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## *Abstracts of recently accepted papers*

### A Young Stellar Cluster Surrounding the Peculiar Eruptive Variable V838 Monocerotis

**Melike Afşar[1] and Howard E. Bond[1]**

[1] Space Telescope Science Institute, Baltimore, MD, USA

E-mail contact: melike.afsar@ege.edu.tr

V838 Monocerotis is an unusual variable star that underwent a sudden outburst in 2002. Unlike a classical nova, which quickly evolves to high temperatures, V838 Mon remained an extremely cool, luminous supergiant throughout its eruption. It continues to illuminate a spectacular series of light echoes, as the outburst light is scattered from nearby circumstellar dust. V838 Mon has an unresolved B3 V companion star.

During a program of spectroscopic monitoring of V838 Mon, we serendipitously discovered that a neighboring 16th magnitude star is also of type B. We then carried out a spectroscopic survey of other stars in the vicinity, revealing two more B-type stars, all within 45″ of V838 Mon. We have determined the distance to this sparse, young cluster based on spectral classification and photometric main-sequence fitting of the three B stars. The cluster distance is found to be $6.2 \pm 1.2$ kpc, in excellent agreement with the geometric distance to V838 Mon of 6.1 kpc obtained from Hubble Space Telescope polarimetry of the light echoes. An upper limit to the age of the cluster is about 25 Myr, and its reddening is E(B - V) = 0.85.

The absolute luminosity of V838 Mon during its outburst, based on our distance measurement, was very similar to that of M31 RV, an object in the bulge of M31 that was also a cool supergiant throughout its eruption in 1988. However, there is no young population at the site of M31 RV.

Using our distance determination, we show that the B3 V companion of V838 Mon is sufficient to account for the entire luminosity of the variable star measured on sky-survey photographs before its outburst. The B3 star is currently, however, about 1 mag fainter than before the eruption, suggesting that it is now suffering extinction due to dust ejected from V838 Mon. These results indicate that, whatever the nature of the progenitor object, it was not of high luminosity. Nor does it appear possible to form a nova-like cataclysmic binary system within the young age of the V838 Mon cluster. These considerations appear to leave stellar collision or stellar merger scenarios as one of the remaining viable explanations for the outbursts of V838 Mon and M31 RV.

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### Multiple Formation of Chondrules in the Early Solar System: Chronology of a Compound Al-rich Chondrule

**T. Akaki[1], T. Nakamura[2], T. Noguchi[3], and A. Tsuchiyama[4]**

[1] Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, Hakozaki, Fukuoka, Japan
[2] Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, Hakozaki, Fukuoka, Japan
[3] Department of Materials and Biological Sciences, Ibaraki University, Mito, Japan
[4] Department of Earth and Space Science, Graduate School of Science, Osaka University, Toyonaka, Osaka, Japan

E-mail contact: akaki@geo.kyushu-u.ac.jp

Chondrules are high-temperature components of meteorites and are formed during flash heating episodes in the early solar system. From the presence of compound chondrules, which consist of an early formed unit enclosed within a later phase, it has been concluded that the chondrule formation event is repeatable. We report on the chronology of one Al-rich compound chondrule from the Allende meteorite, together with its mineralogy, petrography, and oxygen isotope composition. The earlier formed primary chondrule is rich in $^{26}$Al with an initial $^{26}\text{Al}/^{27}\text{Al}$ ratio of $(2.7 \pm 1.0) \times 10^{-5}$, whereas the later formed secondary chondrule is depleted in $^{26}$Al with an initial $^{26}\text{Al}/^{27}\text{Al}$ ratio of $(9.9 \pm 2.0) \times 10^{-6}$. The difference between the primary and secondary initial ratios corresponds to 1 Myr. We conclude that the primary unit formed during an earlier melting episode and went into a secondary melt that formed 1 Myr later during a later melting episode. The oxygen isotope composition of silicates in the primary and secondary phases shows varying degrees of $^{16}$O-depression but is similar to that of single chondrules from Allende meteorite specimens. Therefore, this primary chondrule in Allende stayed in the same dust reservoir for over 1 Myr and experienced multiple heating events, during which secondary and single chondrules were also produced.

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## New Low-Mass Stars and Brown Dwarfs with Disks in Lupus

**P. R. Allen[1], K. L. Luhman[1], P. C. Myers[2], S. T. Megeath[3], L. E. Allen[2], L. Hartmann[4], and G. G. Fazio[2]**

[1] Department of Astronomy and Astrophysics, Pennsylvania State University, University Park, PA, USA
[2] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA
[3] Department of Physics and Astronomy, University of Toledo, Toledo, OH, USA
[4] Department of Astronomy, University of Michigan, Ann Arbor, MI, USA

E-mail contact: pallen@astro.psu.edu

Using the Infrared Array Camera and the Multiband Imaging Photometer aboard the Spitzer Space Telescope, we have obtained images of the Lupus 3 star-forming cloud at 3.6, 4.5, 5.8, 8.0, and 24$\mu$m. We present photometry in these bands for the 41 previously known members that are in our images. In addition, we have identified 19 possible new members of the cloud based on red 3.6-8.0$\mu$m colors that are indicative of circumstellar disks. We have performed optical spectroscopy on six of these candidates, all of which are confirmed as young low-mass members of Lupus 3. The spectral types of these new members range from M4.75 to M8, corresponding to masses of 0.2-0.03 $M_\odot$ for ages of 1 Myr according to theoretical evolutionary models. We also present optical spectroscopy of a candidate disk-bearing object in the vicinity of the Lupus 1 cloud, 2M 1541-3345, which Jayawardhana & Ivanov recently classified as a young brown dwarf ($M \sim 0.03\ M_\odot$) with a spectral type of M8. In contrast to their results, we measure an earlier spectral type of M5.75 $\pm$ 0.25 for this object, indicating that it is probably a low-mass star ($M \sim 0.1\ M_\odot$). In fact, according to its gravity-sensitive absorption lines and its luminosity, 2M 1541-3345 is older than members of the Lupus clouds ($\tau \sim 1$ Myr) and instead is probably a more evolved premain-sequence star that is not directly related to the current generation of star formation in Lupus.

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## X-ray emission from MP Muscae: an old classical T Tauri star

**C. Argiroffi[1], A. Maggio[2] and G. Peres[1]**

[1] Dip. di Scienze Fisiche ed Astronomiche, Università di Palermo, Italy
[2] INAF - Osservatorio Astronomico di Palermo, Italy

E-mail contact: argi@astropa.unipa.it

We study the properties of X-ray emitting plasma of MP Mus, an old classical T Tauri star. We aim at checking whether an accretion process produces the observed X-ray emission and at deriving the accretion parameters and the characteristics of the shock-heated plasma. We compare the properties of MP Mus with those of younger classical T Tauri stars to test whether age is related to the properties of the X-ray emission plasma. XMM-Newton X-ray spectra allows us to measure plasma temperatures, abundances, and electron density. In particular the density of cool plasma probes whether X-ray emission is produced by plasma heated in the accretion process. X-ray emission from MP Mus originates from high density cool plasma but a hot flaring component is also present, suggesting that both

coronal magnetic activity and accretion contribute to the observed X-ray emission. We find a Ne/O ratio similar to that observed in the much younger classical T Tauri star BP Tau. From the soft part of the X-ray emission, mostly produced by plasma heated in the accretion shock, we derive a mass accretion rate of $5 \times 10^{-11}\, M_\odot\, yr^{-1}$.

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http://www.astropa.unipa.it/Library/OAPA_preprints/argi07.ps.gz

## Adaptive smoothing lengths in SPH

**R.E. Attwood[1], S.P. Goodwin[2] and A.P. Whitworth[1]**

[1] School of Physics & Astronomy, Cardiff University, Queens Buildings, The Parade, Cardiff CF24 3AA, Wales, UK
[2] Department of Physics & Astronomy, University of Sheffield, Hicks Building, Housfield Road, Sheffield S3 7RH, UK

E-mail contact: rhianne.attwood@astro.cf.ac.uk

*Context.* There is a need to improve the fidelity of SPH simulations of self-gravitating gas dynamics.

*Aims.* We remind users of SPH that, if smoothing lengths are adjusted so as to keep the number of neighbours, $\mathcal{N}$, in the range $\mathcal{N}_{\rm NEIB} \pm \Delta\mathcal{N}_{\rm NEIB}$, the tolerance, $\Delta\mathcal{N}_{\rm NEIB}$, should be set to zero, as first noted by Nelson & Papaloizou. We point out that this is a very straightforward and computationally inexpensive constraint to implement.

*Method.* We demonstrate this by simulating acoustic oscillations of a self-gravitating isentropic monatomic gas-sphere (cf. Lucy), using $\mathcal{N}_{\rm TOT} \sim 6,000$ particles and $\mathcal{N}_{\rm NEIB} = 50$.

*Results.* We show that there is a marked reduction in the rates of numerical dissipation and diffusion as $\Delta\mathcal{N}_{\rm NEIB}$ is reduced from 10 to zero. Moreover this reduction incurs a very small computational overhead.

*Conclusions.* We propose that this should become a standard test for codes used in simulating star formation. It is a highly relevant test, because pressure waves generated by the switch from approximate isothermality to approximate adiabaticity play a critical role in the fragmentation of collapsing prestellar cores. Since many SPH simulations in the literature use $\mathcal{N}_{\rm NEIB} = 50$ and $\Delta\mathcal{N}_{\rm NEIB} \geq 10$, their results must be viewed with caution.

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## SPITZER/IRAC-MIPS Survey of NGC2244: Protostellar Disk Survival in the Vicinity of Hot Stars

**Zoltan Balog[1], James Muzerolle[1], G. H. Rieke[1], Kate Y. L. Su[1], Eric T. Young[1] and S. Tom Megeath[2]**

[1] Steward Observatory, University of Arizona, 933 N. Cherry Av. Tucson, AZ USA
[2] Ritter Observatory, MS 113, Department of Physics and Astronomy, University of Toledo, Toledo OH USA

E-mail contact: zbalog@as.arizona.edu

We present the results from a survey of NGC 2244 from 3.6 to 24 micron with the Spitzer Space Telescope. The 24micron-8micron-3.6micron color composite image of the region shows that the central cavity surrounding the multiple O and B stars of NGC2244 contains a large amount of cool dust visible only at 24micron. Our survey gives a detailed look at disk survivability within the hot-star-dominated environment in this cavity. Using mid infrared two color diagrams ([3.6]-[4.5] vs [5.8]-[8.0]) we identified 337 class II and 25 class I objects out of 1084 objects detected in all four of these bands with photometric uncertainty better than 10%. Including the 24 micron data, we found 213 class II and 20 class I sources out of 279 stars detected also at this latter band. The center of the class II density contours is in very good agreement with the center of the cluster detected in the 2MASS images. We studied the distribution of the class II sources relative to the O stars and found that the effect of high mass stars on the circumstellar disks is significant only in their immediate vicinity.

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## Co-orbital terrestrial planets in exoplanetary systems: a formation scenario

**C. Beaugé[1], Zs. Sándor[2], B. Érdi[2], and Á. Süli[2]**

[1] Observatorio Astronômico, Universidad Nacional de Córdoba, Laprida 854, (X5000BGR), Córdoba, Argentina
[2] Department of Astronomy, Lórand Eötvös University, Pázmány Péter sétany. 1/A, 1117, Budapest, Hungary

E-mail contact: beauge@oac.uncor.edu

*Aims.* We study the formation of a hypothetical terrestrial-type body in the equilateral Lagrange points of a giant extrasolar planet. Starting from a swarm of planetesimals in stable tadpole orbits, we simulate its dynamical and collisional evolution under a wide range of different initial conditions and masses for both the Trojan population and its planetary companion. We also analyze the effects of gas drag from the interaction of the planetesimals with the nebular disk.

*Methods.* The formation process is simulated with an N-body code that considers full gravitational interactions between the planetesimals and the giant planet. Gas interaction is modeled with Stokes and Epstein drags, where the drag coefficients are chosen following the results of full hydrodynamic simulations performed with the 2D public hydro-code FARGO.

*Results.* In both gas-free and gas-rich scenarios, we have been able to obtain a single final terrestrial-type body in a stable tadpole orbit around one of the triangular Lagrange points of the system. However, due to gravitational instabilities within the swarm, the accretional process is not very efficient and the mass of the final planet never seems to exceed $\sim$0.6 Earth masses, even when the total mass of the swarm is five times this value. Finally, we also included an orbital decay of the giant planet due to a type II migration. Although the accretional process shows evidence of a lower efficiency, a small terrestrial planet is still able to form, and follows the giant planet towards the habitable zone of the hosting star.

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## Hot ammonia in NGC6334I & I(N)

**H. Beuther[1], A.J. Walsh[2], S. Thorwirth[3], Q. Zhang[4], T.R. Hunter[5], S.T. Megeath[6] and K.M. Menten[3]**

[1] Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany
[2] James Cook University, Townsville, QLD 4811, Australia
[3] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[5] NRAO, 520 Edgemont Rd, Charlottesville, VA 22903, USA
[6] Ritter Observatory, Department of Physics and Astronomy, University of Toledo, Toledo, OH 43606-3390, USA

E-mail contact: beuther@mpia.de

*Aims:* The massive twin cores NGC6334I and I(N) are in different evolutionary stages and hence ideal targets to study evolutionary variations within the same larger-scale environment. Here, we study the warm, compact gas components.
*Methods:* We imaged the two regions with the Australia Telescope Compact Array (ATCA) at high angular resolution in the $NH_3$(3,3) to (6,6) inversion lines.
*Results:* Compact emission is detected toward both regions in all observed inversion lines with energy levels up to 407 K above ground. This is particularly surprising for NGC6334I(N) since it lacks bright infrared emission and is considered a massive cold core at an early evolutionary stage. High optical depth and multiply-peaked line profiles complicate rotation temperature estimates, and we can only conclude that gas components with temperatures $> 100$ K are present in both regions. Toward NGC6334I, we confirm previous reports of $NH_3$(3,3) maser emission toward the outflow bow-shocks. Furthermore, we report the first detection of an $NH_3$(6,6) maser toward the central region of NGC6334I. This maser is centered on the second millimeter (mm) peak and elongated along the outflow axis, indicating that this mm continuum core harbors the driving source of the molecular outflow. Toward the main mm peak in NGC6334I(N), we detect a double-horn line profile in the $NH_3$(6,6) transition. The current data do not allow us to differentiate whether this double-horn profile is produced by multiple gas components along the line of sight, or whether it may trace a potential underlying massive accretion disk. *The data to Figures 3 to 7 are also available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/.*

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

## Testing grain-surface chemistry in massive hot-core regions

**Suzanne E. Bisschop[1], Jes K. Jørgensen[2], Ewine F. van Dishoeck[1] and Evelyn B. M. de Wachter[1]**

[1] Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, Netherlands
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street MS42, MA 02138, U.S.A.

E-mail contact: bisschop@strw.leidenuniv.nl

*Aims:* To establish the chemical origin of a set of complex organic molecules thought to be produced by grain surface chemistry in high mass young stellar objects (YSOs).

*Methods:* A partial submillimeter line-survey was performed toward 7 high-mass YSOs aimed at detecting $H_2CO$, $CH_3OH$, $CH_2CO$, $CH_3CHO$, $C_2H_5OH$, HCOOH, HNCO and $NH_2CHO$. In addition, lines of $CH_3CN$, $C_2H_5CN$, $CH_3CCH$, $HCOOCH_3$, and $CH_3OCH_3$ were observed. Rotation temperatures and beam-averaged column densities are determined. To correct for beam dilution and determine abundances for hot gas, the radius and $H_2$ column densities of gas at temperatures >100 K are computed using 850 $\mu$m dust continuum data and source luminosity.

*Results:* Based on their rotation diagrams, molecules can be classified as either cold (<100 K) or hot (>100 K). This implies that complex organics are present in at least two distinct regions. Furthermore, the abundances of the hot oxygen-bearing species are correlated, as are those of HNCO and $NH_2CHO$. This is suggestive of chemical relationships within, but not between, those two groups of molecules.

*Conclusions:* The most likely explanation for the observed correlations of the various hot molecules is that they are "first generation" species that originate from solid-state chemistry. This includes $H_2CO$, $CH_3OH$, $C_2H_5OH$, $HCOOCH_3$, $CH_3OCH_3$, HNCO, $NH_2CHO$, and possibly $CH_3CN$, and $C_2H_5CN$. The correlations between sources implies very similar conditions during their formation or very similar doses of energetic processing. Cold species such as $CH_2CO$, $CH_3CHO$, and HCOOH, some of which are seen as ices along the same lines of sight, are probably formed in the solid state as well, but appear to be destroyed at higher temperatures. A low level of non-thermal desorption by cosmic rays can explain their low rotation temperatures and relatively low abundances in the gas phase compared to the solid state. The $CH_3CCH$ abundances can be fully explained by low temperature gas phase chemistry. No cold N-containing molecules are found.

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## X-rays from protostellar jets: emission from continuous flows

**R. Bonito[1,2], S. Orlando[2], G. Peres[1], F. Favata[3] and R. Rosner[4,5]**

[1] Dip. Scienze Fisiche ed Astronomiche, Sez. Astronomia, Università di Palermo, P.zza del Parlamento 1, 90134 Palermo, Italy
[2] INAF - Osservatorio Astronomico di Palermo, P.zza del Parlamento 1, 90134 Palermo, Italy
[3] Astrophysics Div. - Research and Science Support Dept. of ESA, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands
[4] Dept. of Astronomy and Astrophysics, Univ. of Chicago, Chicago, IL 60637, USA
[5] Center for Astrophysical Thermonuclear Flashes, University of Chicago, 5640 S. Ellis Avenue, Chicago, IL 60637, USA

E-mail contact: sbonito@astropa.unipa.it

*Context.* Recently X-ray emission from protostellar jets has been detected with both XMM-Newton and Chandra satellites, but the physical mechanism which can give rise to this emission is still unclear.

*Aims.* We performed an extensive exploration of the parameter space for the main parameters influencing the jet/ambient medium interaction. Aims include: 1) to constrain the jet/ambient medium interaction regimes leading to the X-ray emission observed in Herbig-Haro objects in terms of the emission by a shock forming at the interaction front between a continuous supersonic jet and the surrounding medium; 2) to derive detailed predictions to be compared with optical and X-ray observations of protostellar jets; 3) to get insight into the protostellar jet's physical conditions.

*Methods.* We performed a set of two-dimensional hydrodynamic numerical simulations, in cylindrical coordinates, modeling supersonic jets ramming into a uniform ambient medium. The model takes into account the most relevant physical effects, namely thermal conduction and radiative losses.

*Results.* Our model explains the observed X-ray emission from protostellar jets in a natural way. In particular, we find that a protostellar jet that is less dense than the ambient medium well reproduces the observations of the nearest Herbig-Haro object, HH 154, and allows us to make detailed predictions of a possible X-ray source proper motion ( $v_{\rm sh} \approx 500$ km s$^{-1}$) detectable with Chandra. Furthermore, our results suggest that the simulated protostellar jets which best reproduce the X-rays observations cannot drive molecular outflows.

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## Evolution of the Solar Nebula. VIII. Spatial and Temporal Heterogeneity of Short-Lived Radioisotopes and Stable Oxygen Isotopes

**Alan P. Boss**

DTM, Carnegie Institution of Washington, 5241 Broad Branch Road, NW, Washington, DC 20015-1305, USA

E-mail contact: boss@dtm.ciw.edu

Isotopic abundances of short-lived radionuclides such as $^{26}$Al provide the most precise chronometers of events in the early solar system, provided that they were initially homogeneously distributed. On the other hand, the abundances of the three stable isotopes of oxygen in primitive meteorites show a mass-independent fractionation that survived homogenization in the solar nebula. As as result of this and other cosmochemical evidence, the degree of spatial heterogeneity of isotopes in the solar nebula has long been a puzzle. We show here that based on hydrodynamical models of the mixing and transport of isotopic anomalies formed at, or injected onto, the surface of the solar nebula, initially high levels of isotopic spatial heterogeneity are expected to fall to steady state levels ($\sim 10\%$) low enough to validate the use of $^{26}$Al for chronometry, but high enough to preserve the evidence for mass-independent fractionation of oxygen isotopes. The solution to this puzzle relies on the mixing being accomplished by the chaotic fluid motions in a marginally gravitationally unstable disk, as seems to be required for the formation of gas giant planets and by the inability of alternative physical processes to drive large-scale mixing and transport in the planet-forming midplane of the solar nebula. Such a disk is also capable of large-scale outward transport of the thermally annealed dust grains found in comets, and of driving the shock fronts that appear to be responsible for much of the thermal processing of the components of primitive meteorites, creating a self-consistent picture of the basic physical processes shaping the early solar nebula.

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

## The Photoevaporation of Discs Around Young Stars in Massive Clusters

**C.J. Clarke**[1]

[1] Institute of Astronomy, Madingley Road, Cambridge, CB3 OHA, UK
E-mail contact: cclarke@ast.cam.ac.uk

We present models in which the photoevaporation of discs around young stars by an external ultraviolet source (as computed by Adams et al 2004) is coupled with the internal viscous evolution of the discs. These models are applied to the case of the Orion Nebula Cluster, where the presence of a strong ultraviolet field from the central OB stars, together with a detailed census of circumstellar discs and photoevaporative flows, is well established. In particular we investigate the constraints that are placed on the initial disc properties in the ONC by the twin requirement that most stars possess a disc on a scale of a few A.U., but that only a minority ($< 20\%$) are resolved by HST at a scale of 50 A.U.. We find that these requirements place very weak constraints on the initial radius distribution of circumstellar discs: the resulting size distribution readily forgets the initial radius distribution, owing to the strong positive dependence of the photoevaporation rate on disc radius. Instead, the scarcity of large discs reflects the relative scarcity of initially massive discs (with mass $> 0.1 M_\odot$). The ubiquity of discs on a small scale, on the other hand, mainly constrains the timespan over which the discs have been exposed to the ultraviolet field ($< 2$Myr). We argue that the discs that are resolved by HST represent a population of discs in which self-gravity was important at the time that the dominant central OB star switched on, but that, according to our models, self-gravity is unlikely to be important in these discs at the present time. We discuss the implications of our results for the so-called proplyd lifetime problem.

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## Spitzer/IRAC and JH$K_s$ Observations of h & $\chi$ Persei: Constraints on Protoplanetary Disk and Massive Cluster Evolution at $\sim 10^7$ yr

**Thayne Currie[1], Zoltan Balog[2,3], S. J. Kenyon[1], G. Rieke[2], L. Prato[4], E. T. Young[2], J. Muzerolle[2], D.P. Clemens[5], M. Buie[4], D. Sarcia[5], A. Grabau[5], E. V. Tollestrup[5], B. Taylor[4], E. Dunham[4] and G. Mace[4]**

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St. Cambridge, MA 02140, USA

[2] Steward Observatory, University of Arizona, 933 N. Cherry Av. Tucson, AZ 85721, USA

[3] on leave from Dept. of Optics and Quantum Electronics, University of Szeged, H-6720, Szeged, Hungary

[4] Lowell Observatory

[5] Institute for Astrophysical Research, Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA

E-mail contact: tcurrie@cfa.harvard.edu

We describe IRAC 3.6-8 $\mu m$ observations and ground-based near-IR JH$K_s$ photometry from Mimir and 2MASS of the massive double cluster h & $\chi$ Persei complete to J=15.5 ($M \sim 1.3 M_\odot$). Within 25' of the cluster centers we detect $\sim 11,000$ sources with J$\leq$ 15.5, $\sim$ 7000 sources with [4.5] $\leq$ 15, and $\sim$ 5000 sources with [8]$\leq$ 14.5. In both clusters, the surface density profiles derived from the 2MASS data decline with distance from the cluster centers as expected for a bound cluster. Within 15' of the cluster centers, $\sim$ 50% of the stars lie on a reddened $\sim$ 13 Myr isochrone; at 15'-25' from the cluster centers, $\sim$ 40% lie on this isochrone. Thus, the optical/2MASS color-magnitude diagrams indicate that h & $\chi$ Per are accompanied by a halo population with roughly the same age and distance as the two dense clusters. The double cluster lacks any clear IR excess sources for J$\leq$ 13.5 ($\sim 2.7 M_\odot$). Therefore, disks around high-mass stars disperse prior to $\sim 10^7$ yr. At least $2-3$% of the fainter cluster stars have strong IR excess at both [5.8] and [8]. About $4-8$% of sources slightly more massive than the Sun ($\sim 1.4 M_\odot$) have IR excesses at [8]. Combined with the lack of detectable excesses for brighter stars, this result suggests that disks around lower-mass stars have longer lifetimes. The IR excess population also appears to be larger at longer IRAC bands ([5.8], [8]) than at shorter IRAC/2MASS bands ($K_s$, [4.5]), a result consistent with an inside-out clearing of disks.

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## The Virial Balance of Clumps and Cores in Molecular Clouds

**Sami Dib[1,2], Jongsoo Kim[1], Enrique Vazquez-Semadeni[2], Andreas Burkert[3] and Mohsen Shadmehri[4,5]**

[1] Korea Astronomy and Space Science Institute, Hwaam-dong, Yuseong-gu, Daejeon 305-348, Korea

[2] Centro de Radioastronomia y Astrofisica, UNAM, Apdo 72-3 (Xangari), 58089 Morelia, Michoacan, Mexico

[3] University Observatory Munich, Scheinerstrasse 1, D-81679 Munich, Germany

[4] School of Mathematical Sciences, Dublin City University, Glasnevin, Dublin 9, Ireland

[5] Department of Physics, School of Science, Ferdowsi University, Mashad, Iran

E-mail contact: dib@kasi.re.kr

We study the instantaneous virial balance of clumps and cores (CCs) in three-dimensional numerical simulations of driven, magnetohydrodynamical, isothermal molecular clouds (MCs). The models represent a range of magnetic field strengths in MCs from subcritical to non-magnetic regimes. We identify CCs at different density thresholds in the simulations, and for each object, we calculate all the terms that enter the Eulerian form of the virial theorem (EVT). A CC is considered gravitationally bound when the gravitational term in the EVT is larger than the amount for the system to be virialized, which is more stringent than the condition that it be large enough to make the total volume energy negative. We also calculate, quantities commonly used in the observations to indicate the state of gravitational boundedness of CCs such as the Jeans number $J_c$, the mass-to magnetic flux ratio $\mu_c$, and the virial parameter $\alpha_{vir}$. Our results suggest that: a) CCs are dynamical out-of-equilibrium structures. b) The surface energies are of the same order than their volume counterparts and thus are very important in determining the exact virial balance c) CCs are either in the process of being compressed or dispersed by the velocity field. Yet, not all CCs that have a compressive net kinetic energy are gravitationally bound. d) There is no one-to-one correspondence between the state of gravitational boundedness of a CC as described by the virial analysis or as implied by the classical indicators. In general, in the virial analysis, we observe that only the inner regions of the objects (the dense cores selected at high threshold levels) are gravitationally bound, whereas $J_c$, $\alpha_{vir}$, and $\mu_c$ estimates tend to show that they are more gravitationally bound at the lowest threshold levels and more magnetically supercritical. g) We observe, in the non-magnetic simulation, the

existence of a bound core with structural and dynamical properties that resemble those of the Bok globule Barnard 68 (B68). This suggests that B68 like cores can form in a larger MC and then be confined by the warm gas of a newly formed, nearby HII region, which can heat the gas around the core and confine it.

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## Spiral shocks and the formation of molecular clouds in a two phase medium

**Clare Dobbs[1,2] and Ian Bonnell[1]**

[1] SUPA, School of Physics & Astronomy, University of St Andrews, North Haugh, St Andrews, Fife, KY16 9SS
[2] School of Physics, University if Exeter, Stocker Road, Exeter, EX4 4QL
E-mail contact: dobbs@astro.ex.ac.uk

We extend recent numerical results (Dobbs et. al. 2006) on molecular cloud formation in spiral galaxies by including a multi-phase medium. The addition of a hot phase of gas enhances the structure in the cold gas, and significantly increases the fraction of molecular hydrogen that is formed when the cold gas passes through a spiral shock. The difference in structure is reflected in the mass power spectrum of the molecular clouds, which is steeper for the multi-phase calculations. The increase in molecular gas occurs as the addition of a hot phase leads to higher densities in the cold gas. In particular, cold gas is confined in clumps between the spiral arms and retains a higher molecular fraction. Unlike the single phase results, molecular clouds are present in the inter-arm regions for the multi-phase medium. However the density of the inter-arm molecular hydrogen is generally below that which can be reliably determined from CO measurements. We therefore predict that for a multi-phase medium, there will be low density clouds containing cold atomic and molecular hydrogen, which are potentially entering the spiral arms.

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## HD 97048's Circumstellar Environment as Revealed by a *HST*/ACS Coronagraphic Study of Disk Candidate Stars

**R. L. Doering[1,2], M. Meixner[2], S. T. Holfeltz[2], J. E. Krist[3], D. R. Ardila[4], I. Kamp[5], M. C. Clampin[6] and S. H. Lubow[2]**

[1] Department of Physics, University of Illinois, 1110 West Green Street, Urbana, IL 61801, USA
[2] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[3] Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
[4] *Spitzer* Science Center, IPAC, MS 220-6, California Institute of Technology, Pasadena, CA 91125, USA
[5] Space Telescope Division of ESA, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[6] NASA Goddard Space Flight Center, Code 681, Greenbelt, MD 20771, USA
E-mail contact: doering@stsci.edu

We present the results of a coronagraphic scattered-light imaging survey of six young disk candidate stars using the *Hubble Space Telescope* Advanced Camera for Surveys. The observations made use of the 1.8″ occulting spot through the F606W (broad $V$) filter. Circumstellar material was imaged around HD 97048, a Herbig Ae/Be star located in the Chamaeleon I dark cloud at a distance of 180 pc. The material is seen between $\sim$2″ (360 AU) and $\sim$4″ (720 AU) from the star in all directions. A $V$-band azimuthally-averaged radial surface brightness profile peaks at r = 2″ with a value of 19.6 $\pm$ 0.2 mag arcsec$^{-2}$ and smoothly decreases with projected distance from the star as $I \propto r^{-3.3\pm0.5}$. An integrated flux of 16.8 $\pm$ 0.1 mag is measured between 2″ and 4″, corresponding to a scattered-light fractional luminosity lower limit of $L_{sca}/L_* > 8.4 \times 10^{-4}$. Filamentary structure resembling spiral arms similar to that seen in Herbig Ae/Be disks is observed. Such structure has been attributed to the influence of orbiting planets or stellar encounters. Average surface brightness upper limits are determined for the five non-detections: HD 34282, HD 139450, HD 158643, HD 159492, and HD 195627. Possible reasons for the non-detections are disks that are too faint or disks hidden by the occulter.

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## A Survey of OH Masers Towards High Mass Protostellar Objects

**K.A. Edris[1,2], G.A. Fuller[1] and R. J . Cohen[3]**

[1] University of Manchester, School of Physics and Astronomy, PO Box 88, Manchester, M60 1QD, UK
[2] Al-Azhar University, Faculty of Science, Astronomy Department, PO Box 11884, Naser City, Cairo, Egypt
[3] Jodrell Bank Observatory, University of Manchester, UK

E-mail contact: G.Fuller@manchester.ac.uk

We present a survey of OH maser emission towards a sample of high mass protostellar objects made using the Nancay and GBT telescopes.OH maser emission was detected towards 63 objects with 36 new detections. There are 56 star-forming regions and 7 OH/IR candidates. There is no evidence that sources with OH masers have a different range of luminosities from the non-maser sources. The results of this survey are compared with previous water and class II methanol maser observations of the same objects. Some of the detected sources are only associated with OH masers and some sources are only associated with the 1720 MHz OH maser line. The velocity range of the maser emission suggests that the water maser sources may be divided into two groups. The detection rates and velocity range of the OH and Class II methanol masers support the idea that there is a spatial association of the OH and Class II methanol masers. The sources span a wide range in R, the ratio of the methanol maser peak flux to OH 1665 MHz maser peak flux, however there are only a few sources with intermediate values of R, 8¡R¡32, which has characterised previous samples. Sources which have masers of any species, OH, water or methanol, have redder [100um-12um] IRAS colours than those without masers. However, there is no evidence for different maser species tracing different stages in the evolution of these young high mass sources. Previous observations which have shown that the OH maser emission from similar sources traces the circumstellar disks around the objects. This combined with the sensitivity of the OH emission to the magnetic field, make the newly detected sources interesting candidates for future follow-up at high angular resolution.

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## MO Lup: a hierarchical triple T Tauri system

**Massimiliano Esposito[1,3], Elvira Covino[2], Juan M. Alcalá[2], Eike W. Guenther[3] and Eugenio Schisano[4]**

[1] Università di Salerno, Via S. Allende, I-84081 Baronissi (SA), Italy
[2] INAF - Osservatorio Astronomico di Capodimonte, Via Moiariello 16, I-80131 Napoli, Italy
[3] Thüringer Landessternwarte Tautenburg, Sternwarte 5, D-07778 Tautenburg, Germany
[4] Dipartimento di Scienze Fisiche, Università di Napoli, "Federico II" , I-80126 Napoli, Italy

E-mail contact: mesposito@sa.infn.it

In this paper we present a thorough study of the T Tauri system MO Lup. We report on its previously unrecognized triple spectroscopic nature. Our study is mainly based on a high-resolution spectroscopic monitoring. The elements of the spectroscopic orbits are derived from a detailed analysis of radial velocity data for the short-period SB2 components, revealing the existence of a long-term variation in the systemic radial velocity due to a third body orbiting the SB2 system with a period longer than the 5.25 yr span of our data. The estimated stellar parameters, combined with the high lithium content, allow us to confirm the PMS status of the system. In addition, variability is observed both in the line intensities and profiles of the main emission features, in particular the H$\alpha$ line, indicative of an intense chromospheric activity in the low-mass SB2 components, possibly suggesting a modulation with the orbital phase. The preliminary orbital solution for the hierarchical triple system, makes this object a very suitable target for follow-up observations with the Very-Large Telescope Interferometer (VLTI), for the determination of precise masses of the components that will allow constraints on PMS evolutionary models.

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## Globulettes as seeds of brown dwarfs and free-floating planetary-mass objects

**G.F. Gahm[1], T. Grenman[2], S. Fredriksson[2] and H. Kristen[3]**

[1] Stockholm Observatory, AlbaNova, SE-10691 Stockholm, Sweden
[2] Division of Physics, Luleå University of Technology, SE-97187 Luleå, Sweden

[3] CTO, Imminent Training Technologies AB, IDEON Research Park, SE 22370 Lund, Sweden

E-mail contact: gahm@astro.su.se

Some H II regions surrounding young stellar clusters contain tiny dusty clouds, which on photos look like dark spots or teardrops against a background of nebular emission. From our collection of H$\alpha$ images of 10 H II regions gathered at the Nordic Optical Telescope, we found 173 such clouds, which we call *Globulettes*, since they are much smaller than normal globules and form a distinct class of objects. Many globulettes are quite isolated and located far from molecular shells and elephant trunks associated to the regions. Others are attached to the trunks (or shells) suggesting how globulettes may form as a consequence of erosion of these larger structures. None of our objects appears to contain stellar objects.

The globulettes were measured for position, dimension and orientation, and we find that most objects are smaller than 10 kAU. The Rosette Nebula and IC 1805 are particularly rich in globulettes, for which the size distributions peak at mean radii of $\sim 2.5$ kAU, similar to what was found by Reipurth et al. (2003) and De Marco et al. (2006) for similar objects in other regions.

We estimate total mass and density distributions for each object from extinction measures and conclude that a majority contain $< 13$ Jupiter masses, corresponding to planetary-mass objects. We then estimate the internal thermal and potential energies and find, when including also the effects from the outer pressure, that a large fraction of the globulettes could be unstable and would contract on short time-scales $< 10^6$ years. Also the radiation pressure and ram pressure exerted on the side facing the clusters would stimulate contraction. Since the globulettes are not screened from stellar light by dust clouds further in, one expects that photoevaporation will dissolve the objects. However, surprisingly few objects show bright rims or teardrop forms. We calculate the expected lifetimes against photoevaporation. These lifetimes scatter around 4 $10^6$ years, much longer than estimated in previous studies, and also much longer than the free-fall time.

We conclude that a large number of our globulettes have time to form central low-mass objects long before the ionization front, driven by the impinging Lyman photons, has penetrated far into the globulette. Hence, the globulettes may be one source in the formation of brown dwarfs and free-floating planetary-mass objects in the galaxy.

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## Discovery of an energetic bipolar molecular outflow towards IRAS 16547-4247

**G. Garay[1], D. Mardones[1], L. Bronfman[1], K. J. Brooks[2], L. F. Rodríguez[3], R. Güsten[4], L.-Å Nyman[5], R. Franco-Hernández[6], and J. M. Moran[6]**

[1] Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile
[2] Australia Telescope National Facility, PO Box 76, Epping 1710 NSW, Australia
[3] Centro de Radioastronomía y Astrofíca, UNAM, Apdo. Postal 3-72, Morelia, Michoacán, 58089, México
[4] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
[5] European Southern Observatory, Casilla 19001, Santiago, Chile
[6] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
E-mail contact: guido@das.uchile.cl

*Aims.* We present molecular line observations of the molecular core associated with IRAS 16547-4247, which have allowed us to determine its physical and kinematical properties at angular resolutions of $\sim$ 18″.

*Methods.* The observations were made using the Atacama Pathfinder Experiment Telescope in the $J = 3 \rightarrow 2$ transitions of $^{12}$CO and $^{13}$CO, $J = 4 \rightarrow 3$ transitions of $HCO^+$ and $H^{13}CO^+$, and $J = 7 \rightarrow 6$ transition of CS.

*Results.* Our observations reveal the presence of a collimated bipolar outflow with lobes ∼0.7 pc in extent and aligned with the thermal jet located at the center of the core. The morphology and velocity structure of the flow are well described by a biconical outflow that is inclined from the line of sight by an angle of 84°, has a semi-opening angle of 14°, and in which the gas moves outwards with a constant total velocity, with respect to the cone apex, of ∼120 km s$^{-1}$. The outflow is massive and energetic (flow mass $\sim$110 $M_\odot$; mass outflow rate $\sim 2\times10^{-2}$ $M_\odot$ yr$^{-1}$; momentum $\sim 2\times10^3$ $M_\odot$ km s$^{-1}$ and kinetic energy $\sim 9\times10^{47}$ erg), and has a dynamical time scale of $6\times10^3$ yr. These parameters are consistent with the flow being driven by a young massive stellar object with $L_{\rm bol} \sim 6\times10^4$ $L_\odot$.

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## The onset of X-ray emission in young stellar objects: A Chandra observation of the Serpens star-forming region

**G. Giardino[1], F. Favata[1], G. Micela[2], S. Sciortino[2], and E. Winston[3]**

[1] Astrophysics Division - Research and Science Support Department of ESA, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands

[2] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy

[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

*Aims.* To study the properties of X-ray emission from young stellar objects (YSOs) through their evolution from Class I to Class III and determine whether Class 0 protostars emit X-rays.

*Methods.* A deep Chandra X-ray observation of the Serpens star-forming region was obtained. The Serpens Cloud Core is ideally suited for this type of investigation, being populated by a dense and extremely young cluster whose members are found in all evolutionary stages, including six well-studied Class 0 sources.

*Results.* None of the six Class 0 protostars is detected in our observations, excluding the presence of sources with typical X-ray luminosities $\gtrsim 0.4 \times 10^{30}$ erg s$^{-1}$ (for column densities of the order of $4 \times 10^{23}$ cm$^{-2}$, or $A_V \sim 200$). A total of 85 X-ray sources are detected and the light curves and spectra of 35 YSOs are derived. There is a clear trend of decreasing absorbing column densities as one moves from Class I to Class III sources, and some evidence of decreasing plasma temperatures, too. We observe a strong, long-duration, flare from a Class II low-mass star, for which we derive a flaring loop length of the order of 20 stellar radii. We interpret the flaring event as originating from a magnetic flux tube connecting the star to its circumstellar disk. The presence of such a disk is supported by the detection, in the spectrum of this star, of 6.4 keV Fe fluorescent emission.

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## High-Resolution Mid-Infrared Imaging of Radio Ultracompact H II Regions

**U. Giveon[1], M.J. Richter[1], R.H. Becker[2], and R.L. White[3]**

[1] Department of Physics, University of California, Davis, CA, USA

[2] Lawrence Livermore National Laboratory, Livermore, CA, USA

[3] Space Telescope Science Institute, Baltimore, MD, USA

E-mail contact: giveon@physics.ucdavis.edu

We present data from mid-infrared Keck Telescope imaging of 18 radio-selected ultracompact H II region candidates at diffraction-limited resolution. The goal of these observations is to determine the sizes, luminosities, and morphologies of the mid-infrared-emitting dust surrounding the stellar sources. All 18 sources were imaged at 11.7 and 17.65$\mu$m, and 10 of them were also imaged at 24.5$\mu$m. All the sources were resolved. We have generated dust temperature and optical depth maps and combined them with radial velocity measurements and radio data (1.4 and 5 GHz) to constrain the properties of these star-forming regions. Half of our objects are excited by B-type stars, and all our objects have derived types that are later than an O6 star. We find a significant correlation between infrared and radio flux densities and a weaker one between infrared diameters and the central source ionizing photon rates. This latter correlation suggests that the more compact sources result from later spectral types rather than young age. Our new data may suggest a revision to the infrared color selection criteria of ultracompact H II regions at resolutions $\lesssim 1''$. These 18 sources are part of a sample of 687 sources dominated by ultracompact H II regions selected by matching radio and infrared maps of the first Galactic quadrant by Giveon and coworkers. The new mid-infrared images constitute a significant improvement in resolving substructure at these wavelengths. If applied to all of this sample, our analysis will improve our understanding of embedded star formation in the Galaxy.

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## Simulating the formation of molecular clouds. I. Slow formation by gravitational collapse from static initial conditions

**S. C. O. Glover[1,2] and M.-M. Mac Low[2]**

[1] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany

[2] Department of Astrophysics, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024, USA

E-mail contact: sglover@aip.de

We study the formation of $H_2$ in the ISM, using a modified version of the astrophysical magnetohydrodynamical code ZEUS-MP that includes a non-equilibrium treatment of the formation and destruction of $H_2$. We examine two different approximations to treat the shielding of $H_2$ against photodissociation: a local approximation, which gives us a solid lower bound on the amount of shielding, and a method based on ray-tracing that is considerably more accurate in some circumstances but that produces results that are harder to clearly interpret. In both cases, the computational cost of determining $H_2$ photodissociation rates is reduced by enough to make three-dimensional high-resolution simulations of cloud formation feasible with modest computational resources. Our modification to ZEUS-MP also includes a detailed treatment of the thermal behaviour of the gas.

In this paper, we focus on the problem of molecular cloud formation in gravitationally unstable, initially static gas. (In a subsequent paper, we consider turbulent flow). We show that in these conditions, and for initial densities consistent with those observed in the cold, neutral atomic phase of the interstellar medium, $H_2$ formation occurs on a timescale $t \geq 10$ Myr, comparable to or longer than the gravitational free-fall timescale of the cloud. We also show that the collapsing gas very quickly reaches thermal equilibrium and that the equation of state of the thermal equilibrium gas is generally softer than isothermal.

Finally, we demonstrate that although these results show little sensitivity to variations in most of our simulation parameters, they are highly sensitive to the assumed initial density $n_{\rm i}$. Reducing $n_{\rm i}$ significantly increases the cloud formation timescale and decreases the amount of hydrogen ultimately converted to $H_2$.

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## Simulating the formation of molecular clouds. II. Rapid formation from turbulent initial conditions

**S. C. O. Glover[1,2] and M.-M. Mac Low[2]**

[1] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany
[2] Department of Astrophysics, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024, USA

E-mail contact: sglover@aip.de

The characteristic lifetimes of molecular clouds remain uncertain and subject to debate, with arguments having recently been advanced in support of short-lived clouds, with lifetimes of only a few Myr, and in support of much longer-lived clouds, with lifetimes of 10 Myr or more. One argument that has been advanced in favour of long cloud lifetimes is the apparent difficulty involved in converting sufficient atomic hydrogen to molecular hydrogen within the short timescale required by the rapid cloud formation scenario. However, previous estimates of the time required for this conversion to occur have not taken into account the effects of the supersonic turbulence which is inferred to be present in the atomic gas.

In this paper, we present results from a large set of numerical simulations that demonstrate that $H_2$ formation occurs rapidly in turbulent gas. Starting with purely atomic hydrogen, large quantities of molecular hydrogen can be produced on timescales of 1–2 Myr, given turbulent velocity dispersions and magnetic field strengths consistent with observations. Moreover, as our simulations underestimate the effectiveness of $H_2$ self-shielding and dust absorption, we can be confident that the molecular fractions that we compute are strong lower limits on the true values. The formation of large quantities of molecular gas on the timescale required by rapid cloud formation models therefore appears to be entirely plausible.

We also investigate the density and temperature distributions of gas in our model clouds. We show that the density probability distribution function is approximately log-normal, with a dispersion that agrees well with the prediction of Padoan, Nordlund & Jones (1997). The temperature distribution is similar to that of a polytrope, with an effective polytropic index $\gamma_{\rm eff} \simeq 0.8$, although at low gas densities, the scatter of the actual gas temperature around this mean value is considerable, and the polytropic approximation does not capture the full range of behaviour of the gas.

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## Magnetic Fields in Stellar Jets

**P. Hartigan[1], A. Frank[2], P. Varniere[2] and E. Blackman[2]**

[1] Rice University
[2] University of Rochester

E-mail contact: hartigan@sparky.rice.edu

Although several lines of evidence suggest that jets from young stars are driven magnetically from accretion disks, existing observations of field strengths in the bow shocks of these flows imply that magnetic fields play only a minor role in the dynamics at these locations. To investigate this apparent discrepancy we performed numerical simulations of expanding magnetized jets with stochastically variable input velocities with the AstroBEAR MHD code. Because the magnetic field B is proportional to the density n within compression and rarefaction regions, the magnetic signal speed drops in rarefactions and increases in the compressed areas of velocity-variable flows. In contrast, B $\sim$ $n^{0.5}$ for a steady-state conical flow with a toroidal field, so the Alfven speed in that case is constant along the entire jet. The simulations show that the combined effects of shocks, rarefactions, and divergent flow cause magnetic fields to scale with density as an intermediate power $1 > p > 0.5$. Because $p > 0.5$, the Alfven speed in rarefactions decreases on average as the jet propagates away from the star. This behavior is extremely important to the flow dynamics because it means that a typical Alfven velocity in the jet close to the star is significantly larger than it is in the rarefactions ahead of bow shocks at larger distances, the one place where the field is a measurable quantity. Combining observations of the field in bow shocks with a scaling law B $\sim$ $n^{0.85}$ allows us to infer field strengths close to the disk. We find that the observed values of weak fields at large distances are consistent with strong fields required to drive the observed mass loss close to the star. The increase of magnetic signal speed close to the star also means that typical velocity perturbations which form shocks at large distances will produce only magnetic waves close to the star. For a typical stellar jet the crossover point inside which velocity perturbations of $30 - 40$ km s$^{-1}$ no longer produce shocks is $\sim$ 300 AU from the source.

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http://sparky.rice.edu/~hartigan/pub.html

## Proper Motions and Physical Conditions in the HH 30 Jet from HST Slitless Spectroscopy

**Patrick Hartigan[1] and Jon Morse[2]**

[1] Rice University
[2] NASA Goddard Space Flight Center
E-mail contact: hartigan@sparky.rice.edu

We present Space Telescope Imaging Spectrograph (STIS) spectral images of the HH 30 stellar jet taken through a wide slit over two epochs. The jet is unresolved spectrally, so the observations produce emission-line images for each line in the spectrum. This rich dataset shows how physical conditions in the jet vary with distance and time, produces precise pr oper motions of knots within the jet, resolves the jet width close to the star, and gives a spectrum of the reflected light from the disk over a large wavelength range at several positions. We introduce a new method for analyzing a set of line ratios based on minimizing a quadratic form between models and data. The method generates images of the density, temperature and ionization fraction computed using all the possible line ratios appropriately weighted. In HH 30, the density declines with distance from the source in a manner consistent with an expanding flow, and is larger by a factor of two along the axis of the jet than it is at the periphery. Ionization in the jet ranges from $\sim 5\% - 40\%$, and high ionization/excitation knots form at about 100 AU from the star and propagate outward with the flow. These high-excitation knots are not accompanied by corresponding increases in the density, so if formed by velocity variations the knots must have a strong internal magnetic pressure to smooth out density increases while lengthening recombination times.

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## Structure Generation by Irradiation: What Can GLIMPSE Teach Us about the ISM Structure?

**Fabian Heitsch[1,2], Barbara A. Whitney[3], Remy Indebetouw[4], Marilyn R. Meade[5], Brian L. Babler[5], and Ed Churchwell[5]**

[1] Department of Astronomy, University of Michigan, Ann Arbor, MI, USA
[2] University Observatory Munich, Munich, Germany
[3] Space Science Institute, Boulder, CO, USA
[4] Spitzer Fellow; Department of Astronomy, University of Virginia, Charlottesville, VA, USA
[5] Department of Astronomy, University of Wisconsin, Madison, WI, USA

E-mail contact: fheitsch@umich.edu

Diffuse emission in the mid-infrared shows a wealth of structure, which lends itself to high-resolution structure analysis of the interstellar gas. A large part of the emission comes from polycyclic aromatic hydrocarbons (PAHs), excited by nearby ultraviolet sources. Can the observed diffuse emission structure be interpreted as column density structure? We discuss this question with the help of a set of model molecular clouds bathed in the radiation field of a nearby O star. The correlation strength between column density and "observed" flux density strongly depends on the absolute volume density range in the region. Shadowing and irradiation effects may completely alter the appearance of an object. Irradiation introduces additional small-scale structure, and it can generate structures resembling shells around H II regions in objects that do not possess any shell-like structures whatsoever. Nevertheless, with some effort, structural information about the underlying interstellar medium can be retrieved. In the more diffuse regime [$n(\mathrm{HI}) \lesssim 100\ \mathrm{cm}^{-3}$], flux density maps may be used to trace the 3D density structure of the cloud via density gradients. Thus, while caution definitely is in order, mid-infrared surveys such as GLIMPSE will provide quantitative insight into the turbulent structure of the interstellar medium.

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## Large Scale Flows from Orion-South

**W. J. Henney[1], C. R. O'Dell[2], Luis A. Zapata[1], Ma. T. García-Díaz[1,3], Luis F. Rodríguez[1] and Massimo Robberto[4]**

[1] Centro de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, Morelia, Michaoacán, México
[2] Department of Physics and Astronomy, Vanderbilt University, Nashville, TN
[3] Instituto de Astronomía, Universidad Nacional Autónoma de México, Ensenada, B.C., México
[4] Space Telescope Science Institute, Baltimore, MD

E-mail contact: w.henney@astrosmo.unam.mx

Multiple optical outflows are known to exist in the vicinity of the active star formation region called Orion-South (Orion-S). We have mapped the velocity of low ionization features in the brightest part of the Orion Nebula, including Orion-S, and imaged the entire nebula with the Hubble Space Telescope. These new data, combined with recent high resolution radio maps of outflows from the Orion-S region, allow us to trace the origin of the optical outflows. It is confirmed that HH 625 arises from the blueshifted lobe of the CO outflow from 136–359 in Orion-S while it is likely that HH 507 arises from the blueshifted lobe of the SiO outflow from the nearby source 135–356. It is likely that redshifted lobes are deflected within the photon dominated region behind the optical nebula. This leads to a possible identification of a new large shock to the southwest from Orion-S as being driven by the redshifted CO outflow arising from 137–408. The distant object HH 400 is seen to have two even further components and these all are probably linked to either HH 203, HH 204, or HH 528. Distant shocks on the west side of the nebula may be related to HH 269. The sources of multiple bright blueshifted Herbig-Haro objects (HH 202, HH 203, HH 204, HH 269, HH 528) remain unidentified, in spite of earlier claimed identifications. Some of this lack of identification may arise from the fact that deflection in radial velocity can also produce a change in direction in the plane of the sky. The best way to resolve this open question is through improved tangential velocities of low ionization features arising where the outflows first break out into the ionized nebula.

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`http://www.ifront.org/wiki/Orion_South_Outflows_Paper` and `astro-ph/0701614`

## A Possible Correlation between the Gaseous Drag Strength and Resonant Planetesimals in Planetary Systems

**Ing-Guey Jiang[1] and Li-Chin Yeh[2]**

[1] Department of Physics, National Tsing-Hua University, Hsin-Chu, Taiwan
[2] Department of Applied Mathematics, National Hsinchu University of Education, Hsin-Chu, Taiwan

We study the migration and resonant capture of planetesimals in a planetary system consisting of a gaseous disk analogous to the primordial solar nebula and a Neptune-like planet. Using a simple treatment of the drag force, we find that planetesimals are mainly trapped in the 3 : 2 and 2 : 1 resonances and that the resonant populations are correlated with the gaseous drag strength in a sense that the 3 : 2 resonant population increases with the stronger gaseous drag, but the 2 : 1 resonant population does not. Since planetesimals can lead to the formation of larger bodies similar to asteroids and Kuiper Belt objects, the gaseous drag can play an important role in the configuration of a planetary system.

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## Chemistry and line emission from evolving Herbig Ae disks

**B. Jonkheid[1], C. P. Dullemond[2], M. R. Hogerheijde[1], and E. F. van Dishoeck[1]**

[1] Sterrewacht Leiden, Leiden University, PO Box 9513, 2300 RA Leiden, The Netherlands
[2] Max Planck Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

E-mail contact: jonkheid@strw.leidenuniv.nl

*Aims.* To calculate chemistry and gas temperature of evolving protoplanetary disks with decreasing mass or dust settling, and to explore the sensitivity of gas-phase tracers.

*Methods.* The density and dust temperature profiles for a range of models of flaring and self-shadowed disks around a typical Herbig Ae star are used together with 2-dimensional ultraviolet (UV) radiative transfer to calculate the chemistry and gas temperature. In each model the line profiles and intensities for the fine structure lines of [OI], [CII] and [CI] and the pure rotational lines of CO, CN, HCN and $HCO^+$ are determined.

*Results.* The chemistry shows a strong correlation with disk mass. Molecules that are easily dissociated, like HCN, require high densities and large extinctions before they can become abundant. The products of photodissociation, like CN and $C_2H$, become abundant in models with lower masses. Dust settling mainly affects the gas temperature, and thus high temperature tracers like the O and $C^+$ fine structure lines. The carbon chemistry is found to be very sensitive to the adopted PAH abundance. The line ratios $CO/^{13}CO$, $CO/HCO^+$ and [OI] 63 $\mu$m/ 146 $\mu$m can be used to distinguish between disks where dust growth and settling takes place, and disks that undergo overall mass loss.

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## The photophoretic sweeping of dust in transient protoplanetary disks

**O. Krauss[1], G. Wurm[1], O. Mousis[2], J.-M. Petit[2], J. Horner[3], and Y. Alibert[3]**

[1] Institut für Planetologie, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany
[2] Observatoire de Besançon, CNRS-UMR 6091, BP 1615, 25010 Besançon Cedex, France
[3] Physikalisches Institut, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland

E-mail contact: okrauss@uni-muenster.de

*Context.* Protoplanetary disks start their lives with a dust free inner region where the temperatures are higher than the sublimation temperature of solids. As the star illuminates the innermost particles, which are immersed in gas at the sublimation edge, these particles are subject to a photophoretic force.

*Aims.* We examine the motion of dust particles at the inner edge of protoplanetary disks due to photophoretic drag.

*Methods.* We give a detailed treatment of the photophoretic force for particles in protoplanetary disks. The force is applied to particles at the inner edge of a protoplanetary disk and the dynamical behavior of the particles is analyzed.

*Results.* We find that, in a laminar disk, photophoretic drag increases the size of the inner hole after accretion onto the central body has become subdued. This region within the hole becomes an optically transparent zone containing gas and large dusty particles (≫10 cm), but devoid of, or strongly depleted in, smaller dust aggregates. Photophoresis can clear the inner disk of dust out to 10 AU in less than 1 Myr. The details of this clearance depend on the size distribution of the dust. Any replenishment of the dust within the cleared region will be continuously and rapidly swept out to the edge. At late times, the edge reaches a stable equilibrium between inward drift and photophoretic outward drift, at a distance of some tens of AU. Eventually, the edge will move inwards again as the disk disperses, shifting the equilibrium position back from about 40 AU to below 30 AU in 1-2 Myr in the disk model. In a turbulent disk, diffusion can delay the clearing of a disk by photophoresis. Smaller and/or age-independent holes of radii of a few AU are also possible outcomes of turbulent diffusion counteracting photophoresis.

*Conclusions.* This outward and then inward moving edge marks a region of high dust concentration. This density enhancement, and the efficient transport of particles from close to the star to large distances away, can explain features of comets such as high measured ratios of crystalline to amorphous silicates, and has a large number of other applications.

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## Insights from Simulations of Star Formation

**Richard B. Larson**[1]

[1] Department of Astronomy, Yale University, New Haven, CT 06520-8101, USA

E-mail contact: richard.larson@yale.edu

Although the basic physics of star formation is classical, numerical simulations have yielded essential insights into how stars form. They show that star formation is a highly nonuniform runaway process characterized by the emergence of nearly singular peaks in density, followed by the accretional growth of embryo stars that form at these density peaks. Circumstellar disks often form from the gas being accreted by the forming stars, and accretion from these disks may be episodic, driven by gravitational instabilities or by protostellar interactions. Star-forming clouds typically develop filamentary structures, which may, along with the thermal physics, play an important role in the origin of stellar masses because of the sensitivity of filament fragmentation to temperature variations. Simulations of the formation of star clusters show that the most massive stars form by continuing accretion in the dense cluster cores, and this again is a runaway process that couples star formation and cluster formation. Star-forming clouds also tend to develop hierarchical structures, and smaller groups of forming objects tend to merge into progressively larger ones, a generic feature of self-gravitating systems that is common to star formation and galaxy formation. Because of the large range of scales and the complex dynamics involved, analytic models cannot adequately describe many processes of star formation, and detailed numerical simulations are needed to advance our understanding of the subject.

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## Resolving the Nature of the Rosette HH1 Jet Facing Strong UV Dissipation

**J. Z. Li**[1], **Y. -H. Chu**[2], **R. A. Gruendl**[2], **J. Bally**[3], **W. Su**[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China
[2]Department of Astronomy, University of Illinois, Urbana-Champaign, IL, 61801, USA
[3]Center for Astrophysics and Space Astronomy, and Department
of Astrophysical and Planetary Sciences, University of Colorado, Campus Box 389, Boulder, CO 80309-0389, USA

E-mail contact: ljz@bao.ac.cn

The Rosette HH1 jet is a collimated flow immersed in the strong UV radiation field of the Rosette Nebula. We investigate the physical properties of the Rosette HH1 jet using high-quality narrow-band images and high-dispersion spectroscopy. The new images show that the axis of the jet is not precisely aligned with the star near the base of the jet. The high resolution of the spectra allows us to accurately determine the contributions from the HII region, jet, and star. The appoaching and receding sides of the expanding shell of the Rosette Nebula are at heliocentric velocities of 13 and 40 km $s^{-1}$, while the jet reaches a maximum velocity offset at a heliocentric velocity of $-30$ km $s^{-1}$. The [SII] doublet ratios indicate an electron density of $\sim$1000 $cm^{-3}$ in the jet and $\leq$100 $cm^{-3}$ in the HII

region. With a careful subtraction of the nebular and jet components, we find the stellar H$\alpha$ line is dominated by a broad absorption profile with little or no emission component, indicating a lack of substantial circumstellar material. The circumstellar material has most likely been photo-evaporated by the strong UV radiation field in the Rosette Nebula. The evaporation time scale is $10^3 - 10^4$ yr. The Rosette HH1 jet source provides evidence for an accelerated evolution from a CTTS to a WTTS due to the strong UV radiation field; therefore, both CTTSs and WTTSs can be spatially mixed in regions with massive star formation.

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## Collisional Particle Disks

**Yoram Lithwick[1], and Eugene Chiang[2]**

[1] Canadian Institute for Theoretical Astrophysics, Toronto, ON, Canada
[2] Astronomy Department, University of California at Berkeley, CA, USA

We present a new, simple, fast algorithm to numerically evolve disks of inelastically colliding particles surrounding a central star. Our algorithm adds negligible computational cost to the fastest existing collisionless N-body codes and can be used to simulate, for the first time, the interaction of planets with disks over many viscous times. Although the algorithm is implemented in two dimensions-i.e., the motions of bodies need only be tracked in a plane-it captures the behavior of fully three-dimensional disks in which collisions maintain inclinations that are comparable to random eccentricities. The method simulates vertically optically thin disks of identical collisional, massless, inelastic, indestructible test particles. We subject the algorithm to a battery of tests for the case of an isolated narrow circular ring. Numerical simulations agree with analytic theory with regard to how particles' random velocities equilibrate, how the ring viscously spreads, and how energy dissipation, angular momentum transport, and material transport are connected. We derive and measure the critical value of the coefficient of restitution, above which viscous stirring dominates inelastic damping and the particles' velocity dispersion runs away.

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## Formation of Earth-like Planets During and After Giant Planet Migration

**Avi M. Mandell[1,3], Sean N. Raymond[2] and Steinn Sigurdsson[1]**

[1] Pennsylvania State University, University Park, PA 16803, USA
[2] NASA Postdoctoal Program Fellow,University of Colorado, Boulder, CO 80309-0389, USA
[3] NASA Goddard Space Flight Center, Code 693, Greenbelt, MD 20771, USA

E-mail contact: Avi.Mandell@gsfc.nasa.gov

Close-in giant planets are thought to have formed in the cold outer regions of planetary systems and migrated inward, passing through the orbital parameter space occupied by the terrestrial planets in our own Solar System. We present dynamical simulations of the effects of a migrating giant planet on a disk of protoplanetary material and the subsequent evolution of the planetary system. We numerically investigate the dynamics of post-migration planetary systems over 200 million years using models with a single migrating giant planet, one migrating and one non-migrating giant planet, and excluding the effects of a gas disk. Material that is shepherded in front of the migrating giant planet by moving mean motion resonances accretes into "hot Earths", but survival of these bodies is strongly dependent on dynamical damping. Furthermore, a significant amount of material scattered outward by the giant planet survives in highly excited orbits; the orbits of these scattered bodies are then damped by gas drag and dynamical friction over the remaining accretion time. In all simulations Earth-mass planets accrete on approximately 100 Myr timescales, often with orbits in the Habitable Zone. These planets range in mass and water content, with both quantities increasing with the presence of a gas disk and decreasing with the presence of an outer giant planet. We use scaling arguments and previous results to derive a simple recipe that constrains which giant planet systems are able to form and harbor Earth-like planets in the Habitable Zone, demonstrating that roughly one third of the known planetary systems are potentially habitable.

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## A GLIMPSE of the Southern Jellyfish Nebula and Its Massive YSO

**E. P. Mercer[1], D. P. Clemens[1], J. M. Rathborne[1], M. R. Meade[2], B. L. Babler[2], R. Indebetouw[3], B. A. Whitney[4], C. Watson[5], M. G. Wolfire[6], M. J. Wolff[4], T. M. Bania[1], R. A. Benjamin[7], M. Cohen[8], J. M. Dickey[9], J. M. Jackson[1], H. A. Kobulnicky[10], J. S. Mathis[2], S. R. Stolovy[11], B. Uzpen[10], and E. B. Churchwell[2]**

[1] Institute for Astrophysical Research, Boston University, Boston, MA, USA
[2] Astronomy Department, University of Wisconsin, Madison, WI, USA
[3] Department of Astronomy, University of Virginia, Charlottesville, VA, USA
[4] Space Science Institute, Boulder, CO, USA
[5] Department of Physics, Manchester College, North Manchester, IN, USA
[6] Department of Astronomy, University of Maryland, College Park, MD, USA
[7] Physics Department, University of Wisconsin-Whitewater, Whitewater, WI, USA
[8] Radio Astronomy Laboratory, University of California, Berkeley, CA, USA
[9] Department of Astronomy, University of Minnesota, Minneapolis, MN, USA
[10] Department of Physics and Astronomy, University of Wyoming, Laramie, WY, USA
[11] Spitzer Science Center, California Institute of Technology, Pasadena, CA, USA

In Spitzer/IRAC images obtained under the GLIMPSE Legacy Survey, we have identified a unique and provocative nebular object we call the "Southern Jellyfish Nebula." The Southern Jellyfish Nebula is characterized by a fan of narrow tendrils with extreme length-to-width ratios that emanate from the vicinity of a bright infrared point source embedded in a smaller resolved nebula. From CO observations of the Nebula's morphologically associated molecular cloud, we have derived a kinematic distance of $5.7 \pm 0.8$ kpc and a cloud mass of $3.2 \pm 0.9 \times 10^3$ $M_\odot$. The tendril-like ropes of the Nebula have widths of $\sim$0.1 pc and lengths of up to $\sim$2 pc. We have integrated the infrared spectral energy distribution (SED) of the point source to establish it as a massive young stellar object (MYSO), most likely forming alone, but possibly masking fainter cluster members. The shape of the SED is consistent with the shape of a late Class 0 SED model. Based on its far-IR luminosity of $3.3 \pm 0.9 \times 10^4$ $L_\odot$, the Southern Jellyfish's MYSO has a zero-age main sequence (ZAMS) spectral type of B0. Given the curious nature of this nebula, we suspect its peculiar IR-bright structure is directly related to its current state of star formation.

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## Abundant crystalline silicates in the disk of a very low mass star

**B. Merín[1], J.-C. Augereau[2], E. F. van Dishoeck[1], J. Kessler-Silacci[3], C. P. Dullemond[4], G. A. Blake,[5], F. Lahuis[6],1, J. M. Brown[5], V. C. Geers[1], K. M. Pontoppidan[5], F. Comerón[7], A. Frasca[8], S. Guieu[2], J. M. Alcalá[9], A. C. A. Boogert[10], N. J. Evans, II[3], P. D'Alessio[11], L. G. Mundy[12], N. Chapman[12]**

[1]Leiden Observatory, Leiden University, PO Box 9513, NL-2300 RA, Leiden. The Netherlands
[2]Laboratoire d'Astrophysique de Grenoble, Université Joseph Fourier, B.P. 53, 38041 Grenoble Cedex 9, France
[3]Department of Astronomy, University of Texas at Austin, 1 University Station C1400 Austin, TX 78712-0259, USA
[4]Max-Planck-Institut für Astronomie, Königstuhl 17 D-69117, Heidelberg, Germany
[5]Division of Geological and Planetary Sciences, MS 150-21, CalTech, Pasadena, CA 91125, USA
[6]SRON Netherlands Institute for Space Research, PO Box 800, 9700 AV Groningen, The Netherlands
[7]European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748 Garching bei München, Germany
[8]INAF - Osservatorio Astrofisico di Catania, via S. Sofia, 78, 95123 Catania, Italy
[9]INAF - Osservatorio Astronomico di Capodimonte, via Moiariello 16, I-80131, Naples, Italy
[10]Division of Physics, Mathematics and Astronomy, MS 105-24, California Institute of Technology, Pasadena, CA 91125, USA
[11]Centro de Radioastronomía y Astrofísica, UNAM, Apdo. Postal 3-72 (Xangari) 58089 Morelia, Michoacan, Mexico
[12]Astronomy Department, University of Maryland, College Park, MD 20742, USA

E-mail contact: merin@strw.leidenuniv.nl

We announce the discovery of SST-Lup3-1, a very low mass star close to the brown dwarf boundary in Lupus III with a circum(sub)stellar disk, discovered by the 'Cores to Disks' Spitzer Legacy Program from mid-, near-infrared and optical data, with very conspicuous crystalline silicate features in its spectrum. The Spectral Energy Distribution of the system is fit with stellar and disk models to study the disk structure. It is the first of such objects with a full 5 to

35 $\mu$m spectrum taken with the IRS and it shows strong 10 and 20 $\mu$m silicate features with high feature to continuum ratios and clear crystalline features out to 33 $\mu$m. The mass of its flared disk is constrained to lie between $2\times10^{-4}$ and $10^{-7}$ $M_\odot$ (80–0.03 $M_\oplus$ masses) and the dust in the upper layer has a crystalline silicate grain fraction between 15% and 33%, depending on the assumed dust continuum. The availability of the full Spitzer infrared spectrum allows an analysis of the dust composition as a function of temperature and position in the disk. The hot (∼300 K) dust responsible for the 10 $\mu$m feature consists of a roughly equal mix of small (∼ 0.1 $\mu$m) and large (∼ 1.5 $\mu$m) grains, whereas the cold (∼70 K) dust responsible for the longer wavelength silicate features contains primarily large grains ($\geq 1\,\mu$m). Since the cold dust emission arises from deeper layers in the inner (< 3 AU) disk as well as from the surface layers of the outer (3-5 AU) disk, this provides direct evidence for combined grain growth and settling in the disk. The inferred crystalline mass fractions in the two components are comparable. Since only the inner 0.02 AU of the disk is warm enough to anneal the amorphous silicate grains, even the lowest fraction of 15% of crystalline material requires either very efficient mixing or other formation mechanisms.

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## The shape and composition of interstellar silicate grains

**M. Min[1], L. B. F. M. Waters[1,2], A. de Koter[1], J. W. Hovenier[1], L. P. Keller[3] and F. Markwick-Kemper[4]**

[1] Astronomical institute Anton Pannekoek, University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands

[2] Instituut voor Sterrenkunde, Katholieke Universiteit Leuven, Celestijnenlaan 200B, 3001 Heverlee, Belgium

[3] Mail Code KR, NASA Johnson Space Center, Houston, TX 77058, USA

[4] University of Virginia, Department of Astronomy, PO Box 400325, Charlottesville VA 22904-4325, USA

E-mail contact: mmin@science.uva.nl

We investigate the composition and shape distribution of silicate dust grains in the interstellar medium. The effects of the amount of magnesium and iron in the silicate lattice are studied in detail. We fit the spectral shape of the interstellar 10 $\mu$m extinction feature as observed towards the galactic center using various particle shapes and dust materials. We use very irregularly shaped coated and non-coated porous Gaussian Random Field particles as well as a statistical approach to model shape effects. For the dust materials we use amorphous and crystalline silicates with various composition as well as silicon carbide (SiC). The results of our analysis of the 10 $\mu$m feature are used to compute the shape of the 20 $\mu$m silicate feature and to compare this with observations of this feature towards the galactic center. By using realistic particle shapes to fit the interstellar extinction spectrum we are, for the first time, able to derive the magnesium fraction in interstellar silicates. We find that the interstellar silicates are highly magnesium rich ( $\mathrm{Mg}/(\mathrm{Fe}+\mathrm{Mg}) > 0.9$) and that the stoichiometry lies between pyroxene and olivine type silicates ( $\mathrm{O/Si} \approx 3.5$). This composition is not consistent with that of the glassy material found in GEMS in interplanetary dust particles indicating that the amorphous silicates found in the Solar system are, in general, not unprocessed remnants from the interstellar medium. Also, we find that a significant fraction of silicon carbide (∼3%) is present in the interstellar dust grains. We discuss the implications of our results for the formation and evolutionary history of cometary and circumstellar dust. We argue that the fact that crystalline silicates in cometary and circumstellar grains are almost purely magnesium silicates is a natural consequence of our findings that the amorphous silicates from which they were formed were already magnesium rich.

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## Capture-formed Binaries via Encounters with Massive Protostars

**Nickolas Moeckel[1] and John Bally[1]**

[1] Center for Astrophysics and Space Astronomy and Department of Astrophysical and Planetary Sciences, University of Colorado, Boulder, CO, USA

E-mail contact: moeckel@colorado.edu

Most massive stars are found in the center of dense clusters and have a companion fraction much higher than their lower mass siblings; the massive stars of the Trapezium core in Orion have ∼1.5 companions each. This high multiplicity could be a consequence of formation via a capture scenario, or it could be due to fragmentation of the cores that form the massive stars. During stellar formation circumstellar disks appear to be nearly ubiquitous. Their large radii compared to stellar sizes increase the interaction radius significantly, suggesting that disk interactions with neighboring stars could assist in capturing binary companions. This mechanism has been studied for stars of approximately solar mass and found to be inefficient. In this paper we present simulations of interactions between a 22 $M_\odot$ star-disk system and less massive impactors in order to study the disk-assisted capture formation of binaries in a regime suited to massive stars. The formation of binaries by capture is found to be much more efficient for massive capturers. We discuss the effects of a mass-dependent velocity dispersion and mass segregation on the capture rates and consider the long-term survival of the resulting binaries in a dense cluster.

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## The Morphology of M17-UC1: A Disk Candidate Surrounding a Hypercompact H II Region

**M. Nielbock[1,2], R. Chini[1], V. H. Hoffmeister[1], C. M. Scheyda[1], J. Steinacker[2,3], D. Nürnberger[4], and R. Siebenmorgen[5]**

[1] Astronomisches Institut der Ruhr-Universität Bochum, Bochum, Germany
[2] Max Planck Insitut für Astronomie, Heidelberg, Germany
[3] Astronomisches Rechen-Institut am Zentrum für Astronomie Heidelberg, Heidelberg, Germany
[4] European Southern Observatory, Vitacura, Santiago, Chile
[5] European Southern Observatory, Garching, Germany

E-mail contact: nielbock@mpia-hd.mpg.de

We investigate the morphology and the evolutionary stage of the hypercompact H II region M17-UC1 using observations at infrared wavelengths and NIR radiative transfer modeling. For the first time, this region is resolved into two emission areas separated by a dark lane reminiscent of an obscuring silhouette caused by a circumstellar disk. So far, the observational data as well as model calculations suggest that M17-UC1 is surrounded by a disk of cool dust. This direct detection of a circumstellar disk candidate around a hypercompact H II region is in agreement with the expectations of the disk accretion model for high-mass star formation.

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## Molecular Hydrogen Emission from Protoplanetary Disks II. Effects of X-ray Irradiation and Dust Evolution

**H. Nomura[1,3], Y. Aikawa[1], M. Tsujimoto[2], Y. Nakagawa[1] and T.J. Millar[3]**

[1] Department of Earth and Planetary Sciences, Kobe University, Kobe 657-8501, Japan
[2] Department of Physics, Rikkyo University, Toshima, Tokyo 171-8501, Japan
[3] Astrophysics Research Centre, Queen's University Belfast, Belfast BT7 1NN, UK

E-mail contact: h.nomura@qub.ac.uk

Detailed models for the density and temperature profiles of gas and dust in protoplanetary disks are constructed by taking into account X-ray and ultraviolet (UV) irradiation from a central T Tauri star, as well as dust size growth and settling toward the disk midplane. The spatial and size distributions of dust grains in the disks are numerically computed by solving the coagulation equation for settling dust particles, with the result that the mass and total surface area of dust grains per unit volume of the gas in protoplanetary disks are very small, except at the disk midplane. The level populations and line emission of molecular hydrogen are calculated using the derived physical structure of the disks. X-ray irradiation is the dominant heating source of the gas in the inner disk region and in the surface layer, while the far UV heating dominates otherwise. If the central star has strong X-ray and weak UV radiation, the level populations of molecular hydrogen are controlled by X-ray pumping, and the X-ray induced transition lines could be observable. If the UV irradiation is strong, the level populations are controlled by thermal collisions or UV pumping, depending on the properties of the dust grains in the disks. As the dust particles evolve in the disks, the gas temperature at the disk surface drops because the grain photoelectric heating becomes less efficient, while the UV radiation fields become stronger due to the decrease of grain opacity. This makes the level populations of molecular hydrogen change from local thermodynamic equilibrium (LTE) to non-LTE distributions, which results in changes to the line ratios of molecular hydrogen emission. Our results suggest that dust evolution in protoplanetary disks could be observable through the line ratios of molecular hydrogen. The emission lines are strong from disks irradiated by strong UV and X-rays and possessing small dust grains; such disks will be good targets in which to observe molecular hydrogen emission.

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## Age Sequence in Small Clusters Associated with Bright-Rimmed Clouds

**Katsuo Ogura[1], Neelam Chauhan[2], Anil K. Pandey[2], Bhuwan C. Bhatt[3], Devendra Ojha[4] and Yoichi Itoh[5]**

[1] Kokugakuin University, Higashi, Shibuya-ku, Tokyo 150-8440, Japan
[2] Aryabhatta Research Institute of Observational Sciences, Manora Peak, Naini Tal - 263 129, India
[3] CREST, Indian Institute of Astrophysics, Shidlaghatta Road, Hosakote - 562 114, India
[4] Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Mumbai - 400 005, India
[5] Graduate School of Science and Technology, Kobe University, 1-1 Rokkodai, Nada, Kobe, Hyogo 657-8501, Japan

E-mail contact: ogura@kokugakuin.ac.jp

Bright-rimmed clouds (BRCs) found in HII regions are probable sites of triggered star formation due to compression by ionization/shock fronts, and it is hypothesized that star formation proceeds from the exciting star(s) side outward of the HII region (”*small-scale sequential star formation*”). In order to quantitatively test this hypothesis we undertook $BVI_c$ photometry of four BRC aggregates. The amounts of interstellar extinction and reddening for each star have been estimated by using the $JHK_s$ photometry. We then constructed reddening-corrected $V/\,V\text{-}I_c$ color-magnitude diagrams, where the age of each star was derived. All the stars turned out to be a few tenths to a few Myr old. Although the scatters are large and the numbers of the sample stars are small, we found a clear trend that the stars inside or in the immediate vicinity of the bright rim are younger than those outside it in all four aggregates, confirming the hypothesis in question.

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## Depletion and low gas temperature in the L183 prestellar core : the $N_2H^+ - N_2D^+$ tool

**L. Pagani[1], A. Bacmann[2], S. Cabrit[1] and C. Vastel[3]**

[1] LERMA, UMR8112, Observatoire de Paris, France
[2] Universit de Bordeaux 1, OASU, Bordeaux, France
[1] LERMA, UMR8112, Observatoire de Paris, France
[3] CESR, Toulouse, France

E-mail contact: laurent.pagani@obspm.fr

*Context.*The study of pre-stellar cores (PSCs) suffers from a lack of undepleted species to trace the gas physical properties in their very dense inner parts.

*Aims.* We want to carry out detailed modelling of $N_2H^+$ and $N_2D^+$ cuts across the L183 main core to evaluate the depletion of these species and their usefulness as a probe of physical conditions in PSCs.

*Methods.* We have developed a non-LTE (NLTE) Monte-Carlo code treating the 1D radiative transfer of both $N_2H^+$ and $N_2D^+$, making use of recently published collisional coefficients with He between individual hyperfine levels. The code includes line overlap between hyperfine transitions. An extensive set of core models is calculated and compared with observations. Special attention is paid to the issue of source coupling to the antenna beam.

*Results.* The best fitting models indicate that i) gas in the core center is very cold (7± 1 K) and thermalized with dust, ii) depletion of $N_2H^+$ does occur, starting at densities 5–$7 \times 10^5$ cm$^{-3}$ and reaching a factor of $6^{+13}_{-3}$ in abundance, iii) deuterium fractionation reaches ∼70% at the core center, and iv) the density profile is proportional to r$^{-1}$ out to ∼4000 AU, and to r$^{-2}$ beyond.

*Conclusions.* Our NLTE code could be used to (re-)interpret recent and upcoming observations of $N_2H^+$ and $N_2D^+$ in many pre-stellar cores of interest, to obtain better temperature and abundance profiles.

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http://aramis.obspm.fr/∼pagani/l134n.html

## The Arecibo Methanol Maser Galactic Plane Survey–I: Data

**Jagadheep D. Pandian[1], Paul F. Goldsmith[2] and Avinash A. Deshpande[3]**

[1] Cornell University, Ithaca, NY 14853
[2] Jet Propulsion Laboratory, Pasadena, CA 91109
[3] Raman Research Institute, Bangalore 560 080, India

E-mail contact: jagadheep@astro.cornell.edu

We present the results of an unbiased survey for 6.7 GHz methanol masers in the Galactic plane carried out using the 305 m Arecibo radio telescope. A total of 18.2 square degrees was surveyed with uniform sampling at $35.2° \leq l \leq 53.7°$, $|b| \leq 0.41°$. The large collecting area of Arecibo and the sensitive C-Band High receiver allowed the survey to be complete at the level of 0.27 Jy making this the most sensitive blind survey carried out to date. We detected a total of 86 sources, 48 of which are new detections. Most of the new detections have a peak flux density below 2 Jy. Many methanol masers are clustered, reflecting the formation of massive stars in clusters.

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## SMA Observations of 321 GHz Water Maser Emission in Cepheus-A

**Nimesh A. Patel[1], Salvador Curiel[2], Qizhou Zhang[1], T. K. Sridharan[1], Paul T. P. Ho[1,3] and José M. Torrelles[4]**

[1] Harvard-Smithsonian Center for Astrophysics
[2] Instituto de Astronomía, Universidad Nacional Autónoma de México, Apartado Postal 70-264, 04510 Mexico DF, Mexico
[3] Academia Sinica Institute of Astronomy and Astrophysics, Taipei, Taiwan
[4] Instituto de Ciencias del Espacio, Facultat de Física, Planta 7a, Universitat de Barcelona, Av. Diagonal 647, 08028 Barcelona, Spain

E-mail contact: npatel@cfa.harvard.edu

Using the Submillimeter Array (SMA) we have imaged for the first time the 321.226 GHz, $10_{29} - 9_{36}$ ortho-$H_2O$ maser emission. This is also the first detection of this line in the Cepheus-A high-mass star-forming region. The 22.235 GHz, $6_{16} - 5_{23}$ water masers were also observed with the Very Large Array (VLA) 43 days following the SMA observations. Three out of the nine detected submillimeter maser spots are associated with the centimeter masers spatially as well as kinematically, while there are 36 22 GHz maser spots without corresponding submillimeter masers. In the HW2 source, both the 321 GHz and 22 GHz masers occur within the region of $\sim$ 1" which includes the disk-jet system, but the position angles of the roughly linear structures traced by the masers indicate that the 321 GHz masers are along the jet while the 22 GHz masers are perpendicular to it. We interpret the submillimeter masers in Cepheus A to be tracing significantly hotter regions (600∼2000 K) than the centimeter masers.

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## The Spitzer c2d Survey of Large, Nearby, Interstellar Clouds. V. Chamaeleon II Observed with IRAC

**Alicia Porras[1,2], Jes K. Jørgensen[1], Lori E. Allen[1], Neal J. Evans II[3], Tyler L. Bourke[1], Juan M. Alcalá[4], Michael M. Dunham[3], Geoffrey A. Blake[5], Nicholas Chapman[6], Lucas Cieza[3], Paul M. Harvey[3], Tracy L. Huard[1], David W. Koerner[7], Lee G. Mundy[6], Philip C. Myers[1], Deborah L. Padgett[8], Anneila I. Sargent[9], Karl R. Stapelfeldt[10], Peter Teuben[6], Ewine F. van Dishoeck[11], Zahed Wahhaj[7,12], and Kaisa**

**E. Young**[3,13]

[1] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA
[2] Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE), Tonantzintla, Pue., México
[3] Department of Astronomy, University of Texas at Austin, Austin, TX, USA
[4] INAF-Osservatorio Astronomico di Capodimonte, Napoli, Italy
[5] Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA, USA
[6] Department of Astronomy, University of Maryland, College Park, MD, USA
[7] Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ, USA
[8] Spitzer Science Center, California Institute of Technology, Pasadena, CA, USA
[9] Division of Physics, Mathematics, and Astronomy, California Institute of Technology, Pasadena, CA, USA
[10] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
[11] Leiden Observatory RA Leiden, The Netherlands
[12] Institute for Astronomy, Honolulu, HI, USA
[13] Department of Physical Sciences, Nicholls State University, Thibodaux, LA, USA

E-mail contact: aporras@cfa.harvard.edu

We present IRAC (3.6, 4.5, 5.8, and 8.0$\mu$m) observations of the Chamaeleon II molecular cloud. The observed area covers about 1 deg$^2$ defined by $A_V > 2$. Analysis of the data in the 2005 c2d catalogs reveals a small number of sources (40) with properties similar to those of young stellar or substellar objects (YSOs). The surface density of these YSO candidates is low, and contamination by background galaxies appears to be substantial, especially for sources classified as Class I or flat spectral energy distribution (SED). We discuss this problem in some detail and conclude that very few of the candidate YSOs in early evolutionary stages are actually in the Cha II cloud. Using a refined set of criteria, we define a smaller, but more reliable, set of 24 YSO candidates.

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## The Spitzer c2d Survey of Large, Nearby, Interstellar Clouds: VI. Perseus Observed with MIPS

**L. M. Rebull**[1], **K. R. Stapelfeldt**[2] **and the c2d team (see paper for full list)**[3]

[1] Spitzer Science Center
[2] JPL
[3] (see paper for full listing)

E-mail contact: rebull@ipac.caltech.edu

We present observations of 10.6 square degrees of the Perseus molecular cloud at 24, 70, and 160 $\mu$m with the *Spitzer Space Telescope* Multiband Imaging Photometer for Spitzer (MIPS). The image mosaics show prominent, complex extended emission dominated by illuminating B stars on the East side of the cloud, and by cold filaments of 160 $\mu$m emission on the West side.

Of 3950 point sources identified at 24 $\mu$m, 1141 have 2MASS counterparts. A quarter of these populate regions of the $K_s$ vs. $K_s-[24]$ diagram that are distinct from stellar photospheres and background galaxies, and thus are likely to be cloud members with infrared excess. Nearly half (46%) of these 24 $\mu$m excess sources are distributed outside the IC 348 and NGC 1333 clusters. NGC 1333 shows the highest fraction of stars with flat or rising spectral energy distributions (28%), while Class II SEDs are most common in IC 348. These results are consistent with previous relative age determinations for the two clusters. A significant number of IRAS PSC objects are not recovered by *Spitzer*/MIPS, most often because the IRAS objects were confused by bright nebulosity. There is no evidence for 24 $\mu$m source variability to 10% between the ~3-6 hours of our two observation epochs.

The intercluster region contains several tightly clumped ($r$ ~0.1 pc) young stellar aggregates whose members exhibit a wide variety of infrared spectral energy distributions characteristic of different circumstellar environments. One possible explanation is a significant age spread among the aggregate members, such that some have had time to evolve more than others. Alternatively, if the aggregate members all formed at roughly the same time , then remarkably rapid circumstellar evolution would be required to account for the association of Class I and Class III sources at ages $<\sim$ 1 Myr.

We highlight important results for the HH 211 flow, where the bowshocks are detected at both 24 and 70 $\mu$m; and

for the debris disk candidate BD +31D643, where the MIPS data shows the linear nebulosity to be an unrelated interstellar feature. Our data, mosaics, and catalogs are available at the Spitzer Science Archive for use by interested members of the community.

Accepted by ApJS

http://peggysue.as.utexas.edu/SIRTF/ then click on 'publications' or http://spider.ipac.caltech.edu/staff/rebull/research.html (astro-ph version has degraded figures, so please download from one of these sites)

## Discovery of $\delta$ Scuti pulsation in the Herbig Ae star VV Serpentis

**V. Ripepi[1], S. Bernabei2, 3, M. Marconi[1], A. Ruoppo[1], 4, F. Palla[5], M. J. P. F. G. Monteiro[6], J. P. Marques[6], P. Ferrara[1], S. Marinoni[2], and L. Terranegra[1]**

[1] INAF - Osservatorio Astronomico di Capodimonte, via Moiariello 16, 80131 Napoli, Italy
[2] INAF - Osservatorio Astronomico di Bologna, via Ranzani 1, 40127 Bologna, Italy
[3] Departimento de Astrofíca, Universidad de La Laguna, Avda. Astrofisico F. Sánchez sn, 30071 La Laguna, Spain
[4] Dipartimento di Scienze Fisiche, Università Federico II, Complesso Monte S. Angelo, 80126 Napoli, Italy
[5] INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy
[6] DMA-Faculdade de Ciências and Centro de Astrofíca da Universidade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal

E-mail contact: ripepi@na.astro.it

*Context.* The study of pulsation in pre-main-sequence intermediate mass stars represents an important tool for deriving information on the stellar parameters and structure, as well as for testing the validity of current theoretical models. The interest in this class of variable stars has significantly increased during the last decade and about 30 members are presently known in the literature.

*Aims.* A new observational study of the Herbig Ae star VV Ser has been performed to detect and accurately measure pulsation frequencies in the $\delta$ Scuti range, thus enlarging the sample of known pulsators and contributing to the empirical definition of the pre-main-sequence instability strip. As it belongs to the continuous field of view of the asteroseismological satellite COROT, this study also aims at characterizing the properties of VV Ser as a potential "COROT additional program" candidate.

*Methods.* CCD time series photometry in the Johnson V filter has been obtained for three consecutive years. The resulting light curves have been subject to detailed frequency analysis and the derived frequencies have been compared to model predictions.

*Results.* Seven pulsation frequencies have been measured on the basis of the best data set obtained in 2004, ranging from $\sim$31 to $\sim$118 $\mu$Hz, with an accuracy of the order of 0.5 $\mu$Hz. The comparison with an extensive set of asteroseismological models shows that all the observed periodicities can be reproduced if the stellar mass is close to 4 $M_\odot$. Conversely, the measured frequencies can be associated with p modes only if the effective temperature is significantly lower than that obtained from the spectral type conversion.

*Conclusions.* The present results seem to suggest that more accurate spectral type determination is necessary to discriminate the best-fit model solution. In any case, the stellar mass of VV Ser is close to the upper mass limit ($\sim$ 4 $M_\odot$) for this class of pulsators.

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## Optical polarimetry of HH135/HH136

**C. V. Rodrigues[1], G. R.Hickel[2], A. H. Cerqueira[3] and C. G. Targon[1]**

[1] Instituto Nacional de Pesquisas Espaciais - Brazil
[2] IP&D - Universidade do Vale do Paraiba - Brazil
[3] LATO-DCET/Universidade Estadual de Santa Cruz - Brazil

E-mail contact: claudiavr@das.inpe.br

We present optical linear polarimetry in the line of sight to HH 135/HH 136. The polarimetry of the field stars reveals two populations: one corresponds to a foreground interstellar component; the other originates in the interstellar

medium in the vicinity of the Herbig-Haro pair and, therefore, can be used to study the magnetic field in the star forming region. Its direction is aligned with the jet of HH 135/HH 136, which could be an indication that the interstellar magnetic field is important in the outflow collimation. The interstellar magnetic field magnitude was estimated to be of order 90 $\mu$G. According to recent numerical simulations, an interstellar magnetic field of such strength can be important in the definition of the outflow direction. There is also evidence that the associated dark cloud has an elongation parallel to the magnetic field. Our image polarimetry of the extended emission associated with HH 135/HH 136 shows a centro-symmetric pattern pointing to the knot E of HH 136. Previous near infrared polarimetry traces a different illumination center, namely IRAS 11101−5829 - the probable exciting source of the system. This discrepancy can be explained if the YSO emission is completely blocked in optical wavelengths and the dominant optical source in the region is the knot E, whose nature is uncertain. A discussion of the spectral energy distributions of HH 136-E and IRAS 11101−5829 is presented.

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## Magnetic fields at the periphery of UCHII regions from carbon recombination line observations

**D. Anish Roshi**[1]

[1] Raman Research Institute, Sadashivanagar, Bangalore 560080, India

E-mail contact: anish@rri.res.in

Several indirect evidences indicate a magnetic origin for the non-thermal width of spectral lines observed toward molecular clouds. In this letter, I suggest that the origin of the non-thermal width of carbon recombination lines (CRLs) observed from photo-dissociation regions (PDRs) near ultra-compact H II regions is magnetic and that the magnitude of the line width is an estimate of the Alfv́en speed. The magnetic field strengths estimated based on this suggestion compare well with those measured toward molecular clouds with densities similar to PDR densities. I conclude that multi-frequency CRL observations have the potential to form a new tool to determine the field strength near star forming regions.

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## Deuterium fractionation in warm dense interstellar clumps

**E. Roueff**[1]**, B. Parise**[2] **and E. Herbst**[3]

[1] LUTH, Observatoire de Paris, Section de Meudon, Place Jules Janssen, 92195 Meudon, France
[2] MPIfR, Auf dem Hügel 69, 53121 Bonn, Germany
[3] Departments of Physics, Astronomy and Chemistry,The Ohio State University, Columbus, Ohio, USA

E-mail contact: evelyne.roueff@obspm.fr

**Aims:** In a recently published 1-millimeter line survey of the Orion Bar by Leurini et al., the confirmation of dense neutral clumps was reported based mainly on an analysis of methanol spectral lines. Within these clumps, a high abundance ratio was found between the deuterated isotopologue DCN and HCN.
**Methods:** In this paper, we use steady-state chemical modelling to determine if the DCN/HCN abundance ratio can be understood in terms of gas-phase processes.
**Results:** Our results show that, at temperatures (50-75 K) and densities (5-20 $\times$ $10^6$ cm$^{-3}$) in the vicinity of those measured, the calculated DCN/HCN abundance ratio can reach 0.01 or even higher, in good agreement with the measured range of 0.007 - 0.009. Moreover, the fractional abundance of HCN is also calculated to be in the vicinity of that reported. Other computed abundance ratios between deuterated and normal isotopologues are reported for the physical conditions of the clumps. The abundance ratios are analyzed as functions of temperature and density in terms of a simple formula. In general, calculated ratios can be somewhat dependent on the choice of two very different sets of elemental abundances, one of which is the "standard" low-metal set, while the other we term the "warm-core" set.

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http://www.aanda.org/index.php?option=forthcoming&Itemid=18

## Lithium-depleted stars in the young $\sigma$ Orionis cluster

**G. G. Sacco[1,2], S. Randich[3], E. Franciosini[1], R. Pallavicini[1], and F. Palla[3]**

[1] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy
[2] Dipartimento di Scienze Fisiche ed Astronomiche, Sezione Astronomia, Piazza del Parlamento 1, 90134 Palermo, Italy
[3] INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy

E-mail contact: sacco@astropa.unipa.it

*Context.* Knowledge of the age distribution of stars in young clusters and associations is crucial to constrain models of star formation. HR diagrams of different young clusters and associations suggest the presence of age spreads, but the influence of errors on the derived ages is still largely debated. Determination of lithium abundances in low-mass stars represents an alternative and robust way to infer stellar ages.

*Aims.* We measured lithium in a sample of low mass members of the young (4-5 Myr) $\sigma$ Ori cluster with the main goal of investigating its star formation history.

*Methods.* Using the FLAMES multi-object spectrograph on VLT/UT2, we obtained spectra of 98 candidate cluster members. The spectra were used to determine radial velocities, to infer the presence of H$\alpha$ emission, and to measure the strength of the Li I 670.8 nm absorption line.

*Results.* Using radial velocities, H$\alpha$ and Li, together with information on X-ray emission, we identified 59 high probability cluster members. Three of them show severe Li depletion. The nuclear ages inferred for these highly depleted stars exceed 10-15 Myr; for two of them these values are in good agreement with the isochronal age, while for the third star the nuclear age exceeds the isochronal one.

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## Molecular Gas in the Inner 1 AU of the TW Hya and GM Aur Transitional Disks

**C. Salyk[1], G. A. Blake[1], A. C. A. Boogert[2], and J. M. Brown[3]**

[1] Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA, USA
[2] NOAO, Gemini Science Center, La Serena, Chile
[3] Division of Physics, Mathematics and Astronomy, California Institute of Technology, Pasadena, CA, USA

E-mail contact: csalyk@gps.caltech.edu

We report the detection of CO rovibrational emission from the transitional disks around the T Tauri stars TW Hya and GM Aur. Transitional disks are characterized by significant mid- to far-infrared (IR) dust emission combined with a relative deficit in the near-IR, indicating the presence of an optically thick outer disk but a reduced surface density of small dust grains in the inner disk. Kinematic fits to the resolved CO emission lines demonstrate that they arise from within the tenuous inner disk. Excitation diagram analyses yield rotational temperatures also consistent with small emission radii as well as densities implying dynamically significant amounts of gas in the inner disk and a gas-to-small dust grain ratio in excess of that in dense clouds. Nevertheless, gas densities are not high enough to maintain current accretion rates for more than a few hundred years without replenishment, and transfer of gas from the outer to inner disk is therefore likely required.

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## Discovery of variable X-ray absorption in the cTTS AA Tauri

**J. H. M. M. Schmitt[1] and J. Robrade[1]**

[1] Hamburger Sternwarte, Gojenbergsweg 112, 21029 Hamburg, Germany

E-mail contact: jschmitt@hs.uni-hamburg.de

We present XMM-Newton X-ray and UV observations of the classical T Tauri star AA Tau covering almost two rotational periods where $P_{\rm rot} \sim 8.5$ days. Clear, but uncorrelated variability is found at both wavebands. The variability observed at ~2100 Å follows the previously known optical period. Spectral analysis of the X-ray data results in significant variability in the X-ray absorption such that the times of maximal X-ray absorption and UV extinction

coincide. Placing the coronal emission in regions at low up to moderate magnetic latitudes and attribution of the variable X-ray absorption to accretion curtains and/or the disk warp provides a consistent physical picture. However, the derived X-ray absorption and optical extinction at times of maximal optical/UV brightness, i.e. outside occultation, are difficult to reconcile, requiring additional absorption in a disk wind or a peculiar dust grain distribution.

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## A Herbig-Haro object associated with GGD30 and its exciting source

**R.G. Smith[1], W.A. Lawson[1], and C.M. Wright[1]**

[1] School of Physical, Environmental & Mathematical Sciences, The University of New South Wales, Australian Defence Force Academy, Canberra, ACT 2600, Australia

E-mail contact: r.smith@adfa.edu.au

GGD30 has been suggested to be either a small reflection nebulosity or a Herbig-Haro (HH) object formed in the outflow from a nearby obscured star. Observations to date have not been able to distinguish between these two scenarios. In addition, there are conflicting proposals for the location of the exciting source for GGD30. To resolve these questions, we have carried out optical spectroscopy and near-infrared (J, K and 3.6-$\mu$m) imaging of GGD30. Taken together, these observations reveal that the bright optical knot in GGD30 must be a HH object, excited by the outflow from an optically obscured pre-main-sequence (PMS) star located $\sim$3 arcsec to the southwest. Based on mid-infrared fluxes from the Mid-course Space Experiment (MSX) satellite, we estimate the luminosity of this PMS star to be $\sim$12.5 $L_\odot$ which suggests it is an intermediate-mass object rather than low-mass as previously proposed. The optical spectroscopy indicates projected velocities of $\sim$ -270 km s$^{-1}$ associated with the HH object. The fact that these velocities are blueshifted and relatively high compared to the velocities typical of HH flows suggests that the outflow from the PMS star must be almost aligned with the line of sight. There is an additional low-velocity ($\sim$ -70 km s$^{-1}$) H$\alpha$ component but its origin is not clear.

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## A WFI survey in the Chamaeleon II dark cloud

**L. Spezzi[1], J.M. Alcalá[2], A. Frasca[1], E. Covino[2] and D. Gandolfi[3]**

[1] INAF - Osservatorio Astrofisico di Catania, via S. Sofia, 78, 95123 Catania, Italy

[2] INAF - Osservatorio Astronomico di Capodimonte, Salita Moiariello, 16, 80131 Napoli, Italy

[3] Dipartimento di Fisica e Astronomia, Universitá di Catania, via S. Sofia 78, 95123 Catania, Italy

E-mail contact: lspezzi@oact.inaf.it

We present the results of an optical multi-band survey for low-mass Pre-Main Sequence (PMS) stars and young Brown Dwarfs (BDs) in the Chamaeleon II (Cha II) dark cloud. This survey constitutes the complementary optical data to the c2d Spitzer Legacy survey in Cha II.

Using the Wide-Field Imager (WFI) at the ESO 2.2 m telescope, we surveyed a sky area of about 1.75 square degrees in Cha II. The region was observed in the $R_c$, $I_c$ and $z$ broad-bands, in H$\alpha$ and in two medium-band filters centered at 856 and 914 nm. We select PMS star and young BD candidates using colour-magnitude diagrams (CMDs) and theoretical isochrones reproduced *ad-hoc* for the WFI at the ESO2.2m telescope system. The selection criteria are also reinforced by using the previously known PMS stars in Cha II to define the PMS locus on the CMDs and by investigating the infrared (IR) colours of the candidates. By exploiting the WFI intermediate-band photometry we also estimate the effective temperature and the level of H$\alpha$ emission of the candidates.

Our survey, which is one of the largest and deepest optical surveys conducted so far in Cha II, recovered the majority of the PMS stars and 10 member candidates of the cloud from previous IR surveys. In addition, the survey revealed 10 new potential members. From our photometric characterisation, we estimate that some 50% of the 20 candidates will result in true Cha II members. Based on our temperature estimates, we conclude that several of these objects are expected to be sub-stellar and give a first estimate of the fraction of sub-stellar objects.

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ftp://astrct.oact.inaf.it/pub/lspezzi/preprints/lspezzi_ChaII_WFI_survey_preprint.ps.gz

## Protostar Formation in Magnetic Molecular Clouds beyond Ion Detachment: I. Formulation of the Problem and Method of Solution

**Konstantinos Tassis[1] and Telemachos Ch. Mouschovias[2]**

[1] University of Chicago, Chicago, IL 60637, USA
[2] University of Illinois, Urbana, IL 61801, USA

E-mail contact: tassis@cfcp.uchicago.edu

We formulate the problem of the formation of magnetically supercritical cores in magnetically subcritical parent molecular clouds, and the subsequent collapse of the cores to high densities, past the detachment of ions from magnetic field lines and into the opaque regime. We employ the six-fluid MHD equations, accounting for the effects of grains (negative, positive and neutral) including their inelastic collisions with other species. We do not assume that the magnetic flux is frozen in any of the charged species. We derive a generalized Ohm's law that explicitly distinguishes between flux advection (and the associated process of ambipolar diffusion) and Ohmic dissipation, in order to assess the contribution of each mechanism to the increase of the mass-to-flux ratio of the central parts of a collapsing core and possibly to the resolution of the magnetic flux problem of star formation. We show how our formulation is related to and can be transformed into the traditional, directional formulation of the generalized Ohm's law, and we derive formulae for the perpendicular, parallel and Hall conductivities entering the latter, which include, for the first time, the effect of inelastic collisions between grains. In addition, we present a general (valid in any geometry) solution for the velocities of charged species as functions of the velocity of the neutrals and of the effective flux velocity (which can in turn be calculated from the dynamics of the system and Faraday's law). The last two sets of formulae can be adapted for use in any general non-ideal MHD code to study phenomena beyond star formation in magnetic clouds. The results, including a detailed parameter study, are presented in two accompanying papers.

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## Protostar Formation in Magnetic Molecular Clouds beyond Ion Detachment: II. Typical Axisymmetric Solution

**Konstantinos Tassis[1] and Telemachos Ch. Mouschovias[2]**

[1] University of Chicago, Chicago, IL 60637, USA
[2] University of Illinois, Urbana, IL 61801, USA

E-mail contact: tassis@cfcp.uchicago.edu

We follow the ambipolar-diffusion–driven formation and evolution of a fragment in a magnetically supported molecular cloud, until a hydrostatic protostellar core forms at its center. This problem was formulated in Paper I. We determine the density, velocity and magnetic field as functions of space and time, and the contribution of ambipolar diffusion and Ohmic dissipation to the resolution of the magnetic flux problem of star formation. The issue of whether the magnetic field ever decouples from the (neutral) matter is also addressed. We also find that the electrons do not decouple from the field lines before thermal ionization becomes important and recouples the magnetic field to the neutral matter. Ohmic dissipation becomes more effective than ambipolar diffusion as a flux reduction mechanism only at the highest densities (a few $\times 10^{12}\,\mathrm{cm}^{-3}$). In the high-density central parts of the core, the magnetic field acquires an almost spatially uniform structure, with a value that, at the end of the calculation (number density $\sim 5 \times 10^{14}\,\mathrm{cm}^{-3}$), is found to be in excellent agreement with meteoritic measurements of magnetic fields in the protosolar nebula. Outside the hydrostatic protostellar core, a concentration of magnetic flux (a "magnetic wall") forms, which gives rise to a magnetic shock. This magnetic shock is the precursor of the repeated shocks found by Tassis & Mouschovias (2005) which cause spasmodic accretion onto the hydrostatic core at later times.

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## Protostar Formation in Magnetic Molecular Clouds beyond Ion Detachment: III. A Parameter Study

**Konstantinos Tassis[1] and Telemachos Ch. Mouschovias[2]**

[1] University of Chicago, Chicago, IL 60637, USA
[2] University of Illinois, Urbana, IL 61801, USA

E-mail contact: tassis@cfcp.uchicago.edu

In two previous papers we formulated and solved, for a fiducial set of free parameters, the problem of the formation and evolution of a magnetically supercritical core inside a magnetically subcritical parent cloud. In this paper we present a parameter study to assess the sensitivity of the results (1) to the density at which the equation of state becomes adiabatic; (2) to the initial mass-to-flux ratio of the parent cloud; and (3) to ionization by radioactive decay of different nuclei ($^{40}$K and $^{26}$Al) at high densities (number density $> 10^{12}\,\mathrm{cm}^{-3}$). We find that (1) the results depend only slightly on the density at which the onset of adiabaticity occurs; (2) memory of the initial mass-to-flux ratio is completely lost at late times, which emphasizes the relevance of this work, idependently of the adopted theory of core formation; and (3) the precise source of radioactive ionization alters the degree of attachment of the electrons to the field lines (at high densities), and the relative importance of ambipolar diffusion and Ohmic dissipation in reducing the magnetic flux of the protostar. The value of the magnetic field at the end of the runs is insensitive to the values of the free parameters and in excellent agreement with meteoritic measurements of the protosolar nebula magnetic field. The magnetic flux problem of star formation is resolved for at least strongly magnetic newborn stars. A complete detachment of the magnetic field from the matter is unlikely. The formation of a "magnetic wall" (with an associated magnetic shock) is independent of the assumed equation of state, although the process is enhanced and accelerated by the formation of a central hydrostatic core.

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## Overcoming Migration during Giant Planet Formation

**Edward W. Thommes[1], Leif Nilsson[2], and Norman Murray[1]**

[1] Canadian Institute for Theoretical Astrophysics, University of Toronto, Toronto, ON, Canada
[2] Department of Physics, University of Toronto, Toronto, ON, Canada

E-mail contact: thommes@cita.utoronto.ca

In the core accretion model, gas giant formation is a race between growth and migration; for a core to become a Jovian planet, it must accrete its envelope before it spirals into the host star. We use a multizone numerical model to extend our previous investigation of the "window of opportunity" for gas giant formation within a disk. When the collision cross section enhancement due to core atmospheres is taken into account, we find that a broad range of protoplanetary disks possess such a window.

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## 2-D preplanetary accretion disks: I. Hydrodynamics, chemistry, and mixing processes

**W. M. Tscharnuter[1] and H.-P. Gail[1]**

[1] Zentrum für Astronomie (ZAH), Institut für Theoretische Astrophysik (ITA), University of Heidelberg, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

E-mail contact: wmt@ita.uni-heidelberg.de

*Aims.* We outline a numerical method to calculate spatially two-dimensional (2-D) reactive flows and mixing processes in preplanetary accretion disks and present first results. The numerical efficiency and robustness is demonstrated by following the hydrodynamical and chemical evolution of the disk from a highly non-stationary dynamical "switch-on" phase asymptotically into the quasi-stationary, viscous accretion regime. One major question we address is the C-, H-, O-chemistry. The leit-motif of our investigation is the attempt to preserve as much consistency as possible when modelling the hydrodynamical, chemical, transport/mixing processes and their mutual interactions in preplanetary disks.

*Methods.* We use an explicit scheme for solving the Navier-Stokes equations combined with an implicit solver for the energy equation. The viscosity coefficient is modelled according to the so-called $\beta$-prescription of "turbulent" viscosity. In contrast to the well-known $\alpha$-viscosity, the $\beta$-parameterization of the viscosity warrants physical consistency if self-

gravitation of the disk material is to be taken into account. However, up to now we have neglected self-gravitation. For the radiative energy transport we have adopted the (grey) Eddington approximation. The opacity is assumed to be caused by microscopic dust particles. Diffusive mixing of the various chemical species is modelled by taking the diffusion coefficient, D, proportional to the (turbulent) viscosity, $\nu_{\rm turb}$. For comparison purposes, we have considered two extreme choices of the Schmidt number, $\mathcal{S} := \nu_{\rm turb}/D$, that is, $\mathcal{S} = 1$ ( $D = \nu_{\rm turb}$) and $\mathcal{S} = \infty$ (D=0, i.e., no diffusive mixing at all), respectively. We have not yet included coagulation processes and grain growth.

*Results.* The main outcome of the 2-D simulations so far carried out is a characteristic circulation pattern of the quasi-stationary accretion flow: Near the disk's equatorial plane which is assumed to be a plane of symmetry the material moves in the outward direction, whereas the accretion flow proper develops in higher altitudes of the disk. Species that are produced or undergo chemical reactions in the warm inner zones of the disk are advectively transported into the cool outer regions. At the same time, they either diffusively mix up with the surrounding material or freeze out on the dust grains to form "ice"-coated particles. By virtue of the large-scale circulation, which is driven by viscous angular momentum transfer, advective transport dominates diffusive mixing in the outer part of the disk.

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## Photon Bubbles in the Circumstellar Envelopes of Young Massive Stars

**N. J. Turner[1], E. Quataert[2] and H. W. Yorke[1]**

[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109, USA

[2] Astronomy Department, University of California, Berkeley, California 94720, USA

E-mail contact: neal.turner@jpl.nasa.gov

We show that the optically-thick dusty envelopes surrounding young high-mass stars are subject to the photon bubble instability. The infrared radiation passing through the envelope amplifies magnetosonic disturbances, with growth rates in our local numerical radiation MHD calculations that are consistent with a linear analysis. Modes with wavelengths comparable to the gas pressure scale height grow by more than two orders of magnitude in a thousand years, reaching non-linear amplitudes within the envelope lifetime. If the magnetic pressure in the envelope exceeds the gas pressure, the instability develops into trains of propagating shocks. Radiation escapes readily through the low-density material between the shocks, enabling accretion to continue despite the Eddington limit imposed by the dust opacity. The supersonic motions arising from the photon bubble instability can help explain the large velocity dispersions of hot molecular cores, while conditions in the shocked gas are suitable for maser emission. We conclude that the photon bubble instability may play a key role in the formation of massive stars.

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## $H_2O$ maser emission from bright rimmed clouds in the southern hemisphere

**R. Valdettaro[1], J.M. Chapman[2], J.E.J. Lovell[2,3] and F. Palla[1]**

[1] INAF-Osservatorio Astrofisico di Arcetri, Largo E. Fermi, 5, I-50125 Firenze, Italy

[2] CSIRO Australia Telescope National Facility, PO Box 76, Epping, NSW 1710, Australia

[3] CSIRO Industrial Physics, PO Box 218, Lindfield NSW 2070

E-mail contact: rv@arcetri.astro.it

Water maser emission is a powerful tracer of the presence of embedded sources in dense clouds since it requires elevated temperatures (>100 K) and densities ($> 10^7$ cm$^{-3}$) that can be found in circumstellar disks and/or jets/outflows associated with Young Stellar Objects. Bright rimmed clouds compressed by ionization fronts from nearby massive stars are considered good examples of externally triggered star formation, possibly resulting in the formation of massive stars. We aim to determine the water maser emission frequency and characteristics of 45 bright rimmed clouds in the southern hemisphere identified by Sugitani & Ogura (1994). We have used the Tidbinbilla 70-m radiotelescope to perform a high sensitivity survey at 22.2 GHz of the maser emission from the $6_{16} - 5_{23}$ rotational transition of $H_2O$ molecules. We found 7 water maser sources out of 44 (16% detection rate), 5 being new detections. With the exception of the maser associated with BRC 68, all the other maser are characterized by low integrated fluxes and luminosities. Most maser sources fall below the correlation between the $H_2O$ and far-infrared luminosity found in other studies

towards a variety of star forming regions. These results are similar to those found in the companion survey of BRCs in the northern hemisphere by Valdettaro et al. (2005). The low detection frequency and the properties of water maser emission from BRCs indicate that *low-mass* star formation is the most natural outcome of the external compression induced by the ionization front from nearby massive stars.

Accepted by Astronomy and Astrophysics

preprint available at http://www.arcetri.astro.it/~starform/publ2007.htm

## Inferences from the kinematic properties of 6.7 GHz methanol masers

**D.J. van der Walt[1], A.M. Sobolev[2] and H. Butner[3]**

[1] Unit for Space Research, NWU, Private Bag X6001, Potchefstroom, South Africa
[2] Ural State University, Lenin Ave. 51, Ekaterinburg, Russia
[3] Joint Astronomy Centre, 660 N. A' ohoku Place, University Park, Hilo , Hawaiim USA

E-mail contact: johan.vanderwalt@nwu.ac.za

It is now well established that the strong and widespread 6.7 GHz methanol masers are associated with young high mass stars. A still unsolved question is where in the circumstellar environment the masers arise. We address this question by considering an ensemble of rest frame maser velocities of 337 maser features. The CS(2-1) spectra of 63 methanol maser sources were used to derive systemic velocities and velocity dispersion of the thermal gas. Using the systemic velocities and the velocities of the 337 maser features in the 63 sources, a single distribution of rest frame maser velocities was constructed. This distribution as well as other kinematic information about the masers are used to evaluate four proposed scenarios for where the masers might arise in the circumstellar environment. It is shown that kinematically the masers are not associated with hot cores. We also argue that the scenario in which the masers are associated with an external generated planar shock that propagates into a rotating core cannot explain the observed kinematic properties of the masers. It was found that a simple Keplerian-like disk model is consistent with the observed distribution of rest frame maser velocities. Although outflows have the potential to explain the data, it was not possible to fully test this possibility due to the diverse nature of outflows.

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## Molecular Cloud Evolution II. From cloud formation to the early stages of star formation in decaying conditions

**Enrique Vázquez-Semadeni[1], Gilberto C. Gómez[1], A. Katharina Jappsen[2], Javier Ballesteros-Paredes[1], Ricardo F. Gonzalez[1] and Ralf S. Klessen[2]**

[1] CRyA, Universidad Nacional Autónoma de Mexico
[2] CITA
[3] Institut für Theoretische Astrophysik, Heidelberg

E-mail contact: e.vazquez@astrosmo.unam.mx

We study the formation of giant dense cloud complexes and of stars within them by means of SPH numerical simulations of the collision of gas streams ("inflows") in the warm neutral medium (WNM) at moderately supersonic velocities. The collisions cause compression, cooling and turbulence generation in the gas, forming a cloud that then becomes self-gravitating and begins to collapse globally. Simultaneously, the turbulent, nonlinear density fluctuations induce fast, local collapse events. The simulations show that: a) The clouds are *not* in a state of equilibrium. Instead, they undergo secular evolution. During the early stages of the evolution, their mass and gravitational energy $|E_{\rm g}|$ increase steadily, while the turbulent energy $E_{\rm k}$ reaches a plateau. b) When $|E_{\rm g}|$ becomes comparable to $E_{\rm k}$, global collapse begins, causing a simultaneous increase in $|E_{\rm g}|$ and $E_{\rm k}$ that maintains a near-equipartition condition $|E_{\rm g}| \sim 2E_{\rm k}$. c) Longer inflow durations delay the onset of global and local collapse, by maintaining a higher turbulent velocity dispersion in the cloud over longer times. d) The star formation rate is large from the beginning, without any period of slow and accelerating star formation. e) The column densities of the local star-forming clumps are very similar to reported values of the column density required for molecule formation, suggesting that locally molecular gas and star formation occur nearly simultaneously. The MC formation mechanism discussed here naturally explains the apparent "virialized" state of MCs and the ubiquitous presence of HI halos around them. Also, within their assumptions, our simulations

support the scenario of rapid star formation *after* MCs are formed, although long ( $\gtrsim$ 15 Myr) accumulation periods do occur during which the clouds build up their gravitational energy, and which are expected to be spent in the atomic phase.

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## PAH chemistry and IR emission from circumstellar disks

**R. Visser[1], V.C. Geers[1], C.P. Dullemond[2], J.-C. Augereau[1,3], K.M. Pontoppidan[4] and E.F. van Dishoeck[1]**

[1] Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA Leiden, The Netherlands
[2] Max-Planck-Institut für Astronomie, Koenigstuhl 17, 69117 Heidelberg, Germany
[3] Laboratoire d'Astrophysique de l'Observatoire de Grenoble, B.P. 53, 38041 Grenoble Cedex 9, France
[4] Division of GPS, Mail Code 150-21, California Institute of Technology, Pasadena, CA 91125, USA

E-mail contact: ruvisser@strw.leidenuniv.nl

Aims. The chemistry of, and infrared (IR) emission from, polycyclic aromatic hydrocarbons (PAHs) in disks around Herbig Ae/Be and T Tauri stars are investigated. PAHs can exist in different charge states and they can bear different numbers of hydrogen atoms. The equilibrium (steady-state) distribution over all possible charge/hydrogenation states depends on the size and shape of the PAHs and on the physical properties of the star and surrounding disk.
Methods. A chemistry model is created to calculate the equilibrium charge/hydrogenation distribution. Destruction of PAHs by ultraviolet (UV) photons, possibly in multi-photon absorption events, is taken into account. The chemistry model is coupled to a radiative transfer code to provide the physical parameters and to combine the PAH emission with the spectral energy distribution (SED) from the star+disk system.
Results. Normally hydrogenated PAHs in Herbig Ae/Be disks account for most of the observed PAH emission, with neutral and positively ionized species contributing in roughly equal amounts. Close to the midplane, the PAHs are more strongly hydrogenated and negatively ionized, but these species do not contribute to the overall emission because of the low UV/optical flux deep inside the disk. PAHs of 50 carbon atoms are destroyed out to 100 AU in the disks surface layer, and the resulting spatial extent of the emission does not agree well with observations. Rather, PAHs of about 100 carbon atoms or more are predicted to cause most of the observed emission. The emission is extended on a scale similar to that of the size of the disk, with the short-wavelength features less extended than the long-wavelength features. For similar wavelengths, the continuum emission is less extended than the PAH emission. Furthermore, the emission from T Tauri disks is much weaker and concentrated more towards the central star than that from Herbig Ae/Be disks. Positively ionized PAHs are predicted to be largely absent in T Tauri disks because of the weaker radiation field.

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## Comparison of $^{13}$CO line and far-infrared continuum emission as a diagnostic of dust and molecular gas physical conditions - I. Motivation and modelling

**W.F. Wall[1]**

[1] Instituto Nacional de Astrofísica, Óptica y Electrónica, Apdo. Postal 51 y 216, Puebla, PUE., México

E-mail contact: wwall@inaoep.mx

Determining temperatures in molecular clouds from ratios of CO rotational lines or from ratios of continuum emission in different wavelength bands suffers from reduced temperature sensitivity in the high-temperature limit. In theory, the ratio of far-infrared (FIR), submillimetre or millimetre continuum to that of a $^{13}$CO (or C$^{18}$O) rotational line can place reliable upper limits on the temperature of the dust and molecular gas. Consequently, FIR continuum data from the COBE/Diffuse Infrared Background Experiment (DIRBE) instrument and Nagoya 4-m $^{13}$CO J=1-0 spectral line data were used to plot 240$\mu$m/$^{13}$CO J=1-0 intensity ratios against 140/240$\mu$m dust colour temperatures, allowing us to constrain the multiparsec-scale physical conditions in the Orion A and B molecular clouds.

The best-fitting models to the Orion clouds consist of two components: a component near the surface of the clouds that

is heated primarily by a very large scale (i.e. ∼1 kpc) interstellar radiation field and a component deeper within the clouds. The former has a fixed temperature and the latter has a range of temperatures that vary from one sightline to another. The models require a dust-gas temperature difference of $0 \pm 2$ K and suggest that 40-50 per cent of the Orion clouds are in the form of dust and gas with temperatures between 3 and 10 K. The implications are discussed in detail in later papers and include stronger dust-gas thermal coupling and higher Galactic-scale molecular gas temperatures than are usually accepted, and an improved explanation for the $N(H_2)/I(CO)$ conversion factor. It is emphasized that these results are preliminary and require confirmation by independent observations and methods.

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## A Study of the Isolated Dark Globule DC 314.8-5.1: Extinction, Distance, and a Hint of Star Formation

**D. C. Whittet**[1]

[1] Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, Troy, NY, USA

The southern dark globule DC 314.8-5.1 contains a reflection nebula illuminated by a normal B9 V star, HD 130079. This serendipitous association provides the opportunity to evaluate the distance to the globule with greater accuracy than would otherwise be possible, subject to accurate accounting for the effects of interstellar extinction and reddening. It is shown that the dust in the line of sight has optical properties characterized by elevated values of the ratio of extinction to reddening ($R_V = A_V/E_{B-V}$) and the wavelength of maximum polarization ($\lambda_{max}$), signifying growth that most probably results from grain-grain coagulation within the globule. Taking this into account yields a distance of $342 \pm 50$ pc, significantly lower than previous estimates that assume the standard diffuse interstellar medium average extinction law. Comparison of this result with the loci of other major sources of extinction along the line of sight suggests that the globule is isolated; it appears to not be physically associated with the adjacent Circinus molecular cloud and star formation complex G317.0-4.0. Estimates are made of the mean number density ($n_H \gtrsim 9 \times 10^3$ cm$^{-3}$) and mass (30-100 $M_\odot$) of DC 314.8-5.1. A stellar census of the region using the Two Micron All Sky Survey suggests that it is not a site of vigorous star formation, although two (out of 387) sources are identified that appear to be good candidates for young stellar object status on the basis of their near-infrared colors. A deep mid-infrared survey will be needed to determine whether DC 314.8-5.1 is, indeed, starless (with respect to indigenous birth) or a site of sedentary low-mass star formation. The globule may also prove to be a valuable laboratory for future study of the interaction of dense molecular gas and dust in a quiescent core with the relatively soft UV radiation field emanating from the embedded B9 V star.

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## The chemistry of multiply deuterated molecules in protoplanetary disks. I. The outer disk

**Karen Willacy**[1]

[1] Jet Propulsion Laboratory, California Institute of Technology, MS 169-506, 4800 Oak Grove Drive, Pasadena, CA 91109

E-mail contact: karen.willacy@jpl.nasa.gov

We present new models of the deuterium chemistry in protoplanetary disks, including, for the first time, multiply deuterated species. We use these models to explore whether observations in combination with models can give us clues as to which desorption processes occur in disks. We find, in common with other authors, that photodesorption can allow strongly bound molecules such as HDO to exist in the gas phase in a layer above the midplane. Models including this process give the best agreement with the observations. In the midplane, cosmic ray heating can desorb weakly bound molecules such as CO and $N_2$. We find the observations suggest that $N_2$ is gaseous in this region, but that CO must be retained on the grains to account for the observed $DCO^+/HCO^+$. This could be achieved by CO having a higher binding energy than $N_2$ (as may be the case when these molecules are accreted onto water ice) or by a smaller cosmic ray desorption rate for CO than assumed here, as suggested by recent theoretical work.

For gaseous molecules the calculated deuteration can be greatly changed by chemical processing in the disk from the input molecular cloud values. On the grains singly deuterated species tend to retain the D/H ratio set in the

molecular cloud, whereas multiply deuterated species are more affected by the disk chemistry. Consequently the D/H ratios observed in comets may be partly set in the parent cloud and partly in the disk, depending on the molecule.

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http://arxiv.org/abs/astro-ph/0701484

## Rotational Velocities For B0-B3 Stars in 7 Young Clusters: Further Study of the Relationship between Rotation Speed and Density in Star-Forming Regions

**Sidney Wolff[1], Stephen Strom[1] and David Dror[1]**

[1] National Optical Astronomy Observatory, 950 N. Cherry Ave. Tucson, AZ 85719, USA

E-mail contact: swolff@noao.edu

We present the results of a study aimed at assessing the differences in the distribution of rotation speeds, N ($v \sin i$) among young (1-15 Myr) B stars spanning a range of masses $6 < M/M_\odot < 12$ and located in different environments: 7 low density ($\rho < 1\ M_\odot/pc^3$) ensembles that are destined to become unbound stellar associations, and 8 high density ($\rho \gg 1\ M_\odot/pc^3$) ensembles that will survive as rich, bound stellar clusters for ages well in excess of $10^8$ years. Our results demonstrate (1) that independent of environment, the rotation rates for stars in this mass range do not change by more than 0.1 dex over ages t $\sim$ 1 to t $\sim$ 15 Myr; and (2) that stars formed in high density regions lack the cohort of slow rotators that dominate the low density regions and young field stars. We suggest that the differences in N($v \sin i$) between low and high density regions may reflect a combination of initial conditions and environmental effects: (1) the higher turbulent speeds that characterize molecular gas in high density, cluster-forming regions; and (2) the stronger UV radiation fields and high stellar densities that characterize such regions. Higher turbulent speeds may lead to higher time averaged accretion rates during the stellar assembly phase. In the context of stellar angular momentum regulation via “disk-locking,” higher accretion rates lead to both higher initial angular momenta and evolution-driven increases in surface rotation rates as stars contract from the birthline to the Zero Age Main Sequence. Stronger UV radiation fields and higher densities may lead to shorter disk lifetimes in cluster-forming regions. If so, B stars formed in dense clusters are more likely to be “released” from their disks early during their PMS lifetimes and evolve into rapid rotators as they conserve angular momentum and spin up in response to contraction. By contrast, the majority of their brethren in low density, association forming regions can retain their disks for much or all of their PMS lifetimes, are “locked” by their disks to rotate at constant angular speed, and lose angular momentum as they contract toward the ZAMS, and thus arrive on the ZAMS as relatively slowly rotating stars.

Accepted by Astronomical Journal

## The Origin of Diffuse X-ray and $\gamma$-ray Emission from the Galactic Center Region: Cosmic Ray Particles

**F. Yusef-Zadeh[1], M. Muno[2], M. Wardle[3] and D. C. Lis[4]**

[1]Department of Physics and Astronomy, Northwestern University, Evanston, Il. 60208, USA
[2]Dept Physics and Astronomy, University of California, Los Angeles, Box 951547, Los Angeles, CA 90095, USA
[3]Department of Physics, Macquarie University, NSW 2109, Australia
[4]California Institute of Technology, MC 320-47, Pasadena, CA 91125, USA

E-mail contact: zadeh@northwestern.edu

The inner couple hundred pcs of our Galaxy is characterized by significant amount of synchrotron-emitting gas, which appears to co-exist with a large reservoir of molecular gas. Many of the best studied sources in this region exhibit a mixture of 6.4 keV Fe K$\alpha$ emission, molecular line emission and nonthermal radio continuum radiation. The spatial correlation between fluorescent Fe K-$\alpha$ line emission at 6.4 keV and molecular line emission from Galactic center molecular clouds has been explained as reflected X-rays from a past outburst of Sgr A*. Here we present multi-wavelength study of a representative Galactic center cloud Sgr C using *Chandra*, *VLA* and *FCRAO*. We note a correlation between the nonthermal radio filaments in Sgr C and the X-ray features, suggesting that the two are related. This correlation, when combined with the distribution of molecular gas suggests against the irradiation of Sgr C by Sgr A*. Instead, we account for this distribution in terms of the impact of the relativistic particles from local (nonthermal filaments) and extended sources with diffuse neutral gas producing both a nonthermal bremsstrahlung

X-ray continuum emission, as well as diffuse 6.4 keV line emission. The production rate of Fe K$\alpha$ photons associated with the injection of electrons into a cloud as a function of column density is calculated. The required energy density of low-energy cosmic rays associated with the synchrotron emitting radio filaments or extended features is estimated to be in the range between 20 and $\sim 10^3$ eV cm$^{-3}$ for Sgr C, Sgr B1, Sgr B2, and "the 45 and -30 km/s " clouds. We also generalize this idea to explain the cosmic-ray heating of molecular gas, the interstellar cosmic ray ionization, the pervasive production of diffuse K$\alpha$ line and TeV emission from the Galactic center molecular clouds. In particular, we suggest that Inverse Compton scattering of the sub-millimeter radiation from dust by relativistic electrons may contribute substantially to the large-scale diffuse TeV emission observed towards the central regions of the Galaxy.

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## *Dissertation Abstracts*

# Interferometric observations of pre-main sequence disks

**Andrea Isella**

INAF - Osservatorio Astrofisico di Arcetri

Largo E. Fermi 5, I-50125 Firenze, Italy

Electronic mail: isella@arcetri.astro.it

Ph.D dissertation directed by: Antonella Natta

Ph.D degree awarded: December 2006

In my Ph.D thesis I discuss a study of circumstellar disks based on high spatial resolution interferometric observations of intermediate (Herbig Ae; HAe) and low mass (T Tauri; TTS) pre-main sequence stars. The aim was to improve our knowledge of the structure and evolution of the circumstellar material by determining the composition, the size, the density distribution, the temperature and the kinematic of gas and dust. The thesis has been developed following two complementary lines: the characterization of disk regions at fractions of AU from the central star through near-infrared interferometry and the study of the outer disk regions through millimeter interferometry. In order to analyse the observations, I developed physical models of the disk structure and emission, realized their numerical implementations and compared the model predictions with the data.

We show that astronomical interferometry is a powerful technique to investigate the properties of circumstellar disks around nearby pre-main sequence stars. Near-infrared interferometric observations, albeit still challenging and telescope–time consuming, probe the gas and dust distribution at fractions of AU from the central star and allow the investigation of important physical processes responsible for the disk evolution and the planet formation, namely the grain growth, the gas accretion on the central star and the launching mechanism of the observed outflows. On the other hand, long baseline millimeter interferometry remains a fundamental technique to study the gas kinematic and the dust properties in the outer disk regions, on scales of tens of AU.

http://www.arcetri.astro.it/∼isella/

## Postdoctoral Position in High Energy Emission in Young Stellar Objects
## Department of Astronomy, University of Michigan

Applications are invited for a postdoctoral research position focusing on observational studies of accretion in young stellar objects in the University of Michigan Department of Astronomy. The researcher will be expected to work at the interface of IR and X-ray studies in accreting young stellar objects to better understand the nature of the inner accretion flow. The researcher will work with Jon Miller, Nuria Calvet, and Lee Hartmann in this effort. A background in accretion studies, and experience with multi-wavelength data sets is preferred. Past experience with HST, Spitzer, Chandra/XMM, and/or ground-based observations is also preferred. The University of Michigan is a partner in the twin 6.5m Magellan telescopes in Chile. Applicants are asked to send a CV, bibliography, 1-page statement of research experience and proposed future research, and contact information for 3 references to Prof. Miller at the address below by the end of March. The University of Michigan is an AA/EEO institution with respect to federally-funded research.

Submission address:

Jon Miller
Department of Astronomy
University of Michigan
825 Dennison Building
500 Church Street
Ann Arbor, MI 48109

jonmm@umich.edu

## Postdoctoral Researcher Position in Cosmochemistry and Meteoritics
## Department of Earth and Planetary Sciences, University of New Mexico

The Department of Earth and Planetary Sciences, University of New Mexico, invites applications for a full time postdoctoral researcher position in the general area of meteoritics and cosmochemistry. The position will involve mineralogical, petrologic and isotopic studies directed at understanding the origin and evolution of the components of chondritic meteorites, from their formation in the protoplanetary disk to processing in asteroidal parent bodies. This NASA-funded research will involve the extensive use of microbeam techniques such as SEM, EPMA, TEM, SIMS and stable isotope analyses. Analytical experience in one or more of these techniques is desirable. Applicants who either have their PhD in hand or are close to completion in the fields of geochemistry, cosmochemistry, planetary sciences, or related fields are strongly encouraged to apply. Previous experience working with planetary materials is desirable but not required. The position is open immediately and is available initially for one year, but is renewable.

The Department of Earth and Planetary Sciences and Institute of Meteoritics maintains a range of analytical facilities including transmission electron microscopes, electron microprobe, scanning electron microscope, ion microprobe, experimental petrology laboratories, and stable and radiogenic isotope laboratories. Further information about the Department can be obtained from the departmental website: http://epswww.unm.edu

Interested applicants should send a curriculum vitae, including a statement of research experience, and the names and contact information of three references to Dr Adrian Brearley, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque NM 87131. For further information contact; Dr Adrian Brearley, e-mail: brearley@unm.edu, Tel: 505 277 4163.

http://epswww.unm.edu/facstaff/brearley/home.htm

# Postdoctoral research position on Starbursts from the local Universe to high redshift (Geneva Observatory)

The Geneva Observatory in Geneva, Switzerland, announces the availability of a research position at the postdoctoral level, open to applicants of all nationalities.

The succesful candidate will work on projects aimed at studying starburst galaxies nearby, at intermediate redshift ($z \sim 2$-3), or in the early Universe ($z > 6$), involving multi-wavelength observations and/or theoretical modeling. He/she may in particular work with ground-based near-IR and longer wavelength observations including Spitzer and data from upcoming projects with Herschel and sub-mm instruments. He/she will also have access to state-of-the-art modeling tools including 3D radiation transfer, evolutionary synthesis, and photoionisation codes. The candidate will mostly work in collaboration with Prof. Daniel Schaerer in Geneva and within international collaborations.

The Geneva Observatory and the associated Laboratory of Astrophysics of the Swiss Federal Institute of Technology in Lausanne carry out observational, interpretative and theoretical research in the fields of extra-solar planets, stellar evolution, stellar physics, high energy astrophysics, galaxy evolution and dynamics, and observational cosmology.

The appointment will be for one to two years starting around October 1, 2007 (negotiable). It is renewable.

Qualified candidates are encouraged to send their application including a CV and publication list, description of research experience and interests, and contact information of three references preferably via email to the above address. All applications received by 1 May, 2007 will receive full consideration. Informal enquiries with Daniel Schaerer (daniel.schaerer@obs.unige.ch) are welcome.

For more information on the Observatory and the group visit: www.unige.ch/sciences/astro/ and obswww.unige.ch/sfr

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# *New Books*

## Protostars and Planets V

### Edited by Bo Reipurth, David Jewitt, and Klaus Keil

The Protostars and Planets V conference was held at the Hilton Waikoloa Village on the Big Island of Hawaii on October 24-28, 2005. It attracted 805 participants, half from 30 countries outside United States. The resulting book contains 58 chapters, corresponding to the review talks given at the conference, and together they cover in detail the key aspects of our present understanding of star and planet formation, young stars and the early solar system. The average time between Protostars and Planets meetings is 7 years, a period long enough that very substantial progress in a field can be made. Indeed, every preface for the earlier PP books has exulted in the major strides made since the previous PP conference, and PPV is no exception. As documented in this book, we have since PPIV seen the field of extrasolar planets burgeon, with the discovery of new planets around others stars growing by more than a factor 10, with the detection of multiple planets around stars that allow us to compare empirically the architectures of planetary systems, and with the development of detailed theoretical work on the formation of both terrestrial planets and gas giants. The earliest stages of protostars are being routinely studied with new advanced submillimeter detectors, and the collapse process can be followed with sophisticated numerical simulations on ever more powerful computers. While we are gaining confidence that fundamental aspects of low-mass star formation are becoming understood, the formation of massive stars is emerging as a challenging and fruitful area of investigation. X-ray studies of star forming regions have opened entirely new vistas into the active lives of young stars. High spatial resolution techniques have developed in recent years to offer amazingly detailed views of circumstellar disks, allowing meaningful comparisons with detailed theoretical models. Most stars are born in binary systems, and both observations and theory have pointed to the importance for binary formation of dynamical evolution and decay in small multiple systems. The study of the nature and formation of brown dwarfs has now become part of main stream astrophysics, and continues to offer exciting results and new challenges. More locally, a whole new field of research has opened up concerning the contents and structure of the Kuiper belt. New surveys and physical observations with large telescopes show dynamical and compositional complexity that challenges our understanding of the accretion process. Developments in understanding the dynamics of the early solar system have also been dramatic, with firm evidence for the radial migration of the planets setting new and unexpected constraints on early conditions. Refined dating techniques of meteorites have resulted in a more precise age for the solar system of 4567 million years.

The book contains the following 58 chapters:


PART I: MOLECULAR CLOUDS

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*C. J. Lada, J. F. Alves, and M. Lombardi*

An Observational Perspective of Low-Mass Dense Cores I: Internal Physical and Chemical Properties
*J. Di Francesco, N. J. Evans II, P. Caselli, P. C. Myers, Y. Shirley, Y. Aikawa, and M. Tafalla*

An Observational Perspective of Low-Mass Dense Cores II: Evolution Toward the Initial Mass Function
*D. Ward-Thompson, P. Andr, R. Crutcher, D. Johnstone, T. Onishi, and C. Wilson*

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*Second Announcement*

## IAU Symposium No. 243

# Star-Disk Interaction in Young Stars

## Grenoble, France, 21-25 May 2007

## The registration form and call for abstracts (20-min contributed talks and posters) are now open on http://www.iaus243.org

**Dead-lines**

**Abstracts for contributed talks and posters : March 1, 2007**
**Financial support request : March 1, 2007**
**Early Registration (170 euros) : March 26, 2007**
**Late Registration (200 euros) : April 23, 2007**

**The attendance is limited to 150 participants. Hotel reservations must be made as soon as possible.**

*Rationale*: Disk accretion and jet outflows are intimately associated with the formation of stars and planets. One central issue raised by recent observational studies is the origin of the physical connection between accretion and wind/jet processes. It has become clear that the physical connection takes place within 1 AU of the central star, in a region where the interaction between the star and the inner disk is still poorly understood. The conference is intended to review the observational constraints available on the physical processes thought to be at work at the star-disk interface, to confront the predictions of the latest numerical and analytical MHD models of star-disk-jet systems with observations, and to explore the consequences of these processes for stellar angular momentum evolution and inner disk structure.

*Objectives*: The aim of the conference is to gather astronomers from around the world to critically review the MHD processes which are thought to take place within 1 AU of young stellar objects. It will focus on the structure and variability of the inner magnetized disk, the magnetospheric cavity, and the jet launching region. Understanding the structure and evolution of the star-disk interaction region in young stars is critical to our understanding of star and planet formation.

*Program schedule* : http://www.iaus243.org

*Invited speakers* : S. Alencar, I. Appenzeller, D. Ardila, G. Basri, C. Bertout, J. Bouvier, S. Cabrit, N. Calvet, J. Carr, S. Edwards, C. Fendt, L. Ferrario, T. Harries, M. Jardine, C. Johns-Krull, F. Malbet, R. Mathieu, S. Mohanty, T. Montmerle, A. Natta, F. Pont, M. Romanova, T. Ray, F. Shu, C. Terquem

*Scientific Organizing Committee*: Silvia Alencar, Immo Appenzeller, Gibor Basri, Jerome Bouvier (chair), Sylvie Cabrit, Suzan Edwards, Moira Jardine, Rony Keppens, Oded Regev, Bo Reipurth, Kazunari Shibata

*Local Organizing Committee*: Agnes Blanc-Senet, Francoise Bouillet, Jerome Bouvier (chair), Catherine Dougados, Jonathan Ferreira, Fabien Malbet, Thierry Montmerle, Marie-Helene Sztefek

# Circumstellar disks and planets at very high angular resolution
# 28th May – 8th June, Ofir, Portugal

**Overview** The goal of the school is to present an overview of disk and planetary astrophysics emphasizing both the physical mechanisms, and the high angular resolution observational techniques (such as adaptive optics, mm and optical interferometry). Emphasis is given to interferometry given the importance of the Very Large Telescope Interferometer and the ALMA array for disk and planetary studies. Practical sessions will center on proposal preparation for the Very Large Telescope Interferometer. Finally, complementary skills useful for young astronomers will be addressed in a series of lectures.

**Audience** The school is targeted to PhD students and young post-docs working in the field of star formation and high angular resolution techniques.

**Funding** We expect to fund full living and travel expenses of all PhD students and most young post-docs. The number of participants is limited to 50. Participants will be selected to ensure a broad coverage of institutes and countries, and by motivation and area of expertise. Non-european nationals are encouraged to apply. Deadline for applications is the 20th April 2007. Apply and register at **http://www.vlti.org**

# Structure Formation in the Universe: Galaxies, Stars, Planets
# Chamonix, France – 27 May - 1 June 2007

This is the **3rd announcement** of the conference *"Structure formation in the universe"*, to be held in Chamonix, France from 27 May through 1 June 2007. The aim of the conference is to bring together researchers working in the fields of **planet, star and galaxy formation** in order to share their expertise and to address common physical and numerical issues in the understanding of structure formation in astrophysics.

The **registration**, with the possibility to submit a **poster presentation**, is **now open**, with the hotel reservation.

Early Registration (320 euros) and Financial support request: **February 28, 2007**;

Late Registration (380 euros) : **April 30, 2007**.

See information on the conference website: **http://chamonix2007.ens-lyon.fr/**

*Organizer and contact*: **G. Chabrier (ENS-Lyon; chabrier@ens-lyon.fr)**

# 2007 Origins of Solar Systems Gordon conference

Registration is now open for the 2007 Gordon Research Conference on Origins of Solar Systems, to be held at Mt. Holyoke College in South Hadley, MA on 8-13 July 2007. This unique interdisciplinary meeting includes astronomers and astrophysicists interested in star and planet formation, planetary scientists and meteoriticists interested in the early history of the Solar System, and plasma and life scientists. This meeting is much broader than most conferences and many fruitful research collaborations have been initiated at Gordon conferences, encouraged by the relaxed pace of the meeting.

Information on the meeting, registration, etc. is available at

**http://www.grc.org/programs.aspx?year=2007&program=origins**

Speakers and discussion leaders include Yuri Aikawa, Sean Andrews, David Bennett, Ted Bergin, Martin Bizzarro, Alan Boss, Fred Ciesla, Harold Connolly, Marianna Cosarinsky, Andrew Davis, Suzan Edwards, Elise Furlan, Charles Gammie, Matthieu Gounelle, Lynne Hillenbrand, Rhian Jones, Scott Kenyon, Zoe Leinhardt, Doug Lin, James Lyons, Michael Meyer, Amaya Moro-Martin, Frank Podosek, Ken Rice, Scott Sandford, Sara Seager, Meenakshi Wadhwa, Dan Watson, Ed Young, and Michael Zolensky.

The Chair and Vice-Chair of the 2007 Origins of Solar Systems conference are Lee Hartmann (Michigan) and Sara Russell (Natural History Museum, London). Please contact us (lhartm@umich.edu, sara.russell@nhm.ac.uk) with any questions or suggestions.

I am very pleased to invite you to respond to the first Announcement of Opportunity to submit proposals for observations to be performed with the Herschel Space Observatory.

Herschel is the fourth cornerstone of ESAs Horizon 2000 Science Programme, and is planned to be launched on 31 July 2008. It contains three instruments, the Photodetector Array Camera and Spectrometer (PACS) for the wavelengths shortward of 200 m , the Spectral and Photometric Imaging REceiver (SPIRE) for the longer wavelengths, and the very high resolution spectrometer Heterodyne Instrument for the Far Infrared (HIFI).

This Announcement of Opportunity (AO) refers to Key Programme proposals only. The AO is divided into two parts, the first part is for the Guaranteed Time Key Programmes, these will be awarded first while the second part refers to Open Time Key Programmes. Proposers from the general astronomical community from all over the world are welcome to participate in the call for Open Time. All proposals will be subject to independent review by the Herschel Observing Time Allocation Committee (HOTAC).

In order to give Open Time proposers as much time and information for preparation as possible, an Open Time Key Programme workshop is being organised in ESTEC, Noordwijk on 20-21 February 2007. At the workshop, the expected Guaranteed Time proposals will be summarised. Workshop information is available on the internet at the URL below, where the presentations and/or proceedings will also will be posted.

Potential proposers are required to prepare and submit observing time proposals in electronic from, by the deadlines given below, according to the rules and using the Herschel observing planning tool (HSpot) de-scribed in the AO documentation package which is available via the internet at:

**http://herschel.esac.esa.int/**

The key milestones for this AO are:

* Issue of the AO for Key Programme observing proposals 1 February 2007
Open Time Key Programme workshop at ESTEC 20-21 February 2007
Due date for Guaranteed Time proposals 4 April 2007
Announcement of the HOTAC approved GT KP programme 5 July 2007
Due date for Open Time proposals 25 October 2007
Announcement of the HOTAC approved OT KP programme 28 February 2008

I invite you to submit your proposals and wish you success using the Herschel observatory.

Yours sincerely,

Prof. D. Southwood
Director of the ESA Scientific Programme

## Software release announcement

SHAPE: New software for the modeling of astronomical objects in 3D

The Institute of Astronomy at the Universidad Nacional Autnoma de Mxico has released Version 1.0 of a new software system called Shape for general use by the scientific community. Shape is a morpho-kinematic modeling tool for astrophysical nebulae. The main application of Shape is to assist in the interpretation of observations. The morpho-kinematic 3D modeling is done with commonly available 3D modeling software like 3D Studio Max, Blender or the built-in 3D-module. Using a comfortable graphical interface, the user generates a images and position-velocity (pv-) diagrams, channel maps and one dimensional spectral line shapes based on the Doppler-effect. The design purpose of Shape is the analysis of the 3D structure and kinematics of spatially resolved astrophysical nebulae in a way that can be compared directly with observations. It is particularly suited for the study of expanding nebulae like planetary nebulae and other structures with clear kinematical signatures like bow-shocks or accretion disks and other streaming flows that can be analyzed using the Doppler-effect. Shape may be applied to the interpretation of existing observations or the planning and prediction of observations based on a proposed model.

More information about Shape, including the software download, the current development status, published papers, examples and the user manual can be found on the ShapeSite:

http://www.astrosen.unam.mx/shape.

Shape has been designed and developed by Wolfgang Steffen from the Institute of Astronomy, UNAM, Ensenada, Baja California, Mexico, with scientific contributions to the design by Jos Alberto Lpez (also from the IA-UNAM). The development of the public version of Shape has been in collaboration with Nicholas Koning from the University of Calgary (Canada).

Reference:

Steffen, W., López, J.A., 2006, Morpho-kinematic modeling of gaseous nebulae with SHAPE, Revista Mexicana de Astronoma y Astrofsica 42, 99-105

Disclaimer: This software release is a Beta release and the software is provided "as is". No warranty is given for its fitness for a particular purpose. Neither the authors nor their employers can be held responsible in any way for incorrect scientific or other results that may follow from the usage and interpretation of models produced with Shape.

Acknowledgements: This project has obtained financial support by UNAM (DGAPA PAPIIT projects IN108506, IN111803, IN112103), the Consejo Nacional de Ciencia y Tecnologa CONACYT (project 49447) and the University of Calgary through a grant from the Natural Sciences and Engineering Council of Canada awarded to Sun Kwok.

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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