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Abstracts of recently accepted papers

The Episodic, Precessing Giant Molecular Outflow from IRAS 04239+2436 (HH 300)

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We present the first set of detailed molecular line maps of the region associated with the giant Herbig-Haro flow HH 300, from the young star IRAS 04239+2436. Our results indicate that the red lobe of the HH 300 flow is depositing a fair amount of momentum (3.2 $(\sin i)^{-1}$ $M_\odot$ km s^{-1}) and kinetic energy (2.6 $(\sin i)^{-2} \times 10^{43}$ ergs) over a notable volume ($\sim$ 11%) of its host dark cloud. This makes HH 300 a key player in the evolution and fate of its parent cloud. The redshifted molecular outflow lobe of HH 300 is 1.1 pc long and 0.3 pc wide, and has a very clumpy structure. The density, velocity, and momentum distributions in the outflow indicate that the observed clumps arise from the prompt entrainment of ambient gas. Bow shock-shaped structures are associated with the clumps, and we hypothesize that the shocks are produced by different mass ejection episodes. Lines drawn from IRAS 04239+2436 to each of these clumps have different orientations on the plane of the sky, and we conclude that HH 300 is a precessing and episodic outflow.

The observations include a map of the red lobe 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. Due to "contamination" by emission from another molecular cloud along the same light-of-sight, we are not able to study the blueshifted lobe of HH 300. The combined ^{12}CO(1–0) and ^{13}CO(1–0) line observations enable us to estimate the outflow mass accounting for the velocity-dependent opacity of the ^{12}CO(1–0) line. This method is much more precise than using ^{12}CO data alone. We obtain a steep power-law mass spectrum for HH 300, which we believe is best explained by the evolution of the outflow mass kinematics. In addition, our ^{13}CO(1–0) observations show that the HH 300 flow has been able to redistribute (in space and velocity) considerable amounts of its surrounding medium-density ($\sim 10^3$ cm^{-3}) gas.

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`http://cfa-www.harvard.edu/~harce/papers`

Dynamical modeling of large scale asymmetries in the β Pictoris dust disk

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We report a new and complete model of the β Pictoris disk, which succeeds in accounting for both the surface brightness distribution, warp characteristics, the outer "butterfly" asymmetry as observed by HST/STIS in scattered light, as well as the infrared emission. Our model includes the presence of a disk of planetesimals extending out to 120–150 AU, perturbed gravitationally by a giant planet on an inclined orbit, following the approach of Mouillet et al. (1997b). At any time, the planetesimal disk is assumed to be the source of a distribution of grains produced through collisional evolution, with the same initial orbital parameter distribution. The steady state spatial grain distribution is found incorporating the effects of radiation pressure which can cause the distribution of the smallest particles to become very distended. With realistic assumptions about the grains' chemical properties, the modeling confirms the previously evident need for an additional population of hot grains close to the star, to account for the 12 μm fluxes at short distances from the star. It also indicates that this population cannot explain the outer 12 μm flux distribution when the effects of gravity and radiation pressure determine the distribution. Very small grains, produced by collisions among aggregates, are tentatively proposed to account for this 12 μm outer emission.

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The Stellar Content of Obscured Galactic Giant H II Regions III.: W31

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We present near infrared (J, H, and K) photometry and moderate resolution ($\lambda/\Delta\lambda = 3000$) $K-$band spectroscopy of the embedded stellar cluster in the giant H II region W31. Four of the brightest five cluster members are early O–type stars based on their spectra. We derive a spectro–photometric distance for W31 of 3.4 ± 0.3 kpc using these new spectral types and infrared photometry. The brightest cluster source at K is a red object which lies in the region of the $J-H$ vs. $H-K$ color–color plot inhabited by stars with excess emission in the $K-$band. This point source has an H plus $K-$band spectrum which shows no photospheric features, which we interpret as being the result of veiling by local dust emission. Strong Brackett series emission and permitted FeII emission are detected in this source; the latter feature is suggestive of a dense inflow or outflow. The near infrared position of this red source is consistent with the position of a 5 GHz thermal radio source seen in previous high angular resolution VLA images. We also identify several other $K-$band sources containing excess emission with compact radio sources. These objects may represent stars in the W31 cluster still embedded in their birth cocoons.

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New OH Zeeman measurements of magnetic field strengths in molecular clouds

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We present the results of a new survey of 23 molecular clouds for the Zeeman effect in OH undertaken with the ATNF Parkes 64-m radio telescope and the NRAO Green Bank 43-m radio telescope. The Zeeman effect was clearly detected in the cloud associated with the HII region RCW 38, with a field strength of 38 ± 3 μG, and possibly detected in a cloud associated with the HII region RCW 57, with a field strength of -203 ± 24 μG. The remaining 21 measurements give formal upper limits to the magnetic field strength, with typical 1σ sensitivities < 20 μG.

For 22 of the molecular clouds we are also able to determine the column density of the gas in which we have made a sensitive search for the Zeeman effect. We combine these results with previous Zeeman studies of 29 molecular clouds, most of which were compiled by Crutcher (1999), for a comparsion of theoretical models with the data.

This comparison implies that if the clouds can be modeled as initially spherical with uniform magnetic fields and densities that evolve to their final equilibrium state assuming flux-freezing then the typical cloud is magnetically supercritical, as was found by Crutcher (1999). If the clouds can be modeled as highly flattened sheets threaded by uniform perpendicular fields, then the typical cloud is approximately magnetically critical, in agreement with Shu et al. (1999), but only if the true values of the field for the non-detections are close to the 3σ upper limits. If instead these values are significantly lower (for example, similar to the 1σ limits), then the typical cloud is generally magnetically supercritical.

When all observations of the Zeeman effect are considered, the single-dish detection rate of the OH Zeeman effect is relatively low. This result may be due to low mean field strengths, but a more realistic explanation may be significant field structure within the beam. As an example, for clouds associated with HII regions the molecular gas and magnetic field may be swept up into a thin shell, which results in a non-uniform field geometry and measurements of the beam-averaged field strength which are significantly lower than the true values. This effect makes it more difficult to distinguish magnetically subcritical and supercritical clouds.

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`http://cfa-www.harvard.edu/sfgroup/` (CfA Star Formation/ISM www page)
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Near-Infrared Photometric Variability of Stars Toward the Orion A Molecular Cloud

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We present an analysis of J, H, and K_s time series photometry obtained with the southern 2MASS telescope over a $0.84° \times 6°$ region centered near the Trapezium region of the Orion Nebula Cluster. These data are used to establish the near-infrared variability properties of pre-main-sequence stars in Orion on time scales of $\sim$ 1-36 days, $\sim$ 2 months, and $\sim$ 2 years. A total of 1235 near-infrared variable stars are identified, $\sim$ 93% of which are likely associated with the Orion A molecular cloud. The variable stars exhibit a diversity of photometric behavior with time, including cyclic fluctuations with periods up to 15 days, aperiodic day-to-day fluctuations, eclipses, slow drifts in brightness over one month or longer, colorless variability (within the noise limits of the data), stars that become redder as they fade, and stars that become bluer as they fade. The mean peak-to-peak amplitudes of the photometric fluctuations are $\sim 0.2^{\rm m}$ in each band and 77% of the variable stars have color variations less than $0.05^{\rm m}$. The more extreme stars in our sample have amplitudes as large as $\sim 2^{\rm m}$ and change in color by as much as $\sim 1^{\rm m}$. The typical time scale of the photometric fluctuations is less than a few days, indicating that near-infrared variability results primarily from short term processes. We examine rotational modulation of cool and hot star spots, variable obscuration from an inner circumstellar disk, and changes in the mass accretion rate and other physical properties in a circumstellar disk as possible physical origins of the near-infrared variability. Cool spots alone can explain the observed variability characteristics in $\sim$ 56-77% of the stars, while the properties of the photometric fluctuations are more consistent with hot spots or extinction changes in at least 23% of the stars, and with variations in the disk mass accretion rate or inner disk radius in $\sim$ 1% of our sample. However, differences between the details of the observations and the details of variability predicted by hot spot, extinction, and accretion disk models suggest either that another variability mechanism not considered here may be operative, or that the observed variability represents the net results of several of these phenomena. Analysis of the star count data indicates that the Orion Nebula Cluster is part of a larger area of enhanced stellar surface density which extends over a $0.4° \times 2.4°$ (3.4 pc $\times$ 20 pc) region containing $\sim$ 2700 stars brighter than $K_s = 14^{\rm m}$.

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preprints available at http://www.astro.caltech.edu/~jmc/variables/orion

On the Influence of Magnetic Fields on the Structure of Protostellar Jets

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We here present the first results of fully three-dimensional (3-D) MHD simulations of radiative cooling pulsed (time-variable) jets for a set of parameters which are suitable for protostellar outflows. Considering different initial magnetic field topologies in approximate *equipartition* with the thermal gas, i.e., (i) a longitudinal, and (ii) a helical field, both of which permeating the jet and the ambient medium; and (iii) a purely toroidal field permeating only the jet, we find that the overall morphology of the pulsed jet is not very much affected by the presence of the different magnetic field geometries in comparison to a nonmagnetic calculation. Instead, the magnetic fields tend to affect essentially the detailed structure and emission properties behind the shocks at the head and at the pulse-induced internal knots, particularly for the helical and toroidal geometries. In these cases, we find, for example, that the H_α emissivity behind the internal knots can be about three to four times larger than that of the purely hydrodynamical jet. We also find that some features, like the nose cones that often develop at the jet head in 2-D calculations involving toroidal magnetic fields, are smoothed out or absent in the 3-D calculations.

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Comment on "Instabilities of self-gravitating dusty clouds in magnetized plasmas" [Phys. Plasmas 7, 3762 (2000)]

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A study was recently presented on the linear stability of self-gravitating, magnetic interstellar dust clouds, including the effects of fluctuations of the charges of dust grains and collisions with a neutral fluid, and it was suggested that gravitational instability in such systems could lead to the formation of stars. In fact, this particular problem was solved in a series of detailed, nonlinear numerical simulations (which also included the effects of fluctuating grain charges and friction due to collisions with neutral particles) that were published years ago.

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The Structure and Evolution of Magnetized Cloud Cores in a Zero–Density Background

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Molecular-line observations of star-forming cloud cores indicate that they are not the flattened structures traditionally considered by theory. Rather, they are elongated, perhaps in the direction of their internal magnetic field. We are thus motivated to consider the structure and evolution of axisymmetric, magnetized clouds that start from a variety of initial states, both flattened (oblate) and elongated (prolate). In this first contribution, the clouds are of fixed mass, and are surrounded by a fictitious medium of zero density and finite pressure. We devise a new technique, dubbed the q-method, that allows us to construct magnetostatic equilibria of any specified shape. The mass loading of the field lines then follows from the self-consistent model solution, just the reverse of the standard procedure. We find, in agreement with previous authors, that the field lines in oblate clouds bend inward. However, those in prolate clouds bow outward, confining the structures through magnetic tension.

We next follow the quasi-static evolution of these clouds via ambipolar diffusion. An oblate cloud either relaxes to a magnetically force-free sphere or, if sufficiently massive, flattens along its polar axis as its central density runs away.

A prolate cloud always relaxes to a sphere of modest central density. We finally consider the evolution of an initially spherical cloud subject to the tidal gravity of neighboring bodies. Although the structure constricts equatorially, it also shortens along the pole, so that it ultimately flattens on the way to collapse. In summary, none of our initial states can evolve to the point of collapse while maintaining an elongated shape. We speculate that this situation will change once we allow the cloud to gain mass from its environment.

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The Magnetic Decoupling Stage of Star Formation

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We present the results of the first numerical calculations to model magnetic decoupling in a collapsing molecular cloud core. Magnetic decoupling is the stage during which the motion of the neutrals ceases to significantly affect the magnetic field strength *and* the magnetic field ceases to significantly affect this motion. We have analyzed the resistivity of a weakly ionized, magnetic gas and we have separated the contributions of Ohmic dissipation and ambipolar diffusion. The chemical model used to determine the abundances of ionized particles accounts for, among other things, a distribution of grain radii. The evolution of an axisymmetric, magnetic molecular cloud core is followed from central densities of $300\,\mathrm{cm}^{-3}$ to $2\times10^{12}\,\mathrm{cm}^{-3}$. Typically, magnetic decoupling begins at a central density of $3\times10^{10}\,\mathrm{cm}^{-3}$ and is complete by a density of $2\times10^{12}\,\mathrm{cm}^{-3}$. We find that the mechanism responsible for magnetic decoupling is ambipolar diffusion, not Ohmic dissipation, and that decoupling *precedes* the formation of a central stellar object. When the central density is a few $\times10^{12}\,\mathrm{cm}^{-3}$, a nearly uniform magnetic field $B_{\mathrm{dec}}\approx0.1\,\mathrm{G}$ extends over a region $\approx20\,\mathrm{AU}$ in radius that contains a mass $\approx0.01\,M_{\odot}$. This value of B_{dec} is consistent with measurements of remanent magnetization in meteorites. Magnetic decoupling at this stage is not accompanied by hydromagnetic shocks. We estimate that the "magnetic flux problem" of star formation is resolved by ambipolar diffusion before the magnetic field is refrozen in the matter because of thermal ionization.

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Submillimeter mapping and analysis of cold dust condensations in the Orion M42 star forming complex

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We present here the continuum submillimeter maps of the molecular cloud around the M42 Nebula in the Orion region. These have been obtained in four wavelength bands (200, 260, 360 and 580 μm) with the ProNaOS two meter balloon-borne telescope. The area covered is 7 parsecs wide (50 arcmin at a distance of 470 pc) with a spatial resolution of about 0.4 parsec. Thanks to the high sensitivity to faint surface brightness gradients, we have found several cold condensations with temperatures ranging from 12 to 17 K, within 3 parsecs of the dense ridge. The statistical analysis of the temperature and spectral index spatial distribution shows an evidence of an inverse correlation between these two parameters. Being invisible in the IRAS 100 μm survey, some cold clouds are likely to be the seeds for future star formation activity going on in the complex. We estimate their masses and we show that two of them have masses higher than their Jeans masses, and may be gravitationally unstable.

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Far Infrared investigation of Class 0 sources: Line cooling

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We have investigated with ISO-LWS the far infrared spectra (43 - 197 μm) of a sample of 17 Class 0 sources and their associated outflows. In addition to [OI] 63 μm, the pure rotational lines of abundant molecules such as CO, H_2O and OH are frequently observed in these sources, at variance with more evolved young stellar objects. We found, in agreement with previous studies conducted on individual sources, that the molecular lines excitation arises from small regions, with typical sizes of 10^{-9} *sr*, of warm ($200 < T < 2000$ K) and dense gas ($10^4 < n_{H_2} < 10^7$ cm^{-3}), compressed after the passage of shocks. In particular, we found slow, non-dissociative shocks as the main mechanism at the origin of the molecular gas heating, while the bulk of the [OI] 63 μm line emission is due to the dissociative J-shock component arising from the Mach disk at the head of the protostellar jet, as testified by the fact that this line emission results to be a good tracer of the source mass loss rate. Large abundances of gas phase H_2O are commonly estimated, with values which appear to be correlated with the gas temperature. The total far infrared line cooling L_{FIR} = L(OI) + L(CO) + L(H_2O) + L(OH), which amounts to $\sim 10^{-2}$-10^{-1} $L_\odot$, results roughly equal to the outflow kinetic luminosity as estimated by means of millimeter molecular mapping. This circumstance demonstrates that the FIR line cooling can be a valid direct measure of the power deposited in the outflow, not affected by geometrical or opacity problems like the determination of L_{kin}, or by extinction problems like the near infrared shocked H_2 emission. We finally remark that the strong molecular emission observed, and in particular H_2O emission, is a peculiarity of the environments of Class 0 sources. The present analysis shows that the ratio between far infrared molecular line luminosity and bolometric luminosity (L_{mol}/L_{bol}) is always larger than $\sim 10^{-3}$ in Class 0 objects. We suggest that this parameter could be used as a further criterion for identifying future Class 0 candidates.

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ROSAT-HRI detection of the Class I protostar YLW16A in the ρ Ophiuchi dark cloud

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I analyze unpublished or partially published archival ROSAT data of the ρ Ophiuchi dark cloud. This set of seven overlapping ROSAT HRI pointings, composed of eight ∼one-hour exposures, detects mainly the X-ray brightest T Tauri stars of this star-forming region. Only two HRI sources are new X-ray sources, and their optical counterparts are proposed as new Weak T Tauri star candidates. Meanwhile the ROSAT HRI caught during just one exposure a weak X-ray source ($\mathcal{L}$=10; SNR=4.1 σ for Gaussian statistics) among a group of three embedded young stellar objects including two Class I protostars. Previous ROSAT PSPC, ASCA GIS observations, and as I argue here one *Einstein* IPC observation, have already detected an X-ray source in this area, but this higher angular resolution data show clearly that X-rays are emitted by the Class I protostar YLW16A. This is the second Class I protostar detected by the ROSAT HRI in this dark cloud. The determination of the intrinsic X-ray luminosity of this event, L_X[0.1–2.4 keV]=(9.4–450)$\times 10^{30}$ erg s^{-1}, critically depends on the source absorption estimate. Improvements will be obtained only by the direct determination of this parameter from fitting of Chandra and XMM-Newton spectra.

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Chemical Constraints and Microstructure in TMC-1 Core D

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Microstructure has been detected in Core D of TMC-1. Unless it is confined or replenished by an as yet unexamined mechanism, this microstructure will dissipate on the sound-crossing timescale, which is less than 10^5 yr. We reconsider

the large number of models that have been proposed to explain chemical variations in TMC-1 in an effort to determine whether chemical constraints require the microstructure to be confined or replenished for times much longer than the sound crossing timescale. We explore here a chemical model which, though consistent with the assumption of an age of 6×10^4 yr and a number density of H nuclei of 2×10^5 cm^{-3}, shows the richness in both molecular variety and abundances observed in Core D. In particular, the computed HC_3N fractional abundance relative to H_2 is 6 $\times10^{-8}$, in agreement with the latest observations of Ohishi and Kaifu (1998). Apparently, the chemistry of TMC–1 cannot be used to discard the possibility that TMC-1 core D is young. This model has the following characteristics: the cosmic ray ionization rate is consistently larger than that usually assumed for dark regions; carbon atoms and hydrocarbons that strike grains are rapidly hydrogenated and promptly returned to the gas phase as methane; CO and N_2 striking grains are immediately returned to the gas phase unaltered; other chemical species containing at least one atom more massive than helium colliding with dust grains remain frozen on their surfaces; and the material other than hydrogen was initially in atomic form. For such a model to be viable, collapse of Core D must have been triggered by a stellar wind-driven shock of several km s^{-1}. This speed is low enough that magnetic moderation of the shock would have prevented the activation of a high temperature chemistry. The model results indicate that Core D would have fractional abundances of H_2O and O_2 at a core age of 6 $\times10^4$ yr consistent with the upper limits placed by very recent observations of Core D made with SWAS. The implications of this study are (1) that hydrogenation of atoms at the surfaces of dust grains may be a significant contributor to the chemistry of dark clouds; (2) that the special chemical nature of TMC–1 is due primarily to the exceptional youth of Core D.

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http://www.star.ucl.ac.uk/ sv/pub/tmc1.ps

High-Resolution Imaging of Ultracompact HII Regions - III – G11.11-0.40 and G341.21-0.21

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We present the first near-infrared images of the two massive southern star-forming regions G11.11-0.40 and G341.21-0.21, obtained with adaptive optics at sub-arcsecond resolution. Together with conventional narrow-band near-infrared images and polarization maps, mid-infrared data, millimetre and radio data, we were able to determine the morphological structure and to constrain the stellar content of the regions. In both cases the molecular cloud cores have masses of about 500 $M_\odot$ and contain clusters of OB stars. This supports the view that massive stars do not form in isolation. In the case of G11.11-0.40 we could identify the central O star responsible for the ionization of the ultracompact HII region. Our results for G341.21-0.21 indicate that this source is a precursor of an ultracompact HII region.

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http://www.mpia-hd.mpg.de/homes/feldt/uchii_3.pdf

Protoplanetary Disks in the Nearest Star-Forming Cloud: Mid-Infrared Imaging and Optical Spectroscopy of MBM 12 Members

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The recent identification of several groups of young stars within 100 parsecs of the Sun has generated widespread interest. Given their proximity and possible age differences, these systems are ideally suited for detailed studies of star and planet formation. Here we report on the first investigation of protoplanetary disks in one such group, the high-latitude cloud MBM 12 at a distance of ∼65 pc. We present mid-infrared observations of the eight candidate pre-main-sequence (PMS) members and the two main-sequence (MS) stars in the same line-of-sight which may or may not be associated with the group. We have also derived Hα and Li line widths from medium-resolution optical spectra. We report the discovery of significant mid-infrared excess from six PMS stars –LkHα 262, LkHα 263, LkHα 264, E02553+2018, RXJ0258.3+1947 and S18 –presumably due to optically thick circumstellar disks. Our flux measurements for the other two PMS stars and the two MS stars are consistent with photospheric emission, allowing us to rule out dusty inner disks. The disks we have found in MBM 12 represent the nearest known sample of very young protoplanetary systems, and thus are prime targets for high-resolution imaging at infrared and millimeter wavelengths.

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X-ray emission of multiple T Tauri stars in Taurus

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We present a study of X-ray emission of known multiple T Tauri stars (TTS) in Taurus based on ROSAT observations. We used the ROSAT All-Sky Survey (RASS) detection rates of single classical (cTTS) and weak-line TTS (wTTS) to investigate statistically the TTS nature (classical or weak-line) of the components in multiple TTS, which are too close for spatially resolved spectroscopy so far. Because single wTTS show a higher RASS detection rate than single cTTS, the different binary TTS (cTTS-cTTS, cTTS-wTTS, wTTS-wTTS) should also have different detection rates. We find that the observed RASS detection rates of binary wTTS, where the nature of the secondary is unknown, are in agreement with the secondaries being wTTS rather than cTTS, and mixed pairs are very rare.

Furthermore we analyse the X-ray emission of TTS systems resolvable by the ROSAT HRI. Among those systems we find statistical evidence that primaries show larger X-ray luminosity than secondaries, and that the samples of primary and secondary TTS are similar concerning X-ray over bolometric luminosity ratio. Furthermore, primaries always emit harder X-rays than secondaries. In all cases where rotational velocities and/or periods are known for both companions, it is always the primary that rotates faster. Hence, the stronger X-ray emission of the primaries may be due to higher bolometric luminosity and/or faster rotation.

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Discovery of molecular hydrogen line emission associated with methanol maser emission

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We report the discovery of H_2 line emission associated with 6.67 GHz methanol maser emission in massive star forming regions. In our UNSWIRF/AAT observations, H_2 1–0 S(1) line emission was found associated with an ultracompact HII region *IRAS* 14567–5846 and isolated methanol maser sites in G318.95–0.20, *IRAS* 15278–5620 and *IRAS* 16076–5134. Due to the lack of radio continuum in the latter three sources, we argue that their H_2 emission is shock excited, while it is UV-fluorescently excited in *IRAS* 14567–5846. Within the positional uncertainties of 3 arcsec the maser sites correspond to the location of infrared sources. We suggest that 6.67 GHz methanol maser emission is associated with hot molecular cores, and propose an evolutionary sequence of events for the process of massive star formation.

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A jet/sidewind interaction model for the curved jets in the Orion Nebula

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Bally & Reipurth (2000) have recently discovered a number of Herbig-Haro (HH) jets in the periphery of the Orion Nebula (M 42). Many of these outflows show jets and counterjets that both curve away from the central regions of M 42. These curved outflows appear to be evidence for an interaction of the jets with an outwards flow in the H II region. In this paper, we present 3D gasdynamic models of HH jet/sidewind interactions, showing that structures similar to the ones observed in the newly discovered jets are straightforwardly obtained. In particular, we concentrate on modelling the HH 505 jet, and obtain one of the best agreements that have ever been obtained in modelling emission line maps of HH objects with gasdynamic models.

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Dynamical Relaxation and Massive Extrasolar Planets

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Following the suggestion of Black (1997) that some massive extrasolar planets may be associated with the tail of the distribution of stellar companions, we investigate a scenario in which $5 \leq N \leq 100$ planetary mass objects are assumed to form rapidly through a fragmentation process occuring in a disc or protostellar envelope on a scale of 100 au. These are assumed to have formed rapidly enough through gravitational instability or fragmentation that their orbits can undergo dynamical relaxation on a timescale ~ 100 orbits.

Under a wide range of initial conditions and assumptions, the relaxation process ends with either (i) one potential 'hot Jupiter' plus up to two 'external' companions, i.e. planets orbiting near the outer edge of the initial distribution; (ii) one or two 'external' planets or even none at all; (iii) one planet on an orbit with a semi–major axis 10 to a 100 times smaller than the outer boundary radius of the inital distribution together with an 'external' companion. Most of the other objects are ejected and could contribute to a population of free floating planets. Apart from the potential 'hot Jupiters', all the bound objects are on orbits with high eccentricity, and also with a range of inclination with respect to the stellar equatorial plane. We found that, apart from the close orbiters, the probability of ending up with a planet orbiting at a given distance from the central star increases with the distance. This is because of the tendency of the relaxation process to lead to collisions with the central star. The scenario we envision here does not impose any upper limit on the mass of the planets. We discuss the application of these results to some of the more massive extrasolar planets.

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Also available at http://www.iap.fr/users/terquem/index.html

Non-axisymmetric accretion on the classical TTS RW Aur A

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High–resolution spectroscopic monitoring of the exceptionally active classical T Tauri star (CTTS) RW Aur A was carried out in three seasons of 1996, 1998 and 1999 with simultaneous B, V photometry. The high quality spectra

revealed a multicomponent structure of the spectrum, which includes: 1) a veiled photospheric spectrum of a K1–K4 star, 2) broad emission lines of neutrals and ions, 3) narrow emission lines of He I and He II, 4) red–shifted accretion features of many lines, 5) shell lines at about the stellar velocity, 6) blue–shifted wind features and 7) forbidden lines. Periodic modulations in many spectral features were found. The photospheric absorption lines show sinusoidal variations in radial velocity with an amplitude of $\pm 6\,\mathrm{km\,s^{-1}}$ and a period of about $2\overset{\mathrm{d}}{.}77$. The radial velocities of the narrow emission lines of He vary with the same period but in anti–phase to the photospheric lines. The equivalent widths of the narrow emissions vary with a phase–shift with respect to the velocity curve. The strength of the red–shifted accretion components of Na D and other lines is also modulated with the same period. The broad emission lines of metals vary mostly with the double period of about $5\overset{\mathrm{d}}{.}5$.
One unexpected result is that *no correlation* was found between the veiling and the brightness, although both parameters varied in wide ranges. This is partly due to a contribution of the shell absorption to the photospheric line profiles, which make them vary in width and depth thus simulating lower veiling.
The spectral lines of the accreting gas show two distinct components: one is formed at low velocity at the beginning of the accretion column, and the other at high velocity near the stellar surface. The low velocity components are strong in low excitation lines of neutrals, while the high velocity components are strong in high excitation lines of ions, thus showing the gradients of temperature and density along the accretion column.
Most of the observed features can be interpreted in the framework of non–axisymmetric magnetospheric accretion, but the origin of this asymmetry can be explained in different ways. We consider two possible models. The first model suggests that RW Aur A is a binary with a brown dwarf secondary in a nearly circular orbit with a period of $2\overset{\mathrm{d}}{.}77$. The orbiting secondary generates a moving stream of enhanced accretion from one side of the disk towards the primary. The other model assumes that RW Aur A is a single star with a rotational period of $5\overset{\mathrm{d}}{.}5$ and with two footpoints of channeled accretion streams within a global magnetosphere which is tilted relative to the rotational axis or otherwise non–axisymmetric. Both models can explain qualitatively and quantitatively most of the observed variations, but there are some details which are less well accounted for.

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The preprint is available at http://cc.oulu.fi/˜rdummler/publications.html

A numerical model for the Serpens radio jet

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The Serpens ("triple source") radio continuum jet shows a series of aligned knots with $\approx$ 1-2″ angular separations, forming a curved structure circumscribed within a cone of $\sim 10^\circ$ full opening angle. We present a high resolution, 3D numerical simulation of a jet with variable ejection direction and velocity with parameters appropriate for the Serpens jet, from which we obtain predictions of 3.6 cm radio continuum maps. We find that the general morphology of the radio emission, and the time evolution of the successive knots, qualitatively agree with 3.6 cm VLA observations of the Serpens radio jet.

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A precessing, variable velocity jet model for DG Tau

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We present a first attempt at reproducing the morphology and kinematical properties of the DG Tau microjet using a 3D hydrodynamical numerical simulation of a precessing, variable velocity jet. Synthetic maps and position-velocity diagrams in Hα and [O I]λ6300 are calculated and compared with recent imaging and spectro-imaging observations (Lavalley-Fouquet et al. 2000, Dougados et al. 2000). Several observed properties are qualitatively reproduced, such as the knot separation, width, and asymmetric morphology, and the increase in ionization fraction and decrease in electronic density away from the star. However, the predicted kinematics in the region between the two jet knots differs from the observed behaviour. This discrepancy probably results from our simple assumption of a sinusoidal velocity variability, and points to a more complex velocity time-variability in the jet from DG Tau.

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A numerical and experimental study of the time-evolution of a low Mach number jet

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We present a comparison between a plasma-generated "starting jet" experiment, and an axisymmetric numerical simulation of the flow. The experimental flow and the numerical simulation give results that agree both qualitatively and quantitatively, showing that the complex vortical structures arising in the flow are surprisingly well reproduced by the numerical model. This result gives confidence in the accuracy of astrophysical jet numerical simulations. Also, even though the Mach number of our laboratory jet is somewhat low ($M \sim 0.5$), the dimensionless parameters of this jet are not very far from the ones expected for Faranoff-Riley class I radio jets.

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The Formation of Brown Dwarfs as Ejected Stellar Embryos

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We conjecture that brown dwarfs are substellar objects because they have been ejected from small newborn multiple systems which have decayed in dynamical interactions. In this view, brown dwarfs are stellar embryos for which the star formation process was aborted before the hydrostatic cores could build up enough mass to eventually start hydrogen burning. The disintegration of a small multiple system is a stochastic process, which can be described only in terms of the half-life of the decay. A stellar embryo competes with its siblings in order to accrete infalling matter, and the one that grows slowest is most likely to be ejected. With better luck, a brown dwarf would therefore have become a normal star. This interpretation of brown dwarfs readily explains the rarity of brown dwarfs as companions to normal stars (aka the "brown dwarf desert"), the absence of wide brown dwarf binaries, and the flattening of the low mass end of the initial mass function. Possible observational tests of this scenario include statistics of brown dwarfs near Class 0 sources, and the kinematics of brown dwarfs in star forming regions while they still retain a kinematic signature of their expulsion. Because the ejection process limits the amount of gas brought along in a disk, it is predicted that substellar equivalents to the classical T Tauri stars should be very rare.

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New models of interstellar gas-grain chemistry. II. Surface photochemistry in quiescent cores.

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The photodissociation of surface species, caused by photons from the cosmic ray-induced and background interstellar radiation fields, is incorporated into our combined gas-phase and grain-surface chemical models of quiescent dense interstellar cores. For the cores studied here, only cosmic ray-induced photons are important. We find that photodissociation alters gas-phase and surface abundances mainly at large cloud ages ($\gtrsim 10^{6-7}$ yr). The abundances of those surface species, such as H_2O, that are readily reproduced on the surface following photodissociation are not strongly affected at any time. The abundances of surface species that are, on the other hand, reformed slowly via surface reactions possessing activation energy (e.g. CH_3OH) are reduced, while the abundances of associated surface photoproducts (e.g. CO) increase. In the gas phase, inclusion of surface photodissociation tends to increase molecular abundances at late times, slightly improving the agreement with observation for TMC-1.

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New Class II Methanol Masers in W3(OH)

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We report interferometric observations of nine class II methanol maser-candidate lines towards W3(OH). Narrow maser emission spikes at $v_{lsr} = -43.1$ km s^{-1} are present in three of the lines: $3_1 - 4_0$ A$^+$, $7_2 - 6_3$ A$^+$, and $7_2 - 6_3$ A$^-$. For all three lines the maser position is near the northern edge of the W3(OH) ultracompact HII region (maser emission is also seen near the southern edge in the $3_1 - 4_0$ A$^+$ line). For the remaining six lines there is no obvious counterpart to the narrow maser spike at -43.1 km s^{-1}. Additional spatially extended emission is present in all nine lines over the range from -41 to -48 km s^{-1}.

By comparing our observed flux densities with an extensive set of model calculations, we infer physical characteristics of the maser region. In these calculations the methanol is excited by infrared radiation from warm dust, and this excited gas amplifies the free-free background emission from the ultracompact HII region. The gas forming the narrow maser spikes appears to have both high kinetic temperature, $T_{\rm kin} \geq 110$ K, and high density, $n_{\rm H_2} \approx 10^7$ cm^{-3}. Low temperature solutions are ruled out by the observed line ratios, and low density solutions by the unphysically large path length that would be required. The gas is rich in methanol ($2N_{\rm M} = N_{\rm A} + N_{\rm E} \geq 10^{-6}\ N_{H_2}$), and the methanol column density in the tangential direction for each symmetry species (divided by linewidth) is $N_{\rm M}/\Delta V \approx 10^{12}$ cm^{-3} s. Somewhat lower values of $n_{\rm H_2}$ and $N_{\rm M}/\Delta V$ are also acceptable. The size of the region emitting the maser spike is of order 100 x 1000 AU.

In most of the lines the broad emission from -41 to -48 km s^{-1} can also be attributed to weak maser action, produced in gas with similar physical conditions (high density and temperature). It differs from the narrow spike emission mainly through a beaming factor which can be interpreted as an elongation factor for clumps of maser gas. The combination of narrow and broad emission can arise naturally from an ensemble of clumps of different elongations and orientations. In this unified picture the best fit to the data is provided by $n_{\rm H_2} \approx 2 \times 10^6$ cm^{-3} and $N_{\rm M}/\Delta V \approx 4 \times 10^{11}$ cm^{-3} s, somewhat lower than the values obtained for just the spike component. The methanol maser clumps may be present in an expanding shell surrounding the HII region, similar to the material producing OH maser emission in this source.

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Constraints on properties of the protoplanetary disks around UX Ori and CQ Tau

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We present Very Large Array observations of the intermediate mass pre-main-sequence stars UX Ori and CQ Tau at 7 mm, 3.6 cm, and 6 cm. These stars are members of the UX Ori variability class, where the origin of optical variability is thought to derive from inhomogeneities in circumstellar disks. Both stars are detected at 7 mm but not at longer wavelengths, which confirms that the millimeter emission is dominated by dust.

The UX Ori system exhibits a remarkably flat spectral index in the millimeter range, with $\alpha_{mm} \sim 2$ ($F_\nu \propto \nu^{\alpha_{mm}}$). Two different disk models can reproduce this property: i) a physically small disk with optically thick emission, truncated at a radius about 30 AU, or ii) a massive ($\sim 0.3 - 1 M_\odot$) disk mainly composed of dust particles grown to radii of 10 cm ("pebbles"). The observations do not spatially resolve the 7 mm emission. We discuss implications of these two models and suggest observational tests that will discriminate between them.

The CQ Tau system exhibits a spectral index in the millimeter range of $\alpha_{mm} \sim 2.6$, consistent with values commonly found for disks around pre-main-sequence stars. The observations marginally resolve the 7 mm emission as an elongated structure with full width at half maximum of $2.4'' \times 1.1''$ (240×110 AU at 100 pc distance). The size and inclination of ~ 63 degrees (implied by circular symmetry) are consistent with flared disk models previously suggested to explain the optical colors and polarization properties.

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

Discovery of X rays from Class 0 protostar candidates in OMC-3

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We have observed the Orion Molecular Clouds 2 and 3 (OMC-2 and OMC-3) with the Chandra X-ray Observatory (CXO). The northern part of OMC-3 is found to be particularly rich in new X-ray features; four hard X-ray sources are located in and along the filament of cloud cores. Two sources coincide positionally with the sub*mm*-*mm* dust condensations of MMS 2 and 3 or an outflow radio source VLA 1, which are in a very early phase of star formation. The X-ray spectra of these sources show an absorption column of (1–3) $\times 10^{23}$ H cm^{-2}. Assuming a moderate temperature plasma, the X-ray luminosity in the 0.5–10 keV band is estimated to be $\sim 10^{30}$ erg s^{-1} at a distance of 450 pc. From the large absorption, positional coincidence and moderate luminosity, we infer that the hard X-rays are coming from very young stellar objects embedded in the molecular cloud cores.

We found another hard X-ray source near the edge of the dust filament. The extremely high absorption of 3 $\times 10^{23}$ H cm^{-2} indicates that the source must be surrounded by dense gas, suggesting that it is either a YSO in an early accretion phase or a Type II AGN (e.g. a Seyfert 2), although no counterpart is found at any other wavelength.

In contrast to the hard X-ray sources, soft X-ray sources are found spread around the dust filaments, most of which are identified with IR sources in the T Tauri phase.

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The composition of circumstellar gas and dust in 51 Oph

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We analyze ISO archive data of the nearby bright emission-line star 51 Oph, previously classified as a proto-planetary system similar to β Pic. The infrared spectrum reveals the presence of gas-phase emission bands of hot ($\sim$ 850 K) CO, CO_2, H_2O and NO. In addition to this, partially crystalline silicate dust is present. The solid-state bands and the energy distribution are indicative of dust that has formed recently, rather than of debris dust. The presence of hot molecular gas and the composition of the circumstellar dust are highly unusual for a young star and are reminiscent of what is found around evolved (AGB) stars, although we exclude the possibility of 51 Oph belonging to this group. We suggest several explanations for the nature of 51 Oph, including a recent episode of mass loss from a Be star, and the recent destruction of a planet-sized body around a young star.

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

A SCUBA survey of compact dark Lynds clouds

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We present the first results of a submillimetre continuum survey of Lynds dark clouds. Submillimetre surveys of star forming regions are an important tool to obtain representative samples of the very first phases of star formation. Maps of 24 small clouds were obtained with SCUBA, the bolometer array receiver at the James Clark Maxwell Telescope, and 19 clouds were detected. The total dark cloud area surveyed was $\sim$130 arcmin^2, and a total gas mass of 90 $M_\odot$ was detected. The dust emission is in general in good agreement with the extinction of optical starlight. The observed clouds contain a newly discovered protostar in L944, and a previously known protostar IRAS 23228+4320 in L1246. Another 8 starless cores, either gravitationally unbound, or pre-stellar in nature, have also been detected. All starless cores and protostars are detected in only 7 clouds, and the remaining 17 clouds seem quiescent and do not show any signs of recent star formation activity. The 850-μm images of all detected clouds are presented as well as 450-μm images of L328, L944, L1014, and L1262. The outflows of the protostars in L944 and L1246 have also been discovered and are mapped in ^{12}CO $J = 2 \rightarrow 1$. The detection of the young protostar in L944, which is not present in the IRAS point source catalogue, shows the capacity of submillimetre surveys to detect unknown protostars.

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Interstellar oxygen chemistry

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We present results of chemical models for a variety of types of regions shown by SWAS observations to contain less O_2 and H_2O than previously expected. We identify time-dependent models for which O_2 and H_2O abundances meet the SWAS constraints and for which calculated abundances of other species are in harmony with measurements made primarily at millimeter wavelengths. The phases of acceptable composition are transient in these time-dependent

models but are of very substantial length in many models for which CO and N_2 are assumed to be returned promptly and unaltered to the gas phase though other species, except for H_2 and He, freeze-out onto the dust. We also consider whether the presence of bistability in some steady-state models can account for the SWAS and other observations.

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http://www.star.ucl.ac.uk/ sv/pub/oxy.ps

Chemical signatures of shocks in hot cores

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The characteristic chemistry of hot cores arises from the abrupt evaporation of icy mantles when a massive star begins to irradiate the interstellar gas in its vicinity. Such stars are also likely to generate powerful winds which may initiate shocks in the same interstellar gas. In this paper, we consider whether chemical signatures of the passage of a shock through a hot core can be identified. We find that if hydrogenation occurs on surfaces and freeze-out of heavy gas-phase atoms and molecules is complete before the hot core is established then no such chemical signature exists. However, if some residual material is present in the gas when the hot core is established then the following molecular abundance ratios are significantly affected by the presence of a shock: NS/CS, SO/CS, and HCO/H_2CO. This result is more evident if injection of ices into the gas occurs over a finite period, rather than instantaneously. We conclude that these molecular abundance ratios may be useful tracers of the dynamical history of hot cores, and that follow-up observational studies are required.

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http://www.star.ucl.ac.uk/ sv/pub/shock.ps

Hot Cores in W49N and the Timescale for Hot Core Evolution

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We present sub-arcsecond resolution observations of the star forming region W49N made with the Berkeley Illinois Maryland Association (BIMA) Array at 1.4 millimeters wavelength in the continuum and CH_3CN J=12–11 lines. The continuum image, at a resolution of $0\farcs18$ (2000 AU), shows many of the previously identified ultracompact HII regions and at least one new source whose steep spectrum to short wavelengths indicates dust emission. This compact dust concentration also shows the strongest CH_3CN emission in the region. Additional peaks of CH_3CN emission likely mark hot cores produced by other deeply embedded young massive stars that may be precursors to O type stars like those that power the ultracompact HII regions. The number ratio of hot cores to ultracompact HII regions found in W49N provides a measure of the relative timescales of these early evolutionary phases. Although the samples are small, the source counts suggest that the hot core liftetime is most likely shorter than, but comparable to, the ultracompact HII region lifetime.

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Evolution of Planetary Disks: Observations, Modeling and Instrumental Prospect

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The recently discovered extrasolar planets have formed in gaseous and dusty disks possibily analogous to those observed around stars close to the Main Sequence, such as β Pictoris. This thesis deals with the dust in circumstellar environments around such stars and combines: high angular resolution observations, the modeling of grains' physical and chemical properties to deduce their optical behaviour, the modeling of optically thin disks, and the dynamics of planetesimals that release the dust grains observed.

Our images obtained with the Hubble Space Telescope reveal two new circumstellar disks around HD 141569 and HD 100546, two stars sometimes classified as Herbig-like stars. Whereas the two systems have almost the same age ($\sim$10 million years), their morphologies differ. These observations highlight the difficulties to ellaborate a single scenario that would describe the all evolution of protoplanetary systems.

The dust ring surrounding HR 4796 A, a star with an age similar to the two previous stars, is marginaly resolved from the ground. The full modeling of this disk allows to reproduce all the available observations. These results imply that, whereas the star is still quite young, planetesimals should be present to supply the disk in porous and amorphous dust grains which are afterwards blown away by radiation pressure.

A dynamical model for the prototypical disk around β Pictoris is proposed. Assuming realistic optical grain properties, this approach allows to reproduce the main caracteristics of the disk and in particular the fine asymmetries that are observed. This model assumes the presence of a planetary companion which perturbes a disk of planetesimals and takes into account the differential effect of the radiation pressure on the grains.

Finally, the disk model I developped during the thesis is used in order to optimize the use of future observationnal instruments.

Alfvenic Heating of disks and accretion columns of Classical T Tauri Stars

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In this work, we investigate the role that Alfvenic heating plays on protostellar accretion disks and in the magnetic funnels of gas that connect the accretion disk to the surface of a Classical T Tauri star. In order to quantify it, we analyze the damping of Alfvén waves taking into account the intrinsic properties of each one of those environments. The Alfvenic heating on protostellar accretion disks was treated into the standard accretion disk approximation (Pringle 1981) and also into the layered model of Gammie (1996). For both models, two damping mechanisms were studied: nonlinear and turbulent. We derive damping lengths, heating rates and energy fluxes, all of them related to the dissipation of the Alfvén wave modes as a function of the disk density, temperature and magnetic field intensity. The results show us that Alfvenic heating contributes to the temperature increase of the disk gas, mainly if the damping mechanism is turbulent. For the magnetic funnels of T Tauri stars, we studied four damping mechanisms: nonlinear, turbulent, collisional and viscous-resistive. We use the magnetospheric accretion model by Hartmann, Hewett & Calvet (1994), but adopting an *ad hoc* temperature profile slightly different that, however, still fits the observations. We consider two different hypothesis for the generation of Alfvén waves. Firstly, the waves are generated at the surface of the star; then, the waves are generated locally, throughout the tube. Despite the place where they are formed, Alfvén waves are quickly and locally damped. We also analyze thermal conduction in the tube and found it to be very low, unable to transport the locally generated Alfvenic energy to more distant regions. Taking this into account, we conclude that when Alfvén waves are generated locally they can be responsible for the high temperatures obtained from observations. In this case, the degree of turbulence related to the waves is constrained and we found that it doesn't need to be very high to generate the desired heating rates.

New Jobs

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Meetings

First Announcement

Simulations of Magnetohydrodynamic Turbulence in Astrophysics: Recent Achievements and Perspectives

A workshop to be held in Paris, July 2-6, 2001.

Co-chairs: E. Falgarone and T. Passot.

The deadline for submission of abstracts is April 15th.

Information on the workshop can be found on the site:

http://www.obs-nice.fr/passot/conf2001/conf.html

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/ .

The Promise and Pitfalls of High Contrast Imaging

A Special Session at the 198th AAS Meeting
Thursday June 7 2001, Pasadena, CA

The close surroundings of bright astronomical sources is an underexplored frontier of observational astrophysics. Planetary systems form and evolve on a stage deep within the glare of their central stars; the properties of quasars and AGN are linked to the context of their host environments. High contrast imaging at high spatial resolution is becoming increasingly important as a tool to address these and other astronomical topics, but is seldom (if ever) discussed in a unified forum. This session will bring together observers confronting the observational limits of current techniques, and instrumentalists who are developing the next generation of facilities that will enable future advances. The session will address the following topics:

- Studies of circumstellar matter, substellar companions, and quasar host galaxies
- The capabilities and limitations of high contrast imaging with current facilities such as HST, and large telescopes with adaptive optics
- Future instrument concepts leading to the direct detection of extrasolar planets

To encourage debate and freewheeling discussion, the session will be divided into a set of short reviews, followed by a panel discussion in which the reviewers will serve as panelists and the audience will be invited to participate. Abstracts are invited for an associated poster session to be scheduled on the same day, and should be submitted at the meeting webpage: http://www.aas.org/meetings/aas198/prelim/prelim.html.

The abstract deadline is Wednesday March 28 2001. Comments or questions should be directed to Karl Stapelfeldt (krs@exoplanet.jpl.nasa.gov).

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