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Abstracts of recently accepted papers

A reduced efficiency of terrestrial planet formation following giant planet migration

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Substantial orbital migration of massive planets may occur in most extrasolar planetary systems. Since migration is likely to occur after a significant fraction of the dust has been locked up into planetesimals, ubiquitous migration could reduce the probability of forming terrestrial planets at radii of the order of 1 au. Using a simple time dependent model for the evolution of gas and solids in the disk, I show that replenishment of solid material in the inner disk, following the inward passage of a giant planet, is generally inefficient. Unless the timescale for diffusion of dust is much shorter than the viscous timescale, or planetesimal formation is surprisingly slow, the surface density of planetesimals at 1 au will typically be depleted by one to two orders of magnitude following giant planet migration. Conceivably, terrestrial planets may exist only in a modest fraction of systems where a single generation of massive planets formed and did not migrate significantly.

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The evolutionary state of stars in the NGC1333S star formation region

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We present 2μm near-IR spectroscopic observations of a sample of 33 objects in the NGC1333S active star forming cluster centred on the pre-main sequence star SSV 13. We have previously studied this region photometrically in the optical and near-IR and, with the addition of these near-IR spectra, we further probe the pre-main sequence cluster membership and evolutionary state. From the atomic and molecular absorption features observed together with the earlier photometry, we derive spectral types, effective temperatures, masses and ages of the stars and conclude that almost all (90%) the stars observed in this sample are pre-main sequence objects. This result significantly refines the evolutionary information obtained from photometric evidence alone. Comparison with theoretical evolutionary tracks and isochrones suggests that our survey has sampled sources with masses in the range 0.2–2Msun and stellar ages between 7×10^4 and 1×10^8 years with a preponderance of sources around 3×10^6 years. This implies the presence of low- to intermediate mass T Tauri stars of evolutionary designation Class I to Class III. We conclude that star formation seems to have occurred in likely several bursts rather than occurring coevally. Star formation in such a region as NGC1333S is likely significantly affected by the large number of active molecular outflows in the region which could provide a mechanism for cloud turbulence and the onset of subsequent star formation.

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http://ftp.gemini.edu/staff/caa/Aspin.ps.gz

Binarity in Brown Dwarfs: T Dwarf Binaries Discovered with the Hubble Space Telescope WPFC2

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We present the discovery of two T dwarf binaries, 2MASS 1225−2739AB and 2MASS 1534−2952AB, identified in a sample of ten T dwarfs imaged with the Hubble Space Telescope Wide Field Planetary Camera 2. Companionship is established by the uniquely red F814W−F1042M colors of the binary components, caused by heavily pressure-broadened K I absorption centered at 7665 & 7699 Å. The separations of the two binary systems are 0.282±0.005 arcsec and 0.065±0.007 arcsec, implying projected separations of 3.17±0.14 and 1.0±0.3 AU, respectively. These close separations are similar to those found in previous brown dwarf binary searches, and permit orbital mapping over the coming decade. 2MASS 1225−2739AB has a substantially fainter secondary, with $\Delta M_{F814W} = 1.59\pm0.04$ and $\Delta M_{F1042M} = 1.05\pm0.03$; this system is likely composed of a T6 primary and T8 secondary with mass ratio 0.7–0.8. The observed binary fraction of our HST sample, 20^{+17}_{-7}%, is consistent with results obtained for late-M and L field dwarfs, and implies a bias-corrected binary fraction of 9^{+15}_{-4}% for $a \geq 1$ AU and $q \geq 0.4$, significantly lower than the binary fractions of F–G and early-type M dwarf stars. Neither of the T binaries have separations $a \geq 10$ AU, consistent with results from other brown dwarf binary searches. Using the statistical models of Weinberg, Shapiro, & Wasserman, we conclude that tidal disruption by passing stars or Giant Molecular Clouds, which limits the extent of wide stellar binaries, plays no role in eliminating wide brown dwarf binaries, implying either disruption very early in the formation process (ages $\leq 1 - 10$ Myr) or a formation mechanism which precludes such systems. We find that the maximum binary separation in the brown dwarf regime appears to scale as M^2_{total}, a possible clue to the physical mechanism which restricts wide substellar systems.

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VLA Observations of Proper Motions in YLW15

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Using high angular resolution ($\sim 0\farcs3$) Very Large Array observations made at 3.6 cm during the period 1990 to 2002, we report the detection of proper motions in the components of the binary source YLW 15. The absolute proper motions observed in these two protostars, of the order of 26 $mas\ yr^{-1}$, or $\sim 15\ km\ s^{-1}$ at a distance of 120 pc, are very similar in magnitude and direction to those of another protostar and of T Tauri stars in the same region and are attributed to the large-scale motions of the parent molecular complex. The relative astrometry between the two components (separated by $\sim 0\farcs6$) reveals orbital proper motions that suggest that a lower limit to the total mass and an upper limit to the period of the binary system are $\sim 1.7\ M_\odot$ and 360 yr, respectively. The results also suggest that VLA 1 is more massive than VLA 2.

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Orbital Migration and Mass Accretion of Protoplanets in 3D Global Computations with Nested Grids

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We investigate the evolution of protoplanets with different masses embedded in an accretion disk, via global fully three-dimensional hydrodynamical simulations. We consider a range of planetary masses extending from one and a half Earth's masses up to one Jupiter's mass, and we take into account physically realistic gravitational potentials of forming planets. In order to calculate accurately the gravitational torques exerted by disk material and to investigate the accretion process onto the planet, the flow dynamics has to be thoroughly resolved on long as well as short length scales. We achieve this strict resolution requirement by applying a *nested-grid* refinement technique which allows to greatly enhance the local resolution. Our results from altogether 51 simulations show that for large planetary masses, approximately above a tenth of the Jupiter's mass, migration rates are relatively constant, as expected in *type II* migration regime and in good agreement with previous two-dimensional calculations. In a range between seven and fifteen Earth's masses, we find a dependency of the migration speed on the planetary mass that yields time scales considerably longer than those predicted by linear analytical theories. This property may be important in determining the overall orbital evolution of protoplanets. The growth time scale is minimum around twenty Earth-masses, but it rapidly increases for both smaller and larger mass values. Significant differences between two- and three-dimensional calculations are found in particular for objects with masses smaller than ten Earth-masses. We also derive an analytical approximation for the numerically computed mass growth rates.

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The paper is available as an ApJ Preprint at
`http://www.journals.uchicago.edu/ApJ/journal/preprints/ApJ56728.preprint.pdf`

Understanding the spectra of isolated Herbig stars in the frame of a passive disk model

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We discuss spectral energy distributions of a sample of Herbig Ae/Be stars in the context of a passive irradiated disk model. The data have been presented earlier by Meeus et al (2001), and preliminary interpretations of these data were given in that paper. While the spectra of Herbig Ae stars all show similarities, there is significant variation between the spectra, in particular in the shape of the mid-IR rise and in the presence or absence of a silicate feature. We explore the hypothesis that all these different spectra can be interpreted as pure disk spectra without additional components. Using the model of Dullemond, Dominik and Natta (2001) we deduce the disk parameters of a number of the sources, and find that for a large fraction of investigated sources, satisfactory fits can be obtained. The derived model parameters show that some group Ia sources can only be fit with radially increasing surface densities, indicating the presence of depleted inner disk regions. The steep-sloped SEDs of group IIa sources can be fit with very compact disks, probably representing disks with collapsed outer regions. The largest difficulties arise from sources that do not show significant silicate emission features. Our attempts to explain these objects with a pure geometric effect are only partially successful. It seems that these stars indeed require a strong depletion of small silicate grains.

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Studying Infall

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The study of protostellar collapse or infall has proven unusually difficult and controversial. Some historical context will be provided, against which recent advances can be measured. We now have a substantial number of objects with signatures that can be interpreted in terms of collapse, but a number of issues remain. One issue is the effect of chemical variations, especially depletion in the dense, cold interiors of cores that are likely to form low mass stars. Strategies for dealing with this issue depend on using dust emission to constrain the density and temperature distribution, leaving molecular line observations to constrain dynamics and abundance distributions. Recent progress in this area will be described and we will consider the next challenges to be overcome. Interferometeric observations, especially with future instruments, will provide a powerful tool. In combination with chemical studies coupled with dynamical models, the observations made possible by interferometers should finally put this subject on a firm foundation.

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The contributions of J-type shocks to the emission from molecular outflow sources

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We present the results of modelling of the H_2 emission from molecular outflow sources, induced by J-type shock waves propagating in the gas. We emphasize the importance of proper allowance for departures from equilibrium owing to the finite flow velocity of the hot, compressed gas, with special reference to the excitation, dissociation and reformation of H_2. The salient features of our computer code are described. The code is applied to interpreting the spectra of the outflow sources Cepheus A West and HH43. Particular attention is paid to determining the cooling times in shocks whose speeds are sufficient for collisional dissociation of H_2 to take place; the possible observational consequences of the subsequent reformation of H_2 are also examined. Because molecular outflow sources are intrinsically young objects, J-type shocks may be present in conjunction with magnetic precursors, which have a C-type structure. We note that very diferent physical and dynamical conditions are implied by models of C- and J-type shocks which may appear to fit the same H_2 excitation diagram.

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Spatial study with the VLT of a new resolved edge-on circumstellar dust disk discovered at the periphery of the ρ Ophiuchi dark cloud

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We report the discovery in near-infrared (NIR) with SofI at the *New Technology Telescope* (NTT) of a resolved circumstellar dust disk around a 2MASS source at the periphery of the ρ Ophiuchi dark cloud. We present follow-up observations in J, H, and K_s-band obtained with ISAAC at the *Very Large Telescope* (VLT), under $0\farcs4$-seeing conditions, which unveil a dark dust lane oriented East-West between two characteristic northern and southern reflection nebulae. This new circumstellar dust disk has a radius of $2\farcs15$ (300 AU at 140 pc), and a width of $1\farcs2$ (170 AU

at 140 pc). Thanks to its location at the periphery of the dense cores, it suffers small foreground visual extinction ($A_V = 2.1 \pm 2.6$ mag). Although this disk is seen close to edge-on, the two reflection nebulae display very different colors. We introduce a new NIR data visualization called "Pixel NIR Color Mapping" (PICMap for short), which allows to visualize directly the NIR colors of the nebula pixels. Thanks to this method we identify a ridge, $0\farcs3$ (40 AU at 140 pc) to the north of the dark lane and parallel to it, which displays a NIR color excess. This ridge corresponds to an unusual increase of brightness from J to K_S, which is also visible in the NTT observation obtained 130 days before the VLT one. We also find that the northern nebula shows $\sim$3 mag more extinction than the southern nebula. We compute axisymmetric disk models to reproduce the VLT scattered light images and the spectral energy distribution from optical to NIR. Our best model, with a disk inclination $i = 86 \pm 1°$, correctly reproduces the extension of the southern reflection nebula, but it is not able to reproduce either the observed NIR color excess in the northern nebula or the extinction difference between the two reflection nebulae. We discuss the possible origin of the peculiar asymmetrical NIR color properties of this object.

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Dust emission from inhomogeneous interstellar clouds

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Due to the complexity of their structure, the theoretical study of interstellar clouds must be based on three-dimensional models. It is already possible to estimate the distribution of equilibrium dust temperature in fairly large 3D models and, therefore, also to predict the resulting far-infrared and sub-mm emission. Transiently heated particles introduce, however, a significant complication and direct calculation of emission at wavelengths below 100μm is currently not possible in 3D models consisting of millions of cells. Nevertheless, the radiative transfer problem can be solved with some approximations. We present a numerical code for continuum radiative transfer that is based on the idea of a 'library' describing the relation between the intensity of the local radiation field and the resulting dust emission spectrum. Given this mapping it is sufficient to simulate the radiation field only at a couple of reference wavelengths. Based on the library and local intensities at the reference wavelengths the radiative transfer equation can be integrated through the source and an approximation of the emission spectrum is obtained. Tests with small models where the radiative transfer problem can be solved directly show that with our method one can easily obtain an accuracy of a few per cent. This depends, however, on the opacity of the source and the type of the radiation sources included. As examples we show spectra computed from three-dimensional MHD simulations containing up to 128^3 cells. The models represent starless, inhomogeneous interstellar clouds embedded in the normal interstellar radiation field. The intensity ratios between IRAS bands show large variations that follow the filamentary structure of the density distribution. The power law index of the spatial power spectrum of the column density map is -2.8. In infrared maps temperature variations increase the power at high spatial frequencies, and in a model with average visual extinction $\langle A_V \rangle \sim 10$ the power law index varies between -2.5 and -2.7. Assuming constant dust properties throughout the cloud, the IRAS ratio $\langle I_{60}/I_{100} \rangle$ decreases in densest cores only by a factor of $\sim$4 compared with the value in diffuse medium. Observations have shown that the in reality the ratio can decrease twice as much even in optically thinner clouds. This requires that most of the small grains are removed in these regions, and possibly a modification of the properties of large grains.

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Turbulence in Accretion Disks. Vorticity Generation and Angular Momentum Transport via the Global Baroclinic Instability

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In this paper we present the global baroclinic instability as a source for vigorous turbulence leading to angular momentum transport in Keplerian accretion disks. We show by analytical considerations and three-dimensional radiation hydro simulations that, in particular, protoplanetary disks have a negative radial entropy gradient, which makes them baroclinic. Two-dimensional numerical simulations show that a baroclinic flow is unstable and produces turbulence. These findings are tested for numerical effects by performing a simulation with a barotropic initial condition which shows that imposed turbulence rapidly decays. The turbulence in baroclinic disks transports angular momentum outward and creates a radially inward bound accretion of matter. Potential energy is released and excess kinetic energy is dissipated. Finally the reheating of the gas supports the radial entropy gradient, forming a self consistent process. We measure accretion rates in our 2D and 3D simulations of $\dot{M} = -10^{-9}$ to -10^{-7} $M_\odot$ yr^{-1} and viscosity parameters of $\alpha = 10^{-4} - 10^{-2}$, which fit perfectly together and agree reasonably with observations. The turbulence creates pressure waves, Rossby waves, and vortices in the $(R - \phi)$ plane of the disk. We demonstrate in a global simulation that these vortices tend to form out of little background noise and to be long-lasting features, which have already been suggested to lead to the formation of planets.

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The Dynamical State of Barnard 68: A Thermally Supported, Pulsating Dark Cloud

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We report sensitive, high resolution molecular-line observations of the dark cloud Barnard 68 obtained with the IRAM 30-m telescope. We analyze spectral-line observations of $C^{18}O$ (1–0), $C^{32}S$(2–1), $C^{34}S$ (2–1), and N_2H^+ (1–0) in order to investigate the kinematics and dynamical state of the cloud. We find extremely narrow linewidths in the central regions of the cloud, $\Delta V = 0.18 \pm 0.01$ km s^{-1}and 0.15 ± 0.01 km s^{-1}for $C^{18}O$ and $C^{34}S$, respectively. These narrow lines are consistent with thermally broadened profiles for the measured gas temperature of 10.5 K. We determine the thermal pressure to be a factor 4 – 5 times greater than the non-thermal (turbulent) pressure in the central regions of the cloud, indicating that thermal pressure is the primary source of support against gravity in this cloud. This confirms the inference of a thermally supported cloud drawn previously from deep infrared extinction measurements (Alves, Lada, & Lada 2001). We also find the molecular linewidths to systematically increase in the outer regions of the cloud, where we calculate the thermal pressure to be between 1 – 2 times greater than the turbulent pressure. We find the distribution of line-center radial velocities for both $C^{18}O$ and N_2H^+ to be characterized by systematic and well-defined linear gradients across the face of the cloud. The rotational kinetic energy is found to be only a few percent of the gravitational potential energy, indicating that the contribution of rotation to the overall stability of the cloud is insignificant. However, the $C^{18}O$ and N_2H^+ velocity gradients differ from each other in both magnitude and direction, suggesting that the cloud is differentially rotating, with the inner regions rotating slightly more slowly than the outer regions. Finally, our observations show that $C^{32}S$ line is optically thick and self-reversed across nearly the entire projected surface of the cloud. The shapes of the self-reversed profiles are asymmetric and are found to vary across the cloud in such a manner that the presence of both inward and outward motions are observed within the cloud. Moreover, these motions appear to be globally organized in a clear and systematic alternating spatial pattern which is suggestive of a small amplitude, non-radial oscillation or pulsation of the outer layers of the cloud about an equilibrium configuration.

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preprints available at:
`http://cfa-www.harvard.edu/~ebergin/pubs_html/b68_vel.html`

Merged catalogue of reflection nebulae

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Several catalogues of reflection nebulae are merged to create a uniform catalogue of 913 objects. It contains revised coordinates, cross-identifications of nebulae and stars, as well as identifications with IRAS point sources.

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Star formation in the Vela Molecular Ridge V. Young stellar objects and star clusters towards the C-cloud

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We present the latest results from a sensitive ($K \sim 18$ mag) near-infrared (JHK) imaging survey of IRAS selected young stellar objects associated with the Vela Molecular Ridge. These enlarge the sample of 12 fields, previously studied, adding 10 sites of recent star formation. The spectral energy distributions derived from near infrared and 1.3-mm photometry allowed to identify at least 5 Class I sources. Their bolometric luminosities indicate that they are protostellar objects of intermediate mass ($\sim$ 2–10 $M_\odot$). Herbig Ae/Be stars and compact UCHII regions could account for the far infrared emission towards some of the remaining fields. The most luminous IRAS sources have also been found associated with young embedded star clusters. The physical properties of the clusters have been determined and used to improve on the statistical relationships already suggested by our previous work. They have sizes of 0.1 pc and volume densities of 10^3–10^4 stars pc^{-3}. Where identified, the Class I sources tend to lie near the centre of the clusters and it is confirmed that the most massive ones are associated with the richest clusters. The less luminous Class I sources ($\sim 10^2$ $L_\odot$) are found either isolated or within small groups of young stellar objects. It is proposed to use the relationship between the bolometric luminosity of the IRAS sources and the total number of cluster members as a test of the initial mass function at the highest masses.

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http://www.arcetri.astro.it/∼fmassi/projects/pub.html

The Formation of Massive Stars from Turbulent Cores

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Observations indicate that massive stars in the Galaxy form in regions of very high surface density, $\Sigma \sim 1$ g cm^{-2}. Clusters containing massive stars and globular clusters have a column density comparable to this. The total pressure in clouds of such a column density is $P/k \sim 10^8$–10^9K cm^{-3}, far greater than that in the diffuse interstellar medium or the average in giant molecular clouds. Observations show that massive star-forming regions are supersonically turbulent, and we show that the molecular cores out of which individual massive stars form are as well. The protostellar accretion rate in such a core is approximately equal to the instantaneous mass of the star divided by the free-fall time of the gas that is accreting onto the star (Stahler, Shu, & Taam 1980). The star-formation time in this *Turbulent Core* model for massive star formation is several times the mean free-fall time of the core out of which the star forms, but is about equal to that of the region in which the core is embedded. The high densities in regions of massive star formation lead to typical time scales for the formation of a massive star of about 10^5 yr. The corresponding accretion rate is high enough to overcome the radiation pressure due to the luminosity of the star. For the typical case we consider, in which the cores out of which the stars form have a density structure $\rho \propto r^{-1.5}$, the protostellar accretion rate grows

with time as $\dot{m}_* \propto t$. We present a new calculation of the evolution of the radius of a protostar and determine the protostellar accretion luminosity. At the high accretion rates that are typical in regions of massive star formation, protostars join the main sequence at about $20 M_\odot$. We apply these results to predict the properties of protostars thought to be powering several observed hot molecular cores, including the Orion hot core and W3(H_2O). In the Appendixes, we discuss the pressure in molecular clouds and we argue that "logatropic" models for molecular clouds are incompatible with observation.

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The interaction of a giant planet with a disc with MHD turbulence II: The interaction of the planet with the disc

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We present a global MHD simulation of a turbulent accretion disc interacting with a giant protoplanet of 5 Jupiter masses in a fixed circular orbit. The disc model had aspect ratio $H/r = 0.1$, and in the absence of the protoplanet a typical value of the Shakura & Sunyaev (1973) stress parameter $\alpha = 5 \times 10^{-3}$. As expected from previous work the protoplanet was found to open and maintain a significant gap in the disc, with the interaction leading to inward migration of the protoplanet orbit on the expected time scale. No evidence for a persistent net mass flow through the gap was found. However, that may be because an extensive inner cavity could not be formed for the model adopted.

Spiral waves were launched by the protoplanet and although these appeared to be diffused and dissipated through interaction with the turbulence, they produced an outward angular momentum flow which compensated for a reduced flux associated with the MHD turbulence near the planet, so maintaining the gap.

When compared with laminar disc models, with the same estimated α in the absence of the planet, the gap was found to be deeper and wider indicating that the turbulent disc behaved as if it in fact possessed a smaller α, even though analysis of the turbulent stress indicated that it was not significantly affected by the planet in the region away from the gap. This may arise for two reasons. First, unlike a Navier–Stokes viscosity with anomalous viscosity coefficient, the turbulence does not provide a source of constantly acting friction in the near vicinity of the planet that leads to steady mass flow into the gap region. Instead the turbulence is characterised by large fluctuations in the radial velocity, and time averaging of these fluctuations over significant time scales is required to recover the underlying mass flow through the disc. In the vicinity of the planet the disc material experiences high amplitude periodic perturbations on time scales that are short relative to the time scale required for averaging. Consequently the disc response is likely to be significantly altered relative to that expected from a Navier–Stokes model. Second, the simulation indicates that an ordered magnetic connection between the inner and outer disc can occur enabling angular momentum to flow out across the gap, helping to maintain it independently of the protoplanet's tide. This type of effect may assist gap formation for smaller mass protoplanets which otherwise would not be able to maintain them.

There is also some evidence that magnetic connection between the circumstellar disc and material that flows into the protoplanet's Hill sphere may lead to significant magnetic breaking of the resulting circumplanetary disc, thereby modifying the expected gas accretion rate onto forming gas giant planets.

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A Comprehensive Study of the L1551 IRS 5 Binary System

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We model the Class I source L1551 IRS 5, adopting a flattened infalling envelope surrounding a binary disk system and a circumbinary disk. With our composite model, we calculate self-consistently the spectral energy distribution of each component of the L1551 IRS 5 system, using additional constraints from recent observations by ISO, the water ice feature from observations with SpeX, the SCUBA extended spatial brightness distribution at sub-mm wavelengths, and the VLA spatial intensity distributions at 7 mm of the binary disks. We analyze the sensitivity of our results to the various parameters involved. Our results show that a flattened envelope collapse model is required to explain simultaneously the large scale fluxes and the water ice and silicate features. On the other hand, we find that the circumstellar disks are optically thick in the millimeter range and are inclined so that their outer parts hide the emission along the line of sight from their inner parts. We also find that these disks have lower mass accretion rates than the infall rate of the envelope.

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Structure Function Scaling in the Taurus and Perseus Molecular Cloud Complexes

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We compute the structure function scaling of the integrated intensity images of two J=1-0 ^{13}CO maps of Taurus and Perseus. The scaling exponents of the structure functions, normalized to the third order, follow the velocity scaling of supersonic turbulence, suggesting that turbulence plays an important role in the fragmentation of cold interstellar clouds. The data also allows to verify the validity of the two basic assumptions of the hierarchical symmetry model, originally proposed for the derivation of the velocity structure function scaling. This shows that the same hierarchical symmetry holds for the projected density field of cold interstellar clouds.

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The interaction of a giant planet with a disc with MHD turbulence I: The initial turbulent disc models

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This is the first of a series of papers aimed at developing and interpreting simulations of protoplanets interacting with turbulent accretion discs. In this first paper we study the turbulent disc models prior to the introduction of a perturbing protoplanet. We study cylindrical disc models in which a central domain is in Keplerian rotation and unstable to the magnetorotational instability (MRI). Models of varying disc size and aspect ratio H/r are considered with magnetic fields having zero net flux. We relate the properties of the turbulent models to classical viscous disc theory (Shakura & Sunyaev 1973). All models were found to attain a turbulent state in their Keplerian domains with volume averaged stress parameter $\alpha \sim 5 \times 10^{-3}$. At any particular time the vertically and azimuthally averaged value exhibited large fluctuations in radius. However, an additional time average over periods exceeding 3 orbital periods at the outer boundary of the Keplerian domain resulted in a more smoothly varying quantity with radial variations within a factor of two or so.

The vertically and azimuthally averaged radial velocity showed much larger spatial and temporal fluctuations, requiring additional time averaging for at least $7-8$ orbital periods at the outer boundary of the Keplerian domain to limit them. Comparison with the value derived from the averaged stress using viscous disc theory yielded schematic agreement for

feasible averaging times but with some indication that the effects of residual fluctuations remained.

The behaviour described above must be borne in mind when considering laminar disc simulations with anomalous Navier–Stokes viscosity. This is because the operation of a viscosity as in classical viscous disc theory with anomalous viscosity coefficient cannot apply to a turbulent disc undergoing rapid changes due to external perturbation. The classical theory can only be used to describe the time averaged behaviour of the parts of the disc that are in a statistically steady condition for long enough for appropriate averaging to be carried out.

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Preprint available from: www.maths.qmul.ac.uk/∼rpn

Time Dependence of the Ultraviolet Radiation Field in the Local Interstellar Medium

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Far Ultraviolet (FUV, 6 eV< $h\nu$ <13.6 eV) radiation has been suggested as the main source of heating of the neutral interstellar gas, and, in this case, it determines whether the thermal balance of the neutral gas results in cold ($T \sim 50 - 100K$) clouds (CNM), warm ($T \sim 10^4K$) clouds (WNM), or a combination of the two. For gas at fixed mean density, to WNM, while low fields result in CNM. The main sources of interstellar FUV radiation are short-lived massive stars in associations that form in Giant Molecular Clouds. Using McKee & Williams' (1997) distribution of birthrates for OB associations in the Galaxy, we determine the expected behavior of the time-dependent FUV field for random positions in the ISM at the solar circle. The FUV field is calculated in two bands (912 − 1100 Å and 912 − 2070 Å) and at the wavelength 1400 Å. In terms of $U_{-17} \equiv U/(10^{-17}$ erg cm^{-3} Å$^{-1})$, where U is the energy density of the radiation field in some band, we find (mean, median) values at the solar circle of U_{-17} =(15.7, 7.4) and (14.2, 7.2) for the [912-1100 Å] and [912-2070 Å] bands, respectively. At 1400 Å we find (mean, median) values of U_{-17} =(14.4, 7.5). Our median value for the [912-2070 Å] band is $G_0 = 1.6$ times Habing's (1968) value for the radiation field at the solar circle in this band, and quite close to Draine's (1978) value, $G_0 = 1.7$. Habing and Draine's values are based on observations of sources of FUV radiation in the solar neighborhood, so all three values are close to observed values. Due to attenuation by dust, only associations within about 500 pc contribute significantly to the energy density at a given point. Large angle scattering produces a diffuse field that is about 10% of the field produced by the sum of direct and small angle ($< 5^o$) scattering from discrete sources (the associations), as observed. At a point exposed to the median radiation field, the brightest association typically produces about 20% of the total energy density. At a point exposed to an above average radiation field, the brightest association produces most of the energy density. Therefore, the FUV field is asymmetric at a given point, and the asymmetry grows for higher fields. The FUV field fluctuates with a variety of amplitudes, the larger ones being less frequent. The mean field is about twice the median field because of these fluctuations, or spikes, in the radiation field. These spikes, which last ~ 30 Myr, are caused by the infrequent birth of nearby associations. For spikes that are significantly higher than the mean field, the time interval between spikes is $\sim 2U_{-15}^{3/2}$ Gyr. We also model shorter duration spikes caused by runaway OB stars. The presence of a fluctuating heating rate created by the fluctuating FUV field converts CNM to WNM and vice versa.

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Astrophysics of Young Star Binaries

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This paper describes our study of the astrophysics of individual components in close pre−main-sequence binaries. We

observed both stars in 17 systems, located in 4 nearby star forming regions, using low-resolution (R=760), infrared spectroscopy and photometry. For 29 components we detected photospheric absorption lines and were able to determine spectral type, extinction, K-band excess, and luminosity. The other 5 objects displayed featureless or pure emission line spectra. In ∼50 % of the systems, the extinction and K-band excess of the primary stars dominate those of the secondaries. Masses and ages were determined for these 29 objects by placing them on the H-R diagram, overlaid with theoretical pre−main-sequence tracks. Most of the binaries appear to be coeval. The ages span 5×10^5 to 1×10^7 years. The derived masses range from the substellar, 0.06 $M_\odot$, to 2.5 $M_\odot$, and the mass ratios from $M_2/M_1 = 0.04$ to 1.0. Fourteen stars show evidence of circumstellar disks. The K-band excess is well correlated with the $K - L$ color for stars with circumstellar material.

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Radial-velocity survey of members and candidate members of the TW Hydrae association

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We report our spectroscopic observations of stars belonging to the young nearby group known as the TW Hydrae association, as well as of a number of potential members of the association identified in kinematic and X-ray surveys. Multiple radial velocity measurements were obtained for each object, several of which turn out to be multiple systems. Orbital solutions are presented for 3 double-lined binaries, one single-lined binary, and a double-lined triple system, all with short periods. Effective temperatures and projected rotational velocities are presented for each visible object. None of the candidate members of the association in our sample is confirmed as a true member. The large fraction of close binaries among the candidate members has to do with their selection based on X-ray emission from ROSAT, which tends to favor the inclusion of tidally-locked systems that are active but not necessarily young.

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Extending the limits of globule detection ISOPHOT Serendipity Survey observations of interstellar clouds II

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Small isolated clouds were discovered by the ISOPHOT 170 μm Serendipity Survey (ISOSS) as faint $I_{170} < 13\,\mathrm{MJysr^{-1}}$ FIR sources. One of them is ISOSS J 20246+6540, a cold ($T_\mathrm{d} \approx 14.5\,\mathrm{K}$) pointlike ISOSS source without an IRAS pointsource counterpart. In the Digitized Sky Survey B band it is seen as a 3 arcmin size bipolar nebulosity with an average excess DSS blue band surface brightness of 8% of the background's photographical density. The CO column density distribution determined by multi-isotopic, multi-level CO measurements with the IRAM-30m telescope agrees well with the optical appearance. An average hydrogen column density of $\approx 10^{21}\mathrm{cm^{-2}}$ was derived from both the FIR and CO data. Using a kinematic distance estimate of 400 pc the NLTE modelling of the CO, HCO^+, and CS measurements gives a peak density of $\approx 10^4\mathrm{cm^{-3}}$. The multiwavelength data characterise ISOSS 20246+6540 as a representative of a class of globules which has not been discovered so far due to their small angular size and low 100μm brightness. A significant overabundance of ^{13}CO is found $X(^{13}\mathrm{CO}) \geq 150 \times X(\mathrm{C}^{18}\mathrm{O})$. This is likely due to isotope

selective chemical processes.

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Far and mid Infrared Observations of Two Ultracompact H II Regions and One Compact CO Clump

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Two ultracompact H II regions (IRAS 19181+1349 and 20178+4046) and one compact molecular clump (20286+4105) have been observed at far infrared wavelengths using the TIFR 1 m balloon-borne telescope and at mid infrared wavelengths using ISO. Far infrared observations have been made simultaneously in two bands with effective wavelengths of ~ 150 and $\sim$210 μm, using liquid ^{3}He cooled bolometer arrays. ISO observations have been made in seven spectral bands using the ISOCAM instrument; four of these bands cover the emission from Polycyclic Aromatic Hydrocarbon (PAH) molecules. In addition, IRAS survey data for these sources in the four IRAS bands have been processed using the HIRES routine. In the high resolution mid infrared maps as well as far infrared maps multiple embedded energy sources have been resolved. There are structural similarities between the images in the mid infrared and the large scale maps in the far infrared bands, despite very different angular resolutions of the two. Dust temperature and optical depth (τ_{150}) maps have also been generated using the data from balloon-borne observations. Spectral energy distributions (SEDs) for these sources have been constructed by combining the data from all these observations. Radiation transfer calculations have been made to understand these SEDs. Parameters for the dust envelopes in these sources have been derived by fitting the observed SEDs. In particular, it has been found that radial density distribution for three sources is different. Whereas in the case of IRAS 20178+4046, a steep distribution of the form r^{-2} is favoured, for IRAS 20286+4105 it is r^{-1} and for IRAS 19181+1349 it is the uniform distribution (r^0). Line ratios for PAH bands have generally been found to be similar to those for other compact H II regions but different from general H II regions.

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`http://arXiv.org/abs/astro-ph/0211416`

The molecular condensations ahead of Herbig-Haro objects. II A theoretical investigation of the HH 2 condensation

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Clumps of enhanced molecular emission are present close to a number of Herbig-Haro (HH) objects. These enhancement may be the consequence of an active photochemistry driven by the UV radiation originating from the shock front of the HH object. On the basis of this picture and as a follow up to a molecular line survey toward the quiescent molecular clump ahead of the HH object, HH2 (Girart et al. 2002), we present a detailed time and depth dependent chemical model of the observed clump. Despite several difficulties in matching the observations, we constrain some of the physical and chemical parameters of the clump ahead of HH2. In particular, we find that the clump is best described by more than one density component with a peak density of 3×10^5 and a visual extinction of ≤ 3.5 mags; its lifetime can not be much higher than 100 years and the impinging radiation is enhanced with respect to the ambient one by probably no more than 3 orders of magnitude. Our models also indicate that carbon-bearing species should not completely hydrogenate as methane when freezing out on grains during the formation of the clump.

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The Inner Rings of β Pictoris

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We present Keck images of the dust disk around β Pictoris at $\lambda = 17.9$ μm that reveal new structure in its morphology. Within $1''$ (19 AU) of the star, the long axis of the dust emission is rotated by more than 10° with respect to that of the overall disk. This angular offset is more pronounced than the warp detected at $3.5''$ by HST, and in the opposite direction. By contrast, the long axis of the emission contours at $\sim 1.5''$ from the star is aligned with the HST warp. Emission peaks between $1.5''$ and $4''$ from the star hint at the presence of rings similar to those observed in the outer disk at $\sim 25''$ with HST/STIS. A deconvolved image strongly suggests that the newly detected features arise from a system of four non-coplanar rings. Bayesian estimates based on the primary image lead to ring radii of 14±1 AU, 28±3 AU, 52±2 AU and 82±2 AU, with orbital inclinations that *alternate* in orientation relative to the overall disk and decrease in magnitude with increasing radius. We believe these new results make a strong case for the existence of a nascent planetary system around β Pic.

Astrophysical Journal Letter (December 20, 2002)

http://www.journals.uchicago.edu/ApJ/journal/issues/ApJL/v581n2/16743/16743.html

Herbig-Haro Objects in the Monoceros OB1 Molecular Cloud

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We carried out a wide field [S II] emission imaging of the Monoceros OB1 molecular cloud (NGC 2264) to investigate the star formation and outflow activity of the region. Our narrow band [S II] imaging covers an area of sky of $\sim$ 2 square degrees, including the entire Mon OB1 cloud. In the northern part of the cloud, 2 new Herbig-Haro (HH) objects, HH 572 and 575, are discovered. All the 4 previously known HH objects, HH 124, 125, 225, and 226, are also detected in our imaging. Low-dispersion spectroscopic observations of HH 572A, 575B, and 575C1 further confirmed the HH object nature of these objects. Molecular hydrogen $v = 1$-0 S(1) narrow band imaging revealed a bright H_2 emission knot in each of the HH 572 and HH 575 regions. By comparison of the results of our optical [S II] emission survey with those of the CO molecular outflow survey, it is found that the occurrence frequency of HH objects is similar to that of CO outflows in the Mon OB1 cloud. However, HH objects and CO outflows display different spatial distribution.

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http://jets.pmo.ac.cn/starfm/preprints.html

Reduction of chemical networks. I. The case of molecular clouds

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We present a new method to analyse and reduce chemical networks and apply this technique to the chemistry in molecular clouds. Using the technique, we investigated the possibility of reducing the number of chemical reactions and species in the UMIST 95 database simultaneously. In addition, we did the same reduction but with the "objective technique" in order to compare both methods. We found that it is possible to compute the abundance of carbon monoxide and fractional ionisation accurately with significantly reduced chemical networks in the case of pure gas-phase chemistry. For gas-grain chemistry involving surface reactions reduction is not worthwhile. Compared to the "objective technique" our reduction method is more effective but more time-consuming as well.

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http://arxiv.org/abs/astro-ph/0212096

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

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Dissertation Abstracts

Calibration of Herschel/HIFI: system and experimental approach of a scientific space instrument. Observational study of galactic dense cores.

David Teyssier

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Ph.D dissertation directed by: Michel Pérault

Ph.D degree awarded: September 2002

The calibration of a remote-sensing instrument for the observation of the Earth or of the Cosmos is a key to the highest scientific return from the experiment.

In the first part of this thesis, we initiate the preparation of the calibration tools and methods for the submillimetre spectrometer HIFI on board the Herschel satellite. The first aspect concentrates on the data calibration and their convertion into a physical scale. We first collect the requirements of the in-flight calibration and identify the primary and secondary calibrators. We then build a list of potential candidates, complemented by a ground-based preparatory observation campaign. We study the current internal calibration scheme based on two internal loads, and present a first error budget on the HIFI measurements. We show that this approach is *a priori* not adapted to the space conditions, and we give the preliminary elements of a best-suited calibration technique. The second point of this calibration work focusses on the instrument calibration in itself. We analyse the needs of the laboratory measurement campaign of the first HIFI prototype and propose an original system allowing to calibrate various instrumental parameters on the ground. We also show the importance of an instrumental modelling work, and present a description of the standing wave systems expected to affect the HIFI data.

The second part of this thesis is dedicated to the study of dense galactic cores detected in the mid-infrared by the ISO satellite. We show that these objets belong to a new population of massive ($M > 1000\,M_\odot$) and cold ($8 \leq T \leq 25\,\mathrm{K}$) condensations associated to giant molecular clouds. Our analysis indicates visible extinction in excess of 50, and suggests that depletion onto grains affects most of the molecular species. We also show that these objets are fragmented, and that they are very likely future, if not already initiated, progenitor sites of high mass stars.

Manuscript available at http://tel.ccsd.cnrs.fr/documents/archives0/00/00/19/57/index_fr.html

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