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Abstracts of recently accepted papers

HST/NICMOS2 coronagraphic observations of the circumstellar environment of three old PMS stars: HD 100546, SAO 206462 and MWC 480

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The close environment of four old Pre-Main Sequence stars has been observed thanks to the coronagraphic mode of the HST/NICMOS2 camera at $\lambda = 1.6 \mu\text{m}$. In the course of this program, the detection of a circumstellar annulus around HD 141569 has already been presented in Augereau et al.(1999b).

In this paper, we report the detection of an elliptical structure around the Herbig Be star HD 100546 extending from the very close edge of the coronagraphic mask (~ 50 AU) to 350–380 AU ($3.5\text{--}3.8''$) from the star. The axis ratio gives a disk inclination of $51^\circ \pm 3^\circ$ to the line-of-sight and a position angle of $161^\circ \pm 5^\circ$, measured east of north. At 50 AU, the disk has a surface brightness between 10.5 and 11 mag/arcsec², then follows a -2.92 ± 0.04 radial power law up to 250–270 AU and finally falls as $r^{-5.5 \pm 0.2}$. The inferred optical thickness suggests that the disk is at least marginally optically thick inside 80 AU and optically thin further out. Combined with anisotropic scattering properties, this could explain the shape of a brightness asymmetry observed along the minor axis of the disk. This asymmetry needs to be confirmed.

The circumstellar disks around SAO 206462 and MWC 480 are not resolved, leading to constraints on the dust distribution. A tight binary system separated by only $0.32'' \pm 0.04''$ is nevertheless detected in the close vicinity of SAO 206462.

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<http://arXiv.org/abs/astro-ph/0009496>

On the Tidal Inflation of Short-Period Extrasolar Planets

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We examine the consequences of tidal interaction between eccentric short period extrasolar planets and their host stars and of secular perturbations between planets in a given system. If the planet is within 0.05 AU of the star, the dissipation of the stellar tidal disturbance within the planet provides a significant energy source, which causes the planet to inflate as it adjusts to a thermal equilibrium. We determine the planetary size as a function of the tidal dissipation rate with or without the presence of a core. Inflation intensifies the star-planet tidal interaction and accelerates the pace of the planet's spin synchronization and orbital circularization. We apply our results to three systems with short period planets: HD 209458, Upsilon And, and Tau Boo.

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Protostellar Fragmentation Enhanced By Magnetic Fields

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Fragmentation, the break-up of molecular cloud cores during their self-gravitational collapse to form stars, is the leading explanation for the formation of binary and multiple protostars. Molecular cloud cores appear to be supported against collapse in large part by magnetic fields. However, most protostellar fragmentation calculations have either ignored the effects of magnetic fields, or found that in the presence of frozen-in magnetic fields, fragmentation is prohibited. Allowing for magnetic field loss by ambipolar diffusion prior to collapse leads again to fragmentation, but these calculations did not take into account magnetic field tension, which effectively dilutes the self-gravitational forces once a thin disk forms. Because self-gravity drives fragmentation, magnetic tension might then prevent fragmentation. Here we report on the first three-dimensional calculations which show that because magnetic tension also helps in avoiding a central density singularity during protostellar collapse, the net effect is to enhance fragmentation of collapsing magnetic cloud cores. Magnetic clouds can thereby fragment into binary and multiple protostar systems, the latter of which are likely to be unstable to subsequent orbital decay.

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preprint at <http://www.ciw.edu/boss/ftp/bfrag>

An Approximate Determination of the Gas-Phase Metal Abundance in Herbig-Haro Outflows and their Shocks

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It is important to determine whether the observed bow shocks in the working surfaces of Herbig-Haro outflows has lead to a destruction of dust grains and consequently to a change in the gas phase metal abundances (say of Fe) in the cooling regions of HH bow shocks. Detailed studies are currently available for only 5 HH outflows (Beck-Winchatz et al. 1996). This small number is due to the large observational and theoretical effort required to determine metal abundances in HH objects.

Information about metal abundances in more HH objects is badly needed. We therefore use a very approximate method. We introduce a “characteristic number,” A_{me} , whose definition is based only on the often observed line fluxes of [Fe II] 5159, [Fe II] 7155, [Ca II] 7291, as well as $H\alpha$ and $H\beta$. These fluxes can easily be determined from existing observations. We find a good correlation between A_{me} and the Fe abundance for the 5 well-studied HH objects. We use this correlation to determine approximate values of the gas phase Fe abundance in 13 additional high excitation and in 3 additional low excitation HH objects.

The results are the following: Of the 16 high excitation HH objects studied, there are 6 which approximately agree with normal population I abundance (i.e., no depletion due to dust formation). The remaining 10 show some (very modest) Fe gas phase depletion which, however, never gets larger than by a factor of 2.5. This result is in agreement with our qualitative expectations that fast shocks efficiently destroy dust grains. Of the 5 low excitation HH objects studied, there are 4 which show a normal population I abundance (strictly speaking, an even slightly higher abundance than this). This is completely unexpected. In low excitation objects, one might expect strong gas phase Fe depletion (showing the unchanged molecular cloud composition), unless the matter has previously gone through shocks of much higher shock velocities. We discuss this possible explanation and the question of whether low excitation HH objects have a different “history” than usually assumed.

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Unlocking the Keyhole - H₂ and PAH emission from molecular clumps in the Keyhole Nebula

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To better understand the environment surrounding CO emission clumps in the Keyhole Nebula, we have made images of the region in H₂ 1–0 S(1) (2.122 μ m) emission and polycyclic aromatic hydrocarbon (PAH) emission at 3.29 μ m. Our results show that the H₂ and PAH emission regions are morphologically similar, existing as several clumps, all of which correspond to CO emission clumps and dark optical features. The emission confirms the existence of photodissociation regions (PDRs) on the surface of the clumps. By comparing the velocity range of the CO emission with the optical appearance of the H₂ and PAH emission, we present a model of the Keyhole Nebula for which the most negative velocity clumps are in front of the ionization region, the clumps at intermediate velocities are in it and those which have the least negative velocities are at the far side. It may be that these clumps, which appear to have been swept up from molecular gas by the stellar winds from η Car, are now being over-run by the ionization region and forming PDRs on their surfaces. These clumps comprise the last remnants of the ambient molecular cloud around η Car

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Massive and luminous YSO IRAS 05361+3539 and its environment. A study of star formation in the parent cloud - I

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Near-infrared photometry and narrow/broad-band imaging of the massive and luminous young stellar object IRAS 05361+3539 are presented. Imaging observations were made at Mt. Abu while the photometric data were taken from the 2MASS. From the color-color and color-magnitude diagrams, we identified several sources of faint Class II type and about six Class I type in the parent molecular cloud complex. The IRAS 05361+3539 itself was seen to be a Class I object and our images in Br γ and H₂ lines show jets/outflows from this object. The jet/outflow matches with the axis of CO outflow detected earlier. The near-infrared and the IRAS far-infrared flux distribution suggests a possible accretion disk with dust temperatures between 80 to 800K and extent of several tens to hundreds of AU. A possible FU Orionis type of source was detected in the cluster.

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available at the astro-ph web site. astro-ph/0010637

The Most Luminous Protostars in Molecular Clouds: A Hint to Understand The Stellar Initial Mass Function

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The maximum luminosity of protostars forming in molecular clouds is investigated as a function of the parent cloud

mass, on the basis of a rich cloud sample searched for in the literature. In total, we gathered 499 molecular clouds among the published data, out of which 243 clouds are found to be associated with protostellar candidates selected from the IRAS point source catalog. A diagram of the maximum stellar luminosity in each cloud and the parent cloud mass shows that the protostars in the clouds associated with HII regions are apparently more luminous than those in clouds away from HII regions over the entire cloud mass range investigated ($1 < M_{\text{CL}}/M_{\odot} < 10^6$). In addition, we found that there are well-defined upper and lower limits in the maximum stellar luminosity distribution with the lower limit having a steeper dependence on the cloud mass ($L_{\text{MAX}} \propto M_{\text{CL}}^{1.5}$) than the upper one ($L_{\text{MAX}} \propto M_{\text{CL}}^{0.8}$). All these features can be naturally accounted for if we assume that the luminosity function of protostars is controlled by the cloud mass and the external pressure imposed on the cloud surface. We introduce a simple model for the stellar luminosity function as a function of these quantities, which should be closely related to the stellar initial mass function.

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Near Infrared Hydrogen Lines as Diagnostics of Accretion and Winds in T Tauri Stars

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From a sample of 50 T Tauri stars, mostly from the Taurus-Auriga complex, Pa β line profiles were obtained for 49 of the stars and Br γ profiles for 37 of the stars. Emission at Pa β was observed for 42 stars and emission at Br γ was found for 30 stars. The most conspicuous features in the line profiles is the almost complete absence of blueshifted absorption components and the relatively high frequency of inverse P Cygni profiles (IPC). At Pa β , 34% of the profiles are IPC while at Br γ 20% are IPC. The redshifted absorption features indicate infall at velocities of about 200 km s⁻¹, compatible with free fall from a few radii out. In general, line profiles are broad centrally peaked with slightly blueshifted line peaks. Existing wind and accretion models fail, in quantitative terms, to explain the shape of the observed profiles. Magnetospheric accretion models, being the currently preferred ones, produce lines too narrow (by ~ 100 km s⁻¹ FWHM), wings extending to velocities too low (by at least ~ 100 km s⁻¹) and with maximum normalized intensities too high by factors of a few. A qualitative agreement between some of the accretion model predicted profiles and some observations hint that emission in these lines might, at least partially, arise from infalling material. Definite claims regarding the origin of the emission in these lines cannot be made until models match observations much better than they currently do.

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<http://www.astro.up.pt/users/dmf/MS10083folha.ps.gz>

Silicon monoxide and methanol emission from the NGC 2071 molecular outflow

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We report observations of emission in the $J = 3 \rightarrow 2$ and $J = 2 \rightarrow 1$ transitions of SiO and $J_k = 3_k \rightarrow 2_k$ transitions of CH₃OH, made with SEST, toward the high-velocity, collimated molecular outflow in NGC 2071. Emission is detected from the lobes, as well as from the central core region, in both species. The spatial distribution of the SiO wing emission, which is detected over a velocity range of ~ 50 km s⁻¹, shows three distinct features: a blue-shifted clump located toward the northeast, a red-shifted clump located toward the southwest, and a central structure, with moderate red-shifted velocities, located near the cluster of young stellar objects. The shape of the SiO profiles from the northeast and southwest clumps are distinctly different. The SiO lines from the northeast clump exhibit a peak near the velocity of the ambient cloud and a gradual decline toward blue-shifted velocities reaching flow velocities of up to -32 km s⁻¹. On the other hand, the SiO profiles from the southwest clump show a peak emission at a velocity that is red-shifted by ~ 8.5 km s⁻¹ from the ambient gas velocity and a gradual decline in brightness toward the ambient cloud velocity. We suggest that the SiO emission from the clumps are signposts of working surfaces where

a collimated jet is interacting with ambient material, and ascribe the differences in line shape to differences in the density of the environment under which the jet is propagating.

The abundance of silicon monoxide in the outflow lobes is found to be enhanced, with respect to that of quiescent ambient gas in dark globules, by at least two orders of magnitude (peak enhancement ≥ 500 in the southwest clump and ≥ 170 in the northeast clump). The abundance of methanol is considerably more enhanced in the southwest clump (peak enhancement of ~ 500) than in the northwest clump (peak enhancement of ~ 70). We suggest that the large enhancements of methanol and silicon monoxide in the outflow clumps are most likely due to the release from grains of ice mantles and Si-bearing species via shocks produced by the interaction between the outflow and dense ambient gas, and attribute the differences in enhancements to the different shock velocities attained in the northeast clump ($v_s \sim 45 \text{ km s}^{-1}$) and southwest clump ($v_s \sim 12 \text{ km s}^{-1}$).

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Far infrared observations of the southern Galactic star forming complex around IRAS 09002-4732

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The Galactic star forming region in the southern sky, associated with IRAS 09002-4732 has been mapped simultaneously in two far infrared bands ($\lambda_{eff} = 148 \text{ \& } 209 \text{ }\mu\text{m}$), with ~ 1 arcmin angular resolution. Fifteen sources, including IRAS 08583-4719, 08589-4714, 09002-4732 and 09014-4736 have been detected, some of which are well resolved. Taking advantage of similar beams in the two bands, a reliable dust temperature [T(148/209)] map has been obtained, which detects colder dust ($< 30 \text{ K}$) in this region. The HIREs processed IRAS maps at 12, 25, 60 and 100 μm , have also been used for comparison. The optical depth maps, τ_{200} and τ_{100} , generated from these far-IR data quantify the spatial distribution of the dust. The diffuse emission from this entire region has been found to be 35 % of the total FIR luminosity. The slope of the IMF in the mass range 4–16 M_\odot has been estimated to be $-1.25_{-0.65}^{+0.75}$ for this star forming complex.

Radiative transfer models in spherical geometry have been explored to fit available observations of the 4 IRAS sources and extract various physical parameters for corresponding dust-gas clouds. Whereas a constant (r^0) radial density distribution is favoured in IRAS 08583-4719, 08589-4714 and 09002-4732, the r^{-1} law is inferred for IRAS 09014-4736. The dust composition is found to be similar (Silicate dominated) in all the four IRAS sources modelled. The luminosity per unit mass is found to be in the narrow range of 44 – 81 L_\odot/M_\odot for these star forming regions.

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A Near-Infrared Imaging Survey of the Chamaeleon I Dark Cloud

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We describe a near-infrared imaging survey covering $\sim 1 \text{ deg}^2$ of the Chamaeleon I dark cloud. The survey is complete for $K < 15.0$, $H < 16.0$, and $J < 16.5$, roughly two magnitudes more sensitive than previous large scale surveys. We use the large number of background stars detected to derive an accurate near-infrared extinction law for the cloud and select new candidate members with near-infrared color excesses. We list ~ 100 candidates of the cloud with $K \geq 12.0$, based on their positions in the $J - H$, $H - K$ color-color diagram. These new stars have low luminosities ($K \sim 12 - 16$, $H - K \gtrsim 0.5 - 1.5$) and may have masses close to or even below the hydrogen burning limit.

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Measurement of the magnetic field direction in the NGC2024-FIR5 protostellar outflow

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Molecular outflows from young protostars are widely believed to be collimated by magnetic fields, but there has been little observational evidence to support this hypothesis. Using the new technique of millimetre-wavelength spectropolarimetry, we demonstrate the existence of a magnetic field in the NGC2024-FIR5 outflow lobe. The 1.3 mm $J=2-1$ transition of carbon monoxide (CO) is polarized at a level of approximately 1%, in a direction within 10–15° of the outflow axis. This agrees with theoretical models where the magnetic field channels the outflowing gas, and shows that the process can be effective as far as 0.1 pc from the protostar.

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Or: <http://www.astro.cf.ac.uk/pub/Derek.Ward-Thompson/publications.html>

Infrared spectrum and proper motion of the brown dwarf companion of HR 7329 in Tucanae

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Up to now only four brown dwarf companions to normal stars have been found and confirmed by both spectroscopy and proper motion (namely G1229 B, G 196-3, B, G1570 D, and CoD–33°7795 B). On the basis of an optical spectrum taken with HST/STIS Lowrance et al. (2000) recently pointed out another possible candidate companion. The companion candidate is located at a distance of 4'' from the A0-star HR 7329, which is considered as a member of a moving group of young stars in Tucanae located at a distance of only ~ 48 pc. In order to confirm or disregard the companion nature of the candidate, we have determined the proper motion the brown dwarf candidate with an epoch difference of 1.8 years, and found that it is consistent with a co-moving companion of HR 7329. Additional to the proper motion measurement, we have also taken an H-band spectrum using ISAAC on the ESO-VLT. From this spectrum, we conclude that the companion candidate has spectral type M7 to M8, which is in agreement with the optical spectrum.

We thus conclude that HR 7329 B is most likely a brown dwarf companion. The mass ratio of this pair (A0 to M7-8, i.e. $\sim 100 : 1$) is the largest known among brown dwarf companions, which is relevant for studying the formation of brown dwarfs as companions.

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Periodic Photometric Variability in the Becklin-Neugebauer Object

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The Becklin-Neugebauer (BN) object in the Orion Nebula Cluster (ONC) is a well-studied optically invisible, infrared-bright young stellar object, thought to be an intermediate-mass protostar. We report here that BN exhibited nearly-sinusoidal periodic variability at the near-infrared H- and K_s -bands during a one month observing campaign in 2000

March/April. The period was 8.28 days and the peak-to-peak amplitude ~ 0.2 mag. Plausible mechanisms for producing the observed variability characteristics are explored.

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<http://www.astro.caltech.edu/~lah/papers.html>

A High Velocity Molecular Outflow from the G9.62+0.19 Star Forming Region

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We have observed the G9.62+0.19 region of massive star formation with the IRAM 30 m single dish telescope in the HCO⁺(1-0), SO(4₃ - 4₂) and SiO(5-4) spectral lines, and with the IRAM Plateau de Bure interferometer in the 3 mm continuum and the HCO⁺(1-0) and CH₃OH(15₃ - 14₄) A⁻ spectral lines. We detect a high velocity molecular outflow with a total velocity extent of at least 60 km s⁻¹. The orientation of the outflow axis is very close to the line of sight. Our estimates of the mass and energetics of the outflowing gas indicate that a massive object must be responsible for driving the flow, with the Hot Core region G9.62+0.19 F as the most likely candidate. We also detect emission from hot methanol coincident with the position of continuum component E, but CH₃OH(15₃ - 14₄) A⁻ is not detected at the position of the G9.62+0.19 F Hot Core region.

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On the origin of the O and B-type stars with high velocities II. Runaway stars and pulsars ejected from the nearby young stellar groups

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We use milli-arcsecond accuracy astrometry (proper motions and parallaxes) from Hipparcos and from radio observations to retrace the orbits of 56 runaway stars and nine compact objects with distances less than 700 pc, to identify the parent stellar group. It is possible to deduce the specific formation scenario with near certainty for two cases. (i) We find that the runaway star ζ Ophiuchi and the pulsar PSR J1932+1059 originated about 1 Myr ago in a supernova explosion in a binary in the Upper Scorpius subgroup of the Sco OB2 association. The pulsar received a kick velocity of ~ 350 km s⁻¹ in this event, which dissociated the binary, and gave ζ Oph its large space velocity. (ii) Blaauw & Morgan and Gies & Bolton already postulated a common origin for the runaway-pair AE Aur and μ Col, possibly involving the massive highly-eccentric binary ι Ori, based on their equal and opposite velocities. We demonstrate that these three objects indeed occupied a very small volume ~ 2.5 Myr ago, and show that they were ejected from the nascent Trapezium cluster.

We identify the parent group for two more pulsars: both likely originate in the ~ 50 Myr old association Per OB3, which contains the open cluster α Persei. At least 21 of the 56 runaway stars in our sample can be linked to the nearby associations and young open clusters. These include the classical runaways 53 Arietis (Ori OB1), ξ Persei (Per OB2), and λ Cephei (Cep OB3), and fifteen new identifications, amongst which a pair of stars running away in opposite directions from the region containing the λ Ori cluster. Other currently nearby runaways and pulsars originated beyond 700 pc, where our knowledge of the parent groups is very incomplete.

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URL: <http://www.strw.leidenuniv.nl/hoogerw/articles.html>

Binary Formation in Stellar Clusters

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We consider how the tidal potential of a stellar cluster or a dense molecular cloud affects the fragmentation of gravitationally-unstable molecular cloud cores. We find that molecular cloud cores which would collapse to form a single star in the absence of tidal shear, can be forced to fragment if they are subjected to tides. This may enhance the frequency of binaries in star-forming regions such as Ophiuchus and the frequency of binaries with separations $\lesssim 100$ AU in the Orion Trapezium Cluster. We also find that clouds which collapse to form binary systems in the absence of a tidal potential will form bound binary systems if exposed to weak tidal shear. However, if the tidal shear is sufficiently strong, even though the cloud still collapses to form two fragments, the fragments are pulled apart while they are forming by the tidal shear and two single stars are formed. This sets an upper limit for the separation of binaries which form near dense molecular clouds or in stellar clusters.

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Preprints are available at: <http://www.ast.cam.ac.uk/~mbate/>

The Kuiper Belt and Olbers Paradox

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We investigate the constraints that Olbers Paradox, applied to the Zodiacal Background as measured from space, sets on outer solar system objects. If extended to very faint limits, $R \sim 40$ – 50 mag, the steep optical number counts of Kuiper Belt objects (KBOs) at $R \leq 26$ imply an infinitely bright night sky. Small KBOs with radii of $r \sim 1 \mu\text{m}$ to $r \sim 1$ km must have a size distribution $n(r) \propto r^{-a}$, with $a \sim 3.4$ or smaller to satisfy the known limits on the sky-surface brightness at optical and far-infrared wavelengths. Improved limits on the measured KBO surface brightness can yield direct estimates of the albedo, temperature, and size distribution for small KBOs in the outer solar system.

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Preprints available at <http://xxx.lanl.gov/abs/astro-ph/0009162>

Radio Continuum and Recombination Line Study of UC HII Regions with Extended Envelopes

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We have carried out 21 cm radio continuum observations of 16 UC HII regions using the VLA (D-array) in a search for associated extended emission. We have also observed H76 α recombination line towards all the sources and He76 α line at the positions with strong H76 α line emission. The UC HII regions have simple morphologies and large (>10) ratios of single-dish to VLA fluxes. We detected extended emission towards all the sources. The extended emission consists of one to several compact ($\sim 1'$ or 0.5 – 5 pc) components and a diffuse extended ($2'$ – $12'$ or 4 – 19 pc) envelope. All the UC HII regions but two are located in the compact components, where the UC HII regions always correspond to their peaks. The compact components with UC HII regions are usually smaller and denser than those without UC HII regions. For individual sources, we derive the spectral types (O7–O4) of the ionizing stars and the fractions of UV photons absorbed by dust within the nebulae, which are significantly different from previous estimates based on the

UC HII regions alone.

Our recombination line observations show that the ultracompact, compact, and extended components have approximately the same velocity in the individual sources with one exception (G25.72+0.05), implying that they are physically associated. The compact components in each object appear to be ionized by separate sources, while the UC HII regions and their associated compact components are likely to be ionized by the same sources on the basis of the morphological relations mentioned above. This suggests that almost all of the observed UC HII regions are not ‘real’ UC HII regions and that their actual ages are much greater than their dynamical age ($<10^4$ yr). We find that most of simple UC HII regions previously known have large ratios of single-dish to VLA fluxes, similar to our sources. Therefore, the ‘age problem’ of UC HII regions does not seem to be as serious as earlier studies argued. We present a simple model in which the coexistence of the ultracompact, compact, and extended components for a long ($>10^5$ yr) time is easily explained by combining the Champagne flow model with the hierarchical structure of massive star-forming regions. The well-known relation between the density and diameter of HII regions, $n_e \propto D^{-1}$, is a natural consequence of the hierarchical structure according to our model. We discuss some individual sources.

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The Formation of Stellar Clusters: Gaussian Cloud Conditions II

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Using hydrodynamic simulations we investigate the time evolution and fragmentation of regions within molecular clouds which have lost their turbulent support leading to gravitational contraction. The initial density distributions are described by random Gaussian fluctuations with varying slopes ν of the power spectrum $P(k) \propto k^{-\nu}$, covering the range from flat ($\nu = 0$) to very steep spectra ($\nu = 3$). We consider molecular cloud volumes containing different masses relative to the average Jeans mass M_J , from $1 M_J$ to $222 M_J$. This parameter study extends the detailed analysis of systems with initially $P(k) \propto k^{-2}$ and mass $222 M_J$ presented by Klessen & Burkert (2000).

The dynamical evolution of the simulated molecular cloud regions is insensitive to the slope of the initial density fluctuation spectrum. The system evolves into a complex network of intersecting filaments and collapsing clumps leading to the formation of a compact cluster of accreting and interacting embedded protostellar cores. The cluster builds up as bound entity, but dissolves later due to collisional effects. In all simulations, the mass spectrum of collapsed cores is very broad, has approximately log-normal shape and peaks roughly at the average Jeans mass. This supports the hypothesis that the average Jeans mass is the main parameter determining the peak in the stellar spectrum, and suggests that the interplay between self-gravity on the one side and thermal and turbulent pressure on the other side is the dominant process that regulates the formation of stellar clusters.

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The Formation of a Bound Star Cluster: From the Orion Nebula Cluster to the Pleiades

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Direct N -body calculations are presented of the formation of Galactic clusters using GASEX, which is a variant of the code NBODY6. The calculations focus on the possible evolution of the Orion Nebula Cluster (ONC) by assuming that the embedded OB stars explosively drove out 2/3 of its mass in the form of gas about 0.4 Myr ago. A bound cluster forms readily and survives for 150 Myr despite additional mass loss from the large number of massive stars, and the Galactic tidal field. This is the very first time that cluster formation is obtained under such realistic conditions. The cluster contains about 1/3 of the initial 10^4 stars, and resembles the Pleiades Cluster to a remarkable degree,

implying that an ONC-like cluster may have been a precursor of the Pleiades. This scenario predicts the present expansion velocity of the ONC, which will be measurable by upcoming astrometric space missions (DIVA and GAIA). These missions should also detect the original Pleiades members as an associated expanding young Galactic-field sub-population. The results arrived at here suggest that Galactic clusters form as the nuclei of expanding OB associations.

The results have wide implications, also for the formation of globular clusters and the Galactic field and halo stellar populations. In view of this, the distribution of binary orbital periods and the mass function within and outside the model ONC and Pleiades is quantified, finding consistency with observational constraints. Advanced mass segregation is evident in one of the ONC models. The calculations show that the primordial binary population of both clusters could have been much the same as is observed in the Taurus–Auriga star forming region. The computations also demonstrate that the binary proportion of brown dwarfs is depleted significantly for all periods, whereas massive stars attain a high binary fraction.

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Analyses of UV spectra of T Tauri stars observed with HST and IUE: DF Tau

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We analysed UV spectra of binary star DF Tau, the main companion of which is a classical T Tauri star. Spectra were observed with Hubble Space Telescope and IUE satellite. It is demonstrated that DF Tau emission in UV band originates in an accretion shock, such as infall gas velocity $V_0 \simeq 250$ km/s and typical infall gas density $N_0 \leq 10^{11}$ cm⁻³, but sometimes can be up to 30 times larger. It appeared that so large variations of N_0 -value do not accompanied with significant variations of intensity of continuum emission at $\lambda \simeq 1900$ Å. Apparently variability of stellar UV brightness occurs due to variations of V_0 and N_0 values as well as surface area of the accretion hot spot at the stellar surface and its orientation relative to the Earth. We found that interstellar extinction $A_V \simeq 0.5^m$, radius of the main component $\leq 2R_\odot$, luminosity $\leq 0.3L_\odot$ and distance to the star is near 70 pc. Then the average DF Tau accretion rate $\dot{M} \sim 3 \cdot 10^{-9} M_\odot/\text{yr}$.

An upper limit on volume emission measure of DF Tau corona is derived from upper limit of [Fe XXI] 1354.1 and [Fe XII] 1349.4 coronal line fluxes: $EM(T = 10^7 \text{ K}) < 3 \cdot 10^{54}$ cm⁻³, $EM(T = 1.3 \cdot 10^6 \text{ K}) < 3 \cdot 10^{55}$ cm⁻³. Absorption lines, which originate in stellar wind were found in DF Tau spectra as well. Molecular hydrogen lines have practically the same radial velocity as the star, but their full width at half maximum $FWHM \simeq 50$ km/s. We could not explain why intensity ratio of C IV 1550 doublet components exceeds 2.

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Binary stars and the fundamental IMF

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We have carried out Monte Carlo simulations in which we generate a random pairing of objects drawn from a pre-assumed single star power-law IMF, which we call the fundamental IMF. We show how the mass function of primary stars, secondary stars and the mass function of the total mass of systems (if we could resolve them) differs from the underlying fundamental IMF for different slopes of this IMF. We also compare our results with the observed IMF, the binary frequency and the binary mass ratio distributions for field stars and conclude that the fundamental IMF of subsolar mass stars could be steeper than currently believed. In other words: the low-mass turn-over of the observed ("apparent") IMF could be spurious, if the Main Sequence binary fraction of field stars is close to 100% (perhaps due to invisible companions).

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Mid-infrared imaging and spectroscopy of the enigmatic cocoon stars in the Quintuplet Cluster

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In an attempt to determine the nature of the enigmatic cocoon stars in the Quintuplet Cluster, we have obtained mid-infrared imaging and spectrophotometry of the cluster, using the CAM and SWS instruments on ISO, using SpectroCam-10 on the Palomar 5m telescope, and NICMOS on HST. The spectra show smooth continua with various dust and ice absorption features. These features are all consistent with an interstellar origin, and there is no clear evidence for any circumstellar contribution to these features. We find no spectral line or feature that could elucidate the nature of these sources. Detailed modeling of the silicate absorption features shows that they are best reproduced by the μ Cep profile, which is typical of the interstellar medium, with $\tau_{sil} \simeq 2.9$. The high spatial resolution mid-IR images show that three of the five cocoon stars have spatially extended and asymmetric envelopes, with diameters of $\sim 20,000$ AU.

A reddening law similar to that of Lutz (1999) but with silicate features based on the μ Cep profile and normalized to our value of τ_{sil} is used to deredden the observed spectrophotometry. The dereddened energy distributions are characterised by temperatures of 750–925 K, somewhat cooler than determined from near IR data alone. Models of optically thin and geometrically thick dust shells, as used by Williams et al. (1987) for very dusty, late-type WC stars, reproduce the observed SEDs from 4 to 17 μ m, and imply shell luminosities of $\log(L/L_{\odot}) \simeq 4.5$ –4.9 for the brightest four components. An analysis of the various suggestions proposed to explain the nature of the cocoon stars reveals serious problems with all the hypotheses, and the nature of these sources remains an enigma.

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anonymous ftp://ftp.iap.fr/pub/from_users/moneti/quintp/quintp.ps

The circumstellar environment of low-mass protostars: A millimeter continuum mapping survey

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We present a complete 1.3 mm continuum mapping survey of the embedded young stellar objects (YSOs) in the Taurus molecular cloud. We have also imaged several isolated Bok globules, as well as protostellar objects in the Perseus cluster. Our maps, taken with the IRAM 30m telescope and the MPIfR bolometer arrays, are sensitive to the column density structure of the sources on spatial scales ranging from 1500 – 5000 AU to > 15000 – 50000 AU. For the protostellar envelopes mapped in Taurus, the results are roughly consistent with the predictions of the self-similar inside-out collapse model of Shu and collaborators. The envelopes observed in Bok globules are also qualitatively consistent with these predictions, providing the effects of magnetic pressure are included in the model. By contrast, the envelopes of Class 0 protostars in Perseus have finite radii $\lesssim 10000$ AU and are a factor of 3 to 12 denser than is predicted by the standard model. In cluster-forming regions, individual protostellar collapse thus appears to be induced in compact condensations resembling more finite-sized Bonnor-Ebert condensations than singular isothermal spheres. Accordingly, the beginning of protostellar evolution is suggested to be more violent, with larger accretion rates, in protoclusters compared to regions of distributed star formation like Taurus. Follow-up line observations of the envelopes’ velocity fields are required to confirm this suggestion.

We also find that roughly half of the Class I infrared sources of Taurus are either at the very end of the main accretion phase or already in the pre-main sequence phase. These sources are surrounded by only remnant, finite-sized envelopes ($M_{env}^{4200AU} \lesssim 0.01 M_{\odot}$ and $R_{out} \lesssim 1500$ AU). Lastly, our 1.3 mm continuum images reveal the presence of new candidate

pre-stellar condensations and/or Class 0 protostars in the close environment of 8 Taurus Class I YSOs, 2 Bok globules, and 3 Perseus protostars.

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Detection of Disk Accretion at the Substellar Limit

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We have made the first definitive detection of disk accretion in an object near or below the substellar limit. We obtained an echelle-resolution spectrum of the very low mass T Tauri star V410 Anon 13; the emission line profile of H α clearly exhibits the large line width and asymmetry characteristic of a free-falling accretion flow. We use magnetospheric accretion models of the line profile to estimate the mass accretion rate in this object, which is the smallest yet determined. We further augment this with models of the accretion shock and disk to explain the absence of both optical veiling and an infrared excess, obtaining a firm upper limit to the accretion rate that is consistent with the H α model. Our results indicate that disk accretion via magnetospheric infall occurs even in the lowest-mass young objects.

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Warm H₂ in the Galactic center region

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We present ISO observations of several H₂ pure-rotational lines (from S(0) to S(5)) towards a sample of 16 molecular clouds distributed along the central ~ 500 pc of the Galaxy. We also present C¹⁸O and ¹³CO $J = 1 \rightarrow 0$ and $J = 2 \rightarrow 1$ observations of these sources made with the IRAM-30m telescope. With the CO data we derive H₂ densities of $10^{3.5-4.0}$ cm⁻³ and H₂ column densities of a few 10^{22} cm⁻². We have corrected the H₂ data for ~ 30 magnitudes of visual extinction using a self-consistent method. In every source, we find that the H₂ emission exhibits a large temperature gradient. The S(0) and S(1) lines trace temperatures (T) of ~ 150 K while the S(4) and S(5) lines indicate temperatures of ~ 600 K. The warm H₂ column density is typically $\sim 1 - 2 \times 10^{22}$ cm⁻², and is predominantly gas with $T=150$ K. This is the first direct estimate of the total column density of the warm molecular gas in the Galactic center region. These warm H₂ column densities represent a fraction of $\sim 30\%$ of the gas traced by the CO isotopes emission. The cooling by H₂ in the warm component is comparable to that by CO. Comparing our H₂ and CO data with available ammonia (NH₃) observations from literature one obtains relatively high NH₃ abundances of a few 10^{-7} in both the warm and the cold gas. A single shock or Photo-Dissociation Region (PDR) cannot explain all the observed H₂ lines. Alternatives for the heating mechanisms are discussed.

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NGC 1333 - Protostars, Dust Shells, and Triggered Star Formation

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We present large ($13' \times 18'$) and sensitive continuum maps at $850 \mu\text{m}$ and $450 \mu\text{m}$ of the NGC 1333 star formation region. We identify 33 sub-mm sources, some of which are extended and may contain multiple condensations. Very few of the sub-mm sources have optical or near-IR counterparts. In addition to the previously known bright Class 0 sources, this survey suggests that many of the fainter sources are also likely to be very young low mass protostars. We find several dust ridges and shells formed by outflows in the cloud, and in two cases identify protostellar sources whose formation is likely to have been triggered by powerful outflow bowshocks. Outflows thus have influenced the structure and evolution of the cloud over the entire area we have mapped. We derive a shallow dust clump mass spectrum, with $dN/dM \propto M^{-1.4}$ down to rather low masses, suggesting a large population of dust clumps in the brown dwarf mass range.

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A $10 \mu\text{m}$ Search for Inner-Truncated Disks Among Pre-Main-Sequence Stars With Photometric Rotation Periods

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We use mid-IR (primarily $10 \mu\text{m}$) photometry as a diagnostic for the presence of disks with inner cavities among 32 pre-main sequence stars in Orion and Taurus-Auriga for which rotation periods are known and which do not show evidence for inner disks at near-IR wavelengths. Disks with inner cavities are predicted by magnetic disk-locking models that seek to explain the regulation of angular momentum in T Tauri stars. Only three stars in our sample show evidence for excess mid-IR emission. While these three stars may possess truncated disks consistent with magnetic disk-locking models, the remaining 29 stars in our sample do not. Apparently, stars lacking near-IR excesses in general do not possess truncated disks to which they are magnetically coupled.

We discuss the implications of this result for the hypothesis of disk-regulated angular momentum. Evidently, young stars can exist as slow rotators without the aid of present disk-locking, and there exist very young stars already rotating near breakup velocity whose subsequent angular momentum evolution will not be regulated by disks. Moreover, we question whether disks, when present, truncate in the manner required by disk-locking scenarios. Finally, we discuss the need for rotational evolution models to take full account of the large dispersion of rotation rates present at 1 Myr, which may allow the models to explain the rotational evolution of low-mass pre-main sequence stars in a way that does not depend upon braking by disks.

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<http://www.astro.wisc.edu/~keivan/pubs.html>

A young stellar group associated with HD 199143 ($d = 48 \text{ pc}$)

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We present new optical and ultraviolet spectroscopy of the anomalous EUV emitter HD 199143 (F8V). High resolution spectra in the H α and NaID wavelength regions show evidence for very rapid (a few hundred km s⁻¹) rotation of the stellar photosphere. Using archive *IRAS* data we also show that the star has excess emission above photospheric levels at 12 μ m. *IUE* data of HD 199143 reveal the presence of emission lines of Mg II, C I, C II, C III, C IV, Si IV, He II and N V and show a large variability, both in the continuum and line fluxes. We propose that all available data of HD 199143 can be explained by assuming that it has been spun up by accretion of material from a close T Tauri like companion, responsible for the emission lines, the ultraviolet variability and the excess infrared emission. The bursting or flaring nature of this object, mostly in high energies, could be explained as episodic mass transfer between the star and its close companion. We show that HD 199143 and the Li-rich late-type dwarf BD-17 $^{\circ}$ 6128 form a physical pair and suggest that both may be part of a new nearby (48 pc) young ($\sim 10^7$ yr) stellar association in Capricornus.

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<http://cfa-www.harvard.edu/sfgroup/>

An infrared study of the L1551 star formation region

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Spectroscopic observations using the Infrared Space Observatory are reported towards the two well known infrared sources and young stellar objects L1551 IRS 5 and L1551 NE, and at a number of locations in the molecular outflow. The ISO spectrum contains several weak gas-phase lines of O I, C II, [Fe II] and [Si II], along with solid state absorption lines of CO, CO₂, H₂O, CH₄ and CH₃OH. Hubble Space Telescope (HST) images with the NICMOS infrared camera reveal a diffuse conical shaped nebulosity, due to scattered light from the central object, with a jet emanating from L1551 IRS 5. The continuum spectral energy distribution has been modelled using a 2D radiative transfer model, and fitted for a central source luminosity of 45 L_{\odot} , surrounding a dense torus extending to a distance of $\sim 3 \times 10^4$ AU, which has a total mass of $\sim 13 M_{\odot}$. The visual extinction along the outflow is estimated to be ≈ 10 and the mid-plane optical depth to L1551 IRS 5 to be ≈ 120 .

This model provides a good fit to the ISO spectral data, as well as to the spatial structures visible on archival HST/NICMOS data, mid-IR and sub-millimetre radio interferometry, and to ground-based photometry obtained with a range of different aperture sizes. On the basis of the above model, the extinction curve shows that emission at wavelengths shorter than $\sim 2 \mu$ m is due to scattered light from close to L1551 IRS 5, while at wavelengths greater than 4μ m, is seen through the full extinguishing column towards the central source. Several [Fe II] lines were detected in the SWS spectrum towards L1551 IRS 5. Although it would seem at first sight that shocks would be the most likely source of excitation for the [Fe II] in a known shocked region such as this, the line intensities do not fit the predictions of simple shock models. An alternative explanation has been examined where the [Fe II] gas is excited in hot (~ 4000 K) and dense ($\sim 10^9$ cm⁻³) material located close to the root of the outflow. The SWS observations did not detect any emission from rotationally excited H₂. Observations with United Kingdom Infrared Telescope (UKIRT) of the vibrationally excited *S*- and *Q*-branch lines were however consistent with the gas having an excitation temperature of ~ 2500 K. There was no evidence of lower temperature (~ 500 K) H₂ gas which might be visible in the rotational lines. Observations with UKIRT of the CO absorption bands close to 2.4μ m are best fit with gas temperatures ~ 2500 K, and a column density $\sim 6 \times 10^{20}$ cm⁻². There is strong circumstantial evidence for the presence of dense (coronal and higher densities) and hot gas (at least 2500 K up to perhaps 5000 K) close to the protostar. However there is no obvious physical interpretation fitting all the details which can explain this.

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<http://www-star.qmw.ac.uk/~gjw/l1551.ps>

Dissertation Abstracts

An investigation of the Carina Nebula

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that the radiation fields and stellar winds of massive stars can drastically affect the physical conditions, structure and chemistry of the giant molecular cloud (GMC) from which they formed. It is also thought that massive stars are at least partly responsible for triggering further star formation within a GMC. The details of this interaction, however, are not well understood and additional detailed study of massive star-forming regions is needed. This study has focused on a multi-wavelength investigation of the Carina Nebula. This is a spectacular massive star-forming region that contains two of the most massive star clusters in our galaxy, Trumpler 14 and Trumpler 16, and one of the most massive stars known – η Car. The goal of this study has been to obtain information on the molecular gas, ionized gas and photodissociation regions (PDRs) from a collection of instruments which have the highest angular resolution and sensitivity available to date. The Mopra Telescope and the Swedish-ESO Submillimeter Telescope (SEST) were used to obtain a series of molecular line observations of the GMC between 150 and 230 GHz. Observations of H110 α recombination-line emission at 4.874 GHz and the related continuum emission were obtained with the Australia Telescope Compact Array and used to study the ionized gas associated with the two H II regions, Car I and Car II. H₂ 1–0 S(1) (2.12 μ m) and Br γ (2.16 μ m) observations using the University of New South Wales Infrared Fabry-Perot (UNSWIRF) and 3.29 μ m narrow-band observations obtained with the SPIREX/Abu thermal infrared camera were used to study the PDRs on the surface of molecular clumps in the Keyhole region, a dark optical feature in the vicinity of η Car. The results of these observations provide detailed information on the excitation conditions, kinematics and morphology of regions within the H II region/molecular cloud complex of the Carina Nebula. In addition, the results confirm that the Carina Nebula is one of the most extreme and complex cases of massive stars interacting with their environment and show that there is still a wealth of information to be gained from future studies of this region.

Copies currently available at: <http://www.atnf.csiro.au/people/kbrooks/html/publications.html>

Young binary systems and their nearby environment: high-angular resolution observations

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The high frequency of binary systems among main sequence stars as well as in star-forming regions has been largely documented in the last ten years. This raised the issue of the mechanism responsible for the preferred occurrence of multiple systems. Moreover, interactions between a companion and the complex environment of a T Tauri star are only poorly understood. The work conducted during this thesis fits in this framework; the main goals of the thesis are: i) to estimate the binary frequency in various populations of pre-main sequence stars, ii) to study quantitatively the accretion phenomenon in binary T Tauri stars, and iii) to get direct observations and to model circumstellar and circumbinary disks in these systems.

Using the Canada-France-Hawaii Telescope adaptive optics system to search for visual binaries, I took part in the observations of several hundreds objects located in various young stellar clusters. Here, I detail the analysis and results concerning two two-million years-old clusters, IC 348 and NGC 6611. When considering all populations studied to date, we find that the visual binary frequency among solar-type stars is the same in all stellar clusters as on the main sequence. Furthermore, this property does not depend on the age of the cluster, indicating that the binary frequency does not evolve after the first million years in these clusters. On the other hand, the extremely young loose star-forming regions display a significantly enhanced binary frequency. The models that best fit these observations are those where the binary frequency resulting from the gravitational collapse is close to 100 %. In the densest clusters, this frequency can be subsequently decreased due to the numerous disrupting gravitational encounters between systems. OB stars in NGC 6611 retain significantly more companions in the separation range 200–2000 AU than low-mass objects in closer similarly-aged clusters, when one tries to account for incompleteness in the observations.

I then focus on the accretion phenomenon in binary T Tauri systems using spatially-resolved optical spectroscopy of 125–1400 AU binary systems in Taurus. This approach reveals that the accretion phenomenon lasts over the same time span on both components of a binary system. Furthermore, the comparison of the H α emission line luminosities suggests that the accretion rate is higher on the primary than on its companion. These results may be explained by the presence of a mass reservoir around the binary; this envelope would feed simultaneously both circumstellar disks.

I finally present some high-angular resolution images of the GG Tau and UY Aur circumbinary rings and of the HK Tau B and HV Tau C circumstellar disks. These observations were obtained in the optical, the near-infrared and the millimetric ranges, and they allow an accurate description of the environment of these binary systems. I also analyze in details 1 μ m polarimetric maps obtained with HST/NICMOS of the two circumbinary disks. In order to estimate the geometrical properties of these disks, as well as their dust grain properties, I performed Monte-Carlo modelling to describe photon multiple scattering and try to reproduce both the observed shape and the polarization level of the disks. This study confirms that the GG Tau circumbinary ring is geometrically thick (its aspect ratio is $h/r \sim 0.18$), that small dust grains ($< 1 \mu$ m) are still present, and that the dust mass in the ring is at least $10^{-3} M_{\odot}$. The UY Aur environment appears much more complex than that of GG Tau: the circumbinary disk, whose inclination is re-estimated to about 60° , coexists with a filament of material which is close to it but appears independent, and several arcs seem to get away from the main disk, one of which getting close to the stars. The scattering model reproduces the observations provided that the dust mass in the circumbinary disk is at least $10^{-3} M_{\odot}$, in order to account for the non-detection of the back side of the disk from 6000 Å to 2 μ m.

Emission Line Diagnostics of Magnetospheric Accretion in Young Stellar Objects

James Muzerolle

Thesis work conducted at: Harvard-Smithsonian Center for Astrophysics and
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Ph.D dissertation directed by: Nuria Calvet and Lee Hartmann

Ph.D degree awarded: September 2000

This thesis seeks to explain the nature of line emission observed in young stellar objects, and to use the lines as diagnostics of the accretion process that is central to star formation and disk evolution. The results show that the bulk of permitted line emission is produced in free-falling gas streams formed via magnetically-mediated accretion from circumstellar disks. Radiative transfer models of magnetospheric accretion have been calculated, and predicted line profiles exhibit characteristic central peaks, blueward asymmetries, and occasional redshifted absorption components. Model Balmer line fluxes are in good agreement with T Tauri star observations. However, these pure infall models do not adequately explain the extended wings seen in $H\alpha$ nor the observed Balmer decrement.

I present line profile observations of T Tauri stars spanning a range of accretion activity, and show that many optical atomic lines, such as Na I, O I, and Ca II, are qualitatively similar to the models. I find that several emission lines, such as the Ca II infrared triplet and $Br\gamma$, are well-correlated in luminosity with the accretion luminosity in T Tauri stars, and hence can be used as alternate calibrators of the mass accretion rate. I then employ the $Br\gamma$ calibrator to determine accretion luminosities in optically invisible embedded protostars for the first time. The results show that protostellar accretion luminosities are only $\sim 10\%$ of their bolometric luminosities, which indicates that accretion rates are on average only a factor of ten larger than in the older, optically visible T Tauri stars.

Further, more detailed models are presented, treating additional effects such as line damping and rotation, and specific comparisons to well-studied T Tauri stars are shown. Damping wings can account for the significant high-velocity emission at $H\alpha$, and produce larger Balmer decrements in better agreement with observations. Line profiles are not significantly affected by rotation at typical T Tauri rates. An extensive grid of models, in combination with detailed comparisons to observations, provides tight constraints on gas temperatures, and to some extent the magnetospheric geometry. In order to explain the empirical correlations between emission line strength and accretion luminosity, the size of the emitting region must be correlated with the accretion rate.

Finally, I present models of $H\alpha$ profiles and the UV/optical spectral energy distributions for two 10 Myr-old T Tauri stars in the TW Hya association. I find that the accretion rates for these stars are over one order of magnitude smaller than the mean rate for the 1 Myr T Tauri stars, indicating significant disk evolution over this time period.

New Jobs

Research Staff Positions

Astronomy Staff Search Committee
Department of Terrestrial Magnetism
Carnegie Institution of Washington
5241 Broad Branch Road, N.W.
Washington, DC 20015-1305 U.S.A.

URL: <http://www.ciw.edu/DTM-research-astrostaff.html>

Applications are invited for two positions as Members of the Research Staff in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. We are seeking theorists and/or observers in one or more of the fields of planet formation, extrasolar planet detection, planetary astronomy, and star formation. The Department of Terrestrial Magnetism has an active group of researchers in these areas. Alan Boss and George Wetherill lead the theoretical effort to understand the formation and evolution of stellar and planetary systems, while Paul Butler is active in the search for extrasolar planets. Conel Alexander and Larry Nittler perform laboratory studies of pre-planetary materials. Other DTM staff members include astronomers John Graham and Vera Rubin, and planetary scientist Sean Solomon. Carnegie is a lead member institution of the NASA Astrobiology Institute. The Carnegie Institution of Washington operates the Las Campanas Observatory in Chile. Carnegie telescopes include a 1-m, a 2.5-m, and a 50% share of the two 6.5-m Magellan telescopes. Theoretical calculations are performed on the 21 GFLOP Carnegie Alpha Cluster and a large network of workstations. Applicants should have a Ph.D. in a relevant field and a significant record of research and publication. A C.V., bibliography, and brief statement of interest should be submitted to the above address by December 31, 2000. Women and minority candidates are especially encouraged to apply. Carnegie is an equal opportunity/affirmative action institution.

2 Lectureships in Astrophysics & Space Sciences The University of Kent at Canterbury, England

are invited for the above permanent posts, which are tenable from mid-March 2001. The applicants research interests may be related to those of the Unit, which presently focus on studies of star formation, interstellar chemistry, the structure and evolution of protostars, extrasolar planetary systems, interstellar dust, extragalactic star formation, millimetre and submillimetre wave astronomy, hypervelocity impact phenomena (experimental and via modelling), analysis of small samples retrieved from space, and astrobiology. Applicants from these areas and in other fields relating to space sciences, planetary sciences and astronomy/astrophysics will be equally encouraged. Salary will be on the appropriate HEFCE scale at a point appropriate to age and experience (Lecturer = 18,731 - 30,967 UK pounds per annum according to experience and qualifications.).

Informal enquiries may be made to the Head of Department, Prof. R. G. Jones (e-mail r.g.jones@ukc.ac.uk, tel: 01227-823321). You may also wish to consult our appropriate web sites at <http://www.ukc.ac.uk/physical-sciences/> (space and planetary science, astrobiology, star formation and the interstellar medium) and <http://www-star.ukc.ac.uk/> (millimetre wave astronomy) for general background information.

For application forms and further details, please telephone or contact the Personnel Office for further particulars on 01227 827837 (UK) or +44 1227 827837 (Overseas) (24 hours) or 823674 (Minicom) or email: personnel@ukc.ac.uk quoting reference number A01/21. Applications should arrive no later than November 14th for interview in mid-December.

Star Formation Group of the Astrophysikalisches Institut Potsdam

Postdoctoral positions available

We have two new postdoctoral positions in the star formation group of the Astrophysikalisches Institut Potsdam available in 2001, each lasting two years. The group is relatively new and currently includes three staff scientists, a postdoc, and two students. It is also very international, including researchers from Germany, Denmark, France, the USA, and the UK. These two new postdoc positions are aimed at broadening the scope of the group to aid long-term projects we are or expect to be involved in.

Our main interests are the observational study of young stars, binaries, and brown dwarfs, jets and outflows, and circumstellar disks. An important focus is on the formation and evolution of stars, disks, and planetary systems in dense young clusters: the AIP is the coordinating institute for a recently-started three year European Commission Research Training Network on this topic. Other teams in the network are Arcetri, Cambridge, Cardiff, Grenoble, Lisbon, and Saclay.

A predominantly observational group, we welcome people experienced in optical, near- and mid-infrared, and millimetre studies of star formation. We are particularly keen to increase our expertise in near-infrared spectroscopy and infrared interferometry. We are also interested in people with experience in topics relating to the formation and detection of planets, and in theoreticians with an analytical or numerical background to broaden the group's base. Finally, we are involved in the planning of various ground- and space-based projects, including the LBT, the ESO VLT, and the NGST, and thus also have interests in instrumentation development.

The AIP also includes groups spanning galactic and extragalactic X-ray astronomy, theoretical cosmology, turbulence and MHD astrophysics, solar physics, stellar magnetic fields, space astrometry, and instrumentation development. We have access to the Calar Alto observatory, and the ESO telescopes on La Silla and Paranal. and to space facilities including the HST and XMM through ESA. As part of the EC Research Training Network, the star formation group also has collaborative access to British, French, Italian, and Portuguese facilities.

The institute is located on the site of the former Berlin Observatory in forested parkland. Potsdam lies on the outskirts of Berlin with fast (30 minutes) and easy access to this rapidly changing and exciting city via a direct metrorail link or motorway.

The positions are at the German civil service BAT IIa/O level, which includes pension and health insurance benefits, and will typically leave \sim DM 3000–3500/month after deductions, depending on age and family status.

To apply, please send a CV, a full bibliography, the names and contact information for two people familiar with your work, and a cover letter describing your present research and near-term goals. Informal enquiries for additional information are welcome.

Astrophysikalisches Institut Potsdam,
An der Sternwarte 16, D14482 Potsdam, Germany

Mark McCaughrean: tel +49 (0)331 749 9525; email mjm@aip.de
Hans Zinnecker: tel +49 (0)331 749 9347; email hzinnecker@aip.de

Fax: +49 (0)331 749 9429
AIP: www.aip.de
EC RTN: www.aip.de/~mjm/ecrtn_clusters

We will begin evaluating applications on January 15th 2001.

Osservatorio Astronomico di Palermo Giuseppe S. Vaiana

Marie Curie Fellowships
Closing date: 01 March 2001

Osservatorio Astronomico di Palermo Giuseppe S. Vaiana expects to appoint one fellow in the area of X-ray observations of stellar coronae under the European Commission's Marie Curie Development Host Fellowship Scheme.

Osservatorio Astronomico di Palermo has a long tradition in X-ray astronomy and in particular on stellar and solar coronal physics. Part of the recent activity has been centered on the study of stellar coronae considering coeval stellar samples. These studies, initiated with data of the Einstein Observatory and of ROSAT, continue through the access to a large number of X-ray observations of CHANDRA and XMM/NEWTON as part of both guaranteed and guest-observer programs.

The scientific aim of this work is to understand the relationship between the stellar interior structure and the stellar outer atmosphere. The X-ray emitting coronae of late-type stars play a crucial role in stellar evolution from the pre-main sequence phase onward, impacting on a diversity of other areas of astronomy. Coronal properties affect the angular momentum evolution of the stars and hence the dynamo efficiency producing a feedback process with a tight interplay between the properties of the stellar interiors and those of the outer atmospheric layers.

The successful candidate is expected to participate in the analysis of the new X-ray data mainly on open clusters and star forming regions with special emphasis on spectroscopic data.

Candidates should have a PhD in a relevant field or at least four years of full-time research experience at postgraduate level other than doctoral studies. The ability to work in team and possibly a strong and competitive research programme are important skills.

The applicant must be national of a Member State of the European Community (other than Italy) or an Associated State, or otherwise residing in the Community for at least the last five years. The fellow must be of age 35 years or less (allowance is made for time actually served in compulsory military or civil service and for childcare with a maximum of 2 years per child). In addition candidates should not have been resident in Italy for more than 12 months in the two years prior to selection. Gross salary, including all compulsory deductions under Italian legislation, is fixed at 3813 Euro per month plus a mobility allowance for the duration of the contract, which is expected to last for 24 months. Female candidates are explicitly encouraged to apply.

Applications, including CV, publication list, description of applicant's research interests/program (all documents above should be signed by the candidate), documents certifying the doctoral degree or a four years of full time research experience and two letters of recommendations should arrive by 1st March 2001 at:

Osservatorio Astronomico di Palermo
Marie Curie Fellowship Selection
Piazza del Parlamento 1
I-90134 Palermo, Italy

For further information contact:

Giuseppina Micela - giusi@oapa.astropa.unipa.it or <http://www.astropa.unipa.it>

Postdoctoral Research Position in Saclay, France

The Initial Conditions for Clustered Star Formation

As part of a European Commission Research Training Network on “The Formation and Evolution of Young Stellar Clusters” (see http://www.aip.de/~mjm/ecrtn_clusters/), a postdoctoral position is available for two years in the Star Formation Group of the Saclay Astrophysics Department.

The Astrophysics Department (“Service d’Astrophysique”) in Saclay is a major space astrophysics laboratory, located about 20 km south-west of Paris, close to several other astronomy centers. In particular, the department led the development of the ISOCAM mid-infrared camera aboard the Infrared Space Observatory (*ISO*), and is involved in the EPIC X-ray camera of *XMM-Newton*, as well as in the two bolometer-array cameras of the future Far InfraRed and Submillimeter Telescope (*FIRST*).

The Saclay Star Formation group is engaged in multi-wavelength studies of the stellar and gas/dust content of nearby molecular clouds, from the radio to the X-ray range. In recent years, the group has focused on the earliest stages of star formation including the initial conditions for gravitational collapse, and on high-energy/magnetic processes affecting young stars and protostars. We are also involved in hydrodynamical simulations of cloud fragmentation and collapse.

The successful applicant is expected to take an active role in an ongoing effort to improve our understanding of pre-stellar condensations and embedded protostars in cluster-forming clouds. He or she will work primarily on the acquisition and interpretation of (sub)millimeter line and continuum observations, and/or on related theoretical modelling, preferably in collaboration with other teams of the network (Potsdam, Arcetri, Cambridge, Cardiff, Grenoble, Lisbon). The appointment includes a travel budget for observing runs and collaborative trips within the network.

Applicants should have a Ph.D. and observational or theoretical experience in young stellar objects, molecular clouds, or related fields. They should: be 35 or under at the time of appointment; be a national of a European Community member or associated state other than France; or have lived in the EC for at least five years before appointment; and not have lived in France for more than 12 of the 24 months prior to appointment. The position is available immediately but the starting date is very flexible. Interested scientists should submit a curriculum vitae, a list of publications and a statement of research interests, and should arrange for three letters of reference to be sent to:

Philippe André, CEA Saclay, DSM/DAPNIA Service d’Astrophysique,
Orme des Merisiers - Bât. 709, F-91191 Gif-sur-Yvette Cedex, France
(Phone: + 33 1 69 08 92 65; FAX: + 33 1 69 08 65 77; E-mail: pandre@cea.fr)

Review of applications will begin on 15 December 2000 and continue until the position is filled.

New Books

Astrochemistry: From Molecular Clouds to Planetary Systems

Editors Y.C. Minh & E.F. van Dishoeck

These are the proceedings of IAU Symposium No. 197, which was held in Korea 23-27 August 1999. This meeting was the fourth symposium in a series, which has seen a major growth of the field. Because of this, the program was not able to cover all aspects of astrochemistry, but centered around the specific theme of the chemical evolution during star formation. The book is divided into 10 sections, which follow the gas-phase molecules and solid-state species from diffuse interstellar clouds and molecular clouds through both low- and high-mass star formation to incorporation into solar-system bodies.

Listed in the following are the ten sections of the book, which give an overview of the topics covered.

1. *Chemistry in Pre-Stellar Cores and Low-Mass Star-Forming Regions*
2. *Chemistry in High-Mass Star-Forming Regions*
3. *Outflows, Shocks, PDRs and Masers*
4. *Basic Molecular Processes*
5. *Grains and Large Molecules*
6. *Chemistry in the Envelopes of Late-Type Stars*
7. *Circumstellar Disks*
8. *Comets*
9. *Outer Solar Nebula and Planetary Atmospheres*
10. *Inner Solar Nebula, Meteorites and IDPs*

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Astrophysical Discs

Editors **J.A. Sellwood & Jeremy Goodman**

These are the proceedings of a Summer School held June 22–26, 1998 at the Isaac Newton Institute in Cambridge, United Kingdom, and sponsored by the European Community. The Summer School covered topics in star and planet formation, accretion disks, planetary rings, and galaxies, and aimed at presenting ideas and methods useful to the study of all varieties of astrophysical disks, at a level accessible to beginning graduate students.

In the following are listed the invited review lectures:

CV Discs Observed T.R.Marsh
Observations of Accretion Discs in X-ray Binaries F.Verbunt
Accretion Discs: Limit Cycles and Instabilities M.Livio
The General Physics of Warps J.E.Pringle
Nonlinear Fluid Dynamics of Warped Discs G.L.Ogilvie
Tidally-induced Warps in Protostellar Discs C.Terquem, J.C.B.Papaloizou & R.P.Nelson
Propagating Bending Waves in Accretion Discs and the Bardeen-Petterson Effect R.P.Nelson, J.C.B.Papaloizou & C.Terquem
Observations of Circumstellar Discs and Jets C.J.Chandler & J.S.Richer
Angular Momentum Transport: Local and Global Simulations J.F.Hawley & S.A.Balbus
Instabilities in Circumstellar Discs C.F.Gammie
The Fate of an Unstable Mode G.Laughlin, V.Korchagin & F.C.Adams
Jets in Protostellar Systems R.E.Pudritz & R.Ouyed
Self-similar MHD Winds from Discs E.C.Ostriker
Disc Dispersal Around Young Stars P.J.Armitage
Discs and Planetary Formation J.C.B.Papaloizou, C.Terquem & R.P.Nelson
Formation and Orbital Evolution of Planets in Protostellar Discs D.N.C.Lin, G.Bryden & S.Ida
Planetary Rings P.D.Nicholson
Phenomenology of Active Galactic Nuclei J.P.Leahy
Relativistic Accretion R.D.Blandford
Advection-Dominated Accretion Flows I.Yi
Accretion History of Super-massive Black Holes P.Natarajan
Self-gravitating Eccentric Discs around Black Holes S.Sridhar, D.Syer & J.Touma
The Kinematics of Galactic Stellar Discs M.R.Merrifield & K.Kuijken
Stability and Evolution of Galactic Discs J.A.Sellwood
Vortices in Astrophysical Discs A.M.Fridman & O.V.Khoruzhii
N-body Simulations of Interacting Disc Galaxies E.Athanassoula

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Announcements

The proceedings of IAU Symposium No. 200 on *The Formation of Binary Stars*, edited by H. Zinnecker and R.D. Mathieu, are almost ready. Until the book appears in print, the articles will be available at the AIP web site at <http://www.aip.de/IAU200/proc.html>

Meetings

First Announcement

Young Stars Near Earth: Progress and Prospects

NASA Ames Research Center, Mountain View, CA March 28-30, 2001

The recent discovery of several groups of young stars within 100 parsecs of the Sun has generated a lot of interest. Given their proximity and possible age spread, these systems are ideally suited for detailed studies of star and planet formation. Groups such as the TW Hydrae Association (~ 50 pc), MBM12 high-latitude cloud (~ 65 pc) and Eta Chamaeleontis cluster (~ 97 pc) have been the focus of intense investigations over the past few years, and are likely to be prime targets for future ground-based and space-borne observatories. Meanwhile, the search is on for other young stars in the solar neighborhood. Unlike T Tauri stars in well-known star-forming regions, these stars are often not associated with obvious parent molecular clouds, so their nature, origin, and age are still matters of controversy. This workshop will be a forum to present the latest findings, debate unresolved issues, consider implications for local star formation, and discuss prospects for the future including brown dwarf and planet searches.

Topics to be covered include:

- Star formation in the solar neighborhood
- Identifying “isolated” young stars
- Kinematics, astrometry, distances and age estimates
- Origins and parent clouds
- Stellar properties and X-ray emission
- Disk evolution and planet formation
- Brown dwarfs and giant planets
- Prospects for the future (FAME, SIRTf, SOFIA, ALMA, SIM, NGST)

Scientific Organizing Committee:

Ray Jayawardhana (Chair), Dana Backman, Ramiro de la Reza, Thomas Greene, Joel Kastner

Local Organizing Committee:

Thomas Greene (Chair), Natalie Batalha, Karl Haisch, Rich Webb

Please send expressions of interest to: rayjay@astro.berkeley.edu

Workshop Web site: <http://www-space.arc.nasa.gov/ystars>

The number of participants will be limited.

Conference announcement

the 1st *Eddington* Workshop “Stellar structure and habitable planet finding”

June 11 to 15, 2001 – Cordoba, Spain

Organized by the European Space Agency & Centro de Astrobiología (Madrid, Spain)

Eddington is a 1.2-m space telescope with a wide-field imager for extra-solar planet hunting by transits and for asteroseismic observations, with ample opportunities for parallel and ancillary science. This workshop is an invitation to the wider scientific community to get involved in the refinement of the mission concept, and to participate in the science and technology of the *Eddington* mission. This workshop follows on the recent ESA decision to adopt *Eddington* as a “reserve mission”, for a launch in the 2007-2013 time-frame.

Eddington, with a telescope of nominal 1.2-m aperture and a 3 deg field of view with a CCD imager for high-precision photometry, and a five-year life, has two primary goals:

- 1) to find habitable planets outside of our solar system using the transit method
- 2) to provide data on the evolution and age of stars using asteroseismic techniques.

There will also be opportunities for parallel imaging and photometric science during the planet and asteroseismology observations, as well as the possibility, for a fraction of the total time, to point at different type of targets, in an “observatory-like” fashion.

The large collecting area of the *Eddington* telescope allows the detection of habitable planets around solar-type stars (out of reach for smaller missions) and provides the data on oscillation frequencies needed to perform asteroseismic investigations of critical phases of stellar evolution, e.g. stars in open clusters and Pop. II stars, thus allowing for a major quantum step in both disciplines. The baseline plan is that these two main investigations will be done in a series of month-long pointings at asteroseismic targets, followed by a three-year pointing at the planet field. The general astronomy pointings will be done within this time-frame.

In the course of 2000 the mission has been the subject of a study leading to a mission concept which was successfully presented to ESA for approval in September 2000. In the next two years detailed studies of the whole mission concept, and in particular of the payload, will be performed. This workshop is an open invitation to the wider scientific community to provide input to the *Eddington* mission concept, and get involved in the following phases of the *Eddington* mission. More information on the *Eddington* baseline design can be obtained at <http://astro.esa.int/SA-general/Projects/Eddington/>.

The programme will include a presentation of the various aspects of the mission’s present baseline and scientific performance, and an overview of the mission’s science goals. Contributions are solicited on all aspects of the mission, on both the scientific side as well as the industrial side. A formal call for abstracts will be circulated later this year, together with a preliminary program with a list of invited speakers. An “expression of interest” form is available at <http://astro.esa.int/SA-general/Projects/Eddington/Eddi2001/eddi2001form1.txt> to be returned to eddi2001@astro.estec.esa.nl by Nov. 15. Updated information about the Workshop will be made available at the address <http://astro.esa.int/SA-general/Projects/Eddington/Eddi2001>

Scientific Organizing Committee: C. Aerts (U. Leuven, BE) E. Antonello (Obs. Brera, IT), M. Badiali (IAS-CNR, IT), C. Catala (Obs. Midi-Pyrenees, FR), J. Christensen-Dalsgaard (Aarhus Univ., DK), H. Deeg (IAA, SP), F. Favata (ESA/ESTEC), G. Gilmore (IoA, UK), A. Gimenez (LAEFF, ES), M. Grenon (Obs. Geneve, CH), M. Monteiro (CAUP, PT), A. Penny (RAL, UK), H. Rauer (DLR, DE), I. Roxburgh (QM, Univ. of London, UK – chair), J. Schneider (Obs. Paris, FR), N. Waltham (RAL, UK).

Logistics Cordoba is in the middle of the Spanish southern region of Andalusia, about 120 km northeast of Seville and 160 km northwest of Granada. It has a population of 300 000 and lies at the foot of the Sierra Morena and on the bank of the Guadalquivir River. More information about the conference's logistics are to be found at <http://astro.esa.int/SA-general/Projects/Eddington/Eddi2001>

Further Information Please contact Fabio Favata (eddi2001@astro.estec.esa.nl) for any additional information.

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).

Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter.

The Star Formation Newsletter is available on the World Wide Web at <http://casa.colorado.edu/reipurth> or at <http://www.eso.org/gen-fac/pubs/starform/> .

Moving ... ??

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