THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 189 — 1 Sept 2008 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

Binary formation and mass function variations in fragmenting discs with short cooling times

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Accretion discs at sub-pc distances around supermassive black holes are likely to cool rapidly enough that self-gravity results in fragmentation. Here, we use high-resolution hydrodynamic simulations of a simplified disc model to study how the outcome of fragmentation depends upon numerical resolution and cooling time, and to investigate the incidence of binary formation within fragmenting discs. We investigate a range of cooling times, from the relatively long cooling time-scales that are marginally unstable to fragmentation down to highly unstable cooling on a time-scale that is shorter than the local dynamical time. The characteristic mass of fragments decreases with reduced cooling time, though the effect is modest and dependent upon details of how rapidly bound clumps radiate. We observe a high incidence of capture binaries, though we are unable to determine their final orbits or probability of survival. The results suggest that faster cooling in the parent disc results in an increased binary fraction, and that a high primordial binary fraction may result from disc fragmentation. We discuss our results in terms of the young massive stars close to the Galactic Centre, and suggest that observations of some stellar binaries close to the Galactic Centre remain consistent with formation in a fragmenting accretion disc.

Accepted for publication in MNRAS.

Preprint available at `http://strw.leidenuniv.nl/~rda/publications.html` or `arXiv:0807.1731`

Near-Infrared Photometry and Radio Continuum Study of the Massive Star Forming Regions IRAS 21413+5442 and IRAS 21407+5441

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IRAS 21413+5442 and IRAS 21407+5441 are two massive star forming regions of high luminosity, likely associated with each other. Near-infrared photometry on these two IRAS sources was performed at UKIRT using the UFTI under excellent seeing conditions yielding an angular resolution of $\sim$ 0.5 arcsec. Our results reveal details of stellar content to a completeness limit (90%) of J = 18.5, H = 18.0, and K = 17.5 mag in the two regions. In IRAS 21413+5442, we identify a late O type star, having large (H-K) color, to be near the centre of the CO jets observed by earlier authors. The UKIRT images reveal in IRAS 21407+5441, a faint but clear compact HII region around a central high

- intermediate mass star cluster. We have detected a number of sources with large (H-K) color which are not detected in J band. We also present the GMRT radio continuum map at 1.28 GHz covering the entire region surrounding the two star forming clouds. The radio continuum fluxes are used to estimate the properties of HII regions which seem to support our near-IR photometric results. Based on our radio continuum map and the archival MSX 8.2 μm image, we show that the two IRAS sources likely belong to the same parent molecular cloud and conjecture that a high mass star of large IR colors, present in between the two sources, might have triggered star formation in this region. However one can not rule out the alternative possibility that Star A could be a nearby foreground star.

Accepted by MNRAS, 2008

http://arxiv.org/abs/0808.1812

The direction of outflows from filaments: constraints on core formation

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Context. It is generally presumed that the outflows from a YSO are directed close to its rotation axis (i.e. along its angular momentum vector and orthogonal to any attendant accretion disc). Many YSOs are formed from dense prestellar cores embedded in filaments, and therefore the relative orientations of outflows and filaments may place a useful constraint on the dynamics of core formation.
Aims. We explore this possibility, from the viewpoint of what it may tell us about the angular momentum delivered to a core forming in a filament. We stress that we are not here addressing the issue of the relationship of filaments and outflows to the prevailing magnetic field direction, although this is evidently also an interesting issue.
Methods. We use data from the literature and the SCUBA archive to estimate the projected angles between 45 observed outflows and the filaments which appear to contain their driving sources. The distribution of these angles is then compared with model predictions, so as to obtain a statistical constraint on the distribution of intrinsic angles between outflows and filaments.
Results. Using the limited data available, and neglecting any possible selection effects or correlations between nearby outflows, we infer that the observed outflows have a tendency to be orthogonal to the filaments that contain their driving sources. Specfically, in the cases where the directions of the filaments and outflows are well defined, we infer statistically that 72° of outflows are within 45° of being orthogonal to the filament, and only 28° are within 45° of being parallel to the filament.
Conclusions. This suggests that the prestellar cores which spawned the YSOs driving the observed outflows had angular momenta which were approximately orthogonal to the filaments out of which the cores formed. We briefly discuss the implications of this for two proposed core formation mechanisms.

Published by Astronomy & Astrophysics (Vol. 487, p. 605)

Submillimeter Observations of the Young Low-Mass Object IRAS 04158+2805

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We present high spatial resolution Submillimeter Array observations and supplementary single-dish photometry of the molecular gas and dust around IRAS 04158+2805, a young source with spectral type M5-M6 in the Taurus star-forming region. A bright, highly elongated dust structure that extends 8 arcsec (∼1120 AU) in diameter is revealed in a 883 μm thermal continuum image. This emission geometry is in good agreement with optical observations that show a similar structure in absorption, aligned perpendicular to bipolar scattered light nebulae. However, the interferometric data also clearly demonstrate that the submillimeter continuum emission is not centrally concentrated, but rather appears to have a toroidal geometry with substantially lower intensities inside a radius of ∼250-300 AU. Spatially resolved emission from the CO J=3−2 transition exhibits a velocity gradient along the major axis of the dust structure. If this kinematic pattern is interpreted as the signature of rotation around a central object, a relatively low mass is

inferred ($M_* \sim 0.3\,M_\odot$, with a ∼50% uncertainty). We discuss several possible explanations for the observed gas and dust environment around IRAS 04158+2805, including a flattened envelope with an outflow cavity and a large circumbinary ring. This source offers unique views of the gas and dust environment surrounding a young low-mass stellar system. Its properties are generally not commensurate with formation scenarios for such low-mass objects that rely on dynamical ejection, but rather confirms that a single mechanism − molecular cloud core collapse and fragmentation − can produce stars over a wide range of stellar masses (at least an order of magnitude).

Accepted by Astrophysical Journal

http://arxiv.org/abs/0806.4163

Complex Molecules in the L1157 Molecular Outflow

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We report the detection of complex organic molecules in the young protostellar outflow L1157. We identify lines from $HCOOCH_3$, CH_3CN, HCOOH and C_2H_5OH at the position of the B1 shock in the blueshifted lobe, making it the first time that complex species have been detected towards a molecular outflow powered by a young low-mass protostar. The time scales associated with the warm outflow gas ($< 2 \times 10^3$ yr) are too short for the complex molecules to have formed in the gas phase after the shock-induced sputtering of the grain mantles. It is more likely that the complex species formed in the surface of grains and were then ejected from the grain mantles by the shock. The formation of complex molecules in the grains of low-mass star forming regions must be relatively efficient, and our results show the importance of considering the impact of outflows when studying complex molecules around protostars. The relative abundance with respect to methanol of most of the detected complex molecules is similar to that of hot cores and molecular clouds in the galactic center region, which suggests that the mantle composition of the dust in the L1157 dark cloud is similar to dust in those regions.

Published by Astrophysical Journal Letters (Vol. 681, p. L21)

http://www.astro.yale.edu/hga7/publications.html
http://arxiv.org/abs/0805.2550

Molecular gas associated with RCW 121 and RCW 122

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Aims. We analyse the distribution of the molecular gas towards the region containing the open cluster Havlen-Moffat 1 (HM 1) the Wolf-Rayet stars WR 87, WR 89, and WR 91, and the star forming regions RCW 121 and RCW 122, with the aim of looking for a possible physical relationship among these objects.
Methods. We used the carbon monoxide observations carried out at $\lambda \sim 2.6$ mm with the 4 m NANTEN radiotelescope; new flux density determinations derived from already existing radio continuum surveys at 2.417, 5, 8.35, and 14.35 GHz; continuum flux density determinations available in the literature; and the *Midcourse Space Experiment* (MSX) and the *Improved Reprocessing of the IRAS Survey* (IRIS) databases.
Results. Adopting a distance of 5 kpc for RCW 121 and RCW 122, we found a giant molecular cloud (GMC) with a linear extent of ∼100 × 20 pc to be associated with galactic star-forming regions. The total mass of this GMC is of the order of 1.2×10^6 solar masses and its mean radial velocity is about −15 km s^{-1}. Within the GMC there are individual molecular gas concentrations, having total molecular masses in the range from $4.6 \times 10^4\ M_\odot$ (RCW 122 C) to $2.2 \times 10^5\ M_\odot$ (RCW 122). The CO profiles observed toward the peak of the molecular concentrations are broad,

with typical full-width half-maximum around 6 to 7 km s^{-1}, and show line asymmetries and/or double-peaked shape that change with the observed position within a given CO concentration. An analysis of the MSX and IRAS databases show that each CO concentration has a strong IR counterpart. The dust temperature of these concentrations range from 46 K (RCW 121) to 76 K (RCW 122 C). Their infrared luminosity are a few times 10^5 $L_\odot$. The new radio continuum flux density determinations are in good agreement with previous determinations at other frequencies, and confirm the thermal nature of RCW 121 and RCW 122. Based on the newly-determined 5 GHz flux density, we found that to power these HII regions, each of them must harbour a sizable number of O type stars. Under the assumption that all the ionizing stars have a O7 V spectral type, at least ∼8 and ∼4 of these stars would be needed to ionize RCW 122 and RCW 121, respectively.

Published by Astronomy & Astrophysics (Vol. 486, p. 807)

Tides and the Evolution of Planetary Habitability

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Tides raised on a planet by the gravity of its host star can reduce the planet's orbital semi-major axis and eccentricity. This effect is only relevant for planets orbiting very close to their host stars. The habitable zones of low-mass stars are also close in, and tides can alter the orbits of planets in these locations. We calculate the tidal evolution of hypothetical terrestrial planets around low-mass stars and show that tides can evolve planets past the inner edge of the habitable zone, sometimes in less than 1 billion years. This migration requires large eccentricities (> 0.5) and low-mass stars ($\lesssim$0.35 $M_\odot$). Such migration may have important implications for the evolution of the atmosphere, internal heating, and the Gaia hypothesis. Similarly, a planet that is detected interior to the habitable zone could have been habitable in the past. We consider the past habitability of the recently discovered, ~ 5 $M_\oplus$ planet, Gliese 581 c. We find that it could have been habitable for reasonable choices of orbital and physical properties as recently as 2 Gyr ago. However, when constraints derived from the additional companions are included, most parameter choices that indicate past habitability require the two inner planets of the system to have crossed their mutual 3:1 mean motion resonance. As this crossing would likely have resulted in resonance capture, which is not observed, we conclude that Gl 581 c was probably never habitable.

Accepted by Astrobiology (vol. 8, num. 3, 557, 2008)

http://www.lpl.arizona.edu/∼rory/publications/

The early expansion of cluster cores

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The observed properties of young star clusters, such as the core radius and luminosity profile, change rapidly during the early evolution of the clusters. Here we present observations of six young clusters in M51 where we derive their sizes using *Hubble Space Telescope* (HST) imaging and ages using deep Gemini-North spectroscopy. We find evidence for a rapid expansion of the cluster cores during the first 20 Myr of their evolution. We confirm this trend by including data from the literature of both Galactic and extragalactic embedded and young clusters, and possible mechanisms

(rapid gas removal, stellar evolutionary mass loss and internal dynamical heating) are discussed. We explore the implications of this result, focussing on the fact that clusters were more concentrated in the past, implying that their stellar densities were much higher and relaxation times ($t_{\rm relax}$) correspondingly shorter. Thus, when estimating if a particular cluster is dynamically relaxed (i.e. when determining if a cluster's mass segregation is due to primordial or dynamical processes), the current relaxation time is only an upper limit, with $t_{\rm relax}$ likely being significantly shorter in the past.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 389, p. 223)

The young Galactic star cluster [DBS2003] 179

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Context. Recent near- and mid-infrared surveys have brought evidence that the Milky Way continues to form massive clusters.
Aims. We carry out a program to determine the basic physical properties of the new massive cluster candidate [DBS2003] 179.
Methods. Medium-resolution K-band spectra and deep near-infrared images of [DBS2003] 179 were used to derive the spectral types of eight member stars, and to estimate the distance and reddening to the cluster.
Results. Seven of ten stars with spectra show emission lines. Comparison with template spectra indicated that they are early O-type stars. The mean radial velocity of the cluster is $V_{\rm rad} = -77 \pm 6$ km s^{-1}. Knowing the spectral types of the members and the color excesses, we determined extinction $A_V \sim 16.6$ and distance modulus $(m - M)_0 \sim 14.5$ mag ($D \sim 7.9$ Kpc). The presence of early O-stars and a lack of red supergiants suggests a cluster age of 2–5 Myr. The total cluster mass is approximated to 0.7×10^4 $M_\odot$ and it is not yet dynamically relaxed.
Conclusions. The candidate [DBS2003] 179 further increases the family of the massive young clusters in the Galaxy, although it appears less massive than the prototypical starburst clusters.

Published by Astronomy & Astrophysics (Vol. 488, p. 151)

Lithium depletion and the rotational history of exoplanet host stars

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Israelian et al. (2004) reported that exoplanet host stars are lithium depleted compared to solar-type stars without detected massive planets, a result recently confirmed by Gonzalez (2008). We investigate whether enhanced lithium depletion in exoplanet host stars may result from their rotational history. We develop rotational evolution models for slow and fast solar-type rotators from the pre-main sequence (PMS) to the age of the Sun and compare them to the distribution of rotational periods observed for solar-type stars between 1 Myr and 5 Gyr. We show that slow rotators develop a large degree of differential rotation between the radiative core and the convective envelope, while fast rotators evolve with little core-envelope decoupling. We suggest that strong differential rotation at the base of the convective envelope is responsible for enhanced lithium depletion in slow rotators. We conclude that Li-depleted exoplanet host stars were slow rotators on the zero-age main sequence (ZAMS) and argue that slow rotation results

from a long-lasting star-disk interaction during the PMS. Altogether, this suggests that long-lived disks ($\geq$ 5 Myr) may be a necessary condition for massive planet formation/migration.

Accepted by A&A

The Formation and Evolution of Planetary Systems: Grain Growth and Chemical Processing of Dust in T Tauri Systems

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This paper is one in a series presenting results obtained within the Formation and Evolution of Planetary Systems (FEPS) Legacy Science Program on the Spitzer Space Telescope. Here we present a study of dust processing and growth in seven protoplanetary disks. Our spectra indicate that the circumstellar silicate dust grains have grown to sizes at least 10 times larger than observed in the interstellar medium and show evidence for a non-negligible ($\sim$5% in mass fractions) contribution from crystalline species. These results are similar to those of other studies of protoplanetary disks. In addition, we find a correlation between the strength of the amorphous silicate feature and the shape of the spectral energy distribution. This latter result is consistent with the growth and subsequent gravitational settling of dust grains toward the disk midplane. Furthermore, we find a change in the relative abundance of the different crystalline species: more enstatite than forsterite is observed in the inner warm dust population at $\sim$1 AU, while forsterite dominates in the colder outer regions at $\sim$5–15 AU. This change in the relative abundances argues for a localized crystallization process rather than a radial mixing scenario in which crystalline silicates are being transported outwards from a single formation region in the hot inner parts of the disk. Finally, we report the detection of emission from polycyclic aromatic hydrocarbon (PAH) molecules in five out of seven sources. We find a tentative PAH band at 8.2 μm that was previously undetected in the spectra of disks around low-mass pre-main-sequence stars.

Published by The Astrophysical Journal (Vol. 683, p. 479)

Structural and compositional properties of brown dwarf disks: the case of 2MASS J04442713+2512164

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Aims. To improve our understanding of substellar formation, we have performed a compositional and structural study

of a brown dwarf disk.
Methods. We present the results of photometric, spectroscopic, and imaging observations of 2MASS J04442713+2512164, a young brown dwarf (M 7.25) member of the Taurus association. Our dataset, combined with results from the literature, provides a complete coverage of the spectral energy distribution from the optical range to the millimeter, including the first photometric measurement of a brown dwarf disk at 3.7 mm, and allows us to perform a detailed analysis of the disk properties.
Results. The target was known to have a disk. High-resolution optical spectroscopy shows that it is accreting intensely, and powers both a jet and an outflow. The disk structure is similar to what is observed for more massive TTauri stars. Spectral decomposition models of Spitzer/IRS spectra suggest that the mid-infrared emission from the optically thin disk layers is dominated by grains with intermediate sizes (1.5 μm). Crystalline silicates are significantly more abundant in the outer part and/or deeper layers of the disk, implying very efficient mixing and/or additional annealing processes. Submillimeter and millimeter data indicate that most of the disk mass is in large grains (>1 mm).

Published by Astronomy & Astrophysics (Vol. 468, p. 877)

The Damping Rates of Embedded Oscillating Starless Cores

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In a previous paper we demonstrated that nonradial hydrodynamic oscillations of a thermally supported (Bonnor-Ebert) sphere embedded in a low-density, high-temperature medium persist for many periods. The predicted column density variations and molecular spectral line profiles are similar to those observed in the Bok globule B68, suggesting that the motions in some starless cores may be oscillating perturbations on a thermally supported equilibrium structure. Such oscillations can produce molecular line maps which mimic rotation, collapse, or expansion and, thus, could make determining the dynamical state from such observations alone difficult. However, while B68 is embedded in a very hot, low-density medium, many starless cores are not, having interior/exterior density contrasts closer to unity. In this paper we investigate the oscillation damping rate as a function of the exterior density. For concreteness we use the same interior model employed by Broderick et al., with varying models for the exterior gas. We also develop a simple analytical formalism, based on the linear perturbation analysis of the oscillations, which predicts the contribution to the damping rates due to the excitation of sound waves in the external medium. We find that the damping rate of oscillations on globules in dense molecular environments is always many periods, corresponding to hundreds of thousands of years and persisting over the inferred lifetimes of the globules.

Published by The Astrophysical Journal (Vol. 682, p. 1095)

Circumstellar disks in the outer Galaxy: the star-forming region NGC 1893

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Context. It is still debated whether star formation process depends on environment. In particular it is yet unclear whether star formation in the outer Galaxy, where the environmental conditions are, theoretically, less conducive, occurs in the same way as in the inner Galaxy.
Aims. We investigate the population of NGC 1893 , a young cluster (∼3–4 Myr) in the outer part of the Galaxy (R_G $\geq$ 11 kpc), to explore the effects of environmental conditions on star forming regions.
Methods. We present infrared observations acquired using the IRAC camera onboard the *Spitzer* Space Telescope and analyze the color-color diagrams to establish the membership of stars with excesses. We also merge this information with that obtained from *Chandra* ACIS-I observations, to identify the Class III population.

Results. We find that the cluster is very rich, with 242 PMS Classical T Tauri stars and 7 Class 0/I stars. We identify 110 Class III candidate cluster members in the ACIS-I field of view. We estimate a disk fraction for NGC 1893 of about 67%, similar to fractions calculated for nearby star forming regions of the same age. Conclusions. Although environmental conditions are unfavorable, star formation can clearly be very successful in the outer Galaxy, allowing creation of a very rich cluster like NGC 1893 .

Published by Astronomy & Astrophysics (Vol. 488, p. 211)

Accretion-driven core collapse and the collisional formation of massive stars

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We consider the conditions required for a cluster core to shrink, by adiabatic accretion of gas from the surrounding cluster, to densities such that stellar collisions are a likely outcome. We show that the maximum densities attained, and hence the viability of collisions, depend on the balance between core shrinkage (driven by accretion) and core puffing up (driven by relaxation effects). The expected number of collisions scales as $N_{\rm core}^{5/3}\tilde{v}^2$, where $N_{\rm core}$ is the number of stars in the cluster core and $\tilde{v}$ is the free-fall velocity of the parent cluster (gas reservoir). Thus, whereas collisions are very unlikely in a relatively low-mass, low-internal-velocity system such as the Orion Nebula Cluster, they become considerably more important at the mass and velocity scales characteristic of globular clusters. Thus, stellar collisions in response to accretion-induced core shrinkage remain a viable prospect in more massive clusters, and may contribute to the production of intermediate-mass black holes in these systems.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 388, p. 1171)

T Tauri Jet Physics Resolved Near The Launching Region with the Hubble Space Telescope

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We present an analysis of the gas physics at the base of jets from five T Tauri stars based on high angular resolution optical spectra, using the Hubble Space Telescope Imaging Spectrograph (HST/STIS). The spectra refer to a region within 100 AU of the star, i.e. where the collimation of the jet has just taken place. We form PV images of the line ratios to get a global picture of the flow excitation. We then apply a specialised diagnostic technique to find the electron density, ionisation fraction, electron temperature and total density. Our results are in the form of PV maps of the obtained quantities, in which the gas behaviour is resolved as a function of both radial velocity and distance from the jet axis. They highlight a number of interesting physical features of the jet collimation region, including regions of extremely high density, asymmetries with respect to the axis, and possible shock signatures. Finally, we estimate the jet mass and angular momentum outflow rates, both of which are fundamental parameters in constraining models of accretion/ejection structures, particularily if the parameters can be determined close to the jet footpoint. Comparing mass flow rates for cases where the latter is available in the literature (i.e. DG Tau, RW Aur and CW Tau) reveals a mass ejection-to-accretion ratio of 0.01 - 0.07. Finally, where possible (i.e. DG Tau and CW Tau), both mass and angular momentum outflow rates have been resolved into higher and lower velocity jet material. For the clearer case of DG Tau, this revealed that the more collimated higher velocity component plays a dominant role in mass and angular momentum transport.

Accepted by ApJ

Turbulence-driven Polar Winds from T Tauri Stars Energized by Magnetospheric Accretion

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Pre-main-sequence stars are observed to be surrounded by both accretion flows and some kind of wind or jet-like outflow. Recent work by Matt and Pudritz has suggested that if classical T Tauri stars exhibit stellar winds with mass loss rates about 0.1 times their accretion rates, the wind can carry away enough angular momentum to keep the stars from being spun up unrealistically by accretion. This paper presents a preliminary set of theoretical models of accretion-driven winds from the polar regions of T Tauri stars. These models are based on recently published self-consistent simulations of the Sun's coronal heating and wind acceleration. In addition to the convection-driven MHD turbulence (which dominates in the solar case), we add another source of wave energy at the photosphere that is driven by the impact of plasma in neighboring flux tubes undergoing magnetospheric accretion. This added energy, determined quantitatively from the far-field theory of MHD wave generation, is sufficient to produce T Tauri-like mass loss rates of at least 0.01 times the accretion rate. While still about an order of magnitude below the level required for efficient angular momentum removal, these are the first self-consistent models of T Tauri winds that agree reasonably well with a range of observational mass loss constraints. The youngest modeled stellar winds are supported by Alfvén wave pressure, they have low temperatures ("extended chromospheres"), and they are likely to be unstable to the formation of counterpropagating shocks and clumps far from the star.

Accepted by ApJ

http://arXiv.org/abs/0808.2250

Characterizing the nature of embedded young stellar objects through silicate, ice and millimeter observations

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Context. Determining the evolutionary stage of a Young Stellar Object (YSO) is of fundamental importance to test star formation theories. Classification schemes for YSOs are based on evaluating the degree of dissipation of the surrounding envelope, whose main effects are the extinction of the optical radiation from the central YSO and re-emission in the far-infrared to millimeter part of the electromagnetic spectrum. Since extinction is a property of column density along the line of sight, the presence of a protoplanetary disk may lead to a misclassification of pre-main sequence stars with disks when viewed edge-on.
Aims. We performed radiative transfer calculations to show the effects of different geometries on the main indicators of YSO evolutionary stage. In particular we tested not only the effects on the infrared colors, like the slope α of the flux between 2.2 and 24 μm, but also on other popular indicators of YSO evolutionary stage, such as the bolometric temperature and the optical depth of silicates and ices.
Methods. We used the axisymmetric 3D radiative transfer codes RADMC and RADICAL to calculate the spectral energy distribution including silicates and ice features in a grid of models covering the range of physical properties typical of embedded and pre-main sequence sources.
Results. Our set of models compares well with existing observations, supporting the assumed density parametrization and the adopted dust opacities. We show that for systems viewed at intermediate angles (25°–70°) the "classical" indicators of evolution are able to classify the degree of evolution of young stellar objects since they accurately trace the envelope column density, and they all agree with each other. On the other hand, edge-on system are misclassified for inclinations larger than $\sim$65° $\pm$ 5°, where the spread is mostly due to the range of mass and the flaring degree of the disk. In particular, silicate emission, typical of pre-main sequence stars with disks, turns into silicate absorption when the disk column density along the line of sight reaches 1×10^{22} cm^{-2}, corresponding e.g. to a 5×10^{-3} $M_\odot$

flaring disk viewed at 64°. A similar effect is noticed in all the other classification indicators studied: α, $T_{\rm bol}$, and the H_2O and CO_2 ice absorption strengths. This misclassification has a large impact on the nature of the flat-spectrum sources ($\alpha \simeq 0$), whose number can be explained by simple geometrical arguments without invoking evolution. A reliable classification scheme using a minimal number of observations is constituted by observations of the millimeter flux with both a single dish and an interferometer.

Published by Astronomy & Astrophysics (Vol. 486, p. 245)

Formation of water and methanol in star forming molecular clouds

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Aims. We study the formation of water and methanol in the dense cloud conditions to find the dependence of its production rate on the binding energies, reaction mechanisms, temperatures, and grain site number. We wish to find the effective grain surface area available for chemical reaction and the effective recombination timescales as functions of grain and gas parameters.
Methods. We used a Monte Carlo simulation to follow the chemical processes occurring on the grain surface. We carried out the simulations on the Olivine grains of different sizes, temperatures, gas phase abundances and different reaction mechanisms. We consider H, O, and CO as the accreting species from the gas phase and allow ten chemical reactions among them on the grains.
Results. We find that the formation rate of various molecules is strongly dependent on the binding energies. When the binding energies are high, it is very difficult to produce significant amounts of the molecular species. Instead, the grain is found to be full of atomic species. The production rates are found to depend on the number density in the gas phase. When the density is high, the production of various molecules on the grains is small as grain sites are quickly filled up by atomic species. If both the Eley-Rideal and Langmuir-Hinselwood mechanisms are considered, then the production rates are maximum and the grains are filled up relatively faster. Thus, if allowed, the Eley-Rideal mechanism can also play a major role and more so when the grain is full of immobile species. We show that the concept of the effective grain surface area, which we introduced in our earlier work, plays a significant role in grain chemistry.
Conclusions. We compute the abundance of water and methanol and show that the results strongly depend on the density and composition in the gas phase, as well as various grain parameters. In the rate equation, it is generally assumed that the recombination efficiencies are independent of the grain parameters, and the surface coverage. Presently, our computed parameter for each product is found to depend on the accretion rate, the grain parameters and the surface coverage of the grain. We compare our results obtained from the rate equation and the one from the effective rate equation, which includes α. A comparison of our results with the observed abundance shows very good agreement.

Published by Astronomy & Astrophysics (Vol. 486, p. 209)

The dynamics of internal working surfaces in MHD jets

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The dynamical effects of magnetic fields in models of radiative, Herbig-Haro (HH) jets have been studied in a number of papers. For example, magnetized, radiative jets from variable sources have been studied with axisymmetric and 3D numerical simulations. In this paper, we present an analytic model describing the effect of a toroidal magnetic field on the internal working surfaces that result from a variability in the ejection velocity. We find that for parameters appropriate for HH jets the forces associated with the magnetic field dominate over the gas pressure force within

the working surfaces. Depending on the ram pressure radial cross section of the jet, the magnetic field can produce a strong axial pinch, or, alternatively, a broadening of the internal working surfaces. We check the validity of the analytic model with axisymmetric numerical simulations of variable, magnetized jets.

Accepted by ApJ

http://xxx.lanl.gov/abs/0808.2346

The effect of a stellar magnetic variation on the jet velocity

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Stellar jets are normally constituted by chains of knots with some periodicity in their spatial distribution, corresponding to a variability of order of several years in the ejection from the protostar/disk system. A widely accepted theory for the presence of knots is related to the generation of internal working surfaces due to variations in the jet ejection velocity. In this paper we study the effect of variations in the inner disk-wind radius on the jet ejection velocity. We show that a small variation in the inner disk-wind radius produce a variation in the jet velocity large enough to generate the observed knots. We also show that the variation in the inner radius may be related to a variation of the stellar magnetic field.

Accepted by ApJ

http://xxx.lanl.gov/abs/0808.1949

Matching the frequency spectrum of pre-main sequence stars by means of standard and rotating models

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We applied the aton evolutionary code to the computation of detailed grids of standard (non-rotating) and rotating pre-main sequence (PMS) models and computed their adiabatic oscillation spectra, with the aim of exploring the seismic properties of young stars. As, until now, only a few frequencies have been determined for ∼40 PMS stars, the way of approaching the interpretation of the oscillations is not unique. We adopt a method similar to the matching mode method by Guenther and Brown making use, when necessary, also of our rotating evolutionary code to compute the models for PMS stars. The method is described by a preliminary application to the frequency spectrum of two PMS stars (85 and 278) in the young open cluster NGC 6530. For the Star 85, we confirm with self-consistent rotating models, previous interpretation of the data, attributing three close frequencies to the mode n= 4, l= 1 and m= 0 , +1 and −1. For the Star 278, we find a different fit for the frequencies, corresponding to a model within the original error box of the star, and dispute the possibility that this star has a Teff much cooler that the red boundary of the radial instability strip.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 389, p. 325)

CN Zeeman measurements in star formation regions

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Aims. Magnetic fields play a primordial role in the star formation process. The Zeeman effect on the CN radical lines is one of the few methods of measuring magnetic fields in the dense gas of star formation regions.
Methods. We report new observations of the Zeeman effect on seven hyperfine CN $N = 1$–0 lines in the direction of 14 regions of star formation.
Results. We have improved the sensitivity of previous detections, and obtained five new detections. Good upper limits are also achieved. The probability distribution of the line-of-sight field intensity, including non-detections, provides a median value of the total field $B_{\rm tot} = 0.56$ mG while the average density of the medium sampled is $n(\rm H_2) = 4.5\times 10^5$ cm^{-3}. We show that the CN line probably samples regions similar to those traced by CS and that the magnetic field observed mostly pervades the dense cores. The dense cores are found to be critical to slightly supercritical with a mean mass-to-flux ratio $M/\Phi \sim 1$ to 4 with respect to critical. Their turbulent and magnetic energies are in approximate equipartition.

Published by Astronomy & Astrophysics (Vol. 487, p. 247)

Spitzer-MIPS Observations of the η Chamaeleontis Young Association

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We have mapped the η Chamaeleontis young stellar association in the far-infrared with the Multiband Imaging Photometer for Spitzer (MIPS) on the *Spitzer Space Telescope*. All 16 members within the map region were detected at 24 μm, along with five members at 70 μm and two at 160 μm. Ten stars show far-infrared excess emission indicating the presence of circumstellar disks; six of these have central clearings as evidenced by the onset of excess emission at $\lambda > \mu$m. No new infrared-excess sources are identified among the 113 2MASS field stars with 24 μm photometry but not seen as X-ray sources, indicating that membership lists derived from X-ray surveys are reasonably complete. Circumstellar disks in the η Cha association span the range from 10^{-1} to 10^{-4} in their fractional infrared luminosity, with a median L_d/L_* of 0.04. The presence of optically thick, optically thin, and intermediate optical depth disks within the same stellar group, in combination with the large fraction of disks with inner holes, indicates that the η Cha association represents a crucial stage in circumstellar disk evolution.

Published by The Astrophysical Journal (Vol. 683, p. 813)

Initial data release from the INT Photometric Hα Survey of the Northern Galactic Plane (IPHAS)

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The INT/WFC Photometric Hα Survey of the Northern Galactic Plane (IPHAS) is an imaging survey being carried out in Hα, r' and i' filters, with the Wide Field Camera (WFC) on the 2.5-m Isaac Newton Telescope (INT) to a depth of r'= 20 (10σ). The survey is aimed at revealing the large scale organization of the Milky Way and can be applied to identifying a range of stellar populations within it. Mapping emission line objects enables a particular focus on objects in the young and old stages of stellar evolution ranging from early T-Tauri stars to late planetary nebulae. In this paper we present the IPHAS Initial Data Release, primarily a photometric catalogue of about 200 million unique objects, coupled with associated image data covering about 1600 deg^2 in three passbands. We note how access to the primary data products has been implemented through use of standard virtual observatory publishing interfaces. Simple traditional web access is provided to the main IPHAS photometric catalogue, in addition to a number of common catalogues (such as 2MASS) which are of immediate relevance. Access through the AstroGrid VO Desktop opens up the full range of analysis options, and allows full integration with the wider range of data and services available through the Virtual Observatory. The IDR represents the largest data set published primarily through VO interfaces to date, and so stands as an exemplar of the future of survey data mining. Examples of data access are given, including a cross-matching of IPHAS photometry with sources in the UKIDSS Galactic Plane Survey that validates the existing calibration of the best data.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 388, p. 89)

The unusual pre-main-sequence star V718 Per (HMW 15)

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The remarkable pre-main-sequence object V718 Per (HMW 15, H187) in the young cluster IC 348 periodically undergoes long-lasting eclipses caused by variable amounts of circumstellar dust in the line-of-sight to the star. It has been speculated that the star is a close binary and similar to another unusual eclipsing object, KH 15D. We have submitted V718 Per to a detailed photometric and spectroscopic study to find out more about the properties of the stellar object and the occulting circumstellar material, and to look for signatures of a possible binary component. Our photometric data show that the eclipses are very symmetric and persistent, and that the extinction deviates only little from what is expected for normal interstellar material. The spectroscopic data, obtained at minimum as well as at maximum brightness, indicate a primordial abundance of Li and a surface effective temperature of about 5200 K. Remarkably, the in-eclipse spectrum shows a significant broadening of the photospheric absorption lines, as well as a weak increase

in emission components of H-alpha and the Ca II IR triplet. We did not detect any atomic or molecular features from to the occulting body in the in-eclipse spectrum. We also found no evidence of radial velocity changes in V718 Per to within about ±80 m/s, which for an edge-on system corresponds to a maximum companion mass of 6 Jupiter masses. Our observations suggest that V718 Per is a single star, and thus very different from KH 15D. We conclude that V718 Per is surrounded by an edge-on circumstellar disk with an irregular mass distribution orbiting at a distance of 3.3 AU from the star, presumably at the inner disk edge. We ascribe the broadening of photospheric absorption lines during the eclipse to forward scattering of stellar light in the circumstellar dust feature.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/0808.1069

Spatially resolved H_2 emission from the disk around T Tau N

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Context. Molecular hydrogen is the main constituent of circumstellar disks and could be an important tracer for the evolution and structure of such disks. So far, H_2 has only been detected in a few disks and only through spectroscopic observations, resulting in a limited knowledge of the spatial distribution of the H_2 emitting gas.
Aims. We report the detection of quiescent H_2 emission in a spatially resolved ring-like structure within 100 AU of T Tau N. We present evidence to show that the emission most likely arises from shocks in the atmosphere of a nearly face-on disk around T Tau N.
Methods. Using high spatial resolution 3D spectroscopic K-band data, we trace the spatial distribution of several H_2 NIR rovibrational lines in the vicinity of T Tau N. We examine the structure of the circumstellar material around the star through SED modeling. Then, we use models of shocks and UV+X-ray irradiation to reproduce the H_2 line flux and line ratios in order to test how the H_2 is excited.
Results. We detect weak H_2 emission from the v=1-0 S(0), S(1), Q(1) lines and the v=2-1 S(1) line in a ring-like structure around T Tau N between 0.″1 (∼15 AU) and 0.″7 (∼100 AU) from the star. The v=1-0 S(0) and v=2-1 S(1) lines are detected only in the outer parts of the ring structure. Closer to the star, the strong continuum limits our sensitivity to these lines. The total flux of the v=1-0 S(1) line is 1.8×10^{-14} erg s^{-1} cm^{-2}, similar to previous measurements of H_2 in circumstellar disks. The velocity of the H_2 emitting gas around T Tau N is consistent with the rest velocity of the star, and the H_2 does not seem to be part of a collimated outflow. Both shocks impinging on the surface of a disk and irradiation of a disk by UV-photons and X-rays from the central star are plausible candidates for the H_2 excitation mechanism. However, irradiation should not create a large degree of excitation at radii larger than 20 AU. Most likely the H_2 emission arises in the atmosphere of a flared disk with radius 85-100 AU and mass 0.005-0.5 $M_\odot$, where the gas is excited by shocks created when a wide-angle wind impinges on the disk. The H_2 emission could also originate from shock excitation in the cavity walls of an envelope, but this requires an unusually high velocity of the wide-angle wind from T Tau N.

Published by Astronomy & Astrophysics 2008 (Vol. 488, p.235)

Rapid Molecular Cloud and Star Formation: Mechanisms and Movies

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We demonstrate that the observationally inferred rapid onset of star formation after parental molecular clouds have assembled can be achieved by flow-driven cloud formation of atomic gas, using our previous three-dimensional numerical simulations. We post-process these simulations to approximate CO formation, which allows us to investigate the times at which CO becomes abundant relative to the onset of cloud collapse. We find that global gravity in a finite cloud has two crucial effects on cloud evolution. (a) Lateral collapse (perpendicular to the flows sweeping up the cloud) leads to rapidly increasing column densities above the accumulation from the one-dimensional flow. This in turn allows

fast formation of CO, allowing the molecular cloud to "appear" rapidly. (b) Global gravity is required to drive the dense gas to the high pressures necessary to form solar-mass cores, in support of recent analytical models of cloud fragmentation. While the clouds still appear "supersonically turbulent", this turbulence is relegated to playing a secondary role, in that it is to some extent a consequence of gravitational forces.

Accepted by ApJ

http://arxiv.org/abs/0808.1078

Core Formation in Giant Gaseous Protoplanets

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Sedimentation rates of silicate grains in gas giant protoplanets formed by disk instability are calculated for protoplanetary masses between 1 M_{Saturn} to 10 $M_{Jupiter}$. Giant protoplanets with masses of 5 $M_{Jupiter}$ or larger are found to be too hot for grain sedimentation to form a silicate core. Smaller protoplanets are cold enough to allow grain settling and core formation. Grain sedimentation and core formation occur in the low mass protoplanets because of their slow contraction rate and low internal temperature. It is predicted that massive giant planets will not have cores, while smaller planets will have small rocky cores whose masses depend on the planetary mass, the amount of solids within the body, and the disk environment. The protoplanets are found to be too hot to allow the existence of icy grains, and therefore the cores are predicted not to contain any ices. It is suggested that the atmospheres of low mass giant planets are depleted in refractory elements compared with the atmospheres of more massive planets. These predictions provide a test of the disk instability model of gas giant planet formation.
The core masses of Jupiter and Saturn were found to be ~ 0.25 $M_\oplus$ and ~ 0.5 $M_\oplus$, respectively. The core masses of Jupiter and Saturn can be substantially larger if planetesimal accretion is included. The final core mass will depend on planetesimal size, the time at which planetesimals are formed, and the size distribution of the material added to the protoplanet. Jupiter's core mass can vary from 2 to 12 $M_\oplus$. Saturn's core mass is found to be ~ 8 $M_\oplus$.

Accepted by Icarus

http://arxiv.org/abs/0808.2787

Astrometry of H_2O Masers in Nearby Star-Forming Regions with VERA. III. IRAS 22198+6336 in L1204G

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We present results of multi-epoch VLBI observations with VERA (VLBI Exploration of Radio Astrometry) of the

22 GHz H_2O masers associated with a young stellar object (YSO) IRAS 22198+6336 in a dark cloud L1204G. Based on the phase-referencing VLBI astrometry, we derive an annual parallax of IRAS 22198+6336 to be 1.309±0.047 mas, corresponding to the distance of 764±27 pc from the Sun. Although the most principal error source of our astrometry is attributed to the internal structure of the maser spots, we successfully reduce the errors in the derived annual parallax by employing the position measurements for all of the 26 detected maser spots. Based on this result, we reanalyze the spectral energy distribution (SED) of IRAS 22198+6336 and find that the bolometric luminosity and total mass of IRAS 22198+6336 are $450L_\odot$ and $7M_\odot$, respectively. These values are consistent with an intermediate-mass YSO deeply embedded in the dense dust core, which has been proposed to be an intermediate-mass counterpart of a low-mass Class 0 source. In addition, we obtain absolute proper motions of the H_2O masers for the most blue-shifted components. We propose that the collimated jets aligned along the east-west direction are the most plausible explanation for the origin of the detected maser features.

Accepted by PASJ (Vol.60, No.5, October 25, VERA special issue) arXiv:0808.0546

Disk Truncation and Planet Formation in γ Cephei

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The γ Cephei system is one of the most closely bound binary planet hosts known to date. The companion (γ Cep B) to the planet-hosting star (γ Cep A) should have truncated any protoplanetary disk around γ Cep A, possibly limiting planet formation in the disk. We explore this problem by calculating the truncation radii of protoplanetary disk models around γ Cep A to determine whether or not there is sufficient material remaining in the disk to form a planet. We vary the accretion rate and viscosity parameter of the disk models to cover a range of reasonable possibilities for the disk properties and determine that for accretion rates of ≥10–7 $M_\odot$ yr^{-1} and low viscosity parameter, sufficient material in gas and solids exist for planet formation via core accretion to be possible. Disk instability is less favored, as this can only occur in the most massive disk model with an extremely high accretion rate.

Published by The Astrophysical Journal Letters (Vol. 683, p. L191)

Pulsating pre-MS stars in the young open cluster NGC 2264: V588 Monocerotis and V589 Monocerotis

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We report on the first high-accuracy, photometric multisite campaign to study the two, first-detected pulsating, pre-main sequence stars V588 Mon and V589 Mon in the direction of the young open cluster NGC 2264. We carried out the campaign from November 2002 to February 2003 with a photometric coverage of about 216 h at four observatories. A detailed frequency analysis results in well-populated eigenspectra, typical for δ Scuti type pulsation, with 16 and 20 significant frequencies in the V588 Mon and V589 Mon data, respectively. Using Strömgren $uvby\beta$ photometry and spectroscopic observations as well as published Geneva and infrared photometry feasible fundamental parameters were deduced, placing both stars in the δ Scuti instability strip and giving strong evidence that both stars are members of NGC 2264 and are indeed in their pre-main sequence phase of evolution.

Published by Astronomy & Astrophysics (Vol. 488, p. 279)

MAMBO mapping of Spitzer c2d small clouds and cores

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Aims. To study the structure of nearby (<500 pc) dense starless and star-forming cores with the particular goal to identify and understand evolutionary trends in core properties, and to explore the nature of Very Low Luminosity Objects ($\leq 0.1\ L_\odot$; VeLLOs).
Methods. Using the MAMBO bolometer array, we create maps unusually sensitive to faint (few mJy per beam) extended ($\approx 5'$) thermal dust continuum emission at 1.2 mm wavelength. Complementary information on embedded stars is obtained from Spitzer, IRAS, and 2MASS.
Results. Our maps are very rich in structure, and we characterize extended emission features ("subcores") and compact intensity peaks in our data separately to pay attention to this complexity. We derive, e.g., sizes, masses, and aspect ratios for the subcores, as well as column densities and related properties for the peaks. Combination with archival infrared data then enables the derivation of bolometric luminosities and temperatures, as well as envelope masses, for the young embedded stars.
Conclusions. Starless and star-forming cores occupy the same parameter space in many core properties; a picture of dense core evolution in which any dense core begins to actively form stars once it exceeds some fixed limit in, e.g., mass, density, or both, is inconsistent with our data. A concept of *necessary conditions* for star formation appears to provide a better description: dense cores fulfilling certain conditions *can* form stars, but they do not need to, respectively have not done so yet. Comparison of various evolutionary indicators for young stellar objects in our sample (e.g., bolometric temperatures) reveals inconsistencies between some of them, possibly suggesting a revision of some of these indicators. Finally, we challenge the notion that VeLLOs form in cores not expected to actively form stars, and we present a first systematic study revealing evidence for structural differences between starless and candidate VeLLO cores.

Published by Astronomy & Astrophysics (Vol. 487, p. 993)

The Different Structures of the Two Classes of Starless Cores

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We describe a model for the thermal and dynamical equilibrium of starless cores that includes the radiative transfer of gas and dust and simple CO chemistry. The model shows that the structure and behavior of the cores is significantly different depending on whether the central density is either above or below about 10^5 cm^{-3}. This density is significant as the critical density for gas cooling by gas-dust collisions and as the critical density for dynamical stability, given the typical properties of the starless cores. Starless cores thus divide into two classes that we refer to as thermally supercritical and thermally subcritical. This two-class distinction allows an improved interpretation of the different observational data of starless cores within a single model.

Published by The Astrophysical Journal (Vol. 683, p. 238)

Planet formation in binary stars: the case of γ Cephei

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Context. Over 30 planetary systems have been discovered to reside in binary stars. As some of the binary separations are smaller than 20 astronomical units (AU) the gravitational perturbation of the secondary star has a very strong influence on the planet formation process, as it truncates the protoplanetary disc, possibly shortens its lifetime, and stirs up the embedded planetesimals. Due to its small semi-major axis (18.5 AU) and relatively large eccentricity e = 0.35 the binary star γ Cephei represents a particularly challenging example worthy of study in greater detail.
Aims. In the present study we model the orbital evolution and growth of embedded protoplanetary cores of about 30 earth masses in the putative protoplanetary disc surrounding the primary star in the γ Cep system.
Methods. We assume coplanarity of the disc, binary, and planet and perform two-dimensional hydrodynamic simulations of embedded cores in a protoplanetary disc perturbed by a secondary companion. Before embedding the planet, the equilibrium structure of the disc for the observed binary parameters of γ Cep is determined. We initiate the embedded planets in the disc on circular orbits with different initial distances from the primary.
Results. The presence of the eccentric secondary star perturbs the disc periodically and generates strong spiral arms at periapse that propagate toward the disc centre. The disc perturbations then weaken as the secondary approaches apoapse. The disc also becomes slightly eccentric ($e_{disk} \approx 0.1$–0.15), and displays a slow retrograde precession in the inertial frame. Embedded cores interact with the eccentric disc, and are periodically disturbed both by the strong spiral shocks and the eccentric binary. For all initial separations considered (from 2.5 to 3.5 AU) the cores migrate inward. In contrast, their eccentricity evolution depends primarily on the starting position in the disc. For initial semi-major axes $a_{\rm p} > \sim 2.7$ we find a strong increase in the planetary eccentricity despite the presence of inward migration. Only cores that are initially far from the disc outer edge ($a_{\rm p} < \sim 2.7$ AU) have a bounded orbital eccentricity that converges, after mass accretion, roughly to the value of the planet observed in the γ Cep system.
Conclusions. Even though a close binary system such as γ Cep still presents a challenge to planet formation theory, we have shown that under the condition that protoplanetary cores can form at around 2.5 AU, it is possible to evolve and grow such a core to form a planet with a final configuration similar to what is observed.

Published by Astronomy & Astrophysics (Vol. 486, p. 617)

Migration of protoplanets in radiative discs

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Context. In isothermal discs, the migration of protoplanets is directed inwards. For small planetary masses, the standard type I migration rates are so high that this can result in an unrealistic loss of planets into the stars. Aims. We investigate the planet-disc interaction in non-isothermal discs and analyse the magnitude and direction of migration for an extended range of planet masses.
Methods. We performed detailed two-dimensional numerical simulations of embedded planets including heating/cooling effects as well as radiative diffusion for realistic opacities.
Results. In radiative discs, small planets with $M_{\rm planet} < 50\ M_{\rm Earth}$ migrate outwards at a rate comparable to the absolute magnitude of standard type I migration. For larger masses, the migration is inwards and approaches the isothermal, type II migration rate.
Conclusions. Our findings are particularly important for the first growth phase of planets and ease the problem of too rapid inward type I migration.

Published by Astronomy & Astrophysics (Vol. 487, L9)

Clustered and Triggered Star Formation in W5: Observations with Spitzer

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We present images and initial results from our extensive *Spitzer* Space Telescope imaging survey of the W5 H II region with the Infrared Array Camera (IRAC) and Multiband Imaging Photometer for *Spitzer* (MIPS). We detect dense clusters of stars, centered on the O stars: HD 18326, BD +60 586, HD 17505 and HD 17520. At 24 μ, substantial extended emission is visible, presumably from heated dust grains that survive in the strongly ionizing environment of the H II region. With photometry of more than 18000 point sources, we analyze the clustering properties of objects classified as young stars by their IR spectral energy distributions (a total of 2064 sources) across the region using a minimal-spanning-tree algorithm. We find $\sim$40–70% of infrared excess sources belong to clusters with $\geq$10 members. We find that within the evacuated cavities of the H II regions that make up W5, the ratio of Class II to Class I sources is $\sim$7 times higher than for objects coincident with molecular gas as traced by ^{12}CO emission and near-IR extinction maps. We attribute this contrast to an age difference between the two locations, and postulate that at least two distinct generations of star formation are visible across W5. Our preliminary analysis shows that triggering is a plausible mechanism to explain the multiple generations of star formation in W5, and merits further investigation.

Accepted by Astrophysical Journal

http://arxiv.org/abs/0808.3284

An Improved Technique for Measurement of Cold HI in Molecular Cloud Cores

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The presence of atomic gas mixed with molecular species in a “molecular” cloud may significantly affect its chemistry, the excitation of some species, and can serve as probe of the cloud’s evolution. Cold neutral atomic hydrogen (HI) in molecular clouds is revealed by its self absorption of background galactic HI 21-cm emission. The properties of this gas can be investigated quantitatively through observation of HI Narrow Self-Absorption (HINSA). In this paper, we present a new technique for measuring atomic gas physical parameters from HINSA observations that utilizes molecular tracers to guide the HINSA extraction. This technique offers a significant improvement in the precision with which HI column densities can be determined over previous methods, and it opens several new avenues of study of relevance to the field of star formation.

Accepted by Astrophysical Journal

The Atomic to Molecular Transition in Galaxies. I: An Analytic Approximation for Photodissociation Fronts in Finite Clouds

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In this series of papers we study the structure of the atomic to molecular transition in the giant atomic-molecular complexes that are the repositories of most molecular gas in galaxies, with the ultimate goal of attaining a better understanding of what determines galaxies’ molecular content. Here we derive an approximate analytic solution for the structure of a photodissociation region (PDR) in a cloud of finite size that is bathed in an external dissociating radiation field. Our solution extends previous work, which with few exceptions has been restricted to a one-dimensional treatment of the radiation field. We show that our analytic results compare favorably to exact numerical calculations in the one-dimensional limit. However, our more general geometry provides a more realistic representation than a semi-infinite slab for atomic-molecular complexes exposed to the interstellar radiation field, particularly in environments

such as low-metallicity dwarf galaxies where the curvature and finite size of the atomic envelope cannot be neglected. For clouds that are at least 20% molecular we obtain analytic expressions for the molecular fraction in terms of properties of the gas and radiation field that are accurate to tens of percent, while for clouds of lower molecular content we obtain upper limits. As a side benefit, our analysis helps clarify when self-shielding is the dominant process in H_2 formation, and under what circumstances shielding by dust makes a significant contribution.

Accepted by ApJ

http://www.ucolick.org/~krumholz/publications.html
http://arxiv.org/abs/0805.2947

SiO shocks of the protostellar jet HH 212: A search for jet rotation

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HH 212 is a nearby (400 pc) highly collimated protostellar jet powered by a Class 0 source in Orion. Our previous observations with the Submillimeter Array have shown that the inner part of the jet is well traced by SiO (J=8-7) shock emission. Here we present the observations at higher angular resolution of $\sim 0\farcs35$, searching for jet rotation with better resolved shock structures and kinematics. The jet has a transverse width of $\sim 80-140$ AU. The two SiO knots closest to the source are now spatially resolved into two bow shocks. The one in the south is better resolved, a precessing jet or an unseen wide-angle wind component may be required to reproduce its kinematics. Velocity gradients are seen across the tips of these two bow shocks and may arise from jet rotation. The launching radius of the jet, derived from the potential jet rotation, is $\lesssim 0.05-0.30$ AU in the inner disk, consistent with an inner disk wind bearing strong resemblance to the X-wind. Continuum emission is detected at 850 μm toward the source and can be approximately separated into two components. One is extended with a deconvolved size of $\sim 2''$ (800 AU), tracing bases around the SiO jet and probably a flattened envelope around the source. One is compact with a deconvolved size of $\sim 0\farcs25$ (or 100 AU), likely tracing a growing optically thick disk surrounded by an inner envelope and/or inner bases around the source.

Accepted by ApJ

http://www.asiaa.sinica.edu.tw/~cflee/research_publication.html

Star formation in the Trifid Nebula: Cores and filaments

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We aim to characterize the properties of the prestellar and protostellar condensations to understand the star formation processes at work in a young HII region. We have obtained maps of the 1.25mm thermal dust emission and the molecular gas emission over a region of $20' \times 10'$ around the Trifid Nebula (M20), with the IRAM 30m and the CSO telescopes as well as in the mid-infrared wavelength with ISO and SPITZER. Our survey is sensitive to features down to $N(H_2) \sim 10^{22}\,cm^{-2}$ in column density. The cloud material is distributed in fragmented dense gas filaments ($n(H_2)$ of a few $10^3\,cm^{-3}$) with sizes ranging from 1 to 10 pc. A massive filament, WF, with properties typical of Infra Red Dark Clouds, connects M20 to the W28 supernova remnant. We find that these filaments pre-exist the formation of the Trifid and were originally self-gravitating. The fragments produced are very massive (typically $100\,M_\odot$ or more) and are the progenitors of the cometary globules observed at the border of the HII region. We could identify 33 cores, 16 of which are currently forming stars. Most of the starless cores have typical H_2 densities of a few $10^4\,cm^{-3}$. They are usually gravitationally unbound and have low masses of a few $M_\odot$. The densest starless cores several $10^5\,cm^{-3}$ are located in condensation TC0, currently hit by the ionization front, and may be the site for the next generation of stars. The physical gas and dust properties of the cometary globules have been studied in detail and have been found very

similar. They all are forming stars. Several intermediate-mass protostars have been detected in the cometary globules and in the deeply embedded cores. Evidence of clustering has been found in the shocked massive cores TC3-TC4-TC5. M20 is a good example of massive-star forming region in a turbulent, filamentary molecular cloud. Photoionization appears to play a minor role in the formation of the cores. The observed fragmentation is well explained by MHD-driven instabilities and is usually not related to M20. We propose that the nearby supernova remnant W28 could have triggered the formation of protostellar clusters in nearby dense cores of the Trifid.

Accepted by Astronomy and Astrophysics

Planetesimal Evolution in Circumbinary Gaseous Disks: A Hybrid Model

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We study the dynamics of planetesimals embedded in a circumbinary protoplanetary disk. A hybrid numerical approach is developed where the evolution of the gaseous component of the disk is computed with the hydrodynamical code FARGO while the planetesimal trajectories are computed with an N-body code. The local gas density and velocity derived from the hydrodynamical portion are used to calculate the drag force and the gravitational attraction of the disk on the planetesimals. We explore the effects of spiral density wave patterns and of the disk eccentricity, both excited by the binary tidal perturbations, on the dynamical evolution of planetesimal orbits. A new definition of osculating orbital elements is given to properly account for the gravitational attraction of the disk. The outcomes of the numerical simulations show that the pericenter alignment of the planetesimal orbits is a robust result. It occurs for different values of the binary eccentricity and surface density profiles of the disk. However, the pericenters are less collimated compared to early predictions based on codes adopting a stationary and axisymmetric approximation for the disk. In addition, the eccentricity values are higher and depend on the semimajor axis of the bodies. Both these effects favor higher relative velocities between colliding planetesimals, making accretion less likely than previously thought. Small 100 m size bodies (planetesimal precursors) have a very high inward drift rate that might lead to a high-density belt in the proximity of the inner border of the disk. Fast accretion into larger bodies might occur in this region.

Published in The Astrophysical Journal (Vol. 681, p. 1599)

A Sub-AU Outwardly Truncated Accretion Disk around a Classical T Tauri Star

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We present the *Spitzer* Infrared Spectrograph (IRS) spectrum of SR 20, a 5–10 AU binary T Tauri system in the ρ Ophiuchi star-forming region. The spectrum has features consistent with the presence of a disk; however, the continuum slope is steeper than the $\lambda^{-3/4}$ slope of an infinite geometrically thin, optically thick disk, indicating that the disk is outwardly truncated. Comparison with photometry from the literature shows a large increase in the mid-infrared flux from 1993 to 1996. We model the spectral energy distribution and IRS spectrum with a wall+optically thick irradiated disk, yielding an outer radius of $0.39^{-0.01}_{+0.03}$ AU, much smaller than predicted by models of binary orbits. Using a two-temperature χ^2 minimization model to fit the dust composition of the IRS spectrum, we find that the disk has experienced significant grain growth: its spectrum is well fitted using opacities of grains larger than 1 μm. We conclude that the system experienced a significant gravitational perturbation in the 1990s.

Published by The Astrophysical Journal Letters (Vol. 683, p. L187)

Detection of Extended Hot Water in the Outflow from NGC 2071

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We report the results of spectroscopic mapping observations carried out toward an $\sim 1' \times 1'$ region within the northern lobe of the outflow from NGC 2071 using the Infrared Spectrograph (IRS) of the $Spitzer Space Telescope$. These observations covered the 5.237 μm spectral region and have led to the detection of a number of ionic, atomic, and molecular lines, including fine-structure emission of Si^+, Fe^+, S^{++}, S, the $S(0)$–$S(7)$ pure rotational lines of H_2, the $R(3)$ and $R(4)$ transitions of HD, and at least eleven transitions of H_2O. In addition, the 6.2, 7.4, 7.6, 7.9, 8.6, and 11.3 μm PAH emission bands were also observed and several transitions of OH were tentatively detected. Most of the detected line transitions were strong enough to map, including, for the first time, three transitions of hot H_2O. We find that (1) the water emission is extended; (2) the extended emission is aligned with the outflow; and (3) the spatial distribution of the water emission generally follows that observed for H_2. Based on the measured line intensities, we derive an HD abundance relative to H_2 of (1.1–1.8) $\times 10^{-5}$ and an H_2O number density of 12–29 cm^{-3}. The H_2 density in the water-emitting region is not well constrained by our observations, but is likely between 3×10^4 and 10^6 cm^{-3}, yielding an H_2O abundance relative to H_2 of between 2×10^{-5} and 6×10^{-4}. Finally, we note a possible departure from the H_2O ortho-to-para ratio of 3:1 expected for water formed in hot postshocked gas, suggesting that a significant fraction of the water vapor we detect may arise from H_2O sputtered from cold dust grains.

Published by The Astrophysical Journal (Vol. 683, p. 876)

Discovery of a Young Massive Stellar Cluster near HESS J1813–178

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We present the serendipitous discovery of a young stellar cluster in the Galactic disk at $l = 12°$. Using Keck/NIRSPEC, we obtained high- and low-resolution spectroscopy of several stars in the cluster, and we identified one red supergiant and two blue supergiants. The radial velocity of the red supergiant provides a kinematic cluster distance of 4.7 ± 0.4 kpc, implying luminosities of the stars consistent with their spectral types. Together with the known Wolf-Rayet star located 2.4′ from the cluster center, the presence of the red supergiant and the blue supergiants suggests a cluster age of 6–8 Myr and an initial mass of $>\sim 2000\ M_\odot$. Several stars in the cluster are coincident with X-ray sources, including the blue supergiants and the Wolf-Rayet star. This is indicative of a high binary fraction and is reminiscent of the

massive young cluster Westerlund 1. The cluster is coincident with two supernova remnants, SNR G12.72–0.0 and G12.82–0.02, and the highly magnetized pulsar associated with the TeV γ-ray source HESS J1813–178. The mixture of spectral types suggests that the progenitors of these objects had initial masses of 20–30 $M_\odot$.

Published by The Astrophysical Journal Letters (Vol. 683, p. L155)

New very massive stars in Cygnus OB2

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Context. The compact association Cygnus OB2 is known to contain a large population of massive stars, but its total mass is currently a matter of debate. While recent surveys have uncovered large numbers of OB stars in the area around Cyg OB2, detailed study of the optically brightest among them suggests that most are not part of the association.
Aims. We observed an additional sample of optically faint OB star candidates, with the aim of checking if more obscured candidates are correspondingly more likely to be members of Cyg OB2.
Methods. Low resolution spectra of 9 objects allow the rejection of one foreground star and the selection of four O-type stars, which were later observed at higher resolution. In a subsequent run, we observed three more stars in the classification region and three other stars in the far red.
Results. We identify five (perhaps six) new evolved very massive stars and three main sequence O-type stars, all of which are likely to be members of Cyg OB2. The new findings allow a much better definition of the upper HR diagram, suggesting an age ~2.5 Myr for the association and hinting that the O3-5 supergiants in the association are blue stragglers, either younger or following a different evolutionary path from other cluster members. Though the bulk of the early stars seems to belong to an (approximately) single-age population, there is ample evidence for the presence of somewhat older stars at the same distance.
Conclusions. Our results suggest that, even though Cyg OB2 is unlikely to contain as many as 100 O-type stars, it is indeed substantially more massive than was thought prior to recent infrared surveys.

Published by Astronomy & Astrophysics (Vol. 487, p. 575)

Subaru High-dispersion Spectroscopy of Hα and [N II] 6583 Å Emission in the HH 46/47 Jet

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We present slit-scan observations of the Hα and [N II] 6583 Å emission lines toward the HH 46/47 jet with the Subaru Telescope. The spectral resolution of R = 3.6×10^4 allowed us to study the kinematics of individual features in unprecedented detail. The spectra show (1) the main jet component ($V_{\rm LSR} \sim -160$ km s^{-1}), which is seen in both Hα and [N II] emission, and (2) distinct lower velocity components ($|V_{\rm LSR}| \leq 120$ km s^{-1}), which are clearly seen in Hα albeit marginal or absent in [N II]. The measured [N II]/Hα ratios are 0.2–0.5 and <0.2 (typically <0.1) in these two components, respectively. The velocities of the Hα and [N II] emission in the main jet component match each other

well, suggesting that these are associated with the ejecta. The low velocity components are associated with one-sided bow shocks and an Hα filament, where the jet interacts with the ambient gas. The line profiles at the bow shocks and an Hα filament suggest that the surrounding gas moves outwards by $\sim$200 km s^{-1} due to prompt entrainment. The difference in excitation conditions between the two velocity components is explained if the preshock gas is partially ionized in the main jet component, at the apices of bow shocks and Hα filaments, while the ambient gas is almost neutral.

Accepted by Astrophysical Journal

Resolving distance ambiguities towards 6.7 GHz methanol masers

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Context. Distances to most star forming regions are determined using kinematics, through the assumption that the observed radial velocity arises from the motion of the source with respect to the Sun resulting from the differential rotation of Galaxy. The primary challenge associated with the application of this technique in the inner Galaxy is the kinematic distance ambiguity.
Aims. In this work, we aim to resolve the kinematic distance ambiguity towards a sample of 6.7 GHz methanol masers, which are signposts of the early stages of massive star formation.
Methods. We measured 21 cm H I absorption spectra using the Very Large Array in C and CnB configurations. A comparison of the maximum velocity of H I absorption with the source velocity and tangent point velocity was used to resolve the kinematic distance ambiguity.
Results. We resolved the distance ambiguity towards 41 sources. Distance determinations that are in conflict with previous measurements are discussed. The NE2001 spiral arm model is broadly consistent with the locations of the star forming complexes. We find that the use of vertical scale height arguments to resolve the distance ambiguity can lead to erroneous classifications for a significant fraction of sources.

Published by Astronomy & Astrophysics (Vol. 486, p. 191)

Molecular Emission Line Formation in Prestellar Cores

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We investigate general aspects of molecular line formation under conditions which are typical of prestellar cores. Focusing on simple linear molecules, we study formation of their rotational lines by radiative transfer simulations. We present a thermalization diagram to show the effects of collisions and radiation on the level excitation. We construct a detailed scheme (contribution chart) to illustrate the formation of emission line profiles. This chart can be used as an efficient tool to identify which parts of the cloud contribute to a specific line profile. We show how molecular line characteristics for uniform model clouds depend on hydrogen density, molecular column density, and kinetic temperature. The results are presented in a 2D plane to illustrate cooperative effects of the physical factors. We also use a core model with a non-uniform density distribution and chemical stratification to study the effects of cloud contraction and rotation on spectral line maps. We discuss the main issues that should be taken into account when dealing with interpretation and simulation of observed molecular lines.

Accepted by ApJ

The enigmatic young object: Walker 90/V590 Monocerotis

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Aims. We assess the evolutionary status of the intriguing object Walker 90/V590 Mon, which is located about 20 arcmin northwest of the Cone Nebula near the center of the open cluster NGC 2264. This object, according to its most recent optical spectral type determination (B7), which we confirmed, is at least 3 mag too faint in V for the cluster distance, but it shows the classical signs of a young pre-main sequence object, such as highly variable H emission, Mg II emission, IR excess, UV continuum, and optical variability.
Methods. We analyzed a collection of archival and original data on Walker 90, covering 45 years including photometry, imaging, and spectroscopic data ranging from ultraviolet to near-infrared wavelengths.
Results. According to star formation processes, it is expected that, as this object clears its primordial surroundings, it should become optically brighter, show a weakening of its IR excess and present decreasing line emissions. This behavior is supported by our observations and analysis, but timescales are expected to be longer than the one observed here. Based on photometric data secured in 2007, we find Walker 90 at its brightest recorded optical magnitude ($12\bar{.}47 \pm 0.06$) . We document an evolution in spectral type over the past five decades (from A2/A3 to currently B7 and as early as B4), along with a decrease in the near-infrared K fluxes. From near-infrared $VISIR$ images secured in 2004, Walker 90 appears as a point source placing an upper limit of $< 0.1''$ for its diameter. Evidence of turbulent inflows is found in rapidly changing inverse P-Cygni profiles in the lower Balmer lines, with a broadening of ± 400 km s^{-1} in Hα and a redshifted component in Hβ with a terminal velocity of ~ 600 km s^{-1}. The measured steep UV continuum fluxes (mimicking a star as early as B4), added to a tentative identification of N V emission, suggest a strong non-photospheric component, typically of fluxes arising from a thermally inhomogeneous accretion disk. We detect a well defined 2200 Å bump, indicative of dense material in the line-of-sight. We conclude that many observational features are explained if W90 is a flared disk system, surrounded by an inclined optically thick accretion disk.

Published by Astronomy & Astrophysics (Vol. 486, p. 533)

Ionization front-driven turbulence in the clumpy interstellar medium

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We present 3D radiation-gasdynamical simulations of an ionization front running into a dense clump. In our setup, a B0 star irradiates an overdensity which is at a distance of 10 pc and modelled as a supercritical 100 $M_{\rm sol}$ Bonnor-Ebert sphere. The radiation from the star heats up the gas and creates a shock front that expands into the interstellar medium. The shock compresses the clump material while the ionizing radiation heats it up. The outcome of this "cloud-crushing" process is a fully turbulent gas in the wake of the clump. In the end, the clump entirely dissolves. We propose that this mechanism is very efficient in creating short-living supersonic turbulence in the vicinity of massive stars.

Accepted by Physica Scripta (Refereed conference proceedings of the Workshop on Turbulent Mixing, TMBW'07, Trieste, Aug 07)

http://arxiv.org/abs/0808.2744

New Young Brown Dwarfs in the Orion Molecular Cloud 2/3 Region

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Forty new low mass members with spectral types ranging from M4−M9 have been confirmed in the Orion Molecular Cloud 2/3 region. Through deep, $I-$, $J-$, $H-$ and $K-$band photometry of a $20' \times 20'$ field in OMC 2/3, we selected brown dwarf candidates for follow-up spectroscopy. Low resolution far-red and near-infrared spectra were obtained for the candidates, and 19 young brown dwarfs in the OMC 2/3 region are confirmed. They exhibit spectral types of M6.5−M9, corresponding to approximate masses of 0.075−0.015 $M_\odot$ using the evolutionary models of BCAH98. At least one of these *bona fide* young brown dwarfs has strong Hα emission, indicating that it is actively accreting. In addition, we confirm 21 new low mass members with spectral types of M4−M6, corresponding to approximate masses of 0.35−0.10 $M_\odot$ in OMC 2/3. By comparing pre-main sequence tracks to the positions of the members in the H-R diagram, we find that most of the brown dwarfs are less than 1 Myr, but find a number of low mass stars with inferred ages greater than 3 Myr. The discrepancy in the stellar and substellar ages is due to our selection of only low luminosity sources; however, the presence of such objects implies the presence of an age spread in the OMC 2/3 region. We discuss possible reasons for this apparent age spread.

Accepted by Astron. J.

http://xxx.lanl.gov/abs/0806.2818

Tidal Disruption of Protoclusters in Giant Molecular Clouds

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We study the collapse of protoclusters within a giant molecular cloud (GMC) to determine the conditions under which collapse is significantly disrupted. Motivated by observations of star-forming regions which exhibit flattened cloud structures, this study considers collapsing protoclusters with disk geometries. The collapse of a 10^3 $M_\odot$ protocluster initially a distance of 2–10 pc from a 10^3–10^6 $M_\odot$ point mass is numerically calculated. Simulations with zero initial relative velocity between the two are completed, as well as simulations with relative velocities consistent with those observed in GMCs. The results allow us to define the conditions under which it is safe to assume that protocluster collapse proceeds as if in isolation. For instance, we find that the collapse of a 10^3 $M_\odot$ protocluster will be significantly disrupted if it is within 2–4 pc of a 10^4 $M_\odot$ point mass. Thus, the collapse of a 10^3 $M_\odot$ protocluster can be considered to proceed as if in isolation if it is more than $\sim$4 pc away from a 10^4 $M_\odot$ compact object. In addition, in no portion of the sampled parameter space does the gravitational interaction between the protocluster disk and the massive particle significantly disperse the disk into the background GMC. We discuss the distribution of clusters of young stellar objects within the Perseus and Mon R2 star-forming regions, which are consistent with the results of our simulations and the limitations of our results in gas dominated regions such as the Orion cloud.

Published by The Astrophysical Journal (Vol. 683, p. 226)

High-resolution Observations of Molecular Lines toward the Hot Core G28.20-0.04N

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We present the results from arcsecond resolution observations of various line transitions at 1.3 mm toward hypercom-

pact HII region G28.20-0.04N. With the SMA data, we have detected and mapped the transitions in the CH_3CN, CO, ^{13}CO, SO_2, OCS, and CH_3OH molecular lines as well as the radio recombination line H30α. The observations and analysis indicate a hot core associated with G28.20-0.04N. The outflow and possible rotation are detected in this region.

Accepted by ApJL

http://adsabs.harvard.edu/abs/2008arXiv0808.3443Q

Cooling of Young Stars Growing by Disk Accretion

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In the initial formation stages young stars must acquire a significant fraction of their mass by accretion from a circumstellar disk that forms in the center of a collapsing protostellar cloud. Throughout this period mass accretion rates reach 10^{-6} to 10^{-5} $M_\odot$ yr^{-1}, allowing the disk to extend all the way to the stellar surface unimpeded by the protostellar magnetic field. We study the effect of irradiation of the stellar surface produced by the hot inner disk on properties of accreting fully convective low-mass stars and also look at objects such as young brown dwarfs and giant planets. At high $\dot{M}$ irradiation raises the surface temperature of the equatorial region above the photospheric temperature T_0 that a star would have in the absence of accretion. In these regions an almost isothermal outer radiative zone forms on top of the fully convective interior, leading to a suppression of the local internal cooling flux derived from stellar contraction (similar suppression occurs in irradiated "hot Jupiters"). The high-latitude (polar) parts of the stellar surface, where disk irradiation is weak, preserve their temperature at the level of T_0. The total intrinsic luminosity integrated over the whole stellar surface is reduced compared to the nonaccreting case, by up to a factor of several for some objects (young brown dwarfs, stars in quasar disks, and forming giant planets), potentially leading to the retardation of stellar contraction.

Published in The Astrophysical Journal (Vol. 682, p. 527)

Stellar Growth by Disk Accretion: The Effect of Disk Irradiation on the Protostellar Evolution

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Young stars are expected to gain most of their mass by accretion from a disk that forms around them as a result of angular momentum conservation in the collapsing protostellar cloud. Accretion initially proceeds at high rates of 10^{-6} -10^{-5} $M_\odot$ yr^{-1}, resulting in strong irradiation of the stellar surface by the hot inner portion of the disk and leading to the suppression of the intrinsic stellar luminosity. Here we investigate how this luminosity suppression affects evolution of the protostellar properties. Using a simple model based on the energy balance of accreting star, we demonstrate that disk irradiation causes only a slight increase of the protostellar radius, at the level of several percent. Such a weak effect is explained by a minor role played by the intrinsic stellar luminosity (at the time when it is significantly altered by irradiation) in the protostellar energy budget compared to the stellar deuterium burning luminosity and the inflow of the gravitational potential energy brought in by the freshly accreted material. Our results justify the neglect of irradiation effects in previous studies of the protostellar growth via disk accretion. Evolution of some other actively accreting objects such as young brown dwarfs and planets should also be only weakly sensitive to the effects of disk irradiation.

Published by The Astrophysical Journal (Vol. 682, p. 542)

SMA observations of Infrared Dark Clouds: A tale of two cores

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We present high-angular resolution sub-millimeter continuum images and molecular line spectra obtained with the Submillimeter Array toward two massive cores that lie within Infrared Dark Clouds; one actively star-forming (G034.43+00.24 MM1) and the other more quiescent (G028.53−00.25 MM1). The high-angular resolution sub-millimeter continuum image of G034.43+00.24 MM1 reveals a compact ($\sim$ 0.03 pc) and massive ($\sim 29\,M_\odot$) structure while the molecular line spectrum shows emission from numerous complex molecules. Such a rich molecular line spectrum from a compact region indicates that G034.43+00.24 MM1 contains a hot molecular core, an early stage in the formation of a high-mass protostar. Moreover, the velocity structure of its ^{13}CO (3–2) emission indicates that this B0 protostar may be surrounded by a rotating circumstellar envelope. In contrast, the sub-millimeter continuum image of G028.53−00.25 MM1 reveals three compact ($<$ 0.06 pc), massive (9–21 $M_\odot$) condensations but with no lines detected in its spectrum. We suggest that the core G028.53−00.25 MM1 is in a very early stage in the high-mass star-formation process; its size and mass are sufficient to form at least one high-mass star, yet it shows no signs of localized heating. Because the combination of high velocity line wings with a large IR–mm bolometric luminosity ($\sim 10^2\,L_\odot$) indicates that this core has already begun to form accreting protostars, we speculate that the condensations may be in the early phase of accretion and may eventually become high-mass protostars. We, therefore, have found the possible existence of two high-mass star-forming cores; one in a very early phase of star-formation and one in the later hot core phase. Together the properties of these two cores support the idea that the earliest stages of high-mass star-formation occur within IRDCs.

Accepted by ApJ

http://lanl.arxiv.org/abs/0808.2973

New Brown Dwarf Disks in the TW Hydrae Association

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In our analysis of Spitzer IRS archival data on the stellar and substellar members of the TW Hydrae association (TWA), we have discovered two new brown dwarf disks: a flat, optically thick disk around SSSPM J1102–3431 (SSSPM 1102) and a transition disk around 2MASS J1139511–315921 (2M1139). The disk structure for SSSPM 1102 is found to be very similar to the known brown dwarf disk 2MASSW J1207334–393254 (2M1207), with excess emission observed at wavelengths as short as 5 μm. No excess emission shortward of $\sim$20 μm is seen from 2M1139, but it flares up at longer wavelengths and is the first transition disk detected among the substellar members of the TWA. We also report on *Spitzer* 70 μm observations and the presence of a 10 μm silicate absorption feature for 2M1207. The absorption can be attributed to a nearly edge-on disk, at 75° inclination. The 10 μm spectrum for 2M1207 shows crystalline forsterite features, with a peak in absorption near 11.3 μm. No silicate absorption or emission is observed toward SSSPM 1102. While only six of 25 stellar members show excess emission at these mid-infrared wavelengths, *all* of the TWA brown dwarfs that have been observed so far with *Spitzer* show signs of disks around them, resulting in a disk fraction of at least 60%. This is a considerable fraction at the relatively old age of $\sim$10 Myr. A comparison with younger clusters indicates that by the age of the TWA ($\sim$10 Myr), the disk fraction for brown dwarfs has not decreased, whereas it drops by a factor of $\sim$2 for the higher mass stars. This suggests longer disk decay timescales for brown dwarfs as compared with higher mass stars.

Published by The Astrophysical Journal (Vol. 681, p. 1584)

The HST/ACS Atlas of Protoplanetary Disks in the Great Orion Nebula

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We present the atlas of protoplanetary disks in the Orion Nebula based on the ACS/WFC images obtained for the *HST Treasury Program on the Orion Nebula Cluster*. The observations have been carried out in 5 photometric filters nearly equivalent to the standard $B, V, H\alpha, I$, and z passbands. Our master catalog lists 178 externally ionized protoplanetary disks (*proplyds*), 28 disks seen only in absorption against the bright nebular background (*silhouette disks*, 8 disks seen only as dark lanes at the midplane of extended polar emission (*bipolar nebulae* or *reflection nebulae*) and 5 sources showing jet emission with no evidence of neither external ionized gas emission nor dark silhouette disks. Many of these disks are associated with jets seen in $H\alpha$ and circumstellar material detected through reflection emission in our broad-band filters; approximately 2/3 have identified counterparts in x-rays. A total of 47 objects (29 proplyds, 7 silhouette disks, 6 bipolar nebulae, 5 jets with no evidence of proplyd emission or silhouette disk) are new detections with HST. We include in our list 4 objects previously reported as circumstellar disks which have not been detected in our HST/ACS images either because they are hidden by the bleeding trails of a nearby saturated bright star or because of their location out of the HST/ACS Treasury Program field. Other 31 sources previously reported as extended objects do not harbor a stellar source in our HST/ACS images. We also report on the detection of 16 red, elongated sources. Their location at the edges of the field, far from the Trapezium Cluster core ($\gtrsim 10'$), suggests that these are probably background galaxies observed through low extinction regions of the Orion Molecular Cloud OMC-1.

Accepted by Astron. J.

High Angular Resolution Observations at 7-mm of the Core of the Quadrupolar HH 111/121 Outflow

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We present sensitive, high angular resolution ($0\farcs05$) VLA continuum observations made at 7 mm of the core of the HH 111/121 quadrupolar outflow. We estimate that at this wavelength the continuum emission is dominated by dust, although a significant free-free contribution ($\sim$30%) is still present. The observed structure is formed by two overlapping, elongated sources approximately perpendicular to each other as viewed from Earth. We interpret this structure as either tracing two circumstellar disks that exist around each of the protostars of the close binary source at the core of this quadrupolar outflow or a disk and a jet perpendicular to it. Both interpretations have advantages and disadvantages, and future high angular resolution spectroscopic millimeter observations are required to favor one of them in a more conclusive way.

Accepted by Astron. J.

arXiv: 0808.3201

FLAMES spectroscopy of low-mass stars in the young clusters σ Ori and λ Ori

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Aims. We performed a detailed membership selection and studied the accretion properties of low-mass stars in the two apparently very similar young (1-10 Myr) clusters σ Ori and λ Ori .
Methods. We observed 98 and 49 low-mass (0.2-1.0 $M_\odot$) stars in σ Ori and λ Ori respectively, using the multi-object optical spectrograph FLAMES at the VLT, with the high-resolution ($R \sim 17000$) HR15N grating (6470-6790 Å). We used radial velocities, Li and Hα to establish cluster membership and Hα and other optical emission lines to analyze the accretion properties of members.
Results. We identified 65 and 45 members of the σ Ori and λ Ori clusters, respectively, and discovered 16 new candidate binary systems. We also measured rotational broadening for 20 stars and estimated the mass accretion rates in 25 stars of the σ Ori cluster, finding values between 10^{-11} and $10^{-7.7}$ $M_\odot$ yr^{-1} and in 4 stars of the λ Ori cluster, finding values between 10^{-11} and $10^{-10.1}$ $M_\odot$ yr^{-1}. Comparing our results with the infrared photometry obtained by the *Spitzer* satellite, we find that the fraction of stars with disks and the fraction of active disks is larger in the σ Ori cluster (52 ± 9% and 78 ± 16%) than in λ Ori (28 ± 8% and 40 ± 20%).
Conclusions. The different disk and accretion properties of the two clusters could be due either to the effect of the high-mass stars and the supernova explosion in the λ Ori cluster or to different ages of the cluster populations. Further observations are required to draw a definitive conclusion.

Published by Astronomy & Astrophysics (Vol. 488, p. 167)

Extending the Model of KH 15D: Estimating the Effects of Forward Scattering and Curvature of the Occulting Ring Edge

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The periodic eclipses of the premain-sequence binary KH 15D have been explained by a circumbinary dust ring inclined to the orbital plane, which causes occultations of the stars as they pass behind the ring edge. We compute the extinction and forward scattering of light by the edge of the dust ring in order to explain (1) the gradual slope directly preceding total eclipse, (2) the gradual decline at the end of ingress, and (3) the slight rise in flux at mideclipse. The size of the forward-scattering halo indicates that the dust grains have a radius of $a \sim 6(D/3\ \mathrm{AU})$ μm, where D is the distance of the edge of the ring from the system barycenter. This dust size estimate agrees well with estimates of the dust grain size from polarimetry, adding to the evidence that the ring lies at several AU. Finally, the ratio of the fluxes during an eclipse to those not during an eclipse independently indicates that the ring lies at a few AU.

Published in The Astrophysical Journal (Vol. 681, p. 1377)

Long-term monitoring of θ^1 Ori C: the spectroscopic orbit and an improved rotational period

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Context. The young O-type star θ^1 Ori C, the brightest star of the Trapezium cluster in Orion, is one of only two

known magnetic rotators among the O stars. However, not all spectroscopic variations of this star can be explained by the magnetic rotator model. We present results from a long-term monitoring to study these unexplained variations and to improve the stellar rotational period.
Aims. We want to study long-term trends of the radial velocity of θ^1 Ori C, to search for unusual changes, to improve the established rotational period and to check for possible period changes.
Methods. We combine a large set of published spectroscopic data with new observations and analyze the spectra in a homogeneous way. We study the radial velocity from selected photo-spheric lines and determine the equivalent width of the Hα and HeII λ4686 lines.
Results. We find evidence for a secular change of the radial velocity of θ^1 Ori C that is consistent with the published interferometric orbit. We refine the rotational period of θ^1 Ori C and discuss the possibility of detecting period changes in the near future.

Published by Astronomy & Astrophysics (Vol. 487, p. 323)

Millimeter- and Submillimeter- Wave Observations of the OMC-2/3 Region. III. An Extensive Survey for Molecular Outflows

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Using the ASTE 10 m submillimeter telescope and the 1.4 m Infrared Survey Facility (IRSF), we performed an extensive outflow survey in the Orion Molecular Cloud -2 and -3 region. Our survey, which includes 41 potential star-forming sites, has been newly compiled using multi-wavelength data based on millimeter- and submillimeter-continuum observations as well as radio continuum observations. From the CO (3-2) observations performed with the ASTE 10 m telescope, we detected 14 CO molecular outflows, seven of which were newly identified. This higher detection rate, as compared to previous CO (1-0) results in the same region, suggests that CO (3-2) may be a better outflow tracer. Physical properties of these outflows and their possible driving sources were derived. Derived parameters were compared with those of CO outflows in low- and high-mass starforming regions. We show that the CO outflow momentum correlates with the bolometric luminosity of the driving source and with the envelope mass, regardless of the mass of the driving sources. In addition to these CO outflows, seven sources having NIR features suggestive of outflows were also identified.

Accepted by Astrophysical Journal

http://arxiv.org/abs/0808.0561

Dusty disk wind in young binary systems viewed pole-on

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A model of a young binary system with companions of unequal mass whose orbital plane is inclined at a large angle to the line of sight is examined. The system components are assumed to accrete matter from the remains of the protostellar cloud. It is found that eclipsing of the primary component by the disk wind of the secondary can be observed when the plane of the orbit is inclined at a large angle to the line of sight or even when the binary system is observed pole-on.

Published by Astrophysics (Vol. 51, p. 267)

A Tale of Two Herbig Ae stars -MWC275 and AB Aurigae: Comprehensive Models for SED and Interferometry

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We present comprehensive models for the Herbig Ae stars MWC275 and AB Aur that aim to explain their spectral energy distribution (from UV to millimeter) and long baseline interferometry (from near-infrared to millimeter) simultaneously. Data from the literature, combined with new mid-infrared (MIR) interferometry from the Keck Segment Tilting Experiment, are modeled using an axisymmetric Monte Carlo radiative transfer code. Models in which most of the near-infrared (NIR) emission arises from a dust rim fail to fit the NIR spectral energy distribution (SED) and sub-milli-arcsecond NIR CHARA interferometry. Following recent work, we include an additional gas emission component with similar size scale to the dust rim, inside the sublimation radius, to fit the NIR SED and long-baseline NIR interferometry on MWC275 and AB Aur. In the absence of shielding of star light by gas, we show that the gas-dust transition region in these YSOs will have to contain highly refractory dust, sublimating at 1850K. Despite having nearly identical structure in the thermal NIR, the outer disks of MWC275 and AB Aur differ substantially. In contrast to the AB Aur disk, MWC275 lacks small grains in the disk atmosphere capable of producing significant 10-20micron emission beyond 7AU, forcing the outer regions into the "shadow" of the inner disk.

Accepted by ApJ

http://xxx.lanl.gov/abs/0808.1728

New composite models of partially ionized protoplanetary disks

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We study an accretion disk in which three different regions may coexist: MHD turbulent regions, dead zones and gravitationally unstable regions. Although the dead zones are stable, there is some transport due to the Reynolds stress associated with waves emitted from the turbulent layers. We model the transport in each of the different regions by its own α parameter, this being 10 to 10^3 times smaller in dead zones than in active layers. In gravitationally unstable regions, α is determined by the fact that the disk self–adjusts to a state of marginal stability. We construct steady–state models of such disks. We find that for uniform mass flow, the disk has to be more massive, hotter and thicker at the radii where there is a dead zone. In disks in which the dead zone is very massive, gravitational instabilities are present. Whether such models are realistic or not depends on whether hydrodynamical fluctuations driven by the turbulent layers can penetrate all the way inside the dead zone. This may be more easily achieved when the ratio of the mass of the active layer to that of the dead zone is relatively large, which in our models corresponds to α in the dead zone being about 10% of α in the active layers. If the disk is at some stage of its evolution not in steady–state, then the surface density will evolve toward the steady–state solution. However, if α in the dead zone is much smaller than in the active zone, the timescale for the parts of the disk beyond a few AU to reach steady–state may become longer than the disk lifetime. Steady–state disks with dead zones are a more favorable environment for planet formation than standard disks, since the dead zone is typically 10 times more massive than a corresponding turbulent zone at the same location.

Accepted by ApJ

Planet formation in α Centauri A revisited: not so accretion friendly after all

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We numerically explore planet formation around α Centauri A by focusing on the crucial planetesimals-to-embryos phase. Our approach is significantly improved with respect to the earlier work of Marzari & Scholl, since our deterministic N-body code computing the relative velocities between test planetesimals handles bodies with different size. Due to this step-up, we can derive the accretion versus fragmentation trend of a planetesimal population having any given size distribution. This is a critical aspect of planet formation in binaries since the pericenter alignment of planetesimal orbits due to the gravitational perturbations of the companion star and to gas friction strongly depends on size. Contrary to Marzari & Scholl, we find that, for the nominal case of a Minimum-Mass Solar Nebula gas disc, the region beyond ~0.5 au from the primary is strongly hostile to planetesimal accretion. In this area, impact velocities between different-sized bodies are increased, by the differential orbital phasing, to values too high to allow mutual accretion. For any realistic size distribution for the planetesimal population, this accretion-inhibiting effect is the dominant collision outcome and the accretion process is halted. Results are relatively robust with respect to the profile and density of the gas disc. Except for an unrealistic almost gas-free case, the inner 'accretion-safe' area never extends beyond 0.75 au. We conclude that planet formation is very difficult in the terrestrial region around α Centauri A, unless it started from fast-formed very large (>30 km) planetesimals. Notwithstanding these unlikely initial conditions, the only possible explanation for the presence of planets around 1 au from the star would be the hypothetical outward migration of planets formed closer to the star or a different orbital configuration in the binary's early history. Our conclusions differ from those of several studies focusing on the later embryos-to-planets stage, confirming that the planetesimals-to-embryos phase is more affected by binary perturbations.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 388, p. 1528)

A discontinuity in the low-mass IMF – the case of high multiplicity

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The empirical binary properties of brown dwarfs (BDs) differ from those of normal stars suggesting BDs form a separate population. Recent work by Thies and Kroupa revealed a discontinuity of the initial mass function (IMF) in the very-low-mass star regime under the assumption of a low multiplicity of BDs of about 15 per cent. However, previous observations had suggested that the multiplicity of BDs may be significantly higher, up to 45 per cent. This contribution investigates the implication of a high BD multiplicity on the appearance of the IMF for the Orion Nebula Cluster, Taurus-Auriga, IC 348 and the Pleiades. We show that the discontinuity remains pronounced even if the observed MF appears to be continuous, even for a BD binary fraction as high as 60%. We find no evidence for a variation of the BD IMF with star-forming conditions. The BD IMF has a power-law index $\alpha_{\rm BD} \approx +0.3$ and about 2 BDs form per 10 low-mass stars assuming equal-mass pairing of BDs.

Accepted by MNRAS

http://arxiv.org/abs/0808.2644

The RMS survey — ^{13}CO observations of candidate massive YSOs in the northern Galactic plane

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Context. The Red MSX Source (RMS) survey is an ongoing multi-wavelength observational programme designed to return a large, high-resolution mid-infrared colour-selected sample of massive young stellar objects (MYSOs). We have identified ∼2000 MYSO candidates located within our Galaxy by comparing the colours of MSX and 2MASS point sources to those of known MYSOs. The aim of our follow-up observations is to identify other objects with similar colours such as ultra compact (UC) HII regions, evolved stars and planetary nebulae (PNe) and distinguish between genuine MYSOs and nearby low-mass YSOs.
Aims. A critical part of our follow-up programme is to conduct ^{13}CO molecular line observations in order to determine kinematic distances to all of our MYSO candidates. These distances will be used in combination with far-IR and (sub)millimetre fluxes to determine bolometric luminosities which will allow us to identify and remove nearby low-mass YSOs. In addition these molecular line observations will help in identifying evolved stars which are weak CO emitters.
Methods. We have used the 15 m James Clerk Maxwell Telescope (JCMT), the 13.7 m telescope of the Purple Mountain Observatory (PMO), the 20 m Onsala telescope and the 22 m Mopra telescope to conduct molecular line observations towards 508 MYSOs candidates located in the 1st and 2nd Quadrants. These observations have been made at the J=1-0 (Mopra, Onsala and PMO) and J=2-1 (JCMT) rotational transition frequency of ^{13}CO molecules and have a spatial resolution of $\sim 20''$–$55''$, a sensitivity of $T_{\rm A}^* \simeq 0.1$ K and a velocity resolution of ∼0.2 km s^{-1}. We complement these targeted observations with ^{13}CO spectra extracted from the Galactic Ring Survey (GRS), which have a velocity resolution of ∼0.21 km s^{-1} and sensitivity $T_{\rm A}^*$ K, towards a further 403 RMS sources.
Results. In this paper we present the results and analysis of the ^{13}CO spectra obtained towards 911 MYSO candidates. We detect ^{13}CO emission towards 780 RMS sources which corresponds to approximately 84% of those observed. A total of 2595 emission components are detected above 3σ level (typically $T_{\rm A}^* \geq 0.3$ K), with multiple components being observed towards the majority of these sources — 520 sources (∼56%) — with an average of ∼4 molecular clouds detected along each line of sight. These multiple emission features make it difficult to assign a unique kinematic velocity to many of our sample. We have used archival CS (J=2-1) and maser velocities to resolve the component multiplicity towards 175 sources (∼20%) and have derived a criterion which is used to identify the most likely component for a further 191 multiple component sources. Combined with the single component detections we have obtained unambiguous kinematic velocities for 638 of the 780 MYSOs candidates towards which CO is detected (∼80% of the detections). The 141 sources for which we have not been able to determine the kinematic velocity will require additional line data. Using the rotation curve of Brand and Blitz (1993) and their radial velocities we calculate kinematic distances for all detected components.

Published by Astronomy & Astrophysics (Vol. 487, p. 253)

Characterizing Star Formation Activity in Infrared Dark Cloud MSXDC G048.65-00.29

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Infrared Dark Clouds (IRDCs), condensed regions of the ISM with high column densities, low temperatures and high masses, are suspected sites of star formation. Thousands of IRDCs have already been identified. To date, it has not been resolved whether IRDCs always show star formation activity and, if so, if massive star formation ($>\sim 8M_\odot$) is the rule or the exception in IRDCs. Previous analysis of sub-millimeter cores in the cloud MSXDC G048.65-00.29

(G48.65) indicates embedded star formation activity. To characterize this activity in detail, mid-infrared photometry (3–30 μm) has been obtained with the *Spitzer Space Telescope*. This paper analyzes the point sources seen in the 24 μm band, combined with counterparts or upper limits at shorter and longer wavelengths. Data points in wavelength bands ranging from 1 μm up to 850 μm (*Spitzer* IRAC, MIPS 24 and 70 μm, archival 2MASS data and sub-millimeter counterparts) are used to compare each 24 μm source to a set of Spectral Energy Distributions of Young Stellar Object (YSO) models. By assessing the models that fit the data, an attempt is made to identify YSOs as such and determine their evolutionary stages and stellar masses. A total of 17 sources are investigated, 13 of which are classified as YSOs, primarily – but not exclusively – in an early embedded phase of star formation. The modeled masses of the central stellar objects range from sub-solar to $\sim$8 $M_{\odot}$. Every YSO is at less than 1 pc projected distance from its nearest YSO neighbor. We conclude that IRDC G48.65 is a region of active star formation. We find YSOs in various evolutionary phases, indicating that the star formation in this cloud is not an instantaneous process. The inferred masses of the central objects suggest that this IRDC hosts only low to intermediate mass YSOs and none with masses exceeding $\sim 8 M_{\odot}$.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/0807.3628

Infrared Dust Bubbles: Probing the Detailed Structure and Young Massive Stellar Populations of Galactic HII Regions

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We present an analysis of wind-blown, parsec-sized, mid-infrared bubbles and associated star formation using the GLIMPSE IRAC, MIPSGAL MIPS, and MAGPIS VLA surveys. Three bubbles from the Churchwell et al. catalog were selected. The relative distribution of the ionized gas (based on 20 cm emission), PAH emission (based on 8 μm, 5.8 μm, and lack of 4.5 μm emission), and hot dust (24 μm emission) is compared. At the center of each bubble there is a region containing ionized gas and hot dust surrounded by PAHs. We identify the likely source(s) of the stellar wind and ionizing flux producing each bubble based on SED fitting to numerical hot stellar photosphere models. Candidate YSOs are also identified using SED fitting, including several sites of possible triggered star formation.

Published by The Astrophysical Journal (Vol. 681, p. 1341)

The HD 163296 Circumstellar Disk in Scattered Light: Evidence of Time-Variable Self-Shadowing

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We present the first multicolor view of the scattered light disk of the Herbig Ae star HD 163296, based on coronagraphic observations from the Hubble Space Telescope Advanced Camera for Surveys (HST ACS). Radial profile fits of the

surface brightness along the disk's semimajor axis indicate that the disk is not continuously flared, and extends to ∼540 AU. The disk's color $(V-I)=1.1$ at a radial distance of 3.5″ is redder than the observed stellar color $(V-I)=0.15$. This red disk color might be indicative of either an evolution in the grain size distribution (i.e., grain growth) and/or composition, both of which would be consistent with the observed nonflared geometry of the outer disk. We also identify a single ansa morphological structure in our F435W ACS data, which is absent from earlier epoch F606W and F814W ACS data, but corresponds to one of the two ansae observed in archival HST Space Telescope Imaging Spectrograph (STIS) coronagraphic data. Following transformation to similar bandpasses, we find that the scattered light disk of HD 163296 is 1 mag arcsec^{-2} fainter at 3.5″ in the STIS data than in the ACS data. Moreover, variations are seen in (1) the visibility of the ansa(e) structures, (2) the relative surface brightness of the ansa(e) structures, and (3) the (known) intrinsic polarization of the system. These results indicate that the scattered light from the HD 163296 disk is variable. We speculate that the inner disk wall, which Sitko et al. suggests has a variable scale height as diagnosed by near-IR SED variability, induces variable self-shadowing of the outer disk. We further speculate that the observed surface brightness variability of the ansa(e) structures may indicate that the inner disk wall is azimuthally asymmetric.

Published by The Astrophysical Journal (Vol. 682, p. 548)

Rotational Velocities for Early-Type Stars in the Young Large Magellanic Cloud Cluster R136: Further Study of the Relationship Between Rotation Speed and Density in Star-Forming Regions

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We present the results of a study aimed at assessing the distribution of rotation speeds, N(v sin i) among O- and early B-type stars located in R136, a young (t ∼ 1–4 Myr) cluster in the Large Magellanic Cloud (LMC) characterized by a stellar density at least three times that of the densest Galactic clusters in which stellar rotational velocities have been measured. Our goals are (1) to determine whether the distribution of N(v sin i) in R136 shows the same paucity of slowly rotating stars and high mean rotation speed that distinguish early-type stars located in bound clusters in the Milky Way Galaxy (MWG) from their analogs among members of the field and unbound associations and (2) to determine whether the mean rotation speed in the extremely dense R136 cluster is even higher than the values measured for lower-density bound clusters. Our data comprise $v$sin i estimates for 24 stars obtained by comparing line profile measurements obtained with the Gemini Multi-Object Spectograph on the Gemini South Telescope with a grid of He I and He II line profiles generated from model atmospheres and broadened to emulate the effects of stellar rotation. We find that for R136, 13 stars with masses in the range 6–12 $M_\odot$ have an average apparent rotational velocity of $\langle v\sin i\rangle = 233 \pm 19$ km s^{-1}; by comparison, for LMC stars in this same mass range in the field and in lower-density clusters, $\langle v\sin i\rangle$ is, respectively, 105 ± 8 km s^{-1} and 147 ± 14 km s^{-1}. For 11 15–30 $M_\odot$ stars in R136, $\langle v\sin i\rangle = 189 \pm 23$ km s^{-1}; by comparison, the LMC stars in this same mass range but drawn from lower-density regions have $\langle v\sin i\rangle = 129 \pm 13$ km s^{-1}. Moreover, we find that throughout this entire mass range, R136 lacks the cohort of slow rotators characteristic of early-type field stars, both in the LMC and in the MWG. We provide arguments that these differences in N(v sin i) are unlikely to arise from evolution-driven changes in angular momentum (e.g., angular momentum loss through stellar winds), but rather may reflect differences in the rotation speeds imprinted at the time the stars formed. This result appears most certain for stars with masses in the range 6–12 $M_\odot$; for stars of higher masses, larger samples from regions of differing densities are needed to more firmly establish that the observed differences are imprinted during the stellar assembly phase as opposed to being the result of subsequent evolution. We further argue that the differences in N(v sin i) between R136 and the LMC and MWG field stars likely result from a difference in the initial conditions in protostellar cores that are found in the types of molecular cloud regions that form rich, dense clusters (e.g., higher turbulent speeds) rather than from differences in the environment surrounding the core (e.g., stellar density, UV radiation field).

Published by The Astronomical Journal (Vol. 136, p. 1049)

Protostar Formation in the Early Universe

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The nature of the first generation of stars in the universe remains largely unknown. Observations imply the existence of massive primordial stars early in the history of the universe, and the standard theory for the growth of cosmic structure predicts that structures grow hierarchically through gravitational instability. We have developed an ab initio computer simulation of the formation of primordial stars that follows the relevant atomic and molecular processes in a primordial gas in an expanding universe. The results show that primeval density fluctuations left over from the Big Bang can drive the formation of a tiny protostar with a mass 1% that of the Sun. The protostar is a seed for the subsequent formation of a massive primordial star.

Published by Science (Vol. 321 p. 669)

An Extensive, Sensitive Search for SiO Masers in High- and Intermediate-Mass Star-Forming Regions

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We present sensitive Very Large Array observations with an angular resolution of a few arcseconds of the $J = 1 - 0$ line of SiO in the v=1 and 2 vibrationally excited states toward a sample of 60 Galactic regions in which stars of high or intermediate mass are currently forming and/or have recently formed. We report the detection of SiO maser emission in *both* vibrationally excited transitions toward only three very luminous regions: Orion-KL, W51N and Sgr B2(M). Toward all three, SiO maser emission had previously been reported, in Orion-KL in both lines, in W51N only in the $v = 2$ line and in Sgr B2(M) only in the $v = 1$ line. Our work confirms that SiO maser emission in star-forming regions is a rare phenomenon, indeed, that requires special, probably extreme, physical and chemical conditions not commonly found. In addition to this SiO maser survey, we also present images of the simultaneously observed 7 mm continuum emission from a subset of our sample of star-forming regions where such emission was detected. This is in most cases likely to be free-free emission from compact- and ultracompact-HII regions.

Accepted by The Astronomical Journal Supplement Series

http://arxiv.org/abs/0808.3190

PhD position in high-mass star formation research at the Kapteyn Astronomical Institute, University of Groningen (The Netherlands)

Dr. Floris van der Tak has a PhD studentship available in his group studying the physics of the interstellar medium and the formation of stars. The project is to analyze images and spectra of Galactic star-forming regions at submillimeter wavelengths. Data will come from the Herschel space observatory, to be launched early 2009, as well as from ground-based telescopes such as JCMT, APEX and interferometers such as IRAM and SMA. The data will be used to measure physical parameters such as temperatures and densities of the regions, and also to infer their chemical composition. By comparing these quantities to model calculations, we hope to achieve a better understanding of how stars form.

The study is expected to lead directly to a PhD degree at the University of Groningen within a period of four years, and is shared between the University and SRON, the Netherlands Institute for Space Research. The project is being carried out in collaboration with researchers at other institutes in Europe and North America and the selected student will have opportunities to spend periods working with other members of the team.

The student's application should include a curriculum vitae, an academic transcript including indication of the (expected) date of the award of a MSc (doctoraal) degree or equivalent, two reference letters, and a summary of undergraduate research projects carried out and how they fit into the student's aims for PhD research. If English or Dutch is not the student's native language, the reference letters should include an assessment of the English level (written and oral) of the student. All materials should arrive via email, FAX, or regular post no later than 1 November 2008 addressed to

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More information can be obtained by emailing Dr. van der Tak.

PhD position on the modeling of protoplanetary disks in the context of the Herschel open time Key Program GASPS

The Kapteyn Astronomical Institute in Groningen, The Netherlands, is seeking an ambitious, highly motivated applicant for a 4-year PhD AIO position in Star and Planet Formation to work on modeling of protoplanetary disks and Open Time Key Program Observations with the Herschel satellite (GASPS, PI: Bill Dent).

The PhD project will specifically build the theoretical foundation of chemistry and disk structure modeling which is necessary to interpret Herschel PACS data obtained from the Open Time Key Program ?Gas Evolution in Protoplanetary Systems (GASPS)?. The project includes a detailed study of X-ray physics and chemistry around Solar-type stars in various activity and evolution stages. This modeling will be applied and explored in the interpretation of Herschel line observations in terms of gas evolution in protoplanetary disks. The applicant will be embedded within the international GASPS collaboration and thereby also have access to ancillary ground-based observational data. The institute is part of the Netherlands Research School for Astronomy and belongs to the top research institutions in Astronomy worldwide. Research topics currently include cosmology, galaxy evolution, star and planet formation and interstellar matter.

Interested applicants should have a very good academic track record and hold the equivalent of a Masters degree, including a substantial thesis, in Astronomy or Physics when starting the position. Previous numerical experience would be an asset.

Interested candidates should send application material, including curriculum vitae, education history with transcripts of study record, a brief statement of research experience and two letters of reference. Selection of candidates will start September 26, 2008, and will continue until the position is filled.

Please send applications to

Dr. Inga Kamp, Kapteyn Astronomical Institute, Postbus 800, 9700 AV Groningen, The Netherlands, Tel: +31 (0)50 363 4070, email: kamp *at* astro.rug.nl

For inquiries about the position or project, please contact Dr. Kamp. For further information on the Kapteyn Astronomical Institute, please visit the webpages at http://www.rug.nl/sterrenkunde/.

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

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