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Abstracts of recently accepted papers

The Great PV Ceph Outflow: A Case Study in Outflow-Cloud Interaction

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We present a set of detailed molecular line maps of the region associated with the giant Herbig-Haro flow HH 315, from the young star PV Cephei, aimed at studying the outflow-cloud interaction. Our study clearly shows that the HH 315 flow is effecting the kinematics of its surrounding medium, and has been able to redistribute considerable amounts of the surrounding medium-density ($\sim 10^3$ cm^{-3}) gas in its star-forming core as well at parsec-scale distances from the source. The single-dish observations include a map of the outflow in the ^{12}CO(2–1) line, with a beam size of 27″, and more extended maps of the outflow region in the ^{12}CO(1–0) and ^{13}CO(1–0) lines, with 45″ and 47″ beam sizes, respectively. A companion paper to this one presents higher-resolution (IRAM 30-m) observations, and discusses their implications (Arce & Goodman 2002). The giant molecular outflow HH 315 is a highly asymmetric bipolar flow with a projected linear extent of about 2 pc. Our results indicate that the two outflow lobes are each interacting with the ambient medium in different ways. The southern (redshifted) lobe, with a mass of 1.8 $M_\odot$, interacts with a dense ambient medium, very close to the young stellar outflow source, and its kinetic energy is comparable to both the turbulent and gravitational binding energy of its host cloud (of order 10^{44} erg). In addition, we find evidence that the southern lobe is responsible for the creation of a cavity in the ^{13}CO(1–0) emission. In contrast, the northern (mainly blueshifted) outflow lobe, with a total mass of 4.8 $M_\odot$, extends farther from PV Ceph and interacts with ambient gas much less dense than the southern lobe. There is very little ^{13}CO(1–0) emission north of the outflow source, and the only prominent ^{13}CO(1–0) emission is a shell-like structure coincident with the outer edge of the northern lobe, about 1.2 pc northwest of PV Ceph. It appears that the northern lobe of the HH 315 outflow has been able to "push" aside a substantial fraction of the gas in the area, piling it in a dense shell-like structure at its edges. In addition, we find that about 50% of the gas in the region of the northern lobe has been put in motion by the outflow, and that the northern outflow lobe is responsible for a velocity gradient in the ambient gas.

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preprints available at:
`http://www.astro.caltech.edu/~harce/papers`
`http://cfa-www.harvard.edu/sfgroup/`

Bow shocks, Wiggling Jets, and Wide-Angle Winds: A High Resolution Study of the Entrainment Mechanism of the PV Ceph Molecular (CO) Outflow

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We present a new set of high-resolution molecular line maps of the gas immediately surrounding various Herbig-Haro (HH) knots of the giant HH flow HH 315, from the young star PV Cephei. The observations, aimed at studying the entrainment mechanism of the 2.6 pc-long HH 315 flow, include IRAM 30 m maps of the ^{12}CO(2–1), ^{12}CO(1–0), and ^{13}CO(1–0) lines, with beam sizes of 11″, 21″, and 22″, respectively. We compare the morphology and the kinematics of the outflow gas, as well as the temperature and momentum distribution of the molecular outflow with those predicted by different entrainment models. With our detailed study we are able to conclude that jet bow shock entrainment by an episodic stellar wind, with a time-varying axis, produces most of the high-velocity molecular outflow observed far from the source. In addition, near PV Cephei we find evidence for a poorly collimated, wide-angle, molecular outflow *and* a collimated wiggling jet-like molecular outflow. We propose that the poorly collimated component is entrained by a wide-angle wind, and the collimated component is entrained by a variable jet with internal working surfaces. If this picture is true, then a stellar wind model which allows for the coexistence of a wide-angle component *and* a collimated (jet-like) stellar wind component is needed to explain the observed properties of the PV Ceph outflow. The wiggling axis of the redshifted molecular outflow lobe indicates that the outflow ejection axis is changing over time. We find that the time-scale of the axis variation shown by the molecular outflow lobe is about a factor of 10 less than that shown by the large-scale optical HH knots.

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Predictions for the frequency and orbital radii of massive extrasolar planets

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We investigate the migration of massive extrasolar planets due to gravitational interaction with a viscous protoplanetary disc. We show that a model in which planets form at 5 AU at a constant rate, before migrating, leads to a predicted distribution of planets that is a steeply rising function of $\log(a)$, where a is the orbital radius. Between 1 AU and 3 AU, the expected number of planets per logarithmic interval in a roughly doubles. We demonstrate that, once selection effects are accounted for, this is consistent with current data, and then extrapolate the observed planet fraction to masses and radii that are inaccessible to current observations. In total, about 15% of stars targeted by existing radial velocity searches are predicted to possess planets with masses $0.3M_\mathrm{J} < M_p \sin(i) < 10M_\mathrm{J}$, and radii $0.1\mathrm{AU} < a < 5\mathrm{AU}$. A third of these planets (around 5% of the target stars) lie at the radii most amenable to detection via microlensing. A further 5-10% of stars could have planets at radii of $5\mathrm{AU} < a < 8\mathrm{AU}$ that have migrated outwards. We discuss the probability of forming a system (akin to the Solar System) in which significant radial migration of the most massive planet does *not* occur. About 10-15% of systems with a surviving massive planet are estimated to fall into this class. Finally, we note that a smaller fraction of low mass planets than high mass planets is expected to survive without being consumed by the star. The initial mass function for planets is thus predicted to rise more steeply towards small masses than the observed mass function.

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HST/STIS Spectroscopy of the Optical Outflow from DG Tau: Indications for Rotation in the Initial Jet Channel

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We have carried out a kinematical, high angular resolution ($\sim 0.''1$) study of the optical blueshifted flow from DG Tau within $0.''5$ from the source (i.e. 110 AU when de-projected along this flow). We analysed optical emission line profiles extracted from a set of seven long-slit spectra taken with the *Space Telescope Imaging Spectrograph* (STIS) on board the Hubble Space Telescope (HST), obtained by maintaining the slit parallel to the outflow axis while at the same time moving it transversely in steps of $0.''07$. For the spatially resolved flow of moderate velocity (peaking at -70 $\mathrm{km\,s^{-1}}$), we have found systematic differences in the radial velocities of lines from opposing slit positions i.e. on alternate sides of the jet axis. The results, obtained using two independent techniques, are corrected for the spurious wavelength shift due to the uneven illumination of the STIS slit. Other instrumental effects are shown to be either absent or unimportant. The derived relative Doppler shifts range from 5 to 20 $\mathrm{km\,s^{-1}}$. Assuming the flow is axially symmetric, the velocity shifts are consistent with the southeastern side of the flow moving towards the observer faster than the corresponding northwestern side. If this finding is interpreted as rotation, the flow is then rotating clockwise looking from the jet towards the source and the derived toroidal velocities are in the range 6 to 15 $\mathrm{km\,s^{-1}}$, depending on position. Combining these values with estimates of the mass loss rate (Bacciotti et al, 2002), one would obtain an angular momentum flux, for the low to moderate velocity regime of the flow, of $\dot{J}_{w,lm} \sim 3.8\,10^{-5}\,\mathrm{M_\odot\,yr^{-1}\,AU\,km\,s^{-1}}$. Our findings may constitute the first detection of rotation in the initial channel of a jet flow. The derived values appear to be consistent with the predictions of popular magneto-centrifugal jet launching models, although we cannot exclude the possibility that the observed velocity differences are due to some transverse outflow asymmetry other than rotation.

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http://www.arcetri.astro.it/ starform/publ2002.htm
http://www.tls-tautenburg.de/research/tls-research/pub2002.html

A Tidally Interacting Disk in the Young Triple System WL 20?

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We present high-resolution $\lambda = 2.7$ mm imaging of the close triple pre-main-sequence system, WL 20. Compact dust emission with integrated flux density of 12.9 ± 1.3 mJy is associated with two components of the triple system, WL 20 W and WL 20 S. No emission above a 3 σ level of 3.9 mJy is detected towards the third component, WL 20 E, which lies $3.17''$ (400 AU) due East in projection from its neighbors. A possibly warped structure of ~ 0.1 $\mathrm{M_\odot}$ and $\leq 3.2''$ extent encompasses WL 20 W and WL 20 S, which have a projected separation of $2.25''$ ($\sim$ 280 AU) along a North-South axis. This structure is most likely a tidally disrupted disk surrounding WL 20 S. New near-infrared spectra of the individual components show a remarkable similarity between the two T-Tauri stars of the system: WL 20 E has a K7 spectral type ($T_{eff} = 4040$ K) with $r_K = 0.2$, and WL 20 W has an M0 spectral type ($T_{eff} = 3800$ K) with $r_K = 0.2$. The spectrum of WL 20 S is consistent with that of a source intrinsically similar to WL 20 W, with $r_K < 0.9$, but seen through an A_V =25 *in addition* to the $A_V = 16.3$ to the system as a whole. Taken together, these millimeter and infrared data help explain the peculiar nature of the infrared companion, WL 20 S, as resulting from a large enhancement in its dusty, circumstellar environment in relation to its companions.

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CH_3OH and H_2O masers in high-mass star-forming regions

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We present a comparison of Class II CH_3OH (6.7 GHz) and H_2O (22.2 GHz) masers at high spatial resolution in a sample of 29 massive star-forming regions. Absolute positions of both maser types are compared with mm dust continuum, cm continuum and mid-infrared sources. All maser features – regardless of the species – are associated with massive mm cores, but only 3 out of 18 CH_3OH masers and 6 out of 22 H_2O masers are associated with cm emission likely indicating the presence of a recently ignited massive star. These observations of a homogenous sample of massive, young star-forming regions confirm earlier results, obtained for each maser species separately, that both maser types are signposts of high-mass star formation in very early evolutionary stages. The data are consistent with models that explain CH_3OH maser emission by radiative pumping in moderately hot cores, requiring the absence, or only weak, free-free cm continuum radiation due to recently ignited stars. Mid-infrared sources are associated with both maser types in approximately 60% of the observed fields. Thus, mid-infrared objects may power maser sites, but the detection of strong mid-infrared emission is not strictly necessary because it might be heavily extincted. A comparison of the spatial separations between the different observed quantities and other properties of the star-forming regions does not reveal any correlation. Our data suggest that CH_3OH and H_2O masers need a similar environment (dense and warm molecular gas), but that, due to the different excitation processes (radiative pumping for CH_3OH and collisional pumping for H_2O), no spatial correlations exist. Spatial associations are probably coincidences due to insufficient angular resolution and projection effects. The kinematic structures we find in the different maser species show no recognizable pattern, and we cannot draw firm conclusions whether the features are produced in disks, outflows or expanding shock waves.

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Preprints available at http://www.mpifr-bonn.mpg.de/staff/beuther/

A chromospheric scenario for the activity of β-Pictoris, as revealed by FUSE

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We investigate a chromospheric scenario to explain the characteristics of the far-UV emission lines of β-Pictoris, revealed by FUSE spectra of this famous circumstellar disk system. The model assumes a thin region heated up to a few 10^5 K located close to the stellar photosphere. The resonance lines of C III at 977 Å and O VI at 1032-1037 Å, seen in emission, are produced in this chromosphere-transition region complex. Using complementary data in the mid and near UV (specifically, a resonance doublet of C IV at 1548-1550 Å and Mg II h & k), we show that the whole dataset is remarquably well reproduced by the model. In addition, we investigate the properties of the C III* multiplet at 1176 Å and conclude that this line likely forms in a weak warm wind, originating from the prominent circumstellar disk of β-Pictoris. Finally, radiative losses have been calculated and have provided estimates of the amount of non radiative energy dissipated in the external atmosphere of β-Pictoris, which is a measure of the star's activity level. Such behavior for an A5 V star presents a challenge for both evolution and activity models since the former predict that main-sequence A stars should not be active, while the latter are unable to quantitatively account for the characteristics of the chromospheric heating of β-Pictoris

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Molecular Hydrogen in the Lagoon: H_2 line emission from Messier 8

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The 2.12 μm v=1–0 S(1) line of molecular hydrogen has been imaged in the Hourglass region of M8. The line is emitted from a roughly bipolar region, centred around the O7 star Herschel 36. The peak H_2 1–0 S(1) line intensity is 8.2×10^{-15} erg s^{-1} cm^{-2} arcsec^{-2}. The line centre emission velocity varies from -25 km s^{-1} in the SE lobe to +45km s^{-1} in the NW lobe. The distribution is similar to that of the CO J=3–2 line. The H_2 line appears to be shock-excited when a bipolar outflow from Herschel 36 interacts with the ambient molecular cloud. The total luminosity of all H_2 lines is estimated to be ~ 16 L$_\odot$ and the mass of the hot molecular gas $\sim 9 \times 10^{-4}$ M$_\odot$ (without any correction for extinction).

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Paper can be obtained from URL http://www.phys.unsw.edu.au/~mgb/Bibliography/bibliography.html

Near-Infrared Photometric Variability of Stars Toward the Chamaeleon I Molecular Cloud

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We present the results of a J, H, and K_s photometric monitoring campaign of a $0.72^\circ \times 6^\circ$ area centered on the Chamaeleon I star forming region. Data were obtained on 15 separate nights over a 4 month time interval using the 2MASS South telescope. Out of a total of 34,539 sources brighter than the photometric completeness limits (J=16.0, H=15.2, K_s=14.8), 95 exhibit near-infrared variability in one or more bands. The variables can be grouped into a population of bright, red objects that are associated with the Chamaeleon I association, and a population of faint, blue variables that are dispersed over the full 6° of the survey and are likely field stars or older pre-main-sequence stars unrelated to the present-day Chamaeleon I molecular cloud. Ten new candidate members of Chamaeleon I, including 8 brown dwarf candidates, have been identified based on variability and/or near-infrared excess emission in the $J-H$ vs. $H-K_s$ color-color-diagram. We also provide a compendium of astrometry and J, H, and K_s photometry for previously identified members and candidate members of Chamaeleon I.

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Deuterated molecules as a probe of ionization fraction in dense interstellar clouds

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The ionization degree $x(e)$ ($= n(e)/n(H_2)$, with $n(e)$ and $n(H_2)$ the electron and H_2 number density, respectively) plays a key role in the chemical and dynamical evolution of interstellar clouds. Gas phase ion–molecule reactions are major chemical routes to the formation of interstellar molecules. The time scale for ambipolar diffusion of neutrals across field lines is proportional to the ionization degree, which therefore is a crucial parameter in determining the initial conditions which precede the collapse to form a star. A direct measure of $x(e)$ is hindered by the difficulty of observing H_3^+ and H_3O^+, two of the most abundant molecular ions, and atomic species with low ionization potentials, such as atomic carbon and metals, which may be the main repositories of positive charge.

Deuterium fractionation in molecular ions, in particular HCO^+ , has been extensively used to estimate the degree of

ionization in molecular clouds. This paper reviews recent work on ionization degree in homogeneous clouds. We will show that the N(DCO^+)/N(HCO^+) column density ratio furnishes a measurement of $x(e)$ only in regions where CO is not significantly depleted, thus in the outer skirts of dense cloud cores. To probe $x(e)$ deep inside the clouds, one has to gauge deuterium enhancement in molecular ions with parent species not affected by depletion (e.g. N_2H^+), and rely on chemical models which take into account the cloud density structure. Unlike N(DCO^+)/N(HCO^+), the N(N_2D^+)/N(N_2H^+) column density ratio is predicted to considerably increase with core evolution (and/or the amount of CO depletion), reaching large values (≥ 0.2) in cloud cores on the verge of forming a star.

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http://www.arcetri.astro.it/∼starform/publ2002.htm
http://arXiv.org/abs/astro-ph/0204127

Modeling Line Profiles of Protostellar Collapse Observed with High Angular Resolution

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We investigated the line profile of moderately optically thick molecular transitions from collapsing protostellar envelopes. Using the inside-out collapse model, we simulated high angular resolution observations, which can probe the infall motion of the inner region better than low angular resolution observations. The degree of line asymmetry becomes substantially larger as the observing beam size becomes smaller. The self-absorption dip at the central velocity also develops a noticeable asymmetry. Therefore, suitability of collapse tracers depends on the angular resolution of the instrument used. Inclusion of the continuum emission from the central object produces another absorption dip on the redshifted side of the line, i.e., the line shows an inverse P Cygni profile. This effect is larger in the submillimeter band than in longer wavelength bands because of the bright continuum emission from dust grains. This redshifted dip is a good probe of the infall motion at the very inner part of the infalling envelope, and is also sensitive to other physical conditions, such as the depletion of molecules and the distribution of dust grains. We discuss how the line profile is affected by the variation of model parameters, such as molecular abundance, infall radius, and luminosity of the central object. In addition to the inside-out collapse model, we also discuss line profiles generated from Hunter's similarity solutions. Since high angular resolution can be achieved by aperture synthesis, its effect on the line profile was examined by simulating observations of the Sub-Millimeter Array (SMA) toward B335, as an example. Only the central absorption dip part of the line profile is affected when the SMA is simulated. The simulated SMA line profile is weaker than the profile generated with a Gaussian beam because of the missing short-spacing flux. If the source is closer, or if the size of the element antenna of the interferometer is larger, even the line peaks can be affected.

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Shapes of Molecular Cloud Cores and the Filamentary Mode of Star Formation

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Using recent dust continuum data, we generate the intrinsic ellipticity distribution of dense, starless molecular cloud cores. Under the hypothesis that the cores are all either oblate or prolate randomly-oriented spheroids, we show that a satisfactory fit to observations can be obtained with a gaussian prolate distribution having a mean intrinsic axis ratio of 0.52. Further, we show that correlations exist between the apparent axis ratio and both the peak intensity and total flux density of emission from the cores, the sign of which again favours the prolate hypothesis. The latter result shows that the mass of a given core depends on its intrinsic ellipticity. Monte Carlo simulations are performed to find the best-fit power law of this dependence. Finally, we show how these results are consistent with an evolutionary scenario leading from filamentary parent clouds to increasingly massive, condensed, and roughly spherical embedded cores.

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Internal Velocities in the Orion Nebula: Large Proper Motion Features

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motions of Herbig-Haro (HH) objects in the Orion Nebula were measured with a ± 10 km s^{-1} accuracy using HST WFPC2 images in [S II], [N II], Hα, and [O III], taken 4 to 6 years apart. Seven HH flows in the outer region as well as seven HH objects in the inner region of the BN-KL complex were identified. The H_2 finger system was confirmed to be created by an explosive event which took place approximately 1000 years ago. We found a new HH flow toward the northwest originating from the vicinity of OMC-1S, and it may be a part of the low velocity bipolar flows centered at FIR 4. The proper motion of HH 202 was also measured with high accuracy for the first time. The proper motion vectors of HH 202 and HH 203/204 are aligned well with their projected symmetric axis, which may indicate that they emanated from the same source. The proper motion measurements in various emission lines provide generally the same results in the wide range of velocity from 20 km s^{-1} to 400 km s^{-1}, as expected for shocks in a steady state.

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Preprints may be obtained from the anonymous ftp server orion.phy.vanderbilt.edu where all of the files within the directory pub/outgoing/DoiMS/ will be needed.

Chemistry as a probe of the structures and evolution of massive star-forming regions

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We present detailed thermal and gas-phase chemical models for the envelope of the massive star-forming region AFGL 2591. By considering both time- and space-dependent chemistry, these models are used to study both the physical structure proposed by van der Tak et al. (1999; 2000), as well as the chemical evolution of this region. The model predictions are compared with observed abundances and column densities for 29 species. The observational data cover a wide range of of physical conditions within the source, but significantly probe the inner regions where interesting high-temperature chemistry may be occurring. Taking appropriate care when comparing models with both emission and absorption measurements, we find that the majority of the chemical structure can be well-explained. In particular, we find that the nitrogen and hydrocarbon chemistry can be significantly affected by temperature, with the possibility of high-temperature pathways to HCN. While we cannot determine the sulphur reservoir, the observations can be explained by models with the majority of the sulphur in CS in the cold gas, SO_2 in the warm gas, and atomic sulphur in the warmest gas. Because the model overpredicts CO_2 by a factor of 40, various high-temperature destruction mechanisms are explored, including impulsive heating events. The observed abundances of ions such as HCO^+ and N_2H^+ and the cold gas-phase production of HCN constrain the cosmic-ray ionization rate to $\sim 5.6 \times 10^{-17}$ s^{-1}, to within a factor of three. Finally, we find that the model and observations can simultaneously agree at a reasonable level and often to within a factor of three for $7 \times 10^3 \leq t(\mathrm{yrs}) \leq 5 \times 10^4$, with a strong preference for $t \sim 3 \times 10^4$ yrs since the collapse and formation of the central luminosity source.

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Vertical structure models of T Tauri and Herbig Ae/Be disks

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In this paper we present detailed models of the vertical structure (temperature and density) of passive irradiated circumstellar disks around T Tauri and Herbig Ae/Be stars. In contrast to earlier work, we use full frequency- and angle-dependent radiative transfer instead of the usual moment equations. We find that this improvement of the radiative transfer has strong influence on the resulting vertical structure of the disk, with differences in temperature as large as 70%. However, the spectral energy distribution (SED) is only mildly affected by this change. In fact, the SED compares reasonably well with that of improved versions of the Chiang & Goldreich (CG) model. This shows that the latter is a reasonable model for the SED, in spite of its simplicity. It also shows that from the SED alone, little can be learned about the vertical structure of a passive circumstellar disk. The molecular line emission from these disks is more sensitive to the vertical temperature and density structure, and we show as an example how the intensity and profiles of various CO lines depend on the adopted disk model. The models presented in this paper can also serve as the basis of theoretical studies of e.g. dust coagulation and settling in disks.

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The structure of molecular clumps around high-mass young stellar objects

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We have used the IRAM 30-m and FCRAO 14-m telescopes to observe the molecular clumps associated with 12 ultracompact (UC) H_{II} regions in the J=6–5, 8–7 and 13–12 rotational transitions of methyl-acetylene (CH_3C_2H). Under the assumption of LTE and optically thin emission, we have derived temperature estimates ranging from 30 to 56 K. We estimate that the clumps have diameters of 0.2–1.6 pc, H_2 densities of 10^5–10^6 cm^{-3}, and masses of 10^2–$2\,10^4$ $M_\odot$. We compare these values with those obtained by other authors from different molecular tracers and find that the H_2 density and the temperature inside the clumps vary respectively like $n_{H_2} \propto R^{-2.6}$ and $T \propto R^{-0.5}$, with R distance from the centre. We also find that the virial masses of the clumps are $\sim$3 times less than those derived from the CH_3C_2H column densities: we show that a plausible explanation is that magnetic fields play an important role to stabilise the clumps, which are on the verge of gravitational collapse. Finally, we show that the CH_3C_2H line width increases for decreasing distance from the clump centre: this effect is consistent with infall in the inner regions of the clumps. We conclude that the clumps around UC H_{II} regions are likely to be transient ($\sim10^5$ yr) entities, remnants of isothermal spheres currently undergoing gravitational collapse: the high mass accretion rates ($\sim10^{-2}$ $M_\odot$ yr^{-1}) lead to massive star formation at the centre of such clumps

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Chandra Study of Young Stellar Objects in the NGC 1333 Star-forming Cloud

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NGC 1333, a highly active star formation region within the Perseus molecular cloud complex, has been observed with the ACIS-I detector on board the *Chandra X-ray Observatory*. In our image with a sensitivity limit of $\sim 10^{28}$ erg s^{-1}, we detect 127 X-ray sources, most with sub-arcsecond positional accuracy. While 32 of these sources appear to be foreground stars and extragalactic background, 95 X-ray sources are identified with known cluster members. The X-ray luminosity function of the discovered YSO population spans a range of $\log L_x \simeq 28.0$ to 31.5 erg s^{-1} in the $0.5 - 8$ keV band, and absorption ranges from $\log N_H \simeq 20$ to 23 cm^{-2}. Most of the sources have plasma energies between 0.6 and 3 keV, but a few sources show higher energies up to ~ 7 keV. Comparison with K-band source counts indicates that we detect all of the known cluster members with $K < 12$, and about half of members with $K > 12$. $K \simeq 11$, the peak of the K-band luminosity function, corresponds to $0.2 - 0.4$ M$_\odot$ stars for a cluster age of ~ 1 Myr.

We detect seven of the twenty known YSOs in NGC 1333 producing jets or molecular outflows as well as one deeply embedded object without outflows. No evident difference in X-ray emission of young stars with and without outflows is found. Based on the complete subsample of T Tauri stars, we also find no difference in X-ray properties and X-ray production mechanism of stars with and without K-band excess disks.

Several other results are obtained. We suggest that the X-ray emission from two late-B stars which illuminate the reflection nebula originates from unresolved late-type companions. Two T Tauri stars are discovered in the ACIS images as previously unknown components of visual binaries. A good correlation $L_x \propto J$ is seen which confirms the well-known relation $L_x \propto L_{bol}$ found in many star forming regions. Based on spectral analysis for the X-ray counterpart of SVS 16, we establish that the column density N_H is much lower than that expected from near-IR photometry so that its X-ray luminosity, $\log L_x \simeq 30.6$ erg s^{-1}, is not unusually high.

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The Molecular Condensations Ahead of Herbig-Haro Objects. I. Multi-transition Observations of HH 2

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We present a CSO and BIMA molecular line survey of the dense, quiescent molecular environment ahead of HH 2. The molecular gas is cold, 13 K, and moderately dense, $3\,10^5$ cm^{-3}. A total of 14 species has been detected (including different isotopes and deuterated species). The relative abundances of the clump are compared with other dense molecular environments, including quiescent dark clouds, and active low and high mass star forming regions. This comparison confirms the peculiar chemical composition of the quiescent gas irradiated by the HH objects. Thus, from this comparison, we found that the HCO^+, CH_3OH and H_2CO are strongly enhanced. SO and SO_2 are weakly enhanced, whereas HCN and CS are underabundant. The CN abundance is within the range of value found in starless dark clouds, but it is low with respect to high mass star forming regions. Finally, the chemical composition of HH 2 confirms the qualitative results of the Viti & Williams (1999) complex chemical model that follows the chemical behavior of a molecular clump irradiated by a HH object.

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Tentative Detection of Molecular Oxygen in the ρ Ophiuchi Cloud

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We report the tentative detection of molecular oxygen in the interstellar medium. Deep integrations using the *SWAS* satellite of the ρ Oph A cloud have resulted in a detection of an emission feature consistent with the $N_J = 3_3 \rightarrow 1_2$ transition of O_2 at a LSR velocity of 6.0 km s^{-1}. The line width and velocity are suggestive of the red–shifted wing emission seen in species which trace the molecular outflows seen in this region. The fractional abundance of O_2 relative to H_2 in this high velocity gas is approximately 10^{-5}. The fractional abundance of ortho–H_2O in this material is 8×10^{-8}, somewhat higher than found in quiescent material by earlier *SWAS* observations, but less than that found in younger outflows.

We suggest a unified scenario which explains the low O_2 abundance in cloud cores previously reported ($X(O_2) \leq$ few $\times 10^{-7}$), along with the much enhanced abundance in the outflow region. In this picture, quiescent clouds are characterized by significant depletion of gas–phase oxygen, which ends up largely as water ice on the dust grains. A shock associated with the outflow results in almost all oxygen being processed into gas–phase water. In the cool postshock gas, the standard gas–phase chemistry reasserts itself, and after an elapsed time of a few$\times 10^5$ yr, the O_2 abundance has increased to the point that this species is one of the main repositories of oxygen atoms. At the same time, the gas–phase water abundance drops drastically, in agreement with the *SWAS* observations that we report here. On a somewhat longer time scale, depletion again dominates, and the gas–phase abundance of O_2 drops by several orders of magnitude, with a significant fraction of oxygen remaining in atomic form.

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The disk wind in young binary systems with low mass secondary components: the observational appearance at optical wavelengths

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The model of the young binary system with the low-mass secondary component is considered. It is supposed that the accretion of the matter from the remnant of the protostellar cloud on the system components occurs according to the predictions of the current theoretical models, i. e., the matter accretes mainly onto the low-mass component. The accretion process is accompanied with the matter outflow (the disk wind) whose low-velocity component can be partly captured by the primary. As a result, the common envelope is formed whose densest part is involved into the orbital motion of the secondary and can periodically screen the primary from an observer. Assuming the "standard" ratio between the dust and gas components of the disk wind (1:100) we calculated the possible photometric effects of such obscurations and found that they can be observed even at the rather moderate values of the accretion rates on the low-mass system component such as $10^{-8} - 10^{-9} M_{\odot}$ per yr. The parameters of the minima depend on the model of the disk wind, the ratio of its typical velocity to the orbital one of the secondary and also on the angle of the inclination of its orbital plane to the line of sight. This result can be used for the interpretation of the wide range of phenomena observed in the young stars such as cycles of activity in the UX Ori type stars, unusually wide minima in some young eclipsing binary systems and also the search of the substellar objects and giant protoplanets. Besides, the periphery parts of the gas and dust disk surrounding the young binary can be turned out in the shadow zone formed by the opaque part of the common envelope. In such cases one has to observe the shadow of the common envelope which will go on the disk following the orbital motion of the low-mass companion. A discovery and an investigation of such structures on the images of the protoplanetary disks could be one of the method to study the young binaries on the early stages on their evolution.

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A Survey of Near Infrared Nebulosities around Luminous Young Stellar Objects — *J*, *H*, and *K′* imaging

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We present the J, H, and K' images of 45 *IRAS* sources in the list by Campbell, Persson, & Matthews (1989), which have been presumed to be luminous Young Stellar Objects (YSOs) because of their infrared colors and their large *IRAS* fluxes. These objects have been classified into four groups according to two dust features in the 3 μm band — the H_2O ice absorption and the unidentified infrared band (UIB) emission (Ishii et al. 1998). Our near-infrared images reveal that most of them (42/45) have nebulosity in at least one of the three bands. By examining the nebulosities around these YSOs, we find: (1) nebulae around the objects with the ice absorption can be explained by the scattered light of the central stars; (2) nebulae around the objects with the UIB emission cannot be explained by the scattered light alone — additional emission, most likely from very small grains, is necessary to explain the nebular colors and the surface brightness; (3) the objects with neither the ice absorption nor the UIB emission tend to have faint or no nebulosity. We interpret the variation of nebular brightness and the color as evolutionary phases of circumstellar matter of intermediate- to high-mass YSOs.

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Discovery of an Edge-On Disk in the MBM 12 Young Association

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We report the discovery of a spatially-resolved edge-on protoplanetary disk in the ~2-Myr-old MBM 12 young association. Our near-infrared images of LkHα 263C (MBM 12A 3C), obtained with the Hokupa'a adaptive optics system on the Gemini North telescope, clearly show two elongated reflection nebulosities separated by a dark lane, a morphology well-matched by scattered light models of an optically thick (at near-infrared wavelengths) edge-on disk. An optical spectrum of the scattered light nebulosity obtained with the Keck II telescope exhibits a spectral type of M0±0.5 ($T_{\rm eff} = 3850 \pm 100$ K) for the central star and contains Hα and forbidden emission lines, which may indicate the presence of a jet. The absence of a near-infrared point source implies $A_K > 9.5$ toward the unseen central star. The disk is flared and has a radius of ~150 AU (at a distance of 275 pc) and an inclination of 87 degrees. The aspect ratio of the model disk in the $J-$band is 0.72. There is possible evidence for dust settling to the disk midplane. LkHα 263C is 4.115 arcsec from the 0.415 arcsec binary LkHα 263 A and B (MBM 12A 3A and 3B), which is itself 15.5 arcsec from LkHα 262 (MBM 12A 2). Thus, LkHα 263C may be the first disk to be clearly resolved around an individual star in a young quadruple system. The detection of a faint edge-on disk near a bright star demonstrates both the high angular resolution and the high sensitivity that can be achieved with adaptive optics imaging on large telescopes.

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Interaction between Ionized and Molecular Gas in the Active Star-Forming Region W31

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We have carried out 21 cm radio continuum, H76α radio recombination line, and various (^{12}CO, ^{13}CO, CS, & C^{34}S) molecular line observations of the W31 complex. Our radio continuum data show that W31 is composed of two extended HII regions, G10.2−0.3 and G10.3−0.1, each of which comprises an ultracompact HII region, two or more compact components, and diffuse envelope. The W31 cloud appears as an incomplete shell on the whole and consists of

southern spherical and northern flat components, which are associated with G10.2−0.3 and G10.3−0.1, respectively. For an assumed distance of 6 kpc, the molecular cloud has a size of 48 pc and a mass of 6.2×10^5 $M_\odot$. The IR luminosity-to-mass ratio and the star formation efficiency are derived to be 9 $L_\odot/M_\odot$ and 3%, respectively. These estimates are greater than average values of the inner Galactic plane. We detect two large (16 and 11 pc) and massive (2.1×10^5 and 8.2×10^4 $M_\odot$) CS-emitting regions in the northern and southern cloud components. The large amount (48% in mass and 16% in area) of dense gas may suggest that the W31 cloud has ability to form rich stellar clusters and that star formation has only recently begun. The extended envelopes of both G10.2−0.3 and G10.3−0.1 are likely to be results of the champagne flows, based on the distributions of ionized and molecular gas and the velocity gradient of H76α line emission. According to the champagne model, the dynamical ages of the two HII regions would be $(4-12)\times10^5$ yr. We find strong evidence of bipolar molecular outflows associated with the two ultracompact HII regions. In the vicinity of the ultracompact and compact HII regions in G10.3−0.1, the ^{12}CO J=2−1/J=1−0 intensity ratio is high (1.4) and a small but prominent molecular gas hollow exists. Together these observations strongly indicate that the HII regions and their ionizing stars are interacting with the molecular cloud. Therefore, it is most likely that recently formed massive stars are actively disrupting their parental molecular cloud in the W31 complex.

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Imaging the Circumstellar Environments of Young Binaries in Southern Star-Forming Regions

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A sample of 14 pre-main sequence visual binary systems in southern star-forming regions were imaged at 2 μm with the Keck I telescope to search for tertiary companions, scattered-light disks, and compact nebulae at linear scales of 5–100 AU. Speckle holography was used to produce images with diffraction-limited resolution and high dynamic range, and photometry in four filters between J (1.25 μm) and L' (3.8 μm) was used to provide a diagnostic of the infrared excess. Of the 14 visual binary systems studied, 9 contain components which show evidence for resolved structure. Two of them (WSB 18 and B59-1) have well-resolved tertiary companions separated from the primary stars by $\sim$ 100 mas. The remainder are only marginally resolved at the diffraction limit of the telescope. Sz 116, AS 205, Elias 2-22, ESO Hα 282, and B59-2 each have one component which is marginally-resolved along one axis and unresolved on the perpendicular axis, consistent with tertiaries at separations between $\sim$ 6 and 40 mas. If all of these systems are hierarchical triples, then fully half of the nominal binaries in the sample are triple. The primaries in Elias 2-49 and WSB 71 are marginally resolved along all position angles, suggesting the presence of dust halos. No disks were unambiguously detected in the sample.

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Analysis of UV spectra of T Tauri stars observed with HST: DR Tau

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We analysed UV spectra of classical T Tauri star DR Tau, observed with GHRS and STIS spectrographs of Hubble Space Telescope. Profiles of C IV 1550 and He II 1640 emission lines as well as absorption components of some other lines are redshifted indicating that matter falls onto the central star with velocity near 300 km/s. On the other hand profiles of N I, Mg I, Fe II, Mg II, C II and Si II lines has blueshifted absorption components indicating gas outflow with terminal velocity up to 400 km/s. Semiforbidden lines of C II, Si II and Al II have symmetrical profiles, maximum of which has the same radial velocity as the star. The same is true for H_2 emission lines and emission components of Fe II lines.

We concluded that DR Tau's activity is the result of disk accretion, such as the main portion of matter reaches the star throught the boundary layer. At the moment of observation accretion luminocity was $\simeq 2\,L_\odot$ and accretion rate

near 10^{-7} $M_\odot$/yr. At the same time relatively small ($< 10\,\%$) portion of disk's matter falls to the star along magnetic field lines which start from the disk at the distance $\sim R_*$ from the star. At the distances $\leq 3.5\,R_*$ disk has relatively hot (T$\simeq 1.5\,10^4$ K) atmosphere with scale heigh $H_p \sim 0.1\,R_*$. We argue that disk's rotation is essentially non-keplerian in this region. H_2 lines originate in the disk inside the region with r$\leq$ 1.4 a.u.

The outflow occurs from accretion disk's surface. While outflowing gas temperature is $\sim$ 7000 K at the distances $< 10\,R_*$ from the star, almost all iron atoms are ionized here by quanta of H I L_α line, which are radiated from the inner part of the disk and/or boundary layer. Wind's stream lines make an angle $\geq 30^o$ with disk's midplane in the region where gas velocity reaches 400 km/s. We did not find traces of outflowing gas with temperature larger than 10^4 K. It is not clear from our data if there is gas outflow from the formation region of H_2 lines.

According to our estimations DR Tau's mass, radius, intrinsic luminocity and interstellar extinction are: $M_* \simeq 0.9\,M_\odot$, $R_* \simeq 1.8\,R_\odot$, $L_* \simeq 0.9\,L_\odot$, $A_V \simeq 0.9^m$. We found that the angle between disk's rotation axis and the line of site can not be small, but it does not exceed 60^o.

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H_2 Emission around Massive YSOs with Outflows

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We present images in H_2 emission (λ= 2.12μm) of 7 massive young stellar objects, including 4 candidate precursors to ultra-compact HII regions. These images reveal, for the first time, the presence of dense clusters of young stars in the regions around ON1, IRAS22134+5834, and IRAS23033+5951. H_2 line emission is detected in all 7 regions, and we find that the H_2 emission arises in physically distinct regimes: in the shocked regions of the outflows, and in extended (a few thousand AU) roughly circular structures close to the near-infrared sources. While most H_2 features can be attributed to shocked or flourescent emission, the exact nature of the excitation calls for further spectroscopic investigation. A detailed comparison of the H_2 images to the outflow CO maps recently reported by citetbeu02a provides evidence that outflows from massive stars can be jet-like or of poor collimation (wide opening angle at the base), as may be the case for low-mass stars. In particular, IRAS05358+3843 provides a prime example of a jet-driven outflow; it displays most of the ingredients of this kind of object (including a prominent bow shock with its Mach disk tentatively identified in H_2). Some of the outflows are observed to be distorted and re-shaped by their interaction with the dense environment found in the vicinity of newly formed high-mass stars. The morphologies of these flows seem to be affected by associated stellar clusters which can partly account for the lack of *known* well-collimated flows from massive stars compared to that of low mass stars.

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Molecular Gas and Star Formation in Lynds 870

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We present molecular line and submillimeter dust continuum observations of the Lynds 870 cloud in the vicinity of IRAS 20231+3440. Two submillimeter cores, SMM1 and SMM2, are identified mapping the 870 μm dust continuum and ammonia (NH_3) emission. The total molecular mass is $\sim$70 – 110 $M_\odot$. The northern core is warmer and denser than the southern one. Molecular outflows are discovered in both cores. In the northern one a significant amount of low velocity (1.3–2.8 km s^{-1}) outflowing gas is found, that is hidden in the relatively broad CO lines but that is revealed by the narrower HCO^+ spectra. While IRAS 20231+3440 is most likely the exciting star of the northern outflow, the driving source of the southern outflow is not detected by infrared surveys and must be deeply embedded in the cloud core. Large scale (∼0.2 pc) infall motion is indicated by blue asymmetric profiles observed in the HCO^+ $J = 3$–2 spectra. Red K_s band YSO candidates revealed by the 2MASS survey indicate ongoing star formation throughout the cloud. The calculated masses and the measured degree of turbulence are also reminiscent of clouds forming groups of stars. The excitation of the molecular lines, molecular abundances, and outflow properties are discussed. It is concluded that IRAS 20231+3440 is a Class I object, while the southern core most likely contains a Class 0 source.

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Analytic and numerical models for the knots along the HH 111 jet

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We consider a model for HH 111 as a jet ejected with a sawtooth, time-dependent ejection velocity. Such a variability is suggested by the PV diagrams obtained from the HST observations of Raga et al. (2002). We calculate both analytic and numerical models describing the flow resulting from such an ejection velocity time-variability. Analytically, we calculate the flow for the limiting cases of massless working surfaces (i. e., which efficiently eject mass sideways into the cocoon of the jet) and mass conserving working surfaces, and we find that the numerically computed flow lies in between these two limits. From the numerical simulations, we compute position-velocity diagrams which can be directly compared with the corresponding observations. We find a surprisingly good agreement, which can be seen as a partial confirmation of the interpretation of the knots along HH 111 as the result of a time-dependence in the ejection. Also, we show that a sawtooth functional form for the ejection velocity variability appears to be particularly appropriate for modelling the detailed radial velocity structure of the knots along HH 111.

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Magnetic Fields in Star-Forming Molecular Clouds V. Submillimeter Polarization of the Barnard 1 Dark Cloud

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We present 850 μm polarimetry from the James Clerk Maxwell Telescope toward several dense cores within the dark cloud Barnard 1 in Perseus. Significant polarized emission is detected from across the mapped area and is not confined to the locations of bright cores. This indicates the presence of aligned grains and hence a component of the magnetic field in the plane of the sky. Polarization vectors detected away from bright cores are strongly aligned at a position angle of $\sim 90°$ (east of north), while vectors associated with bright cores show alignments of varying orientations. There is no direct correlation between the polarization angles measured in earlier optical polarimetry toward Perseus and the polarized submillimeter thermal emission. Depolarization toward high intensities is exhibited, but toward the brightest core reaches a threshold beyond which no further decrease in polarization percentage is measured. The polarized emission data from the interior envelope are compared with previously published OH Zeeman data to estimate the total field strength and orientation under the assumption of a uniform and non-uniform field component in the region. These results are rough estimates only due to the single independent detection of Zeeman splitting toward Barnard 1. The uniform field component is thus calculated to be $\mathbf{B}_0 = 31\ \mu\text{G}\ [\pm(0.52\hat{N} - 0.01\hat{E}) - 0.86\hat{z}]$ in the case where we have assumed the ratio of the dispersion of the line-of-sight field to the field strength to be 0.2.

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A methanol line survey toward high-mass star-forming regions

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We present the results of a search for methanol maser and thermal lines in 11 transitions in the range 85-112 GHz toward 23 star-forming regions exhibiting class I and class II methanol masers. The selected frequencies are 85.5, 86.6, 94.5, 95.1, 96.7 (quartet line series), 107.0, 108.8 and 111.2 GHz. Five masers were confirmed at 107.0 GHz while new masers were found at 85.5, 86.6 and 108.8 GHz. Many detected emission lines have a quasi-thermal origin. The detection rates of methanol emission are high at 95.1 GHz (87%) and 96.7 GHz (96%), satisfactory at 107.0 and 108.9 GHz ($\sim$ 50%) while the detection rates at 85.5, 94.5 and 111.3 GHz are low ($\sim$ 20%). Most reported 95.1 GHz emission is masing.

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A Complete Search for Dense Cloud Cores in Taurus

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We present the results of an $H^{13}CO^+$ $J = 1$–0 survey for dense molecular condensations in Taurus. The observations were carried out with the 45-m telescope at Nobeyama on the basis of an extensive $C^{18}O$ survey made with the 4-m telescope at Nagoya University (Onishi et al. 1996; Mizuno et al. 1994). The present survey is purely based on molecular line observations and thus provides the most extensive and uniform sample of high-density condensations. We detected 55 $H^{13}CO^+$ condensations of which 44 are starless. These starless condensations are compact ($R \lesssim 0.1$ pc) and of high-density ($\gtrsim 10^5$ cm^{-3}) and thus are highly probable candidates for protostellar condensations just before star formation. The striking feature of these starless compact condensations is the steep slope of the mass spectrum ($dN/dM \sim M^{-2.5}$ for $3.5M_\odot < M < 20.1M_\odot$). Under the assumption of uniform star formation efficiency, the spectrum resembles the stellar IMF for a mass of $\lesssim$ a few solar masses. This suggests that the stellar IMF is the result of the fragmentation process from relatively lower density cores. The statistical analysis of the starless condensations yields the lifetime of the condensations of $\sim 4 \times 10^5$ yr, which is several times longer than free-fall time scale. This short time scale compared with magnetic flux loss time may indicate that the time scale is determined by the dissipation time scale of turbulence.

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Preprint available at `http://www.a.phys.nagoya-u.ac.jp/~ohnishi/papers.html`

Turbulent Velocity Structure in Molecular Clouds

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We compare velocity structure observed in the Polaris Flare molecular cloud at scales ranging from 0.015 pc to 20 pc to the velocity structure of a suite of simulations of supersonic hydrodynamic and MHD turbulence computed with the ZEUS MHD code. We examine different methods of characterising the structure, including a scanning-beam method that provides an objective measurement of Larson's size-linewidth relation, structure functions, velocity and velocity difference probability distribution functions (PDFs), and the Δ-variance wavelet transform, and use them to compare

models and observations.
The Δ-variance is most sensitive to characteristic scales and scaling laws, but is limited in its application by a lack of intensity weighting so that its results are easily dominated by observational noise in maps with large empty areas. The scanning-beam size-linewidth relation is more robust with respect to noisy data. Obtaining the global velocity scaling behaviour requires that large-scale trends in the maps not be removed but treated as part of the turbulent cascade. We compare the true velocity PDF in our models to simulated observations of velocity centroids and average line profiles in optically thin lines, and find that the line profiles reflect the true PDF better unless the map size is comparable to the total line-of-sight thickness of the cloud. Comparison of line profiles to velocity centroid PDFs can thus be used to measure the line-of-sight depth of a cloud.
The observed density and velocity structure is consistent with supersonic turbulence with a driving scale at or above the size of the molecular cloud and dissipative processes below 0.05 pc. Ambipolar diffusion could explain the dissipation. Over most of the observed range of scales the velocity structure is that of a shock-dominated medium driven from large scale. The velocity PDFs exclude small-scale driving such as that from stellar outflows as a dominant process in the observed region. In the models, large-scale driving is the only process that produces deviations from a Gaussian PDF shape consistent with observations, almost independent of the strength of driving or magnetic field. Strong magnetic fields impose a clear anisotropy on the velocity field, reducing the velocity variance in directions perpendicular to the field.

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Exploring the full stellar population of the Upper Scorpius OB Association

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We investigate the stellar population and star formation history of the Upper Scorpius OB association, the most nearby region of recent massive star formation, over the full stellar mass range from $0.1\,M_\odot$ to $20\,M_\odot$. The first part of this paper describes an extension of our large spectroscopic survey (Preibisch et al. 2001) for low-mass pre-main sequence (PMS) stars in Upper Scorpius. Utilizing the multi-object spectrograph 2dF at the Anglo-Australian-Telescope, we obtained spectra of 469 stars with magnitudes $R = 12.5 - 18.0$ in a 6 square-degree area. Among these we find 68 new PMS stars, nearly all of them M-type stars, by their strong lithium absorption lines. The total area covered by our 2dF survey is now 9 square-degrees and contains 166 new PMS stars. Combining these results with our earlier investigation (Preibisch & Zinnecker 1999) yields a sample of 250 PMS stars in the mass range $\sim 0.1\,M_\odot$ to $\sim 2\,M_\odot$. The location of these stars in the HR diagram suggests a mean age of 5 Myr without a significant age spread.

In the second part of this paper, we also consider the population of 114 high-mass members identified in detailed Hipparcos studies. We construct a combined HR diagram for the 364 high- and low-mass members and find that the whole stellar population is very well characterized by a very narrow age distribution around 5 Myr. We estimate individual masses for all members and construct an empirical mass function covering the mass range from $0.1\,M_\odot$ up to $20\,M_\odot$. A power-law fit to the mass function gives a slope of $\alpha \sim -2.6$ above $\sim 2\,M_\odot$ and a much flatter slope ($\alpha \sim -0.9$) below $\sim 0.6\,M_\odot$. The initial mass function of Upper Sco is not identical, but within the errors consistent with recent determinations of the field initial mass function. There is certainly no deficit of low-mass stars in the Upper Sco OB association, but rather a small excess of low-mass stars. Our results on the stellar age distribution confirm earlier indications that the star formation process in Upper Sco was triggered, and support previous conjectures that the triggering event was a supernova shock-wave originating from the nearby Upper Centaurus Lupus association.

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Preprints are available at http://www.mpifr-bonn.mpg.de/staff/tpreibis/publications.html (paper # 29)

Radio Continuum Maps of Deeply Embedded Protostars: Thermal Jets, Multiplicity and Variability

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We have carried out a deep, 3.6 cm radio continuum survey of young outflow sources using the Very Large Array in its A-configuration providing sub-arcsecond resolution. The seven regions observed are L1448-N, IRAS 2 and 4 in NGC 1333, L1551-NE, SSV 63 in L1630, HH 124 IRS in NGC 2264, and B335 IRS. The first three of these objects are known from sub-mm observations to be multiple sources, and we detect almost all known sub-mm components at 3.6 cm. The L1551-NE source is confirmed to be a sub-arcsecond binary. We find a third radio source in the SSV 63 system, which drives the multiple HH 24 jets. HH 124 IRS is embedded in a cometary cloud, where we detect a small cluster of six time-variable radio continuum sources. Six of the observed sources are resolved into compact thermal radio jets.

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VLA observations of water maser emission associated with SVS 13 and other sources in NGC 1333

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The young stellar object SVS 13 is believed to power the chain formed by the HH 7-11 objects. Recent observations have revealed that in the radio continuum (3.6-cm) the source is a binary with components separated by about $0.''3$ in the east-west direction. The members of the binary are named VLA 4A (western component) and VLA 4B (eastern component). In an attempt to ascertain which of the two components of the binary is the most likely candidate to drive the outflow, we obtained accurate positions for the H_2O maser spots toward this source, also known as H_2O(A), derived from Very Large Array observations in its highest angular resolution A configuration. We detected a total of eleven spots over four observational sessions (made in the years 1983, 1985, 1988, and 1989). The spots are segregated in two velocity groups: a velocity group with v_{LSR} similar to that of the ambient cloud ($v_{LSR} \simeq 8$ km s^{-1}), for which we detected five features (with v_{LSR} in the range of 6.5 to 12.2 km s^{-1}) and a blueshifted velocity group (six features with v_{LSR} in the range of -25.4 to -5.6 km s^{-1}). Remarkably, all the spots in the first velocity group are associated with VLA 4A, while all the spots in the blueshifted velocity group are associated with VLA 4B. We discuss the possible implications of this observation. We also present accurate positions of the H_2O maser HH 7(B) and of the masers associated with IRAS4B (VLA 28) and IRAS7 (VLA 27, the exciting source of HH 6).

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http://www.astrosmo.unam.mx/~luisfr/publ.html

The Effect of the Hall Term on the Nonlinear Evolution of the Magnetorotational Instability: II. Saturation Level and Critical Magnetic Reynolds Number

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The nonlinear evolution of the magnetorotational instability (MRI) in weakly ionized accretion disks, including the effect of the Hall term and ohmic dissipation, is investigated using local three-dimensional MHD simulations and various initial magnetic field geometries. When the magnetic Reynolds number, $Re_M \equiv v_{\rm A}^2/\eta\Omega$ (where $v_{\rm A}$ is the Alfvén speed, η the magnetic diffusivity, and Ω the angular frequency), is initially larger than a critical value $Re_{M,{\rm crit}}$, the MRI evolves into MHD turbulence in which angular momentum is transported efficiently by the Maxwell stress. If $Re_M < Re_{M,{\rm crit}}$, however, ohmic dissipation suppresses the MRI, and the stress is reduced by several orders of magnitude. The critical value is in the range of $1 - 30$ depending on the initial field configuration. The Hall effect does not modify the critical magnetic Reynolds number by much, but enhances the saturation level of the Maxwell stress by a factor of a few. We show that the saturation level of the MRI is characterized by $v_{{\rm A}z}^2/\eta\Omega$, where $v_{{\rm A}z}$ is the Alfvén speed in the nonlinear regime along the vertical component of the field. The condition for turbulence and significant transport is given by $v_{{\rm A}z}^2/\eta\Omega \gtrsim 1$, and this critical value is independent of the strength and geometry of the magnetic field or the size of the Hall term. If the magnetic field strength in an accretion disk can be estimated observationally, and the magnetic Reynolds number $v_{\rm A}^2/\eta\Omega$ is larger than about 30, this would imply the MRI is operating in the disk.

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A young very low-mass object surrounded by warm dust

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We present a complete low-resolution (R∼100) near-infrared spectrum of the substellar object GY 11, member of the ρ-Ophiuchi young association. The object is remarkable because of its low estimated mass and age and because it is associated with a mid-infrared source, an indication of a surrounding dusty disk. Based on the comparison of our spectrum with similar spectra of field M-dwarfs and atmospheric models, we obtain revised estimates of the spectral type, effective temperature and luminosity of the central object. These parameters are used to place the object on a Hertzprung-Russell diagram and to compare with the prediction of pre-main sequence evolutionary models. Our analysis suggests that the central object has a very low mass, probably below the deuterium burning limit and in the range 8–12 $M_{Jupiter}$, and a young age, less than 1 Myr. The infrared excess is shown to be consistent with the emission of a flared, irradiated disk similar to those found in more massive brown dwarf and TTauri systems. This result suggests that substellar objects, even the so-called isolated planetary mass objects, found in young stellar associations are produced in a similar fashion as stars, by core contraction and gravitational collapse.

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http://www.arcetri.astro.it/∼lt/preprints/preprints.html

Triply deuterated ammonia in NGC 1333

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The Caltech Submillimeter Observatory has detected triply deuterated ammonia, ND_3, through its $J_K = 1_0^a \rightarrow 0_0^s$ transition near 310 GHz. Emission is found in the NGC 1333 region, both towards IRAS 4A and a position to the South-East where DCO^+ peaks. In both cases, the hyperfine ratio indicates that the emission is optically thin. Column densities of ND_3 are $3-6\times10^{11}$ cm^{-2} for $T_{\rm ex}$=10 K and twice as high for $T_{\rm ex}$=5 K. Using a Monte Carlo radiative transfer code and a model of the structure of the IRAS source with temperature and density gradients, the estimated ND_3 abundance is 3.2×10^{-12} if ND_3/H_2 is constant throughout the envelope. In the more likely case that ND_3/H_2D^+ is constant, ND_3/H_2 peaks in the cold outer parts of the source at a value of 1.0×10^{-11}. To reproduce the observed NH_3/ND_3 abundance ratio of $\sim$1000, grain surface chemistry requires an atomic D/H ratio of $\approx$0.15 in the gas phase, >10 times higher than in recent chemical models. More likely, the deuteration of NH_3 occurs by ion-molecule reactions in the gas phase, in which case the data indicate that deuteron transfer reactions are much faster than proton transfers.

Accepted by Astronomy & Astrophysics (Letters)

Preprint available on www.arxiv.org at: astro-ph/0204448

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://www.ifa.hawaii.edu/~reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .

Moving ... ??

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New Jobs

Postdoctoral and Ph.D. Positions in Infrared Astronomy/Interferometry

Applications are invited for one staff position, one postdoctoral position (stipend), and Ph.D. positions in the Infrared Interferometry Group of the Max Planck Institute for Radioastronomy in Bonn (see http://www.mpifr-bonn.mpg.de/div/ir-interferometry/)

Preference will be given to applicants with experience in one of the following areas: **star formation**, active galactic nuclei, radiative transfer modeling, and infrared long-baseline interferometry.

The successful applicants would be expected to participate in interferometric observations and their interpretation and/or modeling. The positions offer excellent opportunities for the highest-resolution studies possible using the VLT Interferometer (in particular, its AMBER phase closure instrument) and speckle interferometry. Our group is a member of the international AMBER consortium, which has built the AMBER VLTI instrument.

The appointments are initially for two years, and are renewable for up to six years. Interested scientists should email a letter of application with a summary of relevant experience and research interests, a curriculum vitae, a list of publications, and the names and addresses of three referees to Prof. Gerd Weigelt.

Review of applications will begin on 15 July 2002 and continue until the positions are filled. The Max Planck Society is an equal opportunity employer.

Interested scientists should send their application to:

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Meetings

IAU Symposium 221: Star Formation at High Angular Resolution

Preliminary Announcement

One of the symposia selected for the IAU General Assembly in 2003 will be on the theme of star formation: *IAU Symposium 221—Star Formation at High Angular Resolution*. The GA will take place in Darling Harbour in Sydney. This was a major venue for the Olympic Games in 2000 and is adjacent to the Central Business District of the city. The GA runs from 13–26 July, 2003 and IAU 221 will be on 22–25 July.

Recent years have seen an explosive growth in the capabilities for high angular resolution astronomical observations at all wavelength regimes, from the X-rays to the radio. The advent of large telescopes on the ground and in space combined with the implementation of novel techniques such as adaptive optics and interferometry allow us to explore the universe in unprecedented detail. With these dramatic improvements in resolution come the prospect of significant advances in our understanding of a wide range of cosmic phenomena. In particular, high angular resolution observations have begun to play a vital role in studies of the star formation process, providing new insights and testing physical models. That role is likely to become even more dominant over the next decade as instruments such as the Australian Telescope Compact Array, Keck and VLT Interferometers, Sub-Millimeter Array and the Atacama Large Millimetre Array commence operations.

In this Symposium we aim to review what we have learned already about the star formation process through high angular resolution observations and to discuss the prospects for progress with the wide variety of new instruments that will become available over the next decade. The program will centre around the following topics:

- Molecular clouds to protostellar cores
- Low mass star formation
- Massive star formation
- Extragalactic star formation
- Jets, outflows and disks
- Planets

Presentations will feature major review talks on these fields, as well as reviews on various observational techniques used to achieve high angular resolution, with application to the study of star formation. There will also be shorter reviews on specific topics of interest, as well as the opportunity to present poster papers on any area relating to the field.

This is a preliminary announcement about the meeting. Further details will be found shortly on the IAU 2003 General Assembly web site at URL http://www.astronomy2003.com, through which all registration and accommodation arrangements need to be made. You need to register for the General Assembly in order to attend IAU Symposium 221. The Symposium itself has its own site at http://www.phys.unsw.edu.au/iau221, where specific information pertaining to it will be posted. An email address of iau221@phys.unsw.edu.au may be used for enquiries.

Michael Burton
Chair of SOC and LOC for IAU Symposium 221.