise and decay times, event frequency etc. speak for encounters as a possible cause for FUor phenomena.
Method: We combine cluster simulations performed with the Nbody6++ code with particle simulations that describe the effect of a fly-by on the disc around a young star to determine the induced mass accretion.
Results: The induced accretion rates, the overall temporal accretion profile, decay time and possibly the binarity rate we obtain for encounter-induced accretion agree very well with observations of FUors. However, the rise-time of one year observed in some FUors is difficult to achieve in our simulations unless the matter is stored somewhere close to the star and then released after a certain mass limit is transgressed. The severest argument against the FUors phenomenon being caused by encounters is that most FUors are found in environments of low stellar density. We extend the discussion to eccentric binaries and gravitationally unstable discs and find that both models have similar problems in achieving the necessary rise-times.
Conclusions: We find no conclusive answer as to whether the observed FUors are triggered by encounters. However, it seems there should exist an intense accretion burst phase - possibly an FU phase - early on in the development of dense clusters. We predict that in dense young clusters these outbursts should predominantly happen close to the cluster center and with large mass ratios between the involved stars.

Accepted by A&A

astro-ph 0810.2854

Clustered star formation as a natural explanation for the Hα cut-off in disk galaxies

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The rate of star formation in a galaxy is often determined by the observation of emission in the Hα line, which is related to the presence of short-lived massive stars. Disk galaxies show a strong cut-off in Hα radiation at a certain galactocentric distance, which has led to the conclusion that star formation is suppressed in the outer regions of disk galaxies. This is seemingly in contradiction to recent observations in the ultraviolet which imply that disk galaxies have star formation beyond the Hα cut-off, and that the star-formation-rate surface density is linearly related to the underlying gas surface density, which is a shallower relationship than that derived from Hα luminosities. In a galaxy-wide formulation, the clustered nature of star formation has recently led to the insight that the total galactic Hα luminosity is nonlinearly related to the galaxy-wide star formation rate. Here we show that a local formulation of the concept of clustered star formation naturally leads to a steeper radial decrease in the Hα surface luminosity than in the star-formation-rate surface density, in quantitative agreement with the observations, and that the observed Hα cut-off arises naturally.

Accepted by Nature (455, 641-643, 2008)

Probing dust grain evolution in IM Lupi's circumstellar disc. Multi-wavelength observations and modelling of the dust disc

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We present a panchromatic study, involving a multiple technique approach, of the circumstellar disc surrounding the T Tauri star IM Lupi (Sz 82). We have undertaken a comprehensive observational study of IM Lupi using photometry, spectroscopy, millimetre interferometry and multi-wavelength imaging. For the first time, the disc is resolved from optical and near-infrared wavelengths in scattered light, to the millimetre regime in thermal emission. Our data-set, in conjunction with existing photometric data, provides an extensive coverage of the spectral energy distribution, including a detailed spectrum of the silicate emission bands. We have performed a simultaneous modelling of the various observations, using the radiative transfer code MCFOST, and analysed a grid of models over a large fraction of the parameter space via Bayesian inference. We have constructed a model that can reproduce all of the observations of the disc. Our analysis illustrates the importance of combining a wide range of observations in order to fully constrain the disc model, with each observation providing a strong constraint only on some aspects of the disc structure and dust content. Quantitative evidence of dust evolution in the disc is obtained: grain growth up to millimetre-sized particles, vertical stratification of dust grains with micrometric grains close to the disc surface and larger grains which have settled towards the disc midplane, and possibly the formation of fluffy aggregates and/or ice mantles around grains.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/0808.0619

Curved Herbig-Haro jets immersed in a stellar wind

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Several curved Herbig-Haro (HH) jet/counterjet systems have been observed. Some of these systems are the result of a relative motion between the outflow source and the surrounding environment. In this paper, we consider the case of an HH jet/counterjet system that is immersed in an isotropic stellar wind. This situation is somewhat different from the previously studied HH jet/plane-parallel side wind interaction, because the isotropic wind is divergent, and has a radially dependent density structure. We present an analytic model for a jet/wind interaction that is based on the balance between the ram pressure of the wind and the centrifugal pressure along the curved jet/counterjet path. We consider the case of an isothermal jet. We find that, if we have a jet and a wind with similar velocities and mass loss rates, the jet/counterjet system only shows a shallow curvature, with a total deflection angle of only a few degrees. However, if we have stronger winds, quite large deflections are produced (e. g., for the interaction of an HH jet with

the wind from an O star). The deflection angle depends on neither the separation between the jet and wind sources nor on the ejection direction of the jet/counterjet.

Accepted by A&A

Trigonometric Parallaxes of Massive Star Forming Regions: I. S 252 & G232.6+1.0

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We are conducting a large program with the NRAO Very Long Baseline Array (VLBA) to measure trigonometric parallaxes of massive star-forming regions across the Milky Way. Here we report measurement of the parallax and proper motion of methanol masers in S 252 and G232.6+1.0. The parallax of S 252 is 0.476 +/- 0.006 mas (2.10 [+0.027/-0.026] kpc), placing it in the Perseus spiral arm. The parallax of G232.6+1.0 is 0.596 +/- 0.035 mas (1.68 [+0.11/-0.09] kpc), placing it between the Carina-Sagittarius and Perseus arms, possibly in a Local (Orion) spur of the Carina-Sagittarius arm. For both sources, kinematic distances are significantly greater than their parallax distances. Our parallaxes and proper motions yield full space motions accurate to about 1 km/s. Both sources orbit the Galaxy about 13 km/s slower than circular rotation.

Accepted by Astron. J.

http://arxiv.org/abs/0811.0595

Intrinsically Red Sources observed by *Spitzer* in the Galactic Mid-Plane

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We present a highly reliable flux-limited census of 18,949 point sources in the Galactic mid-plane that have intrinsically red mid-infrared colors. These sources were selected from the *Spitzer Space Telescope* GLIMPSE I and II surveys of 274 $\deg^2$ of the Galactic mid-plane, and consist mostly of high- and intermediate-mass young stellar objects (YSOs) and asymptotic giant branch (AGB) stars. The selection criteria were carefully chosen to minimize the effects of position-dependent sensitivity, saturation, and confusion. The distribution of sources on the sky and their location in IRAC and MIPS 24 μm color-magnitude and color-color space are presented. Using this large sample, we find that YSOs and AGB stars can be mostly separated by simple color-magnitude selection criteria into approximately $50-70\%$ of YSOs and $30-50\%$ of AGB stars. Planetary nebulae and background galaxies together represent a t most $2-3\%$ of all the red sources. 1,004 red sources in the GLIMPSE II region, mostly AGB stars with high mass-loss rates, show significant ($\geq$0.3 mag) variability at 4.5 and/or e largest uniform census of AGB stars and high- and intermediate mass YSOs in the Milky-Way Galaxy.

Accepted by The Astronomical Journal

http://arxiv.org/abs/0809.1654

Resolving the Structure and Kinematics of the BN Object at 0.″2 Resolution

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We present sensitive 7 mm observations of the H53α recombination line and adjacent continuum, made toward the Orion BN/KL region. In the continuum we detect the BN object, the radio source I (GMR I) and the radio counterpart of the infrared source n (Orion-n). Comparing with observations made at similar angular resolutions but lower frequency, we discuss the spectral indices and angular sizes of these sources. In the H53α line we only detect the BN object. This is the first time that radio recombination lines are detected from this source. The LSR radial velocity of BN from the H53α line, $v_{LSR} = 20.1 \pm 2.1$ km s^{-1}, is consistent with that found from previous studies in near-infared lines. While the continuum emission is expected to have considerable optical depth at 7 mm, the observed H53α line emission is consistent with an optically-thin nature and we discuss possible explanations for this apparent discrepancy. There is evidence of a velocity gradient, with the NE part of BN being redshifted by ~ 10 km s^{-1} with respect to the SW part. This is consistent with the suggestion of Jiang et al. that BN may be driving an ionized outflow along that direction.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0810.5055

X-ray emission from dense plasma in CTTSs: Hydrodynamic modeling of the accretion shock

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Context. High spectral resolution X-ray observations of classical T Tauri stars (CTTSs) demonstrate the presence of plasma at temperature $T \sim 2-3 \times 10^6$ K and density $n_{\rm e} \sim 10^{11}-10^{13}$ cm^{-3}, which are unobserved in non-accreting stars. Stationary models suggest that this emission is due to shock-heated accreting material, but do not allow us to analyze the stability of the material and its position in the stellar atmosphere.
Aims. We investigate the dynamics and stability of shock-heated accreting material in classical T Tauri stars and the role of the stellar chromosphere in determining the position and thickness of the shocked region.
Methods. We perform one-dimensional hydrodynamic simulations of the impact of an accretion flow on the chromosphere of a CTTS, including the effects of gravity, radiative losses from optically thin plasma, thermal conduction and a well tested detailed model of the stellar chromosphere. We present the results of a simulation based on the parameters of the CTTS MP Mus.
Results. We find that the accretion shock generates an hot slab of material above the chromosphere with a maximum thickness of 1.8×10^9 cm, density $n_{\rm e} \sim 10^{11}-10^{12}$ cm^{-3}, temperature $T \sim 3 \times 10^6$ K, and uniform pressure equal to the ram pressure of the accretion flow (~ 450 dyn cm^{-2}). The base of the shocked region penetrates the chromosphere and remains at a position at which the ram pressure is equal to the thermal pressure. The system evolves with quasi-periodic instabilities of the material in the slab leading to cyclic disappearance and re-formation of the slab. For an accretion rate of $\sim 10^{-10} M_\odot$ yr^{-1}, the shocked region emits a time-averaged X-ray luminosity of $L_{\rm X} \approx 7 \times 10^{29}$ erg s^{-1}, which is comparable with the X-ray luminosity observed in CTTSs of identical mass. Furthermore, the X-ray spectrum synthesized from the simulation reproduces in detail all the main features of the O VIII and O VII lines of the star MP Mus.

Accepted by Astronomy & Astrophysics

Captured at millimeter wavelengths: a flare from the classical T Tauri star DQ Tau

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For several hours on 2008 April 19 the T Tauri spectroscopic binary DQ Tau was observed to brighten, reaching a maximum detected flux of 468 mJy and likely making it (briefly) the brightest object at 3 mm in the Taurus star-forming region. We present the light curve of a rarely before observed millimeter flare originating in the region around a pre-main-sequence star, and the first from a classical T Tauri star. We discuss the properties and nature of the flaring behavior in the context of pulsed accretion flows (the current picture based largely on studies of this object's optically variable spectrum), as well as magnetospheric re-connection models (a separate theory that predicts millimeter flares for close binaries of high orbital eccentricity). We believe that the flare mechanism is linked to the binary orbit, and therefore periodic. DQ Tau makes a strong case for multi-wavelength follow-up studies, performed in parallel, of future flares to help determine whether magnetospheric and dynamical interactions in a proto-binary system are independent.

Accepted by A&A Letters

http://arxiv.org/abs/0810.4162

Shells, jets, and internal working surfaces in the molecular outflow from IRAS 04166+2706

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Context. IRAS 04166+2706 in Taurus is one of the most nearby young stellar objects whose molecular outflow contains a highly collimated fast component.
Aims. The high symmetry and pristine appearance of this outflow suggests that its study could offer unique clues on the nature of the still mysterious underlying driving wind.
Methods. We have observed the IRAS 04166+2706 outflow with the IRAM Plateau de Bure interferometer in CO(J=2–1) and SiO(J=2–1) achieving angular resolutions between $2''$ and $4''$. To improve the quality of the CO(2–1) images, we have added single dish data to the interferometer visibilities.
Results. The outflow consists of two distinct components. At velocities < 10 km s^{-1}, the gas forms two opposed, approximately conical shells that have the YSO at their vertex. These shells coincide with the walls of evacuated cavities and seem to result from the acceleration of the ambient gas by a wide-angle wind. At velocities > 30 km s^{-1}, the gas forms two opposed jets that travel along the center of the cavities and whose emission is dominated by a symmetric collection of at least 7 pairs of peaks. The velocity field of this component presents a sawtooth pattern, with the gas in the tail of each peak moving faster than the gas in the head. This pattern, together with a systematic widening of the peaks with distance to the central source, is consistent with the emission arising from internal working surfaces traveling along the jet and resulting from variations in the velocity field of ejection. We interpret this component as the true protostellar wind, and we find its composition consistent with a chemical model of such type of wind.
Conclusions. Our results support outflow wind models that have simultaneously wide-angle and narrow components, and suggest that the EHV peaks seen in a number of outflows consist of internally-shocked wind material.

Accepted by A&A

http://arxiv.org/abs/0810.2790

AKARI Near-Infrared Spectroscopy: Detection of H_2O and CO_2 Ices toward Young Stellar Objects in the Large Magellanic Cloud

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We present the first results of *AKARI* Infrared Camera near-infrared spectroscopic survey of the Large Magellanic Cloud (LMC). We detected absorption features of the H_2O ice 3.05 μm and the CO_2 ice 4.27 μm stretching mode toward seven massive young stellar objects (YSOs). These samples are for the first time spectroscopically confirmed to be YSOs. We used a curve-of-growth method to evaluate the column densities of the ices and derived the CO_2/H_2O ratio to be 0.45 ± 0.17. This is clearly higher than that seen in Galactic massive YSOs (0.17 μ 0.03). We suggest that the strong ultraviolet radiation field and/or the high dust temperature in the LMC may be responsible for the observed high CO_2 ice abundance.

Published by The Astrophysical Journal Letters (Vol. 686, p. L99)

The properties of brown dwarfs and low-mass hydrogen-burning stars formed by disc fragmentation

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We suggest that a high proportion of brown dwarf stars are formed by gravitational fragmentation of massive extended discs around Sun-like primary stars. We argue that such discs should arise frequently, but should be observed infrequently, precisely because they fragment rapidly. By performing an ensemble of radiation-hydrodynamic simulations, we show that such discs typically fragment within a few thousand years, and produce mainly brown dwarf (BD) stars, but also planetary-mass (PM) stars and very low-mass hydrogen-burning (HB) stars. Subsequently most of the lower-mass stars (i.e. the PM and BD stars) are ejected by mutual interactions. We analyse the statistical properties of these stars, and compare them with observations.

After a few hundred thousand years the Sun-like primary is typically left with a close low-mass HB companion, and two much wider companions: a low-mass HB star and a BD star, or a BD-BD binary. The orbits of these companions are highly eccentric, and not necessarily coplanar, either with one another, or with the original disc. There is a BD desert extending out to at least ~ 100 AU; this is because BDs tend to be formed further out than low-mass HB stars, and then they tend to be scattered even further out, or even into the field.

BDs form with discs of a few Jupiter masses and radii of a few tens of AU, and they are more likely to retain these discs if they remain bound to the primary star. Binaries form by pairing of the newly-formed stars in the disc, giving a low-mass binary fraction of ~ 0.16. These binaries include close and wide BD/BD binaries and BD/PM binaries. Binaries can be ejected into the field and survive, even if they have quite wide separations. BDs that remain as companions to Sun-like stars are more likely to be in BD/BD binaries than are BDs ejected into the field. The presence of close and distant companions around Sun-like stars may inhibit planet formation by core accretion.

We conclude that disc fragmentation is a robust mechanism for BD formation. Even if only a small fraction of Sun-like stars host the required massive extended discs, this mechanism can produce all the PM stars observed, most of the BD stars, and a significant proportion of the very low-mass HB stars.

Accepted by MNRAS

http://www.astro.cf.ac.uk/pub/Dimitrios.Stamatellos/publications/

Further X-ray detections of Herbig stars

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The interpretation of X-ray detections from Herbig Ae/Be stars is disputed as it is not clear if these intermediate-mass pre-main sequence stars are able to drive a dynamo and ensuing phenomena of magnetic activity. Alternative X-ray production mechanisms, related to stellar winds, star-disk magnetospheres, or unresolved late-type T Tauri star companions have been proposed. The companion hypothesis can be tested by resolving Herbig stars in X-rays from their known visual secondaries. Furthermore, their global X-ray properties (such as detection rate, luminosity, temperature, variability), may give clues to the emission mechanism by comparison to other types of stars, e.g. similar-age but lower-mass T Tauri stars, similar-mass but more evolved main-sequence A- and B-type stars, and with respect to model predictions. In a series of papers we have been investigating high-resolution X-ray Chandra images of Herbig Ae/Be and main-sequence B-type stars where known close visual companions are spatially separated from the primaries. Here we report on six as yet unpublished Chandra exposures from our X-ray survey of Herbig stars. The target list comprises six Herbig stars with known cool companions, and three further A/B-type stars that are serendipitously in the Chandra field-of-view. In this sample we record a detection rate of 100 %, i.e. all A/B-type stars display X-ray emission at levels of $\log{(L_x/L_{bol})} \sim -5... -7$. The analysis of hardness ratios confirms that HAeBe's have hotter and/or more absorbed X-ray emitting plasma than more evolved B-type stars. Radiative winds are ruled out as exclusive emission mechanism on basis of the high X-ray temperatures. Confirming earlier results, the X-ray properties of Herbig Ae/Be stars are not vastly different from those of their late-type companion stars (if such are known). The diagnostics provided by the presently available data leave open if the hard X-ray emission of Herbig stars is due to young age or indicative of further coronally active low-mass companion stars. In the latter case, our detection statistics imply a high fraction of higher-order multiple systems among Herbig stars.

Accepted by Astronomy & Astrophysics

`http://www.astropa.unipa.it/$\sim$stelzer/publications.html`

Polarimetric survey of main-line OH masers in star-forming regions

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Context. While there is evidence for considerable circular polarization of OH masers in star-forming regions, no systematic measurements of the four Stokes parameters were done. Determining the full polarization properties of OH emission is vital to test the polarization maser models and to select targets for high-angular resolution studies of magnetic fields.

Aims. The polarimetric measurements of a representative sample of star-forming regions were carried out in order to better characterize the properties of OH masers.

Methods. A sample of 99 star-forming regions was observed in the OH 1665 and 1667 MHz maser transitions using the Nançay radio telescope in full-polarization mode and high spectral resolution ($0.07\,\mathrm{km\,s^{-1}}$).

Results. We present a complete set of polarization spectra for all 98 and 81 sources detected at 1665 and 1667 MHz, respectively. All detections have circularly polarized features, whereas linear polarization is found in 80% and 62% of the 1665 and 1667 MHz sources, respectively. The median degree of linear polarization of 16% of both transitions is a factor of ∼4 lower than that of circular polarization. In consequence, the probability of linear polarization clearly drops for sources with low total flux density because of the sensitivity limit. The linear polarization is almost always accompanied by circular polarization, i.e., elliptically polarized profiles are observed. The mean line-width at half-maximum of the linear polarization profile is $0.26\,\mathrm{km\,s^{-1}}$. The polarization position angle (χ) shows large variations across the profile with a median amplitude close to 90°. The amplitude variations of χ decrease with increasing flux density. Large variations of the total flux density found in three sources are weakly associated with changes in polarization parameters.

Conclusions. The observational characteristics of linear polarization seem to be consistent with theoretical models where narrow profiles result from the overlap of σ-components traversed regions with appreciable velocity gradient and due to off resonance amplification.

Accepted by A&A

http://www.astro.uni.torun.pl/∼msz/msz_public/msz_pub.html

Spatially Resolving the Hot CO around the Young Be Star 51 Ophiuchi

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Aims. 51 Oph is one of the few young Be stars displaying a strong CO overtone emission at 2.3 microns in addition to the near infrared excess commonly observed in this type of stars. In this paper we first aim to locate the CO bandheads emitting region. Then, we compare its position with respect to the region emitting the near infrared continuum.
Methods. We have observed 51 Oph with AMBER in low spectral resolution (R = 35), and in medium spectral resolution (R = 1500) centered on the CO bandheads.
Results. The medium resolution AMBER observations clearly resolve the CO bandheads. Both the CO bandheads and continuum emissions are spatially resolved by the interferometer. Using simple analytical ring models to interpret the measured visibilities, we find that the CO bandheads emission region is compact, located at $0.15^{0.07}_{-0.04}$ AU from the star, and that the adjacent continuum is coming from a region further away ($0.25^{0.05}_{-0.03}$ AU). These results confirm the commonly invoked scenario in which the CO bandheads originate in a dust free hot gaseous disk. Furthermore, the continuum emitting region is closer to the star than the dust sublimation radius (by at least a factor two) and we suggest that hot gas inside the dust sublimation radius significantly contributes to the observed 2 μm continuum emission.

Published by Astronomy & Astrophysics (Vol. 489, p. 1151)

X-Ray Emission from Young Stellar Objects in the ϵ Chamaeleontis Group: The Herbig Ae Star HD 104237 and Associated Low-Mass Stars

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We present *Chandra* HETGS observations of the Herbig Ae star HD 104237 and the associated young stars comprising lower mass stars, in the 0.15–1.75 $M_{\odot}$ mass range, in their pre-main-sequence phase. The brightest X-ray source in the association is the central system harboring the Herbig Ae primary and a K3 companion. Its X-ray variability indicates modulation possibly on timescales of the rotation period of the Herbig Ae star, and this would imply that the primary significantly contributes to the overall emission. The spectrum of the Herbig Ae+K3 system shows a soft component significantly more pronounced than in other K-type young stars. This soft emission is reminiscent of the

unusually soft spectra observed for the single Herbig Ae stars HD 163296 and AB Aur, and therefore we tentatively attribute it to the Herbig Ae of the binary system. The HETGS spectrum shows strong emission lines corresponding to a wide range of plasma temperatures. The He-like triplet of Mg XI and Ne IX suggests the presence of plasma at densities of about 10^{12} cm^{-3}, possibly indicating an accretion-related X-ray production mechanism. The analysis of the zeroth-order spectra of the other sources indicates X-ray emission characteristics typical of pre-main-sequence stars of similar spectral type, with the exception of the T Tauri HD 104237-D, whose extremely soft emission is very similar to the emission of the classical T Tauri star TW Hya and suggests X-ray production by shocked accreting plasma.

Published by The Astrophysical Journal (Vol. 687, p. 579)

Planet formation in the habitable zone of alpha Centauri B

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Recent studies have shown that alpha Centauri B might be, from an observational point of view, an ideal candidate for the detection of an Earth-like planet in or near its habitable zone (0.5-0.9AU). We study here if such habitable planets can form, by numerically investigating the planet-formation stage which is probably the most sensitive to binarity effects: the mutual accretion of km-sized planetesimals. Using a state-of-the-art algorithm for computing the impact velocities within a test planetesimal population, we find that planetesimal growth is only possible, although marginally, in the innermost part of the HZ around 0.5AU. Beyond this point, the combination of secular perturbations by the binary companion and gas drag drive the mutual velocities beyond the erosion limit. Impact velocities might later decrease during the gas removal phase, but this probably happens too late for preventing most km-sized objects to be removed by inward drift, thus preventing accretion from starting anew. A more promising hypothesis is that the binary formed in a crowded cluster, where it might have been wider in its initial stages, when planetary formation was ongoing. We explore this scenario and find that a starting separation roughly 15 AU wider, or an eccentricity 2.5 times lower than the present ones are required to have an accretion-friendly environment in the whole HZ.

Accepted by MNRAS

http://www.astro.su.se/~thebault/thebAlphab.pdf

A Unified Monte Carlo Treatment of Gas-Grain Chemistry for Large Reaction Networks. I. Testing Validity of Rate Equations in Molecular Clouds

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In this study we demonstrate for the first time that the unified Monte Carlo approach can be applied to model gas-grain chemistry in large reaction networks. Specifically, we build a time-dependent gas-grain chemical model of the interstellar medium, involving about 6000 gas-phase and 200 grain surface reactions. This model is used to test the validity of the standard and modified rate equation methods in models of dense and translucent molecular clouds and to specify under which conditions the use of the stochastic approach is desirable.

Two cases are considered: (1) the surface mobility of all species is due to thermal hopping, (2) in addition to thermal hopping, temperature-independent quantum tunneling for H and H_2 is allowed. The physical conditions characteristic for the core and the outer region of TMC1 cloud are adopted. The gas-phase rate file RATE 06 together with an extended set of gas-grain and surface reactions is utilized.

We found that at temperatures 25–30 K gas-phase abundances of H_2O, NH_3, CO and many other gas-phase and surface species in the stochastic model differ from those in the deterministic models by more than an order of magnitude, at

least, when tunneling is accounted for and/or diffusion energies are 3x lower than the binding energies. In this case, surface reactions, involving light species, proceed faster than accretion of the same species. In contrast, in the model without tunneling and with high binding energies, when the typical timescale of a surface recombination is greater than the timescale of accretion onto the grain, we obtain almost perfect agreement between results of Monte Carlo and deterministic calculations in the same temperature range. At lower temperatures (~ 10 K) gaseous and, in particular, surface abundances of most important molecules are not much affected by stochastic processes.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0810.1591

Dichotomy in the Dynamical Status of Massive Cores in Orion

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To study the evolution of high mass cores, we have searched for evidence of collapse motions in a large sample of starless cores in the Orion molecular cloud. We used the Caltech Submillimeter Observatory telescope to obtain spectra of the optically thin ($H^{13}CO^+$) and optically thick (HCO^+) high density tracer molecules in 27 cores with masses > 1 $M_\odot$. The red- and blue-asymmetries seen in the line profiles of the optically thick line with respect to the optically thin line indicate that 2/3 of these cores are not static. We detect evidence for infall (inward motions) in 9 cores and outward motions for 10 cores, suggesting a dichotomy in the kinematic state of the non-static cores in this sample. Our results provide an important observational constraint on the fraction of collapsing (inward motions) versus non-collapsing (re-expanding) cores for comparison with model simulations.

Accepted by ApJ (Letters)

Disk masses in the embedded and T Tauri phases of stellar evolution

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Motivated by a growing concern that masses of circumstellar disks may have been systematically underestimated by conventional observational methods, we present a numerical hydrodynamics study of time-averaged disk masses ($\langle M_{\rm d} \rangle$) around low-mass Class 0, Class I, and Class II objects. Mean disk masses ($\overline{M}_{\rm d}$) are then calculated by weighting the time-averaged disk masses according to the corresponding stellar masses using a power-law weight function with a slope typical for the Kroupa initial mass function of stars. Two distinct types of disks are considered: self-gravitating disks, in which mass and angular momentum are redistributed exclusively by gravitational torques, and viscous disks, in which both the gravitational and viscous torques are at work. We find that self-gravitating disks have mean masses that are slowly increasing along the sequence of stellar evolution phases. More specifically, Class 0/I/II self-gravitating disks have mean masses $\overline{M}_{\rm d} = 0.09$, 0.10, and 0.12 $M_\odot$, respectively. Viscous disks have similar mean masses ($\overline{M}_{\rm d} = 0.10 - 0.11$ $M_\odot$) in the Class 0/I phases but almost a factor of 2 lower mean mass in the Class II phase ($\overline{M}_{\rm d,CII} = 0.06$ $M_\odot$). In each evolution phase, time-averaged disk masses show a large scatter around the mean value. Our obtained mean disk masses are *larger* than those recently derived by Andrews & Williams and Brown et al., regardless of the physical mechanisms of mass transport in the disk. The difference is especially large for Class II disks, for which we find $\overline{M}_{\rm d,CII} = 0.06 - 0.12$ $M_\odot$ but Andrews and Williams report median masses of order 3×10^{-3} $M_\odot$. When Class 0/I/II systems are considered altogether, a least-squares best fit yields the following relation between the time-averaged disk and stellar masses, $\langle M_{\rm d} \rangle = (0.2 \pm 0.05) \langle M_* \rangle^{1.3 \pm 0.15}$. The dependence of $\langle M_{\rm d} \rangle$ on $\langle M_* \rangle$ becomes progressively steeper along the sequence of stellar evolution phases, with exponents 0.7 ± 0.2, 1.3 ± 0.15, and 2.2 ± 0.2 for Class 0, Class I, and Class II systems, respectively.

Accepted by the Astrophysical Journal

Infrared Spectroscopy and Analysis of Brown Dwarf and Planetary Mass Objects in the Orion Nebula Cluster

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We present near-infrared long slit and multi-slit spectra of low mass brown dwarf candidates in the Orion Nebula Cluster. The long slit data were observed in the *H*- & *K*-bands using NIRI on the Gemini North Telescope. The multi-object spectroscopic observations were made using IRIS2 on the Anglo Australian Telescope at *H*-band. We develop a spectral typing scheme based on optically calibrated, near infrared spectra of young sources in the Taurus and IC 348 star forming regions with spectral types M3.0 to M9.5. We apply our spectral typing scheme to 52 sources, including previously published UKIRT and GNIRS spectra. 40 objects show strong water absorption with spectral types of M3 to >M9.5. The latest type objects are provisionally classified as early L types. We plot our sources on H-R diagrams overlaid with theoretical pre-main-sequence isochrones. The majority of our objects lie close to or above the 1 Myr isochrone, leading to an average cluster age that is <1 Myr. We find 38 sources lie at or below the hydrogen burning limit (0.075 $M_\odot$). 10 sources potentially have masses below the deuterium burning limit (0.012 $M_\odot$). We use a Monte Carlo approach to model the observed luminosity function with a variety of cluster age and mass distributions. The lowest χ^2 values are produced by an age distribution centred at 1 Myr, with a mass function that declines at sub-stellar masses according to an M^α power law in the range α=0.3 to 0.6. We find that truncating the mass function at 0.012 $M_\odot$ produces luminosity functions that are starved of the faintest magnitudes, even when using bimodal age populations that contain 10 Myr old sources. The results of these Monte Carlo simulations therefore support the existence of a planetary mass population in the ONC.

Accepted by MNRAS

http://arxiv.org/abs/0810.3584

Planetesimal Accretion in Binary Systems: The Effects of Gas Dissipation

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Currently, one of the major theoretical problems concerning planet formation in close binary systems is whether the strong perturbation from the companion star can increase the relative velocities (ΔV) of planetesimals around the primary and thus hinder their growth. According to previous studies, while gas drag can reduce the ΔV between bodies of the same size by forcing orbital alignment on planetesimals, it increases the ΔV among bodies of different sizes. In this paper, focusing on the γ Cephei binary system, we propose a mechanism that can overcome this difficulty. We show that in a dissipating gas disk (with a typical dissipation timescale of $\sim 10^5$–10^6 yr), all the planetesimals eventually converge toward the same forced orbits regardless of their size, leading to much lower impact velocities. This process of decreasing ΔV progressively increases net mass accretion and can even trigger runaway growth for large bodies (radius above 15 km). The effect of the size distribution of planetesimals is discussed and is found to be one of the dominant factors determining the outcome of collisional evolution. In any case, it can be concluded that by including gas dissipation in the early stages of disk evolution, the conditions for planetesimal accretion become much better, and the progression from planetesimals to planet embryos can be accomplished in close binary systems such as γ Cep.

Published by The Astrophysical Journal (Vol. 686, p. 570)

Trigonometric Parallaxes of Massive Star Forming Regions: III. G59.7+0.1 and W 51 IRS2

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We report trigonometric parallaxes for G59.7+0.1 and W 51 IRS2, corresponding to distances of 2.16 [+0.10/-0.09] kpc and 5.1 [+2.9/-1.4] kpc, respectively. The distance to G59.7+0.1 is smaller than its near kinematic distance and places it between the Carina-Sagittarius and Perseus spiral arms, probably in the Local (Orion) spur. The distance to W 51 IRS2, while subject to significant uncertainty, is close to its kinematic distance and places it near the tangent point of the Carina-Sagittarius arm. It also agrees well with a recent estimate based on O-type star spectro/photometry. Combining the distances and proper motions with observed radial velocities gives the full space motions of the star forming regions. We find modest deviations of 5 to 10 km/s from circular Galactic orbits for these sources, both counter to Galactic rotation and toward the Galactic center.

Accepted by Astron. J.

http://arxiv.org/abs/0811.0701

Trigonometric Parallaxes of Massive Star Forming Regions: IV. G35.20-0.74 and G35.20-1.74

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We report trigonometric parallaxes for the high-mass star forming regions G35.20-0.74 and G35.20-1.74, corresponding to distances of 2.19 (+0.24 -0.20) kpc and 3.27 (+0.56 -0.42) kpc, respectively. The distances to both sources are close to their near kinematic distances and place them in the Carina-Sagittarius spiral arm. Combining the distances and proper motions with observed radial velocities gives the locations and full space motions of the star forming regions. Assuming a standard model of the Galaxy, G35.20-0.74 and G35.20-1.74 have peculiar motions of 13 km/s and 16 km/s counter to Galactic rotation and 9 km/s toward the North Galactic Pole.

Accepted by Astron. J.

http://arxiv.org/abs/0811.0704

Postdoctoral Position in Star and Planet Formation

The University of Rochester invites applications for a post-doctoral position working with Prof. Eric Mamajek on research related to investigating young stellar populations in the solar neighborhood.

The University of Rochester is joining the Small and Moderate Aperture Research Telescope System (SMARTS) consortium in 2009, and the candidate will be involved in projects analyzing optical spectra of young stars. Opportunities may exist for collaborating on projects regarding the formation and evolution of stellar and substellar objects, and the candidate will also be encouraged to pursue independent research as well.

Applicants must have a Ph.D. in astronomy or related field. Experience with analyzing spectroscopic data is essential. The start date is flexible, but preferably no later than September 1st, 2009. The appointment will be for two years, with a possible third year subject to funding availability and performance.

Please provide a cover letter, CV, publication list, and brief statement of research experience and interests. The applicant should also arrange for three letters of recommendation to be sent. All application materials, including letters, can be submitted in PDF via email to Nikki Hatler (nhatler@pas.rochester.edu). For more information, contact Prof. Eric Mamajek (emamajek@pas.rochester.edu; 585-275-5389).

The University of Rochester has a strong commitment to diversity and actively encourages applications from candidates from groups underrepresented in higher education. The University of Rochester is an Equal Opportunity/Affirmative Action employer and encourages applicants from members of minority groups and women. All applications are considered without regard to race, sex, age, religion or national origin. Salary will be competitive.

Postdoctoral and PhD Positions in computational astrophysics for ALMA

Applications are invited for a postdoctoral position and at least one PhD position at the Argelander Institute for Astronomy (AIfA) at University of Bonn. Here the successful applicants will join the local ALMA Regional Center (ARC) node's growing submillimeter-interferometry research group, which has strong scientific interests in low- and high-mass star formation as well as galaxy evolution and evolved stars.

The successful applicants will work on radiative transfer modeling as part of the ASTRONET project "Adaptable Radiative Transfer Innovations for Submillimeter Telescopes (ARTIST)". The ARTIST collaboration between the University of Bonn, Leiden University (Netherlands) and CSIC-IEEC (Spain) aims to develop the next generation model suite for comprehensive multi-dimensional radiative transfer calculation of dust and line emission as well as their polarization. Prior experience in computational astrophysics and/or radiative transfer modeling is highly desirable.

The postdoctoral and PhD positions are for three years, and will include a number of working visits to the partner institutes.

Applicants for the postdoctoral position should send a CV, description of research interests, a publication list and arrange for the submission of three letters of recommendation. For the PhD position a CV and two letters of recommendation are requested. Applications should be sent to chstein@astro.uni-bonn.de (att. Christina Stein-Schmitz; AIfA institute secretary).

Applications received before 15 December 2008 will receive full consideration. Women and minorities are particularly encouraged to apply.

For more information, visit http://www.astro.uni-bonn.de/ARC/artist or contact Jes Jørgensen (jes@astro.uni-bonn.de; ARTIST coordinator, low-mass star formation and radiative transfer modeling), Wouter Vlemmings (wouter@astro.uni-bonn.de; high-mass star formation/evolved stars), or Frank Bertoldi (bertoldi@astro.uni-bonn.de; galaxy evolution).

J. Mayo Greenberg Scholarship Prize

Leiden Observatory and the Leids Universiteitfonds have pleasure in inviting applications for the third J. Mayo Greenberg Scholarship Prize.

The purpose of the prize is to provide an opportunity for a talented graduate student to carry out research and/or receive education at Leiden Observatory in one or more of the fields that were of interest to Professor Greenberg. These include:

* Laboratory astrophysics,
Dust in the early Universe,
Dust in the Milky Way and other galaxies
Comet formation,
Origin of life.

Although applications will be considered from the whole world, preference will be given to applicants resident in developing countries. Candidates should have sufficient educational background in the field to benefit from attendance at graduate courses or participation in the research.

Although applications will be considered from the whole world, preference will be given to applicants resident in developing countries. Candidates should have sufficient educational background in the field to benefit from attendance at graduate courses or participation in the research. The Scholarship Prize will support a visit to Leiden for a maximum duration of 9 months. In very exceptional circumstances there may be a possibility of extending the visit for a longer period.

Applications for the 2009 Prize should be received before 30 November 2008. These should include (i) a curriculum vitae, with details of relevant background, (ii) a statement containing the purpose for which the grant is requested and (iii) a motivation for the request. Applicants should arrange for 2 - 3 references to be sent under separate cover.Applications should be addressed to:

Professor G.K. Miley,
Chairman, Selection Committee,
J. Mayo Greenberg Scholarship Prize,
Sterrewacht,
Postbus 9513, 2300 RA Leiden,
THE NETHERLANDS

Applications can also be sent via email to drost@strw.leidenuniv.nl, with the relevant documentation as attachments in MSWord, latex, pdf or postcript format.

The results of the selection will be announced on or before 31 December 2008.

Postdoctoral Position in Starburst Galaxies

Applications are invited for a postdoctoral research position in theoretical astrophysics to work on starburst galaxies with Prof. Moshe Elitzur at the University of Kentucky, Lexington, KY, USA. The start date is around September 2009. Applicants should send curriculum vita, bibliography and a statement of research interests by e-mail to moshe@pa.uky.edu and arrange for three letters of recommendation to be sent the same way. The initial appointment is for one year, with an expected extension for another year. The review of applications will start at the end of December, and will be continued until the position is filled.

Postdoctoral Research Position in Low-Mass Stars and Brown Dwarfs

The Institute for Astronomy (IfA) at the University of Hawaii invites applications for a postdoctoral research position located in Honolulu, Hawaii. The successful applicant will collaborate with Dr. Michael Liu (mliu@ifa.hawaii.edu) on research related to low-mass stars and brown dwarfs, based on observing programs carried out with premier ground-based and space-based telescopes. Applicants with interest and experience in these areas are encouraged to apply.

The successful applicant will have access to optical and IR telescopes on the summit of Mauna Kea through the IfA's guaranteed share of observing time. The IfA is also the lead institution in the Pan-STARRS-1 wide-field optical telescope, scheduled to begin science operations at the start of 2009. Applicants with interests in science from multi-band, multi-epoch all-sky surveys are especially encouraged to apply.

By the starting date, candidates should have obtained a PhD degree in astronomy, physics or equivalent area relevant to the science themes described above.

The appointment is for up to three years, subject to annual performance and funding. The position is available immediately, but the start date is flexible and can be anytime in 2009. The annual salary will be approximately $56,500 per year and will include support for research activities.

Applications received by the closing date of January 7, 2009 will receive full consideration. Please submit the following: resume/CV; cover letter including Recruitment ID#; statement of research, referral source, narrative of your qualifications for position and salary history; names, phone numbers and addresses of three supervisory references and copy of degree(s)/transcripts/certificate(s) to Director of Human Resources, Research Corporation of the University of Hawaii, 2530 Dole Street, Sakamaki Hall D-100, Honolulu, HI 96822 or by fax to (808) 956-5022. Please also arrange for three letters of recommendation to be sent by the closing date. You may apply online at www.rcuh.com or mail/fax your application by the closing date. If you have questions on the application process and/or need assistance, please call (808)956-3100.

For complete information and application requirements, please go to www.rcuh.com and click on 'Employment'. Please reference ID #28551.

http://members.aas.org/JobReg/JobDetailPage.cfm?JobID=25084

Postdoctoral Position in Theoretical/Computational Star Formation

Applications are invited for a postdoctoral fellowship in theoretical star formation research beginning on, or after Sept. 1, 2009 for an initial period of 2 years. The position will be offered in conjunction with the National Fellows program of the Canadian Institute for Theoretical Astrophysics (CITA). Depending upon the availability of funding a third year may be possible. Preference will be given to individuals who have theoretical expertise in the area of star formation research and who have expertise in numerical modeling and simulation of astrophysical hydrodynamics. Areas of interest include the formation of molecular clouds and star formation in galaxies, the formation of star clusters, and turbulent fragmentation and star formation.

The applicant will work with Drs. Ralph Pudritz and James Wadsley and their research teams. McMaster's astrophysics group consists of twelve faculty members. The group has extensive expertise in star formation in theory, computation, as well as in observations (please see http://www.physics.mcmaster.ca/astroweb/ for more details). McMaster's superb computational facilities include SHARCNET high performance computing systems with over 8000 parallel CPUs. The applicant will be eligible for priority access and programming support. Theorists at McMaster also enjoy strong links with the Canadian Institute for Theoretical Astrophysics.

Funds will be available for travel and research expenses. McMaster University is committed to Employment Equity and encourages applications from all qualified candidates, including aboriginal peoples, persons with disabilities, members of visible minorities, and women.

Applicants should send a CV, bibliography, and a one page summary of their research interests, and arrange for letters of recommendation from three referees (these can be submitted as signed pdf attachments in email) to be sent to:

Theoretical Star Formation PDF
c/o Dr. Ralph Pudritz
Department of Physics and Astronomy

McMaster University
1280 Main Street West
Hamilton, Ontario, CANADA L8S 4M1

Further contact information

pudritz@mcmaster.ca or wadsley@physics.mcmaster.ca
FAX: (905) 546-1252
Tel: (905) 525-9140 ext. 23180 (pudritz); 27016 (wadsley)

Deadline: All materials, including letters from references, must arrive no later than Nov. 10, 2008.

Moving ... ??

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

Star-Disk Interaction in Young Stars

Edited by
Jérôme Bouvier and Immo Appenzeller

These proceedings of an IAU symposium held in Grenoble in 2007 discuss the link between inflow and outflow in young stars, with a focus on the processes that occur within 1 AU of the central star. The folllowing lists the chapters in the book:

Part 1. Setting the Stage

The accretion disk paradigm for young stars *C. Bertout*
T Tauri stars: from mystery to magnetospheric accretion *G. Basri*

Part 2. Magnetic Fields

What can X-rays tell us about accretion, mass loss amd magnetic fields in young stars? *T.Montmerle*
Measurements of magnetic fields on T Tauri stars *C.M. Johns-Krull*
Magnetism, rotation, and accretion in Herbig Ae-Be stars *E. Alecian et al.*
Magnetic field at the inner disk edge *M. Jardine, S.G. Gregory, J.-F. Donati*
Submillimetre polarimetric observations of magnetic fields in star-forming regions *R.L. Curran, A. Chrysostomou, B.C. Matthews*

Part 3. Magnetospheric Accretion and Inner Disk Truncation

Time variable funnel flows *S.H.P. Alencar*
Radiative-transfer modelling of funnel flows *T.J. Harries*
Measuring the physical conditions of accreting gas in T Tauri systems *J.S. Bary & S.P. Matt*
Observations of accretion shocks *D.R. Ardila*
On the origin of continuum and line emission in CTTSs *S.A. Lamzin, M.M. Romanova, & A.S. Kravtsova*
Inner disk regions revealed by infrared interferometry *F. Malbet*
Gas at the inner disk edge *J.S. Carr*
Observational constraints on disk photoevaporation by the central star *G.J. Herczeg*
Accretion and outflow-related X-rays in T Tauri stars *M. Güdel et al.*
Why are accreting T Tauri stars less luminous in X-rays than non-accretors? *S.G. Gregory, K. Wood, & M. Jardine*

Part 4. Magnetospheric Ejection

Spectroscopic diagnostics of T Tauri winds *S. Edwards*
The generation of jets from young stars: an observational perspective *T.P. Ray*
The role of thermal pressure in jet launching *N. Soker*
The accretion-ejection connexion in T Tauri stars: jet models vs. observations *S. Cabrit*
The structure accompanying young star formation *V. Demichev & L.I. Matveyenko*
Last gasp of V1647 Ori: a brief post-outburst warm, molecular wind *S.D. Brittain et al.*

Part 5. Star-Disk Magnetospheric Coupling

The rotational evolution of young low mass stars *J. Bouvier*
The rotation of very low mass stars and brown dwarfs *J. Eislöffel & A. Scholz*
Magnetization, accretion, and outflows in young stellar objects *F.H. Shu et al.*
MHD simulations of star-disk magnetospheres and the formation of outflows and jets *C. Fendt*
MHD simulations of disk-star interaction *M.M. Romanova et al.*
MHD instabilities at the disk-magnetosphere boundary: 3D simulations *A.K. Kulkarni & M.M. Romanova*
The nature of stellar winds in the star-disk interaction *S. Matt & R.E. Pudritz*
Large-scale magnetic fields in disks: jets and reconnection X-winds *J. Ferreira et al.*

Part 6. Companions, Plnets, and Effects of the Stellar Mass

The implications of close binary stars for star-disk interactions *R.D. Mathieu*
Disc-magnetosphere interactions in cataclysmic variable stars *C. Hellier*
The inner gaseous accretion disk around a Herbig Be star revealed by near- and mid-infrared spectro-interferometry *S. Kraus, Th. Preibisch, & K. Ohnaka*
Star-disk interaction in brown dwarfs: implications for substellar formation *S. Mohanty*
Outflow activity in brown dwarfs *E.T. Whelan et al.*

Part 7. Conclusion

Summary and concluding remarks *I. Appenzeller*

Cambridge University Press

ISBN-13:9780521874656, hardbound, 390 pages, 2008
(US$130.00)

Available from:
http://www.cambridge.org:80/us/catalogue/catalogue.asp?isbn=9780521874656

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