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Abstracts of recently accepted papers

ISOCAM-CVF Spectroscopy of the Circumstellar Environment of Young Stellar Objects

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We present the results of a mid-infrared (5–16.5μm) imaging spectroscopy survey of Young Stellar Objects (YSOs) and their surrounding environment in four low-mass star formation regions: RCrA, ρ Ophiuchi, Serpens and Chamaeleon I. This survey was performed using ISOCAM and its Circular Variable Filters (CVF) and observed 42 YSO candidates: we were able to obtain complete 5–16.5μm spectra for 40 of these with a spectral resolving power of $\lambda/\Delta\lambda \simeq 40$. A number of spectral features were measured, most notably the 9.7μm silicate feature, the bending modes of both water and CO_2 ices at 6.0 and 15.2μm respectively and the well-known unidentified feature at 6.8μm. The strength of the unidentified feature was observed to correlate very well with that of the water ice bending mode and far less strongly with the CO_2 ice bending mode. This suggests, in a manner consistent with previous observations, that the carrier of the unidentified feature is a strongly polar ice. Absorption profiles of the bending mode of CO_2 ice are observed to show a significant long wavelength wing, which suggests that a significant fraction of the CO_2 ice observed exists in a polar (H_2O-rich) phase. The sources observed in RCrA, ρ Oph and Serpens show similar spectral characteristics, whilst the sources observed in Cha I are somewhat anomalous, predominantly showing silicate emission and little or no absorption due to volatile ices. However this is consistent with previous studies of this region of the Cha I cloud, which contains an unusual cluster of YSOs. From comparisons of the strengths of the water ice and silicate bands we detect an apparent under-abundance of water ice towards the sources in ρ Oph, relative to both RCrA and Serpens. This may be indicative of differences in chemical composition between the different clouds, or may be due to evaporation. Finally the CO_2:H_2O ice ratios observed towards the sources in ρ Oph show significantly greater scatter than in the other regions, possibly due to varying local conditions around the YSOs in ρ Oph.

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Preprint available at http://xxx.lanl.gov/abs/astro-ph/0302178.

Collapse of Magnetized Singular Isothermal Toroids: I. Non-Rotating Case

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We study numerically the collapse of non-rotating, self-gravitating, magnetized, singular isothermal toroids characterized by sound speed, a, and level of magnetic to thermal support, H_0. In qualitative agreement with previous

treatments by Galli & Shu and other workers, we find that the infalling material is deflected by the field lines towards the equatorial plane, creating a high-density, flattened structure – a pseudodisk. The pseudodisk contracts dynamically in the radial direction, dragging the field lines threading it into a highly pinched configuration that resembles a split monopole. The oppositely directed field lines across the midplane and the large implied stresses may play a role in how magnetic flux is lost in the actual situation in the presence of finite resistivity or ambipolar diffusion. The infall rate into the central regions is given to 5% uncertainty by the formula, $\dot{M} = (1 + H_0)a^3/G$, where G is the universal gravitational constant, anticipated by semi-analytical studies of the self-similar gravitational collapses of the singular isothermal sphere and isopedically magnetized disks. The introduction of finite initial rotation results in a complex interplay between pseudodisk and true (Keplerian) disk formation that is examined in a companion paper.

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Collapse of Magnetized Singular Isothermal Toroids: II. Rotation and Magnetic Braking

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We study numerically the collapse of rotating, magnetized molecular cloud cores, focusing on rotation and magnetic braking during the main accretion phase of isolated star formation. Motivated by previous numerical work and analytic considerations, we idealize the pre-collapse core as a magnetized singular isothermal toroid, with a constant rotational speed everywhere. The collapse starts from the center, and propagates outwards in an inside-out fashion, satisfying exact self-similarity in space and time. For rotation rates and field strengths typical of dense low-mass cores, the main feature remains the flattening of the mass distribution along field lines – the formation of a pseudodisk, as in the nonrotating cases. The density distribution of the pseudodisk is little affected by rotation. On the other hand, the rotation rate is strongly modified by pseudodisk formation. Most of the centrally accreted material reaches the vicinity of the protostar through the pseudodisk. The specific angular momentum can be greatly reduced on the way, by an order of magnitude or more, even when the pre-collapse field strength is substantially below the critical value for dominant cloud support. The efficient magnetic braking is due to the pinched geometry of the magnetic field in the pseudodisk, which strengthens the magnetic field and lengthens the level arm for braking. Both effects enhance the magnetic transport of angular momentum from inside to outside. The excess angular momentum is carried away in a low-speed outflow that has, despite claims made by other workers, little in common with observed bipolar molecular outflows. We discuss the implications of our calculations for the formation of true disks that are supported against gravity by rotation.

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NACO Polarimetric Differential Imaging of TW Hya: A Sharp Look at the Closest T Tauri Disk

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We present high-contrast imaging data on the disk of the classical T Tauri star TW Hya. The images were obtained through the polarimetric differential imaging technique with the adaptive optics system NACO. Our commissioning data show the presence of polarized disk emission between 0.1" and 1.4" from the star. We derive the first Ks-band radial polarized intensity distribution. We show that the polarized intensity compares well to shorter wavelengths

surface brightness observations and confirm the previously reported gradual slope change around 0.8". These results show the potential of the new polarimetric differential imaging technique at 8m-class telescopes to map the inner regions of protoplanetary disks.

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Structuring the HD 141569 A circumstellar dust disk. Impact of eccentric bound stellar companions

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Scattered light images of the optically thin dust disk around the 5 Myr old star HD 141569 A have revealed its complex asymmetric structure. We show in this paper that the surface density inferred from the observations presents similarities with that expected from a circumprimary disk within a highly eccentric binary system. We assume that either the two M stars in the close vicinity of HD 141569 A are bound companions or at least one of them is an isolated binary companion. We discuss the resulting interaction with an initially axisymmetric disk. This scenario accounts for the formation of a spiral structure, a wide gap in the disk and a broad faint extension outside the truncation radius of the disk after 10–15 orbital periods with no need for massive companion(s) in the midst of the disk resolved in scattered light. The simulations match the observations and the star age if the perturber is on an elliptic orbit with a periastron distance of 930 AU and an eccentricity from 0.7 to 0.9. We find that the numerical results can be reasonably well reproduced using an analytical approach proposed to explain the formation of a spiral structure by secular perturbation of a circumprimary disk by an external bound companion. We also interpret the redness of the disk in the visible reported by Clampin et al.(2003) and show that short-lived grains one order of magnitude smaller than the blow-out size limit are abundant in the disk. The most probable reason for this is that the disk sustains high collisional activity. Finally we conclude that additional processes are required to clear out the disk inside 150 AU and that interactions with planetary companions possibly coupled with the remnant gas disk are likely candidates.

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Paper and Animations available at: http://www.strw.leidenuniv.nl/∼augereau/newresults.html

Accretion and Outflow in the Substellar Domain: Magellan Spectroscopy of LS-RCrA 1

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We present low-, medium-, and high-resolution optical spectra, obtained with the Magellan Baade 6.5m telescope, of LS-RCrA 1, a late-type object identified recently by Fernández and Comerón (2001) in the R Coronae Australis star-forming region. We confirm both pre-main sequence status and membership in the R CrA region for this object, through the detection of LiI, presence of narrow KII indicative of low gravity, and measurement of radial velocity. The Hα emission profile is very broad, with a 10% full width of 316 km/s at high-resolution, implying the presence of ongoing accretion. Our spectra also exhibit many forbidden emission lines indicative of mass outflow, in agreement with the Fernández and Comerón results. We derive a spectral type, independent of extinction, of M6.5±0.5 IV. Using new 2MASS near-infrared photometry, no significant NIR excess is found. Our optical veiling measurements yield a mass accretion rate of $10^{-10} \leq \dot{M} \leq 10^{-9}$ $M_{\odot}yr^{-1}$. The presence of prominent outflow signatures at these low accretion rates is initially puzzling. We consider, and discard as improbable, the possibility that these signatures arise in a line-of-sight Herbig-Haro knot unassociated with LS-RCrA 1 itself. However, if LS-RCrA 1 possesses a nearly

edge-on disk, a natural outcome would be the enhancement of any outflow signatures relative to the photosphere; we favor this view. A low accretion/outflow rate, combined with an edge-on orientation, is further supported by the absence of high-velocity components and any significant asymmetries in the forbidden lines. An edge-on geometry is also consistent with the lack of NIR excess in spite of ongoing accretion, and explains the relatively large Hα 10% width compared to other low-mass objects with similar accretion rates. Through comparison with the latest synthetic spectra, we infer Teff = 2700±100K, somewhat lower than the previous estimate (2900±200K). Theoretical evolutionary tracks then imply an age of ∼20 Myr (as derived from Teff and luminosity) or ∼8 Myr (Teff vs. gravity) for LS-RCrA 1. This last value is consistent with the estimated age of other T Tauri stars in R CrA ($\leq$ 10 Myr), and it is substantially less than the ∼ 50 Myr derived previously. Therefore, LS-RCrA 1 indeed appears sub-luminous relative to expectations for an R CrA member. By comparing its position on the H-R diagram with that of other similarly accreting low-mass objects, we show that accretion-induced effects are unlikely to account for its faintness. We suggest instead that LS-RCrA 1 posesses a nearly edge-on disk and its photosphere is seen predominantly in scattered light, making it appear much fainter (and older) than it really is. The ease with which such a disk simultaneously explains all the puzzling aspects of LS-RCrA 1 – sub-luminosity, unusually prominent outflow signatures without high-velocity components or asymmetries, very broad Hα, lack of NIR excess combined with accretion – makes its presence a strong possibility. Finally, the surface gravity and Teff estimates, combined with the latest evolutionary tracks, indicate a mass of ∼0.07 or 0.035±0.010 $M_\odot$ (depending on the Teff scale), i.e., at or below the substellar boundary. Our results, together with those of Fernández and Comerón, imply that young brown dwarfs can not only harbor accretion disks but also generate jets/outflows analogous to those in higher mass classical T Tauri stars. This is further evidence of a common formation mechanism for stars and brown dwarfs.

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On the Power-Law Tail in the Mass Function of Protostellar Condensations and Stars

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We explore the idea that the power-law tail in the mass function of protostellar condensations and stars arises from the accretion of ambient cloud material on to a condensation, coupled with a nonuniform (exponential) distribution of accretion lifetimes. This model allows for the generation of power-law distributions in all star-forming regions, even if condensations start with a lognormal mass distribution, as may be expected from the central limit theorem, and supported by some recent numerical simulations of turbulent molecular clouds. For a condensation mass m with growth rate $dm/dt \propto m$, an analytic three-parameter probability density function is derived; it resembles a lognormal at low mass and has a pure power-law high-mass tail. An approximate power-law tail is also expected for other growth laws, and we calculate the distribution for the plausible case $dm/dt \propto m^{2/3}$. Furthermore, any single time snapshot of the masses of condensations that are still accreting (and are of varying ages) also yields a distribution with a power-law tail similar to that of the IMF.

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Preprint at `http://www.astro.uwo.ca/~basu/pub.html` and astro-ph/0311365.

The Eye of the Tornado—an isolated, high mass young stellar object near the Galactic centre

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We present infrared (AAT, UKIRT) and radio (VLA, SEST) observations of the Eye of the Tornado, a compact source

apparently near the head of the Tornado Nebula. The near-infrared Br γ and He I lines are broad (FWHM 40 and 30 km/s, respectively) and have a line centre at $V_{LSR} \sim -205$ km/s. This corresponds to a feature at the same velocity in the ^{12}CO J=1–0 line profile. The kinematic velocity derived from Galactic rotation places the Eye at the distance of the Galactic Centre (i.e. 8.5 kpc) and separated (probably foreground) from the Tornado Nebula. Four knots of emission are seen in the Br γ line and at 6 and 20 cm. Together with the flat radio spectral index, we confirm that the Eye contains ionized gas, but that this is embedded within a dense molecular core. The spectral energy distribution can be modelled as a two-component blackbody + greybody, peaking at far–IR wavelengths. The knots are UCHII regions, and the core contains a luminous ($\sim 2 \times 10^4$ $L_\odot$), embedded, massive young stellar source. We also propose a geometrical model for the Eye to account for both its spectral energy distribution and its morphology.

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Hot H_2O Emission and Evidence for Turbulence in the Disk of a Young Star

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We report on the detection and analysis of hot ro-vibrational H_2O emission from SVS-13, a young stellar object previously known to have strong CO overtone bandhead emission. Modeling of the high-resolution infrared spectrum shows that the H_2O emission is characterized by temperatures $\approx$ 1500 K, significantly lower than the temperatures that characterize the CO bandhead emission. The widths for the H_2O lines are also found to be smaller than those for the CO lines. We construct a disk model for the emission that reproduces the CO and H_2O spectrum. In this model, the H_2O lines originate at somewhat larger disk radii ($\leq$ 0.3 AU) than the CO overtone lines ($\leq$ 0.1 AU). We find that the H_2O abundance is about a factor of 10 lower than the calculated chemical equilibrium abundance.

Large, approximately transonic, local line broadening is required to fit the profile of the CO bandhead. If this velocity dispersion is identified with turbulence, it is of significant interest regarding the transport of angular momentum in disks. Large local broadening is also required in modeling CO overtone emission from other young stellar objects, suggesting that large turbulent velocities may be characteristic of the upper atmospheres of the inner disks of young stars.

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High Resolution Millimeter Imaging of the R Corona Australis IRS 7 Region

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The R CrA IRS 7 region was observed in the λ = 6.9 mm continuum with a high angular resolution ($\sim 1''$). The map shows three compact objects located within $4''$ (700 AU) of IRS 7A. Since the object in the middle of the complex has no known counterpart at centimeter wavelengths, its millimeter emission may mostly come from dust, suggesting that it may be a deeply embedded object. In contrast, IRS 7A is probably not as deeply embedded as the others since it was detected in near-IR and X-ray bands. It is not clear what causes the difference between IRS 7A and the others. If they belong to a coeval triple stellar system, either IRS 7A may have evolved faster and disrupted the parent cloud faster than the others, or IRS 7A may be in the process of being ejected. Alternatively, IRS 7A could be a relatively older object in the process of being captured by the other two objects that constitute a younger binary system. Yet

another possibility is that IRS 7A may not be a young stellar object but may be a part of the outflow driven by the central object of the complex. The identity of the hard X-ray flare source previously found in this field needs to be clarified by further observations.

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Discovery of a Candidate for the Central Star of the Ultracompact HII Region G5.89-0.39

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We present high-resolution, near-infrared images of the ultracompact HII region G5.89-0.39 that were taken during a commissioning run of the NACO adaptive optics/NIR camera system at the VLT. These data for the first time reveal the exact location of a very promising candidate for the primary, ionizing star of this region and provide a good estimate of its spectral type. We very briefly discuss the implications of finding the star at a location where it was quite unexpected, namely off-center of a shell, and the morphology of the region.

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http://www.mpia-hd.mpg.de/homes/feldt/preprintG589APJL.pdf

An Extremely Young Massive Stellar Object near IRAS 07029-1215

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In the course of a comprehensive mm/submm survey of massive star-forming regions, the vicinities of a sample of 47 luminous IRAS sources were closely investigated with SCUBA and IRAM bolometers in order to search for massive protostellar candidates. A particularly interesting object has been found in the surroundings of the bright FIR source IRAS 07029-1215. Follow-up line observations show that the object is cold, that it has a massive envelope, and that it is associated with an energetic molecular outflow. No infrared point source has been detected at its position. Therefore, it is a very good candidate for a member of the long searched-for group of massive protostars.

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A survey of SiO 5→4 emission towards outflows from low-luminosity protostellar candidates

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We have observed the SiO J=5→4 line towards a sample of 25 low-luminosity ($L_* < 10^3$ $L_\odot$) protostellar outflow systems. The line was detected towards 7 of the 25 sources, a detection rate of 28 per cent. The majority (5 out of 7) of sources detected were of class 0 status. We detected a higher fraction of class 0 sources compared with the class I and II sources, although given the small numbers involved the significance of this result should be regarded as tentative. Most of the detected sources showed emission either at or close to the central position, coincident with the protostar. In four cases (HH 211, HH 25MMS, V-380 Ori NE and HH 212) emission was also detected at positions away from the center, and was stronger than that observed at the centre position.

SiO abundances of 10^{-8} to 8×10^{-7} are derived from LTE analysis. For 2 sources we have additional transitions which we use to conduct statistical equilibrium modeling to estimate the gas density in the SiO-emitting regions. For HH 25MMS these results suggest that the SiO emission arises in a higher-density region than the methanol previously observed. We find that the most likely explanation for the preferential detection of SiO emission towards class 0 sources is the greater density of those environments, reinforced by higher shock velocities. We conclude that while not all class 0 sources exhibit SiO emission, SiO emission is a good signpost for the presence of class 0 sources.

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A Disk Shadow Around the Young Star ASR 41 in NGC 1333

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We present images of the young stellar object ASR 41 in the NGC 1333 star forming region at the wavelengths of Hα and [SII] and in the I, J, H, and K-bands. ASR 41 has the near-infrared morphology of an edge-on disk object, but appears an order of magnitude larger than typical systems of this kind. We also present detailed models of the scattering and radiative transfer in systems consisting of a young star surrounded by a proto-planetary disk, and the whole system being embedded in either an infalling envelope or a uniform molecular cloud.

The best fit to the observed morphology can be achieved with a disk of ≈200 AU diameter, immersed in a low density cloud ($\approx2\times10^{-20}$ gcm^{-3}). The low cloud density is necessary to stay below the sub-mm flux upper limits and to preserve the shadow cast by the disk via single scattering. The results demonstrate that ASR 41 is probably not inherently different from typical edge-on disk objects, and that its large apparent size is due to the shadow of a much smaller disk being projected into the surrounding dusty molecular material.

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Radial mixing in protoplanetary accretion disks. VI. Mixing by large-scale radial flows

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The presence of crystalline dust materials in the outer, cold regions of protoplanetary accretion discs requires conditions for their formation, which are typical for the inner, warm regions of the disc. This suggests the existence of a mechanism that allows an efficient, outward-directed radial transport of material in accretion discs. Higher order

analytical calculations, as well as numerical simulations reveal meridional flow structures in α-discs, which exhibit outflow of matter in regions near the disc midplane and may play a significant role in radial mixing in protoplanetary accretion discs. We present an analytical, isothermal model for the large-scale meridional flow pattern in an α-disc, verifying the approximations which it is based on by means of a 2-D numerical computation. The solution for the flow structure obtained is used for calculating the transport of a tracer in accretion discs in combination with diffusional mixing. The impact of radial flows on mixing of tracers is compared to the height-averaged inflow solution of the standard one-zone approximation.

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The Discovery of a Disk-Jet System Directly Exposed to Strong UV Fields in the Rosette Nebula

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We report on the discovery of an optical jet with a striking morphology in the Rosette Nebula. It could be the most extreme case known of an accretion disk and jet system directly exposed to strong ionization fields that impose strong effects on its disk evolution. Unlike typical optical flows, this jet system is found to have a high excitation nature mainly due to disruptive interaction with the violent environment. As a result, the extension of the highly-collimated jet and possible former episodes of the degenerated counterjet all show bow-shocked structures. Our results provide implications on how incipience of massive stars in giant molecular clouds prevents further generations of low-mass star formation, and possibly also how isolated substellar/planetary mass objects in regions of massive star formation are formed.

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The brown dwarf population in the Chamaeleon I cloud

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We present the results of a multiband survey for brown dwarfs in the Chamaeleon I dark cloud with the Wide Field Imager (WFI) camera at the ESO/MPG 2.2-m telescope on La Silla (Chile). The survey has revealed a substantial population of brown dwarfs in this southern star forming region. Candidates were selected from R, I and Hα imaging observations. We also observed in two medium-band filters, M855 and M915, for the purpose of spectral type determination. The former filter covers a wavelength range containing spectral features characteristic of M-dwarfs, while the latter lies in a relatively featureless wavelength region for these late-type objects. A correlation was found between spectral type and (M855–M915) colour index for mid- to late M-type objects and early L-type dwarfs. With this method, we identify most of our object candidates as being of spectral type M5 or later. Our results show that there is no strong drop in the number of objects for the latest spectral types, hence brown dwarfs may be as abundant as low-mass stars in this region. Also, both kind of objects have a similar spatial distribution. We derive an index $\alpha = 0.6 \pm 0.1$ of the mass function in this region of dispersed star formation, in good agreement with the values obtained in other star forming regions and young clusters. Some of the brown dwarfs have strong Hα emission, suggesting mass accretion. For objects with published infrared photometry, we find that strong Hα emission is related to a mid-infrared excess, indicative of the existence of a circumstellar disk.

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First MHD Simulation of Collapse and Fragmentation of Magnetized Molecular Cloud Cores

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This is the first paper about the fragmentation and mass outflow in the molecular cloud by using three-dimensional MHD nested-grid simulations. The binary star formation process is studied paying particular attention to the fragmentation of a rotating magnetized molecular cloud. We assume an isothermal rotating and magnetized cylindrical cloud in hydrostatic balance. Non-axisymmetric as well as axisymmetric perturbations are added to the initial state and the subsequent evolutions are studied. The evolution is characterized by three parameters: the amplitude of the non-axisymmetric perturbations, the rotation speed, and the magnetic field strength. As a result, it is found that non-axisymmetry hardly evolves in the early phase, but begins to grow after the gas contracts and forms a thin disk. Disk formation is strongly promoted by the rotation speed and the magnetic field strength. There are two types of fragmentation: fragmentation from a ring and that from a bar. Thin adiabatic cores fragment if a thickness is smaller than 1/4 of the radius. For the fragments to survive, they should be formed in a heavily elongated barred core or a flat round disk. In the models showing fragmentation, outflows from respective fragments are found as well as those driven by the rotating bar or the disk.

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The H_2CO abundance in the inner warm regions of low mass protostellar envelopes

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We present a survey of the formaldehyde emission in a sample of eight Class 0 protostars obtained with the IRAM and JCMT millimeter telescopes. The range of energies of the observed transitions allows us to probe the physical and chemical conditions across the protostellar envelopes. The data have been analyzed with three different methods with increasing level of sophistication. We first analyze the observed emission in the LTE approximation, and derive rotational temperatures between 11 and 40 K, and column densities between 1 and 20×10^{13} cm^{-2}. Second, we use a LVG code and derive higher kinetic temperatures, between 30 and 90 K, consistent with subthermally populated levels and densities from 1 to 6×10^5 cm^{-3}. The column densities from the LVG modeling are within a factor of 10 with respect to those derived in the LTE approximation. Finally, we analyze the observations based upon detailed models for the envelopes surrounding the protostars, using temperature and density profiles previously derived from continuum observations. We approximate the formaldehyde abundance across the envelope with a jump function, the jump occurring when the dust temperature reaches 100 K, the evaporation temperature of the grain mantles. The observed formaldehyde emission is well reproduced only if there is a jump of more than two orders of magnitude, in four sources. In the remaining four sources the data are consistent with a formaldehyde abundance jump, but the evidence is more marginal ($\leq 2\ \sigma$). The inferred inner H_2CO abundance varies between 1×10^{-8} and 6×10^{-6}. The absolute values of the jump in the H_2CO abundance are uncertain by about one order of magnitude, because of the uncertainties in the density, ortho to para ratio, temperature and velocity profiles of the inner region, as well as the evaporation temperature of the ices. We discuss the implications of these jumps for our understanding of the origin and evolution of ices in low mass star forming regions. Finally, we give predictions for the submillimeter H_2CO lines, which are particularly sensitive to the abundance jumps.

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A search for evolved dust in Herbig Ae stars

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We present observations of six isolated, pre-main-sequence, intermediate mass stars selected for shallow spectra at submillimeter wavelengths at 1.3, 2.6, 7.0, and 36 millimeters from the IRAM PdBI and the VLA. We analyze the new observations of these stars (HD34282, HD35187, HD142666, HD143006, HD150193, HD163296) together with similar observations of three additional stars from the literature (CQ Tau, UX Ori, TW Hya), in the context of self-consistent irradiated disk models. Our aim is to constrain the wavelength dependence of the dust opacity and the total dust mass in the disks. The shallow wavelength dependence of the opacity is confirmed and for a few stars extended to significantly longer wavelengths. For any plausible dust properties, this requires grain growth from interstellar sizes to maximum sizes of at least a few millimeters, and very likely to several centimeters or more. For four of the stars (HD34282, HD163296, CQ Tau, TW Hya), the millimeter emission has been spatially resolved, and the large disk radii (> 100 AU) rule out that high optical depths play a role. The mass of dust that has been processed into large grains is substantial, and in some cases implies a disk mass comparable to the mass of the central star.

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The physical and chemical structure of hot molecular cores

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We have made self-consistent models of the density and temperature profiles of the gas and dust surrounding embedded luminous objects using a detailed radiative transfer model together with observations of the spectral energy distribution of hot molecular cores. Using these profiles we have investigated the hot core chemistry which results when grain mantles are evaporated, taking into account the different binding energies of the mantle molecules, as well a model in which we assume that all molecules are embedded in water ice and have a common binding energy. We find that most of the resulting column densities are consistent with those observed toward the hot core G34.3+0.15 at a time around 10^4 years after central luminous star formation. We have also investigated the dependence of the chemical structure on the density profile which suggests an observational possibility of constraining density profiles from determination of the source sizes of line emission from desorbed molecules.

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Deuterated interstellar PAHs

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We report infrared spectral evidence of deuterated interstellar polycyclic aromatic hydrocarbons (PAHs). Two bands are detected in the infrared emission from the ionization bar in Orion at 4.4 and 4.65 μm. That at 4.65 μm is present at the 4.4 sigma level while that at 4.4 μm is more tentative, with sigma equal to 1.9. An emission band at 4.65 μm is also detected in the infrared emission from M17 (Verstraete et al. 1996) at the 4.4 sigma level. These wavelengths are unique to C-D stretching modes of deuterated PAHs. The IR spectroscopic properties of deuterated PAHs are summarized and an estimate of the deuterium fractionation between the aromatic and aliphatic carbons associated with the PAHs is given. High deuterium fractionation is implied. This is discussed in terms of interstellar PAH fractionation mechanisms.

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A young and complex binary star - HD 144432

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The southern emission-line star HD 144432 has received considerable attention due to its relative brightness ($V \sim 8.17$), its late spectral type (late A-type or perhaps early F) and its relative isolation from a bona-fide active star formation region. We present new imaging and spectroscopic data of this star, which in the past has been classified as both an evolved (post-AGB) object and an isolated Herbig Ae/Be star. We confirm the presence of a faint companion source located 1.4″ north, which appears physically associated with HD 144432. New infrared spectroscopy reveals this companion to be a late-type (early-mid K) star, devoid of any emission lines. Furthermore, we confirm the pre-main sequence nature of this object, report the detection of Li I 6707.8 Å absorption towards the HD 144432 system, and its apparent association with Sco OB2-2 located at 145 pc.

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Hα Emission Line Stars in Molecular Clouds. I. The NGC 2264 Region

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We present a deep survey of Hα emission line stars in the NGC 2264 region using wide field objective prism films. We find 357 Hα emission line stars, of which 113 were previously detected, within an area of $3^o \times 3^o$ centered on the Cone Nebula, with a majority of stars being concentrated in a dense cluster at the center of the region. We present a large-scale CO map of NGC 2264, and find a strong correlation between the cluster of Hα emission line stars and the most massive core in the cloud complex. A more extended halo of stars poorly correlated with the gas may represent stars that have drifted away from their birth place, suggesting that star formation has taken place in NGC 2264 for several million years.

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Deep Imaging Surveys of Star-forming Clouds I. New Herbig-Haro Flows in NGC 2264

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We have embarked on a major, imaging survey of nearby star forming regions using widefield imaging detectors in order to identify and characterize the full population of Herbig-Haro flows from newborn stars in each region. In this study, we present our survey results for the NGC 2264 region in Monoceros, where we have found a number of new Herbig-Haro objects, HH 571 - HH 585, including several giant, parsec-scale flows. We discuss the individual flows and attempt to locate their region of origin. In particular, we identify two quadrupolar HH flows emanating from two cloud cores, and associated with major molecular outflows. We also draw attention to what appears to be a region of major blow-out of gas from a cloud core rich in young stars.

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Chondrule Formation and Protoplanetary Disk Heating by Current Sheets in Non-Ideal Magnetohydrodynamic Turbulence

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We study magnetic field steepening due to ambipolar diffusion (Brandenburg & Zweibel 1994) in protoplanetary disk environments and draw the following conclusions. Current sheets are generated in magnetically active regions of the disk where the ionization fraction is high enough for the magnetorotational instability to operate. In late stages of solar nebula evolution, the surface density is expected to have lowered and dust grains to have gravitationally settled to the midplane. If the local dust-to-gas mass ratio near the midplane is increased above cosmic abundances by factors $\gtrsim 10^3$, current sheets reach high enough temperatures to melt millimeter-sized dust grains, and hence may provide the mechanism to form meteoritic chondrules. In addition, these current sheets possibly explain the near-infrared excesses observed in spectral energy distributions (SEDs) of young stellar objects. Direct imaging of protoplanetary disks via a nulling interferometer or, in the future, a multi-band, adaptive optics coronagraph can test this hypothesis.

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Spectroscopic [Fe/H] for 98 extra-solar planet-host stars: Exploring the probability of planet formation

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In this paper we present stellar parameters and metallicities, obtained from a detailed spectroscopic analysis, for a

large sample of 98 stars known to be orbited by planetary mass companions (almost all known targets), as well as for a volume-limited sample of 41 stars not known to host any planet. For most of the stars the stellar parameters are revised versions of the ones presented in our previous works. However, we also present parameters for 18 stars with planets not previously published, and a compilation of stellar parameters for the remaining 4 planet-hosts for which we could not obtain a spectrum. A comparison of our stellar parameters with values of $T_{\rm eff}$, $\log g$, and [Fe/H] available in the literature shows a remarkable agreement. In particular, our spectroscopic $\log g$ values are now very close to trigonometric $\log g$ estimates based on Hipparcos parallaxes. The derived [Fe/H] values are then used to confirm the previously known result that planets are more prevalent around metal-rich stars. Furthermore, we confirm that the frequency of planets is a strongly rising function of the stellar metallicity, at least for stars with [Fe/H]>0. While only about 3% of the solar metallicity stars in the CORALIE planet search sample were found to be orbited by a planet, this number increases to more than 25% for stars with [Fe/H] above +0.3. Curiously, our results also suggest that these percentages might remain relatively constant for values of [Fe/H] lower than about solar, increasing then linearly with the mass fraction of heavy elements. These results are discussed in the context of the theories of planetary formation.

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Sub-mm observations and modelling of Vega type stars

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We present new sub-mm observations of Vega excess stars, and consistent modelling for all known Vega excess stars with sub-mm data. Our analysis uses dust grain models with realistic optical properties, with the aim of determining physical parameters of the unresolved disks from just their SEDs. For the resolved targets, we find that different objects require very different dust grain properties in order to simultaneously fit the image data and SED. Fomalhaut and Vega require solid dust grains, whilst HR4796 and HD141569 can only be fitted using porous grains. The older stars tend to have less porous grains than younger stars, which may indicate that collisions in the disks have reprocessed the initially fluffy grains into a more solid form. ϵ Eri appears to be deficient in small dust grains compared to our best fitting model. This may show that it is important to include all the factors which cause the size distribution to depart from a simple power law for grains close to the radiation pressure blowout limit. Alternatively, this discrepancy may be due to some external influence on the disk (e.g. a planet).

When the model is applied to the unresolved targets, an estimate of the disk size can be made. However, the large diversity in dust composition for the resolved disks means that we cannot make a reliable assumption as to the composition of the grains in an unresolved disk, and there is corresponding uncertainty in the disk size. In addition, the poor fit for ϵ Eri shows that the model cannot always account for the SED even if the disk size is known. These two factors mean that it may not be possible to determine a disk's size without actually resolving it.

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Does Magnetic Levitation or Suspension Define the Masses of Forming Stars?

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We investigate whether magnetic tension can define the masses of forming stars by holding up the subcritical envelope of a molecular cloud that suffers gravitational collapse of its supercritical core. We perform an equilibrium analysis of the initial and final states assuming perfect field freezing, no rotation, isothermality, and a completely flattened

configuration. The sheet geometry allows us to separate the magnetic tension into a levitation associated with the split monopole formed by the trapped flux of the central star and a suspension associated with curved field lines that thread the static pseudodisk and envelope of material external to the star. We find solutions where the eigenvalue for the stellar mass is a fixed multiple of the initial core mass of the cloud. We verify the analytically derived result by an explicit numerical simulation of a closely related 3-D axisymmetric system. However, with field freezing, the implied surface magnetic fields much exceed measured values for young stars. If the pinch by the central split monopole were to be eliminated by magnetic reconnection, then magnetic suspension alone cannot keep the subcritical envelope (i.e., the entire model cloud) from falling onto the star. We argue that this answer has general validity, even if the initial state lacked any kind of symmetry, possessed rotation, and had a substantial level of turbulence. These findings strongly support a picture for the halt of infall that invokes dynamic levitation by YSO winds and jets, but the breakdown of ideal magnetohydrodynamics is required to allow the appearance in the problem of a rapidly rotating, centrifugally supported disk. We use these results to calculate the initial mass function and star formation efficiency for the distributed and clustered modes of star formation.

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Detection of a warm molecular wind in DG Tauri

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We detect near-infrared H_2 emission in DG Tau using the Infrared Camera and Spectrograph (IRCS) on the 8.2-m SUBARU telescope. The spectra obtained along the jet axis show that the centroidal position of the 1-0 S(1) emission is offset by 0.2" from the star towards the jet, while those obtained perpendicular to the jet axis show a marginal extension, indicating that the emission line region has a typical width of ∼0.6". Their line profiles show a peak velocity of ∼15 km s^{-1} blueshifted from the systemic velocity. These results indicate that the emission originates from a warm molecular wind with a flow length and width of ∼40 and ∼80 AU, respectively. The line flux ratios ($I_{1-0S(0)}/I_{1-0S(1)}$ and an upper limit for $I_{2-1S(1)}/I_{1-0S(1)}$) suggest that the flow is thermalized at a temperature of ∼2000 K, and is likely heated by shocks or ambipolar diffusion. The observed velocity and spatial extension suggest that the H_2 and forbidden line emission originate from different components of the same flow, i.e., a fast and partially ionised component near the axis and a slow molecular component surrounding it. Such a flow geometry agrees with model predictions of magneto-centrifugal driven winds.

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Near infrared imaging of NGC 2316

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In the present paper we present JHK photometric results of the young embedded cluster NGC 2316. We construct the cluster radial profile from which we determine a radius of 0.63 pc. We find 189 ± 29 cluster members in an extinction limited sub-sample of the survey, 22 ± 19 of which are possibly substellar. An average extinction of 4.5 visual magnitudes is derived using $(H-K)$ colours of control fields. This extinction is due to the presence of residual parental molecular cloud. NGC 2316 presents 16% source fraction of excess emission which is consistent with other results from clusters with an age of 2 – 3 Myr. This age is consistent with the distribution of sources in the colour-magnitude diagram when compared to theoretical isochrones, and the overall shape of the cluster KLF. The substellar population of the cluster is similar or smaller than that observed for other embedded clusters and the stellar objects dominate the cluster membership.

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Preprints available from http://xxx.lanl.gov/abs/astro-ph/0311492
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A quantitative analysis of OCN^- formation in interstellar ice analogs

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The 4.62 μm absorption band, observed along the line-of-sight towards various young stellar objects, is generally used as a qualitative indicator for energetic processing of interstellar ice mantles. This interpretation is based on the excellent fit with OCN^-, which is readily formed by ultraviolet (UV) or ion-irradiation of ices containing H_2O, CO and NH_3. However, the assignment requires both qualitative and quantitative agreement in terms of the efficiency of formation as well as the formation of additional products. Here, we present the first quantitative results on the efficiency of laboratory formation of OCN^- from ices composed of different combinations of H_2O, CO, CH_3OH, HNCO and NH_3 by UV- and thermally-mediated solid state chemistry. Our results show large implications for the use of the 4.62 μm feature as a diagnostic for energetic ice-processing. UV-mediated formation of OCN^- from $H_2O/CO/NH_3$ ice matrices falls short in reproducing the highest observed interstellar abundances. In this case, at most 2.7% OCN^- is formed with respect to H_2O under conditions that no longer apply to a molecular cloud environment. On the other hand, photoprocessing and in particular thermal processing of solid HNCO in the presence of NH_3 are very efficient OCN^- formation mechanisms, converting 60%–85% and ∼100%, respectively of the original HNCO. We propose that OCN^- is most likely formed thermally from HNCO given the ease and efficiency of this mechanism. Upper limits on solid HNCO and the inferred interstellar ice temperatures are in agreement with this scenario.

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Migration of extrasolar planets to large orbital radii

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Observations of structure in circumstellar debris discs provide circumstantial evidence for the presence of massive planets at large (several tens of AU) orbital radii, where the timescale for planet formation via core accretion is prohibitively long. Here, we investigate whether a population of distant planets can be produced via outward migration subsequent to formation in the inner disc. Two possibilities for significant outward migration are identified. First, cores that form early at radii $a \sim 10$ AU can be carried to larger radii via gravitational interaction with the gaseous disc. This process is efficient if there is strong mass loss from the disc – either within a cluster or due to photoevaporation from

a star more massive than the Sun – but does not require the extremely destructive environment found, for example, in the core of the Orion Nebula. We find that, depending upon the disc model, gas disc migration can yield massive planets (several Jupiter masses) at radii of around 20-50 AU. Second, interactions within multiple planet systems can drive the outer planet into a large, normally highly eccentric orbit. A series of scattering experiments suggests that this process is most efficient for lower mass planets within systems of unequal mass ratio. This mechanism is a good candidate for explaining the origin of relatively low mass giant planets in eccentric orbits at large radii.

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BM Ori. 1. The anomalies in radial velocities

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The radial velocities of BM Ori have been measured using spectra secured with HST, IUE and BTA telescopes. The analysis shows that velocities reveal episodic shift at 20-30 km/s. It may mean that there is a third star. New observations permit to improve the spectroscopic elements of the close binary system and to estimate the possible orbit of the third body. Preliminary elements are: Ep=JD 2444744, P=1302^d, /gamma=11 km/s, e=0.92, K=20 km/s, /omega=1.6 rad.

Accepted by Astrofizica (Armenian journal, in Russian)

FU Orionis: A Binary Star?

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By using the ALFA adaptive optics system at the 3.6m telescope of the Calar Alto Observatory we detected a faint red star in the apparent vicinity of FU Ori, the prototype of the FUor outburst stars. Independent confirmation of the detection is obtained from archival PUEO/CFHT images. The separation between the companion candidate and FU Ori is 0.50" and their brightness contrast is around 4 magnitudes. We discuss the possible nature of the newly detected star based on near-infrared photometry and its proper motion relative to FU Ori. The photometric data are consistent with a nearby late-type main sequence star, a background giant star, and a pre-main sequence star. On the basis of the proper motion and the stellar surface density in the direction towards FU Ori, we argue that the probabilities of the first two options are very low.

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Low Mass Stars and Substellar Objects in the NGC 1333 Molecular Cloud

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We present the results of near-infrared imaging and low-resolution near-infrared spectroscopy of low mass objects in the NGC 1333 molecular cloud. A JHK survey of an 11.4′x 11.7′ area of the northern cluster was conducted to a sensitivity of K≤16 mag. Using near-infrared magnitudes and colors from this and previously published surveys,

twenty-five brown dwarf candidates were selected toward the high extinction cloud core. Spectra in the K band were obtained and comparisons of the depths of water vapor absorption bands in our candidate objects with a grid of dwarf, subgiant, and giant standards were made to derive spectral types. These data were then used to derive effective temperatures and stellar luminosities which, when combined with theoretical tracks and isochrones for pre-main sequence objects, resulted in estimates for their masses and ages. The models suggest a median age for the sample of <1 Myr with substellar masses for at least 9 of the candidates including the x-ray flare source ASR 24. Surface gravities have been estimated for the brown dwarf candidates and, for a given spectral type, found to resemble more closely dwarfs than giants. Using the near-infrared imaging data and age estimates from the spectroscopic sample, an extinction-limited sample in the northern cluster was defined. Consistent with recent studies of other young clusters, this sample exhibits an accretion disk frequency of 0.75±0.20 and a mass spectrum slope across the hydrogen-burning limit of $\alpha \leq 1.6$ where $dN/dM \propto M^{-\alpha}$.

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Detection of cool dust around the G2V star HD 107146

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We report the detection of dust emission at sub-millimeter wavelengths from HD 107146, a G2V star with an age estimated to lie between 80 and 200 Myr. The emission is resolved at 450 μm with a size 300 AU × 210 AU. A fit to the spectral energy distribution gives a dust temperature of 51 K and dust mass of 0.10 $M_\oplus$. No excess emission above the photosphere was detected at 18 μm showing that there is very little warm dust and implying the presence of a large inner hole, at least 31 AU ($\sim 1''$) in radius, around the star. The properties of this star-disk system are compared with similar observations of other systems. We also discuss prospects for future observations that may be able to determine whether the inner hole is maintained by the dynamical effect of an unseen orbiting companion.

Accepted by ApJ

astro-ph/0311583

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals, not reviews nor conference notes), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star formation and interstellar medium community), *New Books* (giving details of books relevant for the same community), *New Jobs* (advertising jobs specifically aimed towards persons within our specialty), and *Short Announcements* (where you can inform or request information from the community).

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Dissertation Abstracts

Low Mass Star Formation in the Gum Nebula

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Most stars in the Galaxy form in clusters that contain hot, massive stars, as well as low mass stars (<2 $M_\odot$). Stars, however, do not form only in clusters, but also in small groups ($N_\star < 100$). In this thesis, I investigate the role very massive stars ($M > 30-100\ M_\odot$) may play on stars forming in small groups tens of parsecs away from strong ionizing sources. The UV radiation and strong winds from massive stars ionize the surrounding medium, and may destroy potential star forming cloud cores prohibiting further star formation in their vicinity. Some embedded young stars that were already forming in cores of clouds can be revealed faster due to evaporation of their parental clouds. Various theoretical studies also suggest that the radiation pressure and shocks can induce collapse of dense cores (on a time scale order of $\sim 10^4$ years), thereby triggering low mass star formation. Recently young low mass stars have been discovered in vicinity of O stars, clusters, and in OB associations. In this thesis, I present multi-wavelength photometric and optical spectroscopic studies of selected star forming regions where we find groups of pre-main sequence (PMS) stars associated with evaporating cometary globules (CGs) in the Gum Nebula.

We find 14 new PMS stars, and confirm 2 known Hα emitting PMS stars in CG 30/31/38 region. We identify 17 PMS stars in this CG complex complete to V$\sim$16. Two PMS loci are seen in the color-magnitude diagrams at two different distances: one with an age of 2-5 Myr at d= $200-300$ pc, and the other locus with an age of $<$ 10Myr at d$\sim$ 2kpc. The PMS stars associated with CGs are mostly early to mid M and late K stars. The radial velocities (RV) of K and M stars are consistent with published velocities of the CGs. F$-$G stars and a probable Ae/Be star are seen along the lower isochrone. Given the colors and spectral types, they are likely to be reddened by $A_V = 1-2$ mag. The RVs of the F$-$G stars are inconsistent with that of CGs and K and M stars. The mean Li abundance for M stars (logN(Li) = 2.70 $\pm$0.22 for NLTE) suggests an age of $\leq$ 5 Myr, which confirms the youth of the PMS stars. The Hα line profiles of PMS stars show accretion and outflow signatures in some of the K and M stars, however the circumstellar disk fraction derived using near-IR excesses is $\sim$9%. This is consistent with the mean lifetime of circumstellar disks in star forming regions near OB stars, such as the Upper-Sco, being lower than in quiet regions, such as Taurus. Accreting gas may be lost early on, due to the radiation from O stars. We suggest that there have been two episodes of star formation in the CG 30/31/38 complex: (1) On-going star formation recently triggered by O star radiation in the head of CG 30; and (2) an earlier episode, 2$-$5 Myr, resulting in the low mass PMS stars outlining the CG 31 complex, possibly triggered by pre-existing O stars like ζ Pup or the progenitor of Vela SNR.

Even though most of the CGs are at similar distances from the ionizing sources, not all of the CGs have PMS stars associated with them. The age of the PMS stars (and potential PMS stars) associated with CGs do not show a uniform age range, for example, CG 10 in the Gum Nebula seems to be in the process of early photoionization. The heads of cometary clouds and most of the IR sources are still embedded in the evaporating clouds behind the ionization front. We find no evidence of star formation associated with CG 6, and the few PMS candidates in CG 4 confirm previous studies (*e.g.*, Reipurth & Pettersson 1993, A&A, 267, 439). The 30 PMS candidates in the SA101 cloud include known Hα sources and RASS sources. The SA101 cloud may have been shielded by the CG 4 clouds from UV radiation of γ^2 Vel until recently, allowing enough time to form stars. The onset of star formation in different clouds, therefore, is not uniform, suggesting an overall age distribution between <0.1 - 10 Myr over the nebula. The initial conditions, such as mass, density, size of each parent CG cloud, as well as the strength of radiation field may differ from region to region. In HII regions like the Gum Nebula, there could be many generations of star formation influenced, and/or triggered by different ionizing sources (as seen in the case of CG 30/31/38 region and CG 4/SA 101 cloud). We discuss possible scenario of star formation history in the Gum Nebula suggested by this study and previous studies in literature.

http://globule.as.arizona.edu/ serena/Thesis/Chapters/index.html

Physical and chemical structure of low mass protostars

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Stars like our sun form by the gravitational collapse of fragments of molecular clouds. During the first stage of its formation (the so called Class 0), the star is deeply embedded in a gas and dust envelope, and it is only visible at infrared to millimeter wavelengths. As it evolves, the star progressively disperses this envelope. A protostellar disk remains, which may eventually form planets. In this thesis, I study the physical and chemical structure of low mass protostars. This study is based on ISO observations of water lines, and JCMT and IRAM telescopes observations of formaldehyde lines. In a first part, I study the water lines emission of the protostar NGC1333-IRAS4, which has been observed by ISO-LWS. Using a detailed model of the thermal emission of the protostar, I constrain the density and temperature profile in the envelope, which in turn constrain the central mass and the accretion rate. I also constrain the water abundance inside the envelope, and I show that this abundance is ten times higher in the inner parts of the envelope than in the outer parts. In this inner region, grain mantles evaporate, injecting large amount of water in the gaseous phase. Second, I develop a model of the formaldehyde emission, a molecule which is also abundant in grain mantles, and show that lines of this molecule can also be used to determine the physical and chemical structure of the envelope. Finally, I report a survey of formaldehyde emission of ten low mass Class 0 protostars, obtained at IRAM and JCMT. The comparison between the model predictions and the observations allows me to show that in all the observed protostars but one, formaldehyde is between two and three orders of magnitude more abundant than in the outer envelope. This shows that, like water, formaldehyde is evaporated from grain mantles and that, therefore, all the observed low mass protostars harbor hot cores, where chemistry is very likely influenced, if not dominated, by the evaporation of grain mantles.

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The Young Low-Mass Population of Orion's Belt

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I have conducted a BVRI survey covering $\sim$2.7 deg^2 of the Orion OB1b sub-association, a $\sim$3 Myr old fossil star forming region located in the belt of Orion. I have developed a procedure to use single epoch photometry to estimate the number of pre-main sequence (**PMS**) stars and field stars in the PMS locus as a function of V$-$I color. This is possible in the Orion OB1b sub-association because the low-mass PMS stars occupy a narrow, well defined locus on the color-magnitude diagram (**CMD**) which is brighter than the bulk of the field stars. The PMS locus is most easily detected in cross-sections through the CMD. In control fields away from the OB association, the number of stars falls exponentially along cross-sections through the V$-$I vs. V CMD. In cross-sections through the V$-$I CMD of Orion OB1b the PMS locus is detectable as a clear excess of stars over the expected number of field stars. This excess population follows the predicted isochrone for $\sim$3 Myr old low-mass stars.

I examined three regions in Orion OB1b. The first includes 0.89 deg^2 around σ Ori which covers most of the σ Ori cluster. The second region covers $\sim$1.2 deg^2 of the western belt near ϵ Ori and δ Ori. The final region covers 0.6 deg^2 around ζ Ori. I separated the ζ Ori region from my analysis of the western belt because the ζ Ori region has significant nebula emission and much greater reddening than the other two regions.

In the σ Ori region, I detected $\sim$180 likely members of the σ Orionis cluster with masses between 0.1 M$_\odot$ and 1.0 M$_\odot$. The cluster's radius is 25' to 40' or three to five parsecs for an assumed distance of 440 pc. The cluster has a radial profile which is well fit by a King model with a King radius of r$_0$ $\leq$1 pc. The central density of the cluster is $\sim$30 stars pc^{-3} in the mass range 0.2$\leq$M$\leq$1.0 M$_\odot$. The best fit age of the cluster is 2.6$\pm$0.4$\times$10^6 year. The σ Orionis cluster is the richest region of Orion OB1b and the only region that where a clustered population has been detected.

The PMS locus for the σ Ori region is quite narrow for stars near 0.8 M$_\odot$, but becomes wider at lower masses. At least part of this width must be due to a combination of the intrinsic variability of the PMS stars, binary stars, and observational errors. Part of this width may be caused by the stars in the cluster having formed over a period of several Myrs. It is impossible to interpret the width of the PMS locus in terms of an age-spread without knowing the expected width of a single age (isochronal) population. I constructed several simulated populations of PMS stars that were either coeval or had a range of ages. I compared these models with the observed width of the PMS locus and concluded that the width of the PMS locus is consistent with an isochronal population. My isochronal models have an intrinsic width that is similar to the width caused by an age spread of $\sim$10^6 years, so any age-spread among members of the σ Ori cluster must be *less than one million years*.

I found a significant distributed population of low-mass PMS stars in the western belt with about 240 low-mass PMS stars per square degree. Roughly half the stars are members of the 11 Myr (D$\sim$330 pc) Orion OB1a sub-association which overlaps Orion OB1b. The western belt Orion OB1b population is consistent with the 2.6$\times$10^6 year age of the σ Ori cluster. I found no evidence that Orion OB1b population of the western belt is arranged in clusters around δ Ori and ϵ Ori.

The region around ζ Ori contains a population of low-mass PMS stars, but there is significant obscuration by interstellar matter along the line of sight. The obscuration appears to be greatest near the Orion B cloud which lies to the north and east of ζ Ori. This suggests that the young low-mass population observed near ζ Ori lies at least partially behind the Orion B cloud. I could not determine whether the low-mass population near ζ Ori is clustered around ζ Ori because the spatial distribution of low-mass PMS stars in this region is dominated by the extinction.

A copy of this this thesis is available from http://www.ess.sunysb.edu/wsherry/thesis/thesis.ps

Mass Functions and Mass Segregations in Young Starburst Clusters

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The Milky Way starburst clusters Arches in the Galactic Center and HD 97950 forming the center of the giant HII region NGC 3603 were studied with the aim to gain deeper insight into the stellar mass distribution in starburst clusters. The dense stellar population in both clusters was resolved in detail down into the innermost cluster centers with high angular resolution, near-infrared instruments.

In the case of the Arches cluster, diffraction-limited observations of the Gemini/Hokupa'a and VLT/NAOS-CONICA adaptive optics (AO) systems with resolutions down to 84 mas in H and K-band allowed to resolve the dense cluster center into individual massive and intermediate mass stars down to $M > 4\,M_{\odot}$. A detailed technical analysis was conducted to understand the complex effects of the AO wavefront correction on the derived photometry. In particular, the consequences of low to moderate AO performance for crowded field imaging are discussed in detail. The comparison between Hokupa'a, NAOS-CONICA, and HST/NICMOS observations reveals the achievements and limitations of ground-based vs. space-based diffraction-limited imaging. The technical understanding gained in this study forms the foundation for the scientific analysis of the Arches cluster.

In the case of HD 97950 in NGC 3603, L-band and Hα data complementing seeing-limited, sub-arcsecond resolution JHK photometry allowed to derive colour excess fractions as tracers for circumstellar material. Although a very low excess fraction of only 20% is found in the cluster core, compared to a disk fraction of 80% in similarly young clusters, several Hα emission sources are observed unexpectedly close to the central O-star population. Disk survival indicating ongoing or truncated accretion in massive clusters is discussed.

The present-day mass function (MF) of both clusters is derived from the colour-magnitude diagrams using isochrone fitting. A mass range of $10 < M < 65\,M_{\odot}$ is covered in the case of the severely crowding limited Arches cluster, while lower masses of $0.4 < M < 20\,M_{\odot}$ are traced in NGC 3603, where the high-mass tail is lost to saturation. Despite the different mass ranges covered, both clusters display a consistent, slightly flattened MF with $\Gamma \sim -0.9$, where Salpeter is -1.35, indicating a bias to high-mass stars in the cluster cores. Radial variations in the MFs revealing a heavily mass-segregated core in both starburst clusters support this assumption. While the MF slope Γ has a strong binning dependence, cumulative functions are found to reveal mass segregation more clearly via depletion at the high- or low-mass end than the value of Γ.

Dynamical timescales are estimated from the stellar mass distribution and interpreted with respect to primordial and dynamical segregation, resulting in segregation times of ~ 2 Myr for both clusters, close to the cluster ages. This implies that dynamical and primordial segregation cannot be distinguished easily in starburst clusters. Derived Arches cluster characteristics are used to display the high uncertainties inherent to simple timescale estimates, yielding a range between 2 and 20 Myr for the relaxation time. The implications of short dynamical timescales for massive star and cluster formation scenarios are discussed.

For the first time, evidence for a low-mass cut-off in the MF is observed in the Arches cluster in the mass range $4 < M < 10\,M_{\odot}$. As no truncation is found in the MF of HD 97950, this indicates that the formation of stars with $M \leq 10\,M_{\odot}$ is reduced due to tidal disruption of material in the dense Galactic Center environment. This environmental difference has strong implications for the formation and composition of stellar populations in Galactic Nuclei and starburst galaxies. The effects of star-forming environments are analysed by comparison of HD 97950 and Arches with R 136 in the giant star-forming complex 30 Doradus in the Large Magellanic Cloud, and the more moderate Orion region.

The thesis is available at http://www.ub.uni-heidelberg.de/archiv/3611

New Books

Turbulence and Magnetic Fields in Astrophysics

Edited by Edith Falgarone and Thierry Passot

This book presents a series of reviews on turbulence in magnetized astrophysical environments. The material was originally presented at the conference *Simulations of Magnetohydrodynamic Turbulence in Astrophysics* in Paris in July 2001. The lectures have now been written in a tutorial form, so that the reviews can be read by a broad audience. The book is divided into 4 sections, and contains the chapters listed below.

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