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Abstracts of recently accepted papers

Detection of Knots and Jets in IRAS 06061+2151

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We report detection of a Young Stellar Object with an evidence for an outflow in the form of knots in the molecular hydrogen emission line (2.121μm) towards the massive star forming region IRAS 06061+2151. Near-infrared images reveal IRAS 06061+2151 to be a cluster of at least five sources, four of which seem to be early B type young stellar objects, in a region of 12 arcsecs surrounded by a nebulosity. The presence of the knots that are probably similar to the HH objects in the optical wavelengths, suggests emerging jets from one of the cluster members. These jets appear to excite a pair of knot-like objects (Knot-NW and Knot-SE) and extend over a projected size of 0.5pc. The driving source for the jets is traced back to a member of the cluster whose position in the H-Ks/J-H color-color diagram indicates that it is a Class I type pre-mainsequence star. We also obtained K band spectra of the brightest source in the cluster and of the nearby nebular matter. The spectra show molecular hydrogen emission lines but do not show Br γ line (2.167μm). These spectra suggest that the excitation of the molecular hydrogen lines is probably due to a mild shock.

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http://arXiv.org/abs/astro-ph/0402352

The substellar population of the young cluster lambda Orionis

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By collecting optical and infrared photometry and low resolution spectroscopy, we have identified a large number of low mass stars and brown dwarf candidates belonging to the young cluster (~5 Myr) associated with the binary star lambda Orionis. The lowest mass object found is a M8.5 with an estimated mass of 0.02 Msun (~0.01 Msun for objects without spectroscopic confirmation). For those objects with spectroscopy, the measured strength of the Halpha emission line follows a distribution similar to other clusters with the same age range, with larger equivalent widths for cooler spectral types. Three of the brown dwarfs have Halpha emission equivalent widths of order 100 Å, suggestive that they may have accretion disks and thus are the substellar equivalent of Classical T Tauri stars. We

have derived the Initial Mass Function for the cluster. For the substellar regime, the index of the mass spectrum is alpha=0.60±0.06, very similar to other young associations.

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http://arXiv.org/abs/astro-ph/0404072

High resolution spectroscopy of Brown Dwarfs in Taurus: Detection of accretion in KPNO Tau 3

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We present high resolution optical spectroscopy of three candidate members of the Taurus-Auriga star forming region. Based on the spectral type, the strength, profile and width of the Hα line, the detected lithium at 6708 Å, the location of these objects in a H-R diagram and the comparison with similar objects belonging to young stellar associations, we determine that they are bona fide members of the SFR, with about $\sim$3 Myr, have masses at or below the substellar limit and, at least in one case, there is active accretion from a circum(sub)stellar disk. This result suggests that high mass brown dwarfs go through a Classical TTauri phase and form like stars, from colapse and fragmentation of a molecular cloud.

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http://arXiv.org/abs/astro-ph/0403302

Formation and Collapse of Nonaxisymmetric Protostellar Cores in Planar Magnetic Molecular Clouds

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We extend our earlier work on ambipolar diffusion induced formation of protostellar cores in isothermal sheet-like magnetic interstellar clouds, by studying nonaxisymmetric collapse for the physically interesting regime of magnetically critical and supercritical model clouds ($mui \geq 1$, where mui is the initial mass-to-magnetic flux ratio in units of the critical value for gravitational collapse). Cores that form in model simulations are effectively triaxial, with shapes that are typically closer to being oblate, rather than prolate. Infall velocities in the critical model ($mui = 1$) are subsonic; in contrast, a supercritical model ($mui = 2$) has extended supersonic infall that may be excluded by observations. For the magnetically critical model, ambipolar diffusion forms cores that are supercritical ($muc > 1$) and embedded within subcritical envelopes ($muenv < 1$). Cores in our models have density profiles that eventually merge into a near-uniform background, which is suggestive of observed properties of cloud cores.

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Preprint available at `http://www.astro.uwo.ca/~basu/pub.html` and astro-ph/0404008.

On the fragmentation of magnetized cloud cores

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Recent calculations with a two-fluid smoothed particle hydrodynamics (SPH) code of the collapse of a magnetized dense core have found little evidence for fragmentation. These calculations have been interpreted as implying that magnetic braking by magnetic tension forces is sufficient to inhibit fragmentation, contrary to a suggestion by Boss

(2000) that magnetic fields might encourage fragmentation. However, the type of fragmentation considered by Boss did not require the presence of significant rotation, contrary to the case with the SPH calculations, so the relevance of magnetic braking to Boss's suggestion is unclear. The SPH calculations used a barotropic equation of state which tended to produce a single central clump that resisted fragmentation in clouds where the Eddington approximation radiative transfer used by Boss (2000) led to fragmentation. While a definitive calculation has yet to be accomplished, fragmentation seems to remain as a possible outcome of the collapse of magnetic clouds.

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Preprint available at http://www.ciw.edu/boss/ftp/bfrag2/

Convective Cooling of Protoplanetary Disks and Rapid Giant Planet Formation

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The rapid formation of self-gravitating clumps of gas and dust in a marginally gravitationally unstable disk requires a reasonably efficient means of cooling the disk gas. Clumps form on the dynamical time scale of a few orbital periods in the disk instability scenario. Radiative transfer is not able to cool the midplanes of optically thick protoplanetary disks fast enough to permit the disk instability mechanism to form dense clumps. However, vertically-oriented convective cells, driven by the temperature gradient between the disk's midplane and surface, appear to be capable of cooling the disk midplanes on the desired time scale. We demonstrate this possibility by analyzing in detail the vertical convective energy fluxes in the first three dimensional radiative hydrodynamics model of clump formation by disk instability, presented by Boss (2001). Similarly robust convective fluxes occur in the models presented by Boss (2002a,b). Transient convective cells can be seen in all of these simulations, with vertical velocities (~ 0.1 km s^{-1}) and energy fluxes large enough to cool the outer disk at the desired rate.

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Preprint available at http://www.ciw.edu/boss/ftp/convec/

Modeling the millimeter emission from the Cepheus A young stellar cluster: Evidence for large scale collapse

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Evidence for a large scale flow of low density gas onto the Cepheus A young stellar cluster is presented. Observations of K-band near-infrared and multi-transition CS and N_2H^+ millimeter line emission are shown in relation to a submillimeter map of the cool dust around the most embedded stars. The near-infrared emission is offset from the dust peak suggesting a shift in the location of star formation over the history of the core. The CS emission is concentrated toward the core center but N_2H^+ peaks in two main cores offset from the center, opposite to the chemistry observed in low mass cores. A starless core with strong CS but weak N_2H^+ emission is found toward the western edge of the region. The average CS(2–1) spectrum over the cluster forming core is asymmetrically self-absorbed suggesting infall. We analyze the large scale dynamics by applying a one-dimensional radiative transfer code to a model spherical core with constant temperature and linewidth, and a density profile measured from an archival 850 μm map of the region. The best fit model that matches the three CS profiles requires a low CS abundance in the core and an outer, infalling envelope with a low density and undepleted CS abundance. The integrated intensities of the two N_2H^+ lines is well matched with a constant N_2H^+ abundance. The envelope infall velocity is tightly constrained by the CS(2–1) asymmetry and is sub-sonic but the size of the infalling region is poorly determined. The picture of a high density center with depleted CS slowly accreting a low density outer envelope with normal CS abundance suggests that core growth occurs at least partially by the dissipation of turbulent support on large scales.

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http://arxiv.org/abs/astro-ph/0404215

McNeil's Nebula in Orion: The Outburst History

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We present a sequence of I-band images obtained at the Venezuela 1m Schmidt telescope during the outburst of the nebula recently discovered by J.W. McNeil in the Orion L1630 molecular cloud. We derive photometry spanning the pre-outburst state and the brightening itself, a unique record including 14 epochs and spanning a time scale of ~ 5 years. We constrain the beginning of the outburst at some time between Oct. 28 and Nov. 15, 2003. The light curve of the object at the vertex of the nebula, the likely exciting source of the outburst, reveals that it has brightened ~ 5 magnitudes in about 4 months. The time scale for the nebula to develop is consistent with the light travel time, indicating that we are observing light from the central source scattered by the ambient cloud into the line of sight. We also show recent FLWO optical spectroscopy of the exciting source and of the nearby HH 22. The spectrum of the source is highly reddened; in contrast, the spectrum of HH 22 shows a shock spectrum superimposed on a continuum, most likely due to reflected light from the exciting source reaching the HH object through a much less reddened path. The blue portion of this spectrum is consistent with an early B spectral type, similar to the early outburst spectrum of the FU Ori variable V1057 Cyg; we estimate a luminosity of $L \sim 219 L_{\odot}$. The eruptive behavior of the McNeil nebula source, its spectroscopic characteristics and luminosity, suggest we may be witnessing an FU Ori event on its way to maximum. Further monitoring of this object will decide whether it qualifies as a member of this rare class of objects.

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Detection of H_2D^+: Measuring the midplane degree of ionization in the disks of DM Tau and TW Hya

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We report the first detection of the ground transition of the ortho H_2D^+ molecule towards one disk source, DM Tau, a tentative detection towards TW Hya, and an upper limit towards LkCa15. The three observed sources possess young, gas rich disks with large CO depletion factors. We argue that the observed ground ortho-H_2D^+ line originates in the outer disk midplane gas, which is cold and depleted of CO. Since H_2D^+ is likely the most abundant ion, the measured line intensity allows to estimate the ionization degree in the midplane gas of the outer disk. In DM Tau the electron abundance is 7×10^{-10}, in TW Hya it is about 4×10^{-10}, and in LkCa15 it is less than about 2×10^{-9}. This implies that the ionization in the disks is large enough for the magneto-rotational instability to operate. The required ionization rate, 5×10^{-17} s^{-1}, in TW Hya is consistent, within the associated uncertainty, with normal cosmic ray irradiation, whereas in DM Tau it is a factor ten lower than the canonical value.

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http://www-laog.obs.ujf-grenoble.fr/∼ceccarel/

Multifluid, Magnetohydrodynamic Shock Waves with Grain Dynamics II. Dust and the Critical Speed for C Shocks

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This is the second in a series of papers on the effects of dust on multifluid, magnetohydrodynamic shock waves in weakly-ionized molecular gas. We investigate the influence of dust on the critical shock speed, $v_{\rm crit}$, above which C shocks cease to exist. Chernoff showed that $v_{\rm crit}$ cannot exceed the grain magnetosound speed, $V_{\rm gms}$, if dust grains are dynamically well coupled to the magnetic field. Since $V_{\rm gms} \simeq 5\,{\rm km\ s^{-1}}$ in a dense cloud or core, the potential implications for models of shock emission are profound. We present numerical simulations of steady shocks where the grains may be well- or poorly coupled to the field. We use a time-dependent, multifluid MHD code that models the plasma as a system of interacting fluids: neutral particles, ions, electrons, and various "dust fluids" comprised of grains with different sizes and charges. Our simulations include grain inertia and grain charge fluctuations but to highlight the essential physics we assume adiabatic flow, single-size grains, and neglect the effects of chemistry. We show that the existence of a phase speed v_ϕ does not necessarily mean that C shocks will form for all shock speeds $v_{\rm s}$ less than v_ϕ. When the grains are weakly coupled to the field, steady, adiabatic shocks resemble shocks with no dust: the transition to J type flow occurs at $v_{\rm crit} \approx 2.76 V_{\rm nA}$, where $V_{\rm nA}$ is the neutral Alfvén speed, and steady shocks with $v_{\rm s} > 2.76 V_{\rm nA}$ are J shocks with magnetic precursors in the ion-electron fluid. When the grains are strongly coupled to the field, $v_{\rm crit} = \min(2.76 V_{\rm nA}, V_{\rm gms})$. Shocks with $v_{\rm crit} < v_{\rm s} < V_{\rm gms}$ have magnetic precursors in the ion-electron-dust fluid. Shocks with $v_{\rm s} > V_{\rm gms}$ have no magnetic precursor in any fluid. We present time-dependent calculations to study the formation of steady multifluid shocks. The dynamics differ qualitatively depending on whether or not the grains and field are well coupled.

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Search for class II methanol masers at 23.1 GHz

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In the early days of methanol maser discoveries the $9_2 - 10_1$ A$^+$ transition at 23.1 GHz was found to exhibit maser characteristics in the northern star-forming region W3(OH), and probable maser emission in two other sources. Attention subsequently turned to the 6.6-GHz $5_1 - 6_0$ A$^+$ methanol maser transition, which has proved a valuable tracer of early high-mass star formation. We have undertaken a new search for 23.1-GHz methanol masers in 50 southern star formation regions using the Parkes radiotelescope. The target sources all exhibit class II methanol maser emission at 6.6 GHz, with 20 sources also displaying maser features in the 107.0-GHz $3_1 - 4_0$ A$^+$ methanol line. Strong emission at 23.1 GHz in NGC 6334F was confirmed, but no emission was detected in the remaining sources. Thus the 23.1-GHz methanol masers are rare.

A maser model in which methanol molecules are pumped to the second torsionally excited state by radiation from warm dust can account for class II maser activity in all the transitions in which it is observed. According to this model the 23.1-GHz maser is favoured by conditions representing low gas temperature, high external dust temperature, low gas density, and high column density of methanol; the scarcity of this maser indicates that such combinations of conditions are uncommon. We have undertaken new model calculations to examine the range of parameters compatible with the upper limits on 23.1-GHz emission from our survey. Further constraints apply in sources with upper limits to maser emission at 107.0 GHz, and the combination of data for the two transitions delineates a narrow range of gas density and methanol abundance if the dust temperature is 175 K or greater. While the results are subject to the uncertainties of the chosen model, they may be applicable to the majority of methanol maser sites in the vicinity of newborn high-mass stars, in which methanol masers other than the 6.6- and 12.1-GHz transitions are not detected.

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Observations of L1521F: a highly evolved starless core

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We observed the pre–stellar core L1521F in dust emission at 1.2mm and in two transitions each of N_2H^+, N_2D^+, $C^{18}O$ and $C^{17}O$ in order to increase the sample of well studied centrally concentrated and chemically evolved starless cores, likely on the verge of star formation, and to determine the initial conditions for low–mass star formation in the Taurus Molecular Cloud. The dust observation allows us to infer the density structure of the core and together with measurements of CO isotopomers gives us the CO depletion. N_2H^+ and N_2D^+ lines are good tracers of the dust continuum and thus they give kinematic information on the core nucleus. We derived in this object a molecular hydrogen number density n(H_2)$\sim$ 10^6cm^{-3} and a CO depletion factor, integrated along the line of sight, $f_{\rm D} \equiv 9.5{\times}10^{-5}/x_{\rm obs}({\rm CO}) \sim 15$ in the central 20″, similar to the pre–stellar core L1544. However, the $N({\rm N_2D^+})/N({\rm N_2H^+})$ column density ratio is ~ 0.1, a factor of about 2 lower than that found in L1544. The observed relation between the deuterium fractionation and the integrated CO depletion factor across the core can be reproduced by chemical models if N_2H^+ is slightly (factor of $\sim$2 in fractional abundance) depleted in the central 3000 AU. The N_2H^+ and N_2D^+ linewidths in the core center are ~ 0.3 km s^{-1}, significantly larger than in other more quiescent Taurus starless cores but similar to those observed in the center of L1544. The kinematical behaviour of L1521F is more complex than seen in L1544, and a model of contraction due to ambipolar diffusion is only marginally consistent with the present data. Other velocity fields, perhaps produced by accretion of the surrounding material onto the core and/or unresolved substructure, are present. Both chemical and kinematical analyses suggest that L1521F is less evolved than L1544, but, in analogy with L1544, it is approaching the "critical" state.

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http://arxiv.org/abs/astro-ph/0403517

http://www.arcetri.astro.it/~starform/publ2004.htm

High resolution observations of 6.7-GHz methanol masers with the LBA

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We have used the Australian Long Baseline Array (LBA) to produce milliarcsecond images of five sites of methanol (CH_3OH) maser emission at 6.7 GHz. These are all sites that have linear morphologies at arcsecond resolutions, which have been hypothesised to be due to the masers forming in edge-on circumstellar disks. We find that a simple disk model cannot explain the observations. We discuss various alternatives, and suggest a new model which explains how linear velocity gradients can be produced in methanol masers that arise in planar shocks propagating nearly perpendicular to the line of sight.

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New light on the S235A-B star forming region

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The S235A-B star forming region has been extensively observed in the past from the radio to the near IR, but what was happening in the immediate surroundings of the water maser, placed in between the two nebulosities, was still unclear because of insufficient resolution especially in the spectral range from the Far IR to the mm, even though there were sound indications that new young stellar objects (YSOs) are being formed there. We present here new high resolution maps at mm wavelengths in different molecules (HCO^+, $C^{34}S$, H_2CS, SO_2 and CH_3CN), as well as in the 1.2 and 3.3 mm continuum obtained with the Plateau de Bure interferometer, and JCMT observations at 450 μm and 850 μm that unambiguously reveal the presence of new YSOs placed in between the two HII regions S235A and S235B and associated with the water maser. A molecular core and an unresolved source in the mm and in the sub-mm are centred on the maser, with indication of mass infall onto the core. Two molecular bipolar outflows and a jet originate from the same position. Weak evidence is found for a molecular rotating disk perpendicular to the direction of the main bipolar outflow. The derived parameters indicate that one of the YSOs is an intermediate luminosity object ($L \sim 10^3 L_\odot$) in a very early evolutionary phase, embedded in a molecular core of $\sim 100\ M_\odot$, with a temperature of 30 K. The main source of energy for the YSO could come from gravitational infall, thus making this YSO a rare example of intermediate luminosity protostar representing a link between the earliest evolutionary phases of massive stars and low mass protostars of class 0–I.

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

Spiral Structure in the Circumstellar Disk around AB Aurigae

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We present a near-infrared image of the Herbig Ae star AB Aur obtained with the coronagraphic camera CIAO mounted on the Subaru Telescope. The image shows a circumstellar emission extending out to a radius of $r = 580$ AU, with a double spiral structure detected at $r =$200–450 AU. The surface brightness decreases as $r^{-3.0\pm0.1}$, steeper than the radial profile of the optical emission possibly affected by the scattered light from the envelope surrounding AB Aur. This result, together with the size of the infrared emission similar to that of the ^{13}CO ($J = 1-0$) disk, suggests that the spiral structure is indeed associated with the circumstellar disk but is not part of the extended envelope. We identified four major spiral arms, which are trailing if the brighter, southeastern part of the disk is the near side. The weak gravitational instability, maintained for millions of years by continuous mass supply from the envelope, might explain the presence of the spiral structure at the relatively late phase of the pre-main-sequence period.

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EVN observations of H_2O masers towards the high-mass young stellar object in AFGL 5142

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We have conducted multi-epoch EVN observations of the 22.2 GHz water masers towards the high-mass young stellar object in AFGL 5142. With four observing epochs, spanning a time of ∼1 year, 12 distinct maser features have been detected, 7 of which were detected in more than one epoch. The positions and velocities of the VLBI features agree well with those of the emission centers previously identified by means of VLA observations. For a few features, persistent over three or four epochs, accurate values of the proper motions are derived. The observed proper motions have an amplitude of 15–20 km s^{-1}, significantly larger than the range of variation of the line-of-sight velocities (±4 km s^{-1} around the systemic velocity). On the basis of their spatial distribution, the observed maser features can be divided into two groups. A model fit to the positions and velocities of the maser features of Group I, detected in the same region (within ∼500 mas) where the massive YSO should be located, demonstrates that these might arise on the surface of a nearly edge-on Keplerian disk, rotating around a massive young stellar object. The maser features of Group II, found at large distances from the YSO ($\geq 1''$), have positions and line-of-sight velocities in agreement with the blue-shifted lobe of a large-scale molecular outflow (traced by the HCO^+ and SiO emission), and might result from the interaction between the gas flowing away from the young stellar object and the ambient gas of the progenitor molecular core.

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High Angular Resolution Mid-infrared Imaging of Young Stars in Orion BN/KL

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We present Keck LWS images of the Orion BN/KL star forming region obtained in the first multi-wavelength study to have $0''.3$-$0''.5$ resolution from 4.7μm to 22μm. The young stellar objects designated infrared source n and radio source I are believed to dominate the BN/KL region. We have detected extended emission from a probable accretion disk around source n but infer a stellar luminosity on the order of only $2000\,L_\odot$. Although source I is believed to be more luminous, we do not detect an infrared counterpart even at the longest wavelengths. However, we resolve the closeby infrared source, IRc2, into an arc of knots $\sim 10^3$ AU long at all wavelengths. Although the physical relation of source I to IRc2 remains ambiguous, we suggest these sources mark a high density core (10^7-10^8 pc^{-3} over $\sim 10^3$ AU) within the larger BN/KL star forming cluster. The high density may be a consequence of the core being young and heavily embedded. We suggest the energetics of the BN/KL region may be dominated by this cluster core rather than one or two individual sources.

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Chandra observation of an unusually long and intense X-ray flare from a young solar-like star in M 78

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LkHα 312 has been observed serendipitously with the ACIS-I detector on board the *Chandra X-ray Observatory* with 26 h continuous exposure. This Hα emission line star belongs to M 78 (NGC 2068), one of the star-forming regions of the Orion B giant molecular cloud at a distance of 400 pc. From the optical and the near-infrared (NIR) data, we show that LkHα 312 is a pre-main sequence (PMS) low-mass star with a weak NIR excess. This genuine T Tauri star displayed an X-ray flare with an unusual long rise phase (∼8 h). The X-ray emission was nearly constant during the first 18 h of the observation, and then increased by a factor of 13 during a fast rise phase (∼2 h), and reached a factor of 16 above the quiescent X-ray level at the end of a gradual phase (∼6 h) showing a slower rise. To our knowledge this flare, with ∼0.4–∼0.5 cts s^{-1}, has the highest count rate observed so far with *Chandra* from a PMS low-mass star. By chance, the source position, 8.2′ off-axis, protected this observation from pile-up. We make a spectral analysis of the X-ray emission versus time, showing that the plasma temperature of the quiescent phase and the flare peak reaches 29 MK and 88 MK, respectively. The quiescent and flare luminosities in the energy range 0.5–8 keV corrected from absorption ($N_{\rm H} \approx 1.7\,10^{21}$ cm^{-2}) are $6\,10^{30}$ erg s^{-1} and $\sim 10^{32}$ erg s^{-1}, respectively. The ratio of the quiescent X-ray luminosity on the LkHα 312 bolometric luminosity is very high with $\log(L_{\rm X}/L_{\rm bol}) = -2.9$, implying that the corona of LkHα 312 reached the 'saturation' level. The X-ray luminosity of the flare peak reaches ∼2% of the stellar bolometric luminosity. The different phases of this flare are finally discussed in the framework of solar flares, which leads to the magnetic loop height from $3.1\,10^{10}$ to 10^{11} cm (0.2–0.5 $R_\star$, i.e., 0.5–1.3 $R_\odot$).

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Going Slitless: Images of Forbidden Line Emission Regions of Classical T Tauri Stars Observed with the Hubble Space Telescope

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We have observed five classical T Tauri stars known to have strong forbidden line emission with STIS in slitless mode on the Hubble Space Telescope. This technique makes it possible to image jets within a few tens of AU of their exciting sources, a region of great interest for models of accretion disks and jets. Slitless images generate emission line images at all wavelengths, including those where no narrowband filters exist. Images of the forbidden line regions around each object, constructed by subtracting the stellar continuum and combining observations taken at different orientations, show [O I] jets from CW Tau, HN Tau, UZ Tau-E, DF Tau, and the primary of DD Tau. Jets exist on both sides of the close binary DF Tau, either as a jet and its counterjet or as separate jets from the primary and secondary. Several emission lines not previously seen in jets close to the star exist in the HN Tau jet; the [Fe II] 7155Å/ 8617Å ratio is particularly useful because it measures the electron density in the densest regions of stellar jets, where log(N_e) >∼ 6. Electron densities in the inner 30 AU of the HN Tau jet range from log N_e = 6.2 to 6.9. We construct diagnostic diagrams for the density, temperature, and ionization fraction in jets close to their stars using various emission lines of O I and O II. The red auroral [O II] lines are bright close to HN Tau, indicating that the emitting regions of the inner 35 AU of the jet have a substantial ionized component – 20% if the emission comes from a shock, and 50% for an isothermal flow. We discuss mass loss rates and filling factors for these two cases. The intensity of the HN Tau jet in [O I] 6300Å declines exponentially with distance beyond ∼ 15 AU. The superior continuum subtraction with slitless data as compared with narrowband images makes it possible to resolve widths of jets at distances as close as ∼ 15 AU of the star. The two best examples, HN Tau and UZ Tau-E, have jets that expand with distance. When projected back to the source, the width of the jet in HN Tau is a few AU at the 3-sigma level, while the jet in UZ Tau-E is spatially unresolved. The new images of CW Tau reveal proper motions in this jet, which ejected at least two knots since 1980. There is no indication that CW Tau brightened when it ejected the largest of these knots, but the photometric record

of this star over the last two decades is fragmentary.

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High Resolution Near-Infrared Spectroscopy of FU Ori Objects

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We present an analysis of recent near-infrared, high-resolution spectra of the variable FU Ori objects. During a phase of rapid fading in optical brightness during 1997, V1057 Cyg exhibited shell absorption in first-overtone ($v''-v' = 2-0$) CO lines, blue shifted by about 50km s^{-1} from the system velocity. This shell component had not been seen previously, nor was it present in 1999, although some blue shifted absorption asymmetry is seen at the latter epoch. The appearance of this CO absorption shell is connected with the roughly contemporaneous appearance of blue-shifted, low-excitation optical absorption lines with comparable low velocities; we suggest that this shell was also responsible for some of the peculiar emission features seen in red-optical spectra of V1057 Cyg. FU Ori continues to exhibit broad CO lines, with some evidence for the double-peaked profiles characteristic of an accretion disk; the line profiles are consistent with previous observations. Both FU Ori and V1057 Cyg continue to exhibit lower rotational broadening at 2.3 μm than at optical wavelengths, in agreement with the prediction of differentially-rotating disk models; we have a marginal detection of the same effect in V1515 Cyg. The relative population of the first overtone CO rotational levels in the FU Ori objects suggests low excitation temperatures. We compare disk models to the observations and find agreement with overall line strengths and rotational broadening, but the observed line profiles are generally less double-peaked than predicted. We suggest that the discrepancy in line profiles is due to turbulent motions in FU Ori disks, of an effect qualitatively predicted by recent simulations of the magnetorotational instability in vertically-stratified accretion disks.

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A VLA Search for Water Masers in Six HII Regions: Tracers of Triggered Low-Mass Star Formation

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We present a search for water maser emission at 22 GHz associated with young low-mass protostars in six HII regions — M16, M20, NGC 2264, NGC 6357, S125, and S140. The survey was conducted with the NRAO Very Large Array from 2000 to 2002. For several of these HII regions, ours are the first high-resolution observations of water masers. We detected 16 water masers: eight in M16, four in M20, three in S140, and one in NGC 2264. All but one of these were previously undetected. No maser emission was detected from NGC 6357 or S125. There are two principle results to our study. (1) The distribution of water masers in M16 and M20 does not appear to be random but instead is concentrated in a layer of compressed gas within a few tenths of a parsec of the ionization front. (2) Significantly fewer masers are seen in the observed fields than expected based on other indications of ongoing star formation, indicating that the maser-exciting lifetime of protostars is much shorter in HII regions than in regions of isolated star formation. Both of these results confirm predictions of a scenario in which star formation is first triggered by shocks driven in advance of ionization fronts, and then truncated $\sim 10^5$ years later when the region is overrun by the ionization front.

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Molecular hydrogen as baryonic dark matter

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High-angular resolution CO observations of small-area molecular structures (SAMS) are presented. The feature-less structures seen in the single-dish measurements break up into several smaller clumps in the interferometer map. At an adopted distance of 100pc their sizes are of order a few hundred AU, some of which are still unresolved at an angular resolution of about 3″. The clumps have a fractal structure with a fractal index between 1.7 and 2.0. Their kinetic temperature is between 7 K and 18 K. Adopting standard conversion factors masses are about 1/10 $M_{Jupiter}$ for individual clumps and densities are higher than 20000 cm^{-3}. The clumps are highly overpressured and it is unknown what creates or maintains such structures.

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Free-Free Spectral Energy Distributions of Hierarchically Clumped HII Regions

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In an effort to understand unusual power-law spectral slopes observed in some hypercompact HII regions, we consider the radio continuum energy distribution from an ensemble of spherical clumps. An analytic expression for the free-free emission from a single spherical clump is derived. The radio continuum slope (with $F_\nu \propto \nu^\alpha$) is governed by the population of clump opticaldepths $N(\tau)$, such that (a) at frequencies where all clumps are thick, a continuum slope of +2 is found, (b) at frequencies where all clumps are optically thin, a flattened slope of −0.11 is found, and (c) at intermediate frequencies, a power-law segment of significant bandwidth with slopes between these two limiting values can result. For the ensemble distribution, we adopt a power-law distribution $N(\tau) \propto \tau^{-\gamma}$, and find that significant power-law segments in the SED with slopes from +2 to −0.11 result only for a relatively restricted range of γ values of 1 to 2. Further, a greater range of clump optical depths for this distribution leads to a wider bandwidth over which the intermediate power-law segment exists. The model is applied to the source W49N-B2 with an observed slope of $\alpha \approx +0.9$, but that may be turning over to become optically thin around 2 mm. An adequate fit is found in which most clumps are optically thin and there is little "shadowing" of rearward clumps by foreground clumps (i.e., the geometrical covering factor $C \ll 1$). The primary insight gained from our study is that in the Rayleigh-Jeans limit for the Planck function that applies for the radio band, it is the distribution in optical depth of the clump population that is solely responsible for setting the continuum shape, with variations in the size and temperature of clumps serving to modulate the level of free-free emission.

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The young stellar population in the Serpens Cloud Core: An ISOCAM survey

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We present results from an ISOCAM survey in the two broad band filters LW2 (5-8.5 μm) and LW3 (12-18 μm) of a 0.13 square degree coverage of the Serpens Main Cloud Core. A total of 392 sources were detected in the 6.7 μm band and 139 in the 14.3 μm band to a limiting sensitivity of $\sim$ 2 mJy. We identified 58 Young Stellar Objects (YSOs) with mid-IR excess from the single colour index [14.3/6.7], and 8 additional YSOs from the $H-K/K-m_{6.7}$ diagram. Only 32 of these 66 sources were previously known to be YSO candidates. Only about 50% of the mid-IR excess sources show excesses in the near-IR $J-H/H-K$ diagram. In the 48 square arc minute field covering the central Cloud Core the Class I/Class II number ratio is 19/18, i.e. about 10 times larger than in other young embedded clusters such as ρ Ophiuchi or Chamaeleon. The mid-IR fluxes of the Class I and flat-spectrum sources are found to be on the average larger than those of Class II sources. Stellar luminosities are estimated for the Class II sample, and its luminosity function is compatible with a coeval population of about 2 Myr which follows a three segment power-law IMF. For this age about 20% of the Class IIs are found to be young brown dwarf candidates. The YSOs are in general strongly clustered, the Class I sources more than the Class II sources, and there is an indication of sub-clustering. The sub-clustering of the protostar candidates has a spatial scale of 0.12 pc. These sub-clusters are found along the NW-SE oriented ridge and in very good agreement with the location of dense cores traced by millimeter data. The smallest clustering scale for the Class II sources is about 0.25 pc, similar to what was found for ρ Ophiuchi. Our data show evidence that star formation in Serpens has proceeded in several phases, and that a "microburst" of star formation has taken place very recently, probably within the last 10^5 yrs.

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The influence of the ionisation rate on the chemical composition of dense cores of dark molecular clouds

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We study the influence of variation in the rate ζ of ionization of neutral chemical species by cosmic rays on abundances of some observable molecules in dense cores of dark molecular clouds. Changes in molecular abundances, accompanying the increased (decreased) ionization rate, are caused by the single cause, namely, the acceleration (deceleration) of processes, which are affected directly or indirectly by chemical reactions with charged species. Apart from affecting the gas-phase chemistry, increased cosmic ray flux not only leads to more effective destruction of dust grain mantles, but also accelerates the freeze-out of some components. In particular, in the model with increased ζ destruction of a volatile molecule N_2 by ionized helium causes rapid accumulation of nitrogen atoms in the dust phase ammonia, which has the higher desorption energy in comparison with N_2 desorption energy. As a result, the gas-phase abundance of NH_3 and N_2H^+ decreases significantly. This mechanism is able to explain the unusual chemical structure of some dense globules, e. g., B68, where surprizingly low abundances of N-bearing molecules is observed along with the central depression in NH_3 and N_2H^+ column densities. It is shown that cloud observations in HCN and HNC lines are able to discriminate between the two possible reasons of decreased NH_3 and N_2H^+ abundances, namely, the influence of the increased cosmic ray flux or N_2 freeze-out due to higher desorption energy of this molecule.

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Synthetic infrared images and spectral energy distributions of a young low-mass stellar cluster

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We present three-dimensional Monte Carlo radiative transfer models of a very young ($< 10^5$ years old) low mass ($50\,M_\odot$) stellar cluster containing 23 stars and 27 brown dwarfs. The models use the density and the stellar mass distributions from the large-scale smoothed particle hydrodynamics (SPH) simulation of the formation of a low-mass stellar cluster by Bate, Bonnell and Bromm. Using adaptive mesh refinement, the SPH density is mapped to the radiative transfer grid without loss of resolution. The temperature of the ISM and the circumstellar dust is computed using Lucy's Monte Carlo radiative equilibrium algorithm. Based on this temperature, we compute the spectral energy distributions of the whole cluster and the individual objects. We also compute simulated far-infrared Spitzer Space Telescope (*SST*) images (24, 70, and 160 μm bands) and construct colour-colour diagrams (near-infrared *HKL* and *SST* mid-infrared bands). The presence of accretion discs around the light sources influences the morphology of the dust temperature structure on a large scale (up to a several 10^4 au). A considerable fraction of the interstellar dust is underheated compared to a model without the accretion discs because the radiation from the light sources is blocked/shadowed by the discs. The spectral energy distribution (SED) of the model cluster with accretion discs shows excess emission at $\lambda = 3$–$30\ \mu$m and $\lambda > 500\,\mu$m, compared to that without accretion discs. While the former is caused by the warm dust present in the discs, the latter is cause by the presence of the underheated (shadowed) dust. Our model with accretion discs around each object shows a similar distribution of spectral index (2.2–20 μm) values (i.e. Class 0–III sources) as seen in the ρ Ophiuchus cloud. We confirm that the best diagnostics for identifying objects with accretion discs are mid-infrared ($\lambda = 3$–$10\ \mu$m) colours (e.g. *SST* IRAC bands) rather than *HKL* colours.

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The vertical structure of T Tauri accretion discs. IV. Self-irradiation of the disc in the FU Orionis outburst phase

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I investigate the self-irradiation of intensively accreting circumstellar discs (backwarmed discs). It is modelled using the two-layer disc approach by Lachaume et al. (2003) that includes heating by viscous dissipation and by an external source of radiation. The disc is made of a surface layer directly heated by the viscous luminosity of the central parts of the disc, and of an interior heated by viscosity as well as by reprocessed radiation from the surface. This model convincingly accounts for the infrared excess of some FU Orionis objects in the range 1-200 microns and supports the backwarmed disc hypothesis sometimes invoked to explain the mid- and far-infrared excesses whose origins are still under debate. Detailed simulation of the vertical radiative transfert in the presence of backwarming is still needed to corroborate these results and spectroscopically constrain the properties of intensively accreting discs.

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Discovery of a Dusty Ring in the Coalsack: A Dense Core Caught in the Act of Formation?

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We present a new infrared extinction study of Globule 2, the most opaque molecular cloud core in the Coalsack complex. Using deep near-infrared imaging observations obtained with the ESO NTT we are able to examine the structure of the globule in significantly greater detail than previously possible. We find the most prominent structural feature of this globule to be a strong central ring of dust column density which was not evident in lower resolution studies of this cloud. This ring represents a region of high density and pressure that is likely a transient structure. For a spherical cloud geometry the ring would correspond to a dense inner shell of high pressure that could not be in dynamical equilibrium with its surroundings since there appear to be no sources of pressure in the central regions of the cloud that could support the shell against gravity and prevent its inward implosion. The timescale for the inward collapse of the ring would be less than 2 x 10^5 years, suggesting that this globule is in an extremely early stage of evolution, and perhaps caught in the process of forming a centrally condensed dense core or Bok globule. Outside its central regions the globule displays a well-behaved density profile whose shape is very similar to that of a stable Bonnor-Ebert sphere. Using SEST we also obtained a $C^{18}O$ spectrum toward the center of the cloud. The CO observation indicates that the globule is a gravitationally bound object. Analysis of the CO line profile reveals significant non-thermal gas motions likely due to turbulence. As a whole the globule may be evolving to a global state of quasi-static dynamical equilibrium in which thermal and turbulent pressure balance gravity.

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On the Relative Abundance of $C^{18}O$ and $C^{17}O$ in the Taurus Molecular Cloud

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We present measurements of the $[C^{18}O]/[C^{17}O]$ abundance ratio based on observations of J = $(1 \rightarrow 0)$ lines of these isotopomers toward star-forming cores in the Taurus molecular cloud. Our data set includes measurements along 648 lines of sight through these clouds, covering both low and high column density regions. We compare the integrated intensity ratio for each line of sight with a simple model of emission from a dense cloud to determine this abundance ratio. Using this model, we find a $[C^{18}O]/[C^{17}O]$ abundance ratio of 4.0 ± 0.5 is consistent with the data. However, at low column densities, it appears that a higher abundance ratio may be more appropriate. We examine ways in which the abundance ratio might be changed in the outer parts of molecular clouds and conclude that selective photodissociation of $C^{17}O$ by external ultraviolet light can increase the abundance ratio. A two-phase model, incorporating a $C^{17}O$-free "sheath" of cloud material surrounding a self-shielded inner cloud region, is fit to the data. Using this model and an assumed sheath H_2 column density of 4×10^{21} cm^{-2}, we find a lower abundance ratio of 2.8 ± 0.4 for the material in the shielded inner cloud. This new result is consistent with recent results from ultraviolet absorption spectroscopy through translucent clouds and measurements of the $[^{13}C^{18}O]/[^{13}C^{17}O]$ ratio in the Ophiuchus molecular cloud.

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Testing the locality of transport in self-gravitating accretion discs

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In this paper we examine the issue of characterising the transport associated with gravitational instabilities in relatively cold discs, discussing in particular the conditions under which it can be described within a local, viscous framework. We present the results of global, three-dimensional, SPH simulations of self-gravitating accretion discs, in which the disc is cooled using a simple parametrisation for the cooling function. Our simulations show that the disc settles in a "self-regulated" state, where the axisymmetric stability parameter $Q \approx 1$ and where transport and energy dissipation are dominated by self-gravity. We have computed the gravitational stress tensor and compared our results with expectations based on a local theory of transport. We find that, as long as the disc mass is smaller than $0.25M_\star$ and the aspect ratio $H/R \leq 0.1$, transport is determined locally, thus allowing for a viscous treatment of the disc evolution.

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Discovery of [FeII]- and H_2-emission from protostellar jets in the CB3 and CB230 globules

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Four Bok globules were studied in the Near-Infrared, through narrow-band filters, centered at the 1.644 μm line of [FeII], the H_2-line at 2.122 μm, and the adjacent continuum. We report the discovery of [FeII] and H_2 protostellar jets and knots in the globules CB3 and CB230. The [FeII]-jet in CB230 is defined by a continuous elongated emission feature, superimposed on which two knots are seen; the brighter one lies at the tip of the jet. The jet is oriented in the same direction as the large-scale CO outflow, and emerges from the nebulosity in which a Young Stellar Object is embedded. The H_2 emission associated with this jet is fainter and wider than the [FeII] emission, and is likely coming from the walls of the jet-channel. In CB3 four H_2 emission knots are found, all towards the blue-shifted lobe of the large-scale outflow. There is a good correspondence between the location of the knots and the blue-shifted SiO(5−4) emission, confirming that SiO emission is tracing the jet-like flow rather well. No line emission is found in the other two targets, CB188 and CB205, although in CB205 faint line emission may have been hidden in the diffuse nebulosity near the IRAS position. Around this position a small group of ($\geq$ 10) stars is found, embedded in the nebula. A diffuse jet-like feature near this group, previously reported in the literature, has been resolved into individual stars.

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Does Disk Locking Solve the Stellar Angular Momentum Problem?

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We critically examine the theory of disk locking, which assumes that the angular momentum deposited on an accreting protostar is exactly removed by torques carried along magnetic field lines connecting the star to the disk. In this Letter, we consider that the differential rotation between the star and disk naturally leads to an opening (i.e., disconnecting) of the magnetic field between the two. We find that this significantly reduces the spin-down torque on the star by the disk. Thus, disk-locking cannot account for the slow rotation (~10% of breakup speed) observed in several systems and for which the model was originally developed.

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Classical T Tauri Stars as sources of parsec-scale optical outflows

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Previous studies of young stellar objects (YSOs) have uncovered a number of associated parsec - scale optical outflows,

the majority of which are driven by low-mass, embedded Class I sources. Here we examine more evolved Classical T Tauri stars (CTTSs), i.e. Class II sources, to determine whether these are also capable of driving parsec-scale outflows. Five such sources are presented here - CW Tau, DG Tau, DO Tau, HV Tau C and RW Aur, all of which show optical evidence for outflows of the order of 1pc ($24'$ at the distance of Taurus-Auriga). These sources were previously known only to drive "micro-jets" or small-scale outflows $< \sim 1'$ in length. A parsec-scale outflow from a less evolved source (DG Tau B) which was noted in the course of this work is also included here. Examination of the five newly discovered large-scale outflows from CTTSs shows that they have comparable morphologies, apparent dynamical timescales and degrees of collimation to those from less evolved sources. There is also strong evidence that these outflows have blown out of their parent molecular clouds. Finally we note that the "fossil record" provided by these outflows suggests their sources could have undergone FU Orionis-type outbursts in the past.

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http://www.dias.ie/dias/cosmic/astrophysics/general/Staff/homepages/fmcg/publications.html.

The interaction of a planet with a disc with MHD turbulence IV: Migration rates of embedded protoplanets

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We present the results of global cylindrical disc simulations and local shearing box simulations of protoplanets interacting with a disc undergoing MHD turbulence. The specific emphasis of this paper is to examine and quantify the magnitude of the torque exerted by the disc on the embedded protoplanets as a function of the protoplanet mass, and thus to make a first study of the induced orbital migration of protoplanets resulting from their interaction with magnetic, turbulent discs. This issue is of crucial importance in understanding the formation of gas giant planets through the so–called core instability model, and the subsequent orbital evolution post formation prior to the dispersal of the protostellar disc. Current estimates of the migration time of protoplanetary cores in the $3-30$ Earth mass range in standard disc models are $\tau_{mig} \simeq 10^4 - 10^5$ yr, which is much shorter than the estimated gas accretion time scale of Jupiter type planets.

The global simulations were carried out for a disc with aspect ratio $H/r = 0.07$ and protoplanet masses of $M_p = 3, 10, 30$ Earth masses, and 3 Jupiter masses. The local shearing box simulations were carried out for values of the dimensionless parameter $(M_p/M_*)/(H/R)^3 = 0.1, 0.3, 1.0$, and 2.0, with M_*, R and H being the central mass, the orbital radius and the local disc semi-thickness, respectively. These allow both embedded and gap forming protoplanets for which the disc response is non linear to be investigated.

In all cases the instantaneous net torque experienced by a protoplanet showed strong fluctuations on an orbital time scale, and in the low mass embedded cases oscillated between negative and positive values. Consequently, in contrast to the laminar disc type I migration scenario, orbital migration would occur as a random walk. Running time averages for embedded protoplanets over typical run times of $20-25$ orbital periods, indicated that the averaged torques from the inner and outer disc took on values characteristic of type I migration. However, large fluctuations occurring on longer than orbital time scales remained, preventing convergence of the average torque to well defined values or even to a well defined sign for these lower mass cases.

Fluctuations became relatively smaller for larger masses indicating better convergence properties, to the extent that in the $30M_{\oplus}$ simulation consistently inward, albeit noisy, migration was indicated.

Both the global and local simulations showed this trend with increasing protoplanet mass which is due to its perturbation on the disc increasing to become comparable to and then dominate the turbulence in its neighbourhood. This then becomes unable to produce very large long term fluctuations in the torques acting on the protoplanet. Eventually gap formation occurs and there is a transition to the usual type II migration at a rate determined by the angular momentum transport in the distant parts of the disc.

The existence of significant fluctuations occurring in the turbulent discs on long time scales is an important unexplored issue for the lower mass embedded protoplanets, that are unable to modify the turbulence in their neighbourhood, and which have been studied here. If significant fluctuations occur on the longest disc evolutionary time scales, convergence

of torque running averages for practical purposes will not occur and the migration behaviour of low mass protoplanets considered as an ensemble would be very different from predictions of type I migration theory for laminar discs. The fact that noise levels were relatively smaller in the local simulations may indicate the presence of long term global fluctuations, but the issue remains an important one for future investigation.

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Observations of the Brackett decrement in the Class I source HH100 IR

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The Brackett decrement in the Class I source HH100 IR has been observed and analyzed to set constraints on the origin of the IR HI emission in this young object. We have used both low resolution (R∼800) observations of the Brackett lines from Brγ, to Br24, and medium resolution (R∼9000) spectra of the Brγ, Br12 and Br13 lines. The dereddened fluxes indicates that the lines remain moderately thick up to high quantum numbers. Moreover, the profiles of the three lines observed in medium resolution are all broad and nearly symmetric, with a trend for the lines at high n-number to be narrower than the Brγ, line. With the assumption that the three lines have different optical depths and consequently trace zones at different physical depths, we interprete the observed profiles as evidence that the ionized gas velocity in the HI emitting region is increasing as we move outwards, as expected in an accelerating wind more than in an infalling gas.

We have modelled the observed line ratios and velocities with a simplified model for the HI excitation from a circumstellar gas with a velocity law $V = V_0 + (V_{max} - V_0)(1-(r_i/r)^\alpha)$. Such a comparison indicates that the observations are consistent with the emission coming from a very compact region of 4-6 $R_\odot$, where the gas has been already accelerated to velocities of the order of 200 $km\,s^{-1}$, with an associated mass flow rate of the *ionized* component of the order of 10^{-7} $M_\odot\,yr^{-1}$. This implies that the observed lines should originate either from a stellar wind or from the inner part of a disk wind, providing that the disk inner truncation radius is close to the stellar surface. It is also expected that the gas ionization fraction is relatively high as testified by the high rate of ionized mass loss derived. Our analysis, however, does not resolve the problem of how to reproduce the observed symmetrical line profiles, which at present are apparently difficult to model by both wind and accretion models. This probably points to the fact that the real situation is more complicated than described in the simple model presented here.

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A near-infrared study of the bow shocks within the L1634 protostellar outflow

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The L1634 bright-rimmed globule contains an intriguing arrangement of shock structures: two series of aligned molecular shock waves associated with the Herbig-Haro flows HH 240 and HH 241. We present near-infrared spectroscopy and narrow-band imaging in the (1,0) S(1) and (2,1) S(1) emission lines of molecular hydrogen. These observations yield the spatial distributions of both the molecular excitation and velocity, which demonstrate distinct properties for the individual bow shocks. Bow shock models are applied, varying the shock physics, geometry, speed, density and magnetic field properties to fit two prominent bow shocks. The models predict that both bows move at 60° to the plane of the sky. High magnetic fields and low molecular fractions are implied. The advancing compact bow HH 240C is interpreted as a J-type bow (frozen-in magnetic field) with the flanks in transition to C-type (field diffusion). It is a paraboloidal bow of speed $\sim 42\,\mathrm{km\,s^{-1}}$ entering a medium of quite high density ($2 \times 10^4\,\mathrm{cm^{-3}}$). The following bow HH 240A is faster despite a lower excitation, moving through a lower density medium. We find a C-type bow shock model to fit all the data for HH 240A. The favoured bow models are then tested comprehensively against published H_2 emission line fluxes and CO spectroscopy. We conclude that, while the CO emission originates from cloud gas directly set in motion, the H_2 emission is generated from shocks sweeping through an outflow. Also considering optical data, we arrive at a global outflow model involving episodic slow-precessing twin jets.

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New Aspects of the Formation of the β Pictoris Moving Group

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In a previous work (Ortega et al. 2002) we explored the possibility that the β Pictoris moving group (BPMG), consisting of low mass Post-T Tauri stars, was formed near the Scorpius-Centaurus OB Association. The cause of the formation could be a type II supernova exploding either in Lower Centaurus Crux (LCC) or in Upper Centaurus Lupus (UCL), the two older subgroups of that association. Here we present new results for BPMG. A more detailed analysis of the orbit confinement in this group leads to a star distribution pattern at birth which can be considered as a representation of the density distribution in the natal cloud. We also propose a plausible origin for the supernova which could have triggered the star formation in BPMG by finding the past position of the runaway star HIP 46950. We find that this scenario is capable to explain the origin of all the members of BPMG proposed by Zuckerman et al. (2001) and by Song et al. (2003) with the exception of HIP 79881, probably an old main sequence interloper.

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The interaction of a planet with a disc with MHD turbulence III: Flow morphology and conditions for gap formation in local and global simulations

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We present the results of both global cylindrical disc simulations and local shearing box simulations of protoplanets interacting with a disc undergoing MHD turbulence with zero net flux magnetic fields. We investigate the nature of the disc response and conditions for gap formation. This issue is an important one for determining the type and nature of the migration of the protoplanet, with the presence of a deep gap being believed to enable slower migration.

For both types of simulation we find a common pattern of behaviour for which the main parameter determining the nature of the response is $M_pR^3/(M_*H^3)$, with M_p, M_*, R, and H being the protoplanet mass, the central mass, the orbital radius and the local disc semi–thickness respectively. We find that as $M_pR^3/(M_*H^3)$ is increased to ~ 0.1 the presence of the protoplanet is first indicated by the appearance of the well known trailing wake which, although it may appear to be erratic on account of the turbulence, appears to be well defined. Once $M_pR^3/(M_*H^3)$ exceeds a number around unity a gap starts to develop inside which the magnetic energy density tends to be concentrated in the high density wakes. This condition for gap formation can be understood from simple dimensional considerations of the conditions for nonlinearity and the balance of angular momentum transport due to Maxwell and Reynolds' stresses with that due to tidal torques applied to the parameters of our simulations.

An important result is that the basic flow morphology in the vicinity of the protoplanet is very similar in both the local and global simulations. This indicates that, regardless of potentially unwanted effects arising from the periodic boundary conditions, local shearing box simulations, which are computationally less demanding, capture much of the

physics of disc–planet interactions. Thus they may provide a useful tool for studying the local interaction between forming protoplanets and turbulent, protostellar discs.

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Predicted rotation signatures in MHD disc winds and comparison to DG Tau observations

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Motivated by the first detections of rotation signatures in the DG Tau jet (Bacciotti et al. 2002), we examine possible biases affecting the relation between detected rotation signatures and true azimuthal velocity for self-similar MHD disc winds, taking into account projection, convolution as well as excitation gradients effects. We find that computed velocity shifts are systematically smaller than the true underlying rotation curve. When outer slower streamlines dominate the emission, we predict observed shifts increasing with transverse distance to the jet axis, opposite to the true rotation profile. Determination of the full transverse rotation profile thus requires high angular resolution observations (< 5 AU) on an object with dominant inner faster streamlines. Comparison of our predictions with HST/STIS observations of DG Tau clearly shows that self-similar, *warm* MHD disc wind models with $\lambda = 13$ and an outer radius of the disc $\simeq 3$ AU are able to reproduce detected velocity shifts, while *cold* disc wind models ($\lambda > 50$) are ruled out for the medium-velocity component in the DG Tau jet.

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Imaging the Disk around TW Hya with the Submillimeter Array

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We present $\sim 2''$-$4''$ aperture synthesis observations of the circumstellar disk surrounding the nearby young star TW Hya in the CO J=2–1 and J=3–2 lines and associated dust continuum obtained with the partially completed Submillimeter Array. The extent and peak flux of the 230 and 345 GHz dust emission follow closely the predictions of the irradiated accretion disk model of Calvet et. al. (2002). The resolved molecular line emission extends to a radius of at least 200 AU, the full extent of the disk visible in scattered light, and shows a clear pattern of Keplerian rotation. Comparison of the images with 2D Monte Carlo models constrains the disk inclination angle to $7^\circ \pm 1^\circ$. The CO emission is optically thick in both lines, and the kinetic temperature in the line formation region is $\sim$20 K. Substantial CO depletion, by

an order of magnitude or more from canonical dark cloud values, is required to explain the characteristics of the line emission.

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The HCO^+ Emission Excess in Bipolar Outflows

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A plausible model is proposed for the enhancement of the abundance of molecular species in bipolar outflow sources. In this model, levels of HCO^+ enhancement are considered based on previous chemical calculations, that are assumed to result from shock-induced desorption and photoprocessing of dust grain ice mantles in the boundary layer between the outflow jet and the surrounding envelope. A radiative transfer simulation that incorporates chemical variations within the flow shows that the proposed abundance enhancements in the boundary layer are capable of reproducing the observed characteristics of the outflow seen in HCO^+ emission in the star forming core L1527. The radiative transfer simulation also shows that the emission lines from the enhanced molecular species that trace the boundary layer of the outflow exhibit complex line profiles indicating that detailed spatial maps of the line profiles are essential in any attempt to identify the kinematics of potential infall/outflow sources. This study is one of the first applications of a full three dimensional radiative transfer

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IRAS 05436–0007 and the Emergence of McNeil's Nebula

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We present a study of McNeil's Nebula, a newly appeared reflection nebula in the L1630 cloud, together with photometry and spectroscopy of its source. New IR photometry compared to earlier 2MASS data shows that the star has brightened by about 3 magnitudes in the near-infrared, changing its location in a J-H/H-K$'$ diagram precisely along a reddening vector. A Gemini NIRI K-band spectrum shows strong CO-bandhead emission and Brγ is in emission, indicative of strong accretion. A Gemini GMOS optical spectrum shows only a red, heavily veiled continuum, with Hα strongly in emission and displaying a pronounced P Cygni profile, with an absorption trough reaching velocities up to 600 km s^{-1}. This implies significant mass loss in a powerful wind. However, no evidence is found for any shocks, as commonly seen in collimated outflows from young stars. Apparently the eruption has dispersed a layer of extinction and this, together with the intrinsic brightening of the IRAS source, has allowed an earlier outflow cavity to be flooded with light, thus creating McNeil's Nebula.

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Hyperfine Structure in $H^{13}CO^+$ and ^{13}CO: measurement, analysis, and consequences for the study of dark clouds

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The magnetic moment of the ^{13}C nucleus is shown to provide a potentially useful tool for analysing quiescent cold molecular clouds. We report discovery of hyperfine structure in the lowest rotational transition of $H^{13}CO^+$. The doublet splitting in $H^{13}CO^+$, observed to be of width 38.5±5.2 kHz or 0.133 km s^{-1}, is confirmed by quantum chemical calculations which give a separation of 39.8 kHz and line strength ratio 3:1 when H and ^{13}C nuclear spin-rotation and spin-spin coupling between both nuclei are taken into account. We improve the spectroscopic constants of $H^{13}CO^+$ and determine the hitherto uncertain frequencies of its low-J spectrum to better precision by analysing the dark cloud L 1512. Attention is drawn to potentially high optical depths (3 to 5 in L 1512) in quiescent clouds, and examples are given for the need to consider the $(1-0)$ line's doublet nature when comparing to other molecular species, redirecting or reversing conclusions arrived at previously by single-component interpretations.
We further confirm the hyperfine splitting in the $(1-0)$ rotational transition of ^{13}CO that had already been theoretically predicted, and measured in the laboratory, to be of width about 46 kHz or, again, 0.13 km s^{-1}. By applying hyperfine analysis to the extensive data set of the first IRAM key-project we show that ^{13}CO optical depths can as for $H^{13}CO^+$ be estimated in narrow linewidth regions without recourse to other transitions nor to assumptions on beam filling factors, and linewidth and velocity determinations can be improved. Thus, for the core of L 1512 we find an inverse proportionality between linewidth and column density, resp. linewidth and square root of optical depth, and a systematic inside-out increase of excitation temperature and of the ^{13}CO:C^{18}O abundance ratio. Overall motion toward the innermost region is suggested.

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Rotation and accretion of very low mass objects in the σ Ori cluster

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We report on two photometric monitoring campaigns of Very Low Mass (VLM) objects in the young open cluster around σ Orionis. Our targets were pre-selected with multi-filter photometry in a field of 0.36 sqdeg. For 23 of these objects, spanning a mass range from 0.03 to 0.7 $M_\odot$, we detect periodic variability. Of these, 16 exhibit low-level variability, with amplitudes of less than 0.2 mag in the I-band, which is mostly well-approximated by a sine wave. These periodicities are probably caused by photospheric spots co-rotating with the objects. In contrast, the remaining variable targets show high-level variability with amplitudes ranging from 0.25 to 1.1 mag, consisting of a periodic light variation onto which short-term fluctuations are superimposed. This variability pattern is very similar to the photometric behaviour of solar-mass, classical T Tauri stars. Low-resolution spectra of a few of these objects reveal strong Hα and Ca-triplet emission, indicative of ongoing accretion processes. This suggests that 5-7% of our targets still possess a circumstellar disk. In combination with previous results for younger objects, this translates into a disk lifetime of 3-4 Myr, significantly shorter than for solar mass stars. The highly variable objects rotate on average slower than the low-amplitude variables, which is expected in terms of a disk-locking scenario. There is a trend towards faster rotation with decreasing mass, which might be caused by shortening of the disk lifetimes or attenuation of magnetic fields.

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Synchrotron emission from circumstellar disks around massive stars

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We argue that the interaction of stellar wind with the surface of a circumstellar accretion (or protoplanetary) disk can result in the acceleration of relativistic electrons in an external layer of the disk, and produce synchrotron radiation. Conservative estimates give a total synchrotron luminosity $L_s \sim 10^{-5}\ L_\odot$ for a central star with $\dot{M} = 10^{-6}\ M_\odot\ \mathrm{yr}^{-1}$, comparable with the value observed around the TW object in the W3(OH) region.

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A new mid-infrared map of the BN/KL region using the Keck telescope

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We present a new mid-infrared (12.5 μm) map of the BN/KL high-mass star-forming complex in Orion using the LWS instrument at Keck I. Despite poor weather we achieved nearly diffraction-limited images (FWHM = 0.38 arcsec) over a roughly 25 arcsec×25 arcsec region centered on IRc2 down to a flux limit of $\approx$ 250 mJy. Many of the known infrared (IR) sources in the region break up into smaller sub-components. We have also detected 6 new mid-IR sources. Nearly all of the sources are resolved in our mosaic. The near-IR source "n" is slightly elongated in the mid-IR along a NW–SE axis and perfectly bisects the double-peaked radio source "L". Source n has been identified as a candidate for powering the large IR luminosity of the BN/KL region ($L = 10L_\odot$). We postulate that the 12 μm emission arises in a circumstellar disk surrounding source n. The morphology of the mid-IR emission and the Orion "hot core" (as seen in NH_3 emission), along with the location of water and OH masers, is very suggestive of a bipolar cavity centered on source n and aligned with the rotation axis of the hypothetical circumstellar disk. IRc2, once thought to be the dominant energy source for the BN/KL region, clearly breaks into 4 sub-sources in our mosaic, as seen previously at 3.8 – 5.0 μm. The anti-correlation of mid-IR emission and NH_3 emission from the nearby hot core indicates that the IRc2 sources are roughly coincident (or behind) the dense hot core. The nature of IRc2 is not clear: neither self-luminous sources (embedded protostars) nor external heating by source I can be definitively ruled out. We also report the discovery of a new arc-like feature SW of the BN object, and some curious morphology surrounding near-IR source "t".

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Resolving the Host Galaxy of the Nearby QSO I Zw 1 with Sub-Arcsecond Multi-Transition Molecular Line Observations

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We present the first sub-kpc ($\sim 0.7''\approx 850$ pc) resolution ^{12}CO(1-0) molecular line observations of the ISM in the host galaxy of the QSO I Zw 1. The observations were obtained with the BIMA mm-interferometer in its compact A configuration. The BIMA data are complemented by new observations of the ^{12}CO(2-1) and ^{13}CO(1-0) line with IRAM Plateau de Bure mm-interferometer (PdBI) at $0.9''$ and $1.9''$ resolution, respectively. These measurements, which are part of a multi-wavelength study of the host galaxy of I Zw 1, are aimed at comparing the ISM properties of a QSO host with those of nearby galaxies as well as to obtain constraints on galaxy formation/evolution models. Our images of the ^{12}CO(1-0) line emission show a ring-like structure in the circumnuclear molecular gas distribution with an inner radius of about 1.2 kpc. The presence of such a molecular gas ring was predicted from earlier lower angular resolution PdBI ^{12}CO(1-0) observations. A comparison of the BIMA data with IRAM PdBI ^{12}CO(2-1) observations shows variations in the excitation conditions of the molecular gas in the innermost 1.5″ comprising the nuclear region of I Zw 1. The observed properties of the molecular cloud complexes in the disk of the host galaxy suggest that they can be the sites of massive circumnuclear star formation, and show no indications of excitation by the nuclear AGN. This all indicates that the molecular gas in a QSO host galaxy has similar properties to the gas observed in nearby low luminosity AGNs.

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Radiative transfer models of non-spherical prestellar cores

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We present 2D Monte Carlo radiative transfer simulations of prestellar cores. We consider two types of asymmetry: *disk-like* asymmetry, in which the core is denser towards the equatorial plane than towards the poles; and *axial* asymmetry, in which the core is denser towards the south pole than the north pole. In both cases the degree of asymmetry is characterized by the ratio e between the maximum optical depth from the centre of the core to its surface and the minimum optical depth from the centre of the core to its surface. We limit our treatment here to mild asymmetries with $e = 1.5$ and 2.5. We consider both cores which are exposed directly to the interstellar radiation field and cores which are embedded inside molecular clouds.

The SED of a core is essentially independent of the viewing angle, as long as the core is optically thin. However, the isophotal maps depend strongly on the viewing angle. Maps at wavelengths longer than the peak of the SED (e.g. 850 μm) essentially trace the column-density. This is because at long wavelengths the emissivity is only weakly dependent on temperature, and the range of temperature in a core is small (typically $T_{\rm max}/T_{\rm min} \lesssim 2$). Thus, for instance, cores with disk-like asymmetry appear elongated when mapped at 850 μm from close to the equatorial plane. However, at wavelengths near the peak of the SED (e.g. 200 μm), the emissivity is more strongly dependent on the temperature, and therefore, at particular viewing angles, there are characteristic features which reflect a more complicated convolution of the density and temperature fields within the core.

These characteristic features are on scales 1/5 to 1/3 of the overall core size, and so high resolution observations are needed to observe them. They are also weaker if the core is embedded in a molecular cloud (because the range of temperature within the core is then smaller), and so high sensitivity is needed to detect them. *Herschel*, to be launched in 2007, will in principle provide the necessary resolution and sensitivity at 170 to 250 μm.

Accepted by A&A

`http://www.astro.cf.ac.uk/pub/Dimitrios.Stamatellos/publications/`

X-ray Properties of Pre–Main-Sequence Stars in the Orion Nebula Cluster with Known Rotation Periods

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We re-analyze all archival *Chandra/ACIS* observations of the Orion Nebula Cluster (ONC) to study the X-ray properties of a large sample of pre–main-sequence (PMS) stars with optically determined rotation periods. Our goal is to elucidate the origins of X-rays in PMS stars by seeking out connections between the X-rays and the mechanisms most likely driving their production—rotation and accretion. Stars in our sample have L_X/L_{bol} near, but below, the "saturation" value of 10^{-3}. In addition, in this sample X-ray luminosity is significantly correlated with stellar rotation, in the sense of *decreasing* L_X/L_{bol} with more rapid rotation. These findings suggest that stars with optical rotation periods are in the "super-saturated" regime of the rotation-activity relationship, consistent with their Rossby numbers. However, we also find that stars with optical rotation periods are significantly biased to high L_X. This is not the result of magnitude bias in the optical rotation-period sample but rather to the diminishingly small amplitude of optical variations in stars with low L_X. Evidently, there exists in the ONC a population of stars whose rotation periods are unknown and that possess lower average X-ray luminosities than those of stars with known rotation periods. These stars may sample the linear regime of the rotation-activity relationship. Accretion also manifests itself in X-rays, though in a somewhat counterintuitive fashion: While stars with spectroscopic signatures of accretionshow *harder* X-ray spectra than non-accretors, they show *lower* X-ray luminosities and no enhancement of X-ray variability. We interpret these findings in terms of a common origin for the X-ray emission observed from both accreting and non-accreting stars, with the X-rays from accreting stars simply being attenuated by magnetospheric accretion columns. This suggests that X-rays from PMS stars have their origins primarily in chromospheres, not accretion.

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Preprints: people.vanderbilt.edu/~keivan.stassun/pubs.htm

Decay of Alfvén Waves in a Filamentary Cloud

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The decay of Alfvén waves in a filamentary molecular cloud is investigated through three-dimensional numerical simulations. We have considered a filamentary molecular cloud supported in part by the Alfvén wave against the self-gravity. Our attention has been focused on the basic physical mechanism for the decay. The decay rate is obtained as a function of the wavelength and amplitude. It is found that when the wave is circularly polarized, the decay e-folding timescale is several times the fast wave crossing timescale for the filament and independent of the wavelength, whereas when the wave is linearly polarized, the amplitude of the wave decreases inversely proportional to time. It is also found that the decay of Alfvén waves induces rotation and shear flow in the filamentary cloud. The propagation of two Alfvén waves in the medium results in the excitation of daughter waves due to nonlinear coupling between mother waves. The wavenumber of the daughter waves is the sum or difference between those of the mother waves, and below a critical wavenumber of the daughter wave, the filamentary cloud fragments due to Jeans instability. The fragments collapse to form high-density rotating magnetized disks. In contrast, below a critical wavenumber of the mother wave, the cloud becomes a dense helical filament after the decay of the Alfvén waves. The present models are compared with previous simulations and observations with regard to the rotation, fragmentation, and helical structure of filamentary clouds.

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http://www.journals.uchicago.edu/ApJ/journal/preprints/ApJ59240.preprint.pdf

Methanol in W3(H_2O) and Surrounding Regions

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We present the results of an interferometric study of 38 millimeter-wave lines of $^{12}CH_3OH$ in the vicinity of the massive star forming region W3(OH/H_2O). These lines cover a wide range of excitation energies and line strengths, allowing

for a detailed study of excitation mechanisms and opacities. In this paper we concentrate on the region around the water maser source W3(H_2O) and a region extending about 30 arcsec to the south and west of the hydroxyl maser source W3(OH).

The methanol emitting region around W3(H_2O) has an extent of 2.0 x 1.2 arcsec (4400 x 2600 AU). The density is of order 10^7 cm^{-3}, sufficient to thermalize most of the methanol lines. The kinetic temperature is approximately 140 K and the methanol fractional abundance greater than 10^{-6}, indicative of a high degree of grain mantle evaporation. The W3(H_2O) source contains sub-structure, with peaks corresponding to the TW source and Wyrowski's B/C, separated by 2500 AU in projection. The kinematics are consistent with these being distinct protostellar cores in a wide binary orbit and a dynamical mass for the region of a few tens of $M_\odot$.

The extended methanol emission to the southwest of W3(OH) is seen strongly only from the lowest excitation lines and from lines known elsewhere to be class I methanol masers, namely the 84.5 GHz 5_{-1}–4_0 E and 95.2 GHz 8_0–7_1 A^+ lines. This suggests that this region, like class I maser sources, is dominated by collisional excitation. Within this region there are two compact clumps, which we denote as swA and swB, each about 15 arcsec (0.16 pc projected distance) away from W3(OH). Excitation analysis of these clumps indicates the presence of lines with inverted populations but only weak amplification. The sources swA and swB appear to have kinetic temperatures of order 50–100 K and densities of order 10^5–10^6 cm^{-3}. The methanol fractional abundance for the warmer clump is of order 10^{-7}, suggestive of partial grain mantle evaporation. The clumping occurs on mass scales of order 1 $M_\odot$.

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The Becklin-Neugebauer Object as a Runaway B Star, Ejected 4000 years ago from the $\theta^1 C$ system

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We attempt to explain the properties of the Becklin-Neugebauer (BN) object as a runaway B star, as originally proposed by Plambeck et al. (1995). This is one of the best-studied bright infrared sources, located in the Orion Nebula Cluster — an important testing ground for massive star formation theories. From radio observations of BN's proper motion, we trace its trajectory back to Trapezium star $\theta^1 C$, the most massive ($45 M_\odot$) in the cluster and a relatively tight (17 AU) visual binary with a B star secondary. This origin would be the most recent known runaway B star ejection event, occurring only $\sim$ 4000 yr ago and providing a unique test of models of ejection from multiple systems of massive stars. Although highly obscured, we can constrain BN's mass ($\simeq 7 M_\odot$) from both its bolometric luminosity and the recoil of $\theta^1 C$. Interaction of a runaway B star with dense ambient gas should produce a compact wind bow shock. We suggest that X-ray emission from this shocked gas may have been seen by *Chandra*: the offset from the radio position is $\simeq$ 300 AU in the direction of BN's motion. Given this model, we constrain the ambient density, wind mass-loss rate and wind velocity. BN made closest approach to the massive protostar, source "I", 500 yr ago. This may have triggered enhanced accretion and thus outflow, consistent with previous interpretations of the outflow being a recent ($\sim 10^3$ yr) "explosive" event.

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Detection of D_2H^+ in the dense interstellar medium

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The 692 GHz para ground-state line of D_2H^+ has been detected at the Caltech Submillimeter Observatory towards the pre-stellar core 16293E. The derived D_2H^+ abundance is comparable to that of H_2D^+, as determined by observations of the 372 GHz line of ortho-H_2D^+. This is an observational verification of recent theoretical predictions (Roberts, Herbst & Millar 2003), developed to explain the large deuteration ratios observed in cold, high-density regions of the interstellar medium associated with low mass pre-stellar cores and protostars. This detection confirms expectations that the multiply deuterated forms of H_3^+ were missing factors of earlier models. The inclusion of D_2H^+ and D_3^+ in the models leads to predictions of higher values of the D/H ratio in the gas phase.

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On the influence of uncertainties in chemical reaction rates on results of the astrochemical modelling

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With the chemical reaction rate database UMIST 95, we analyse how errors in rate constants of gas-phase chemical reactions influence the modelling of the time-dependent molecular abundances in the interstellar medium. Random variations are introduced into the rate constants to estimate the scatter in theoretical abundances for dark and translucent molecular clouds. All the species are divided into 6 sensitivity groups according to the value of the scatter in their modelled abundances computed with varied rate constants. Distribution of species over these groups depends on the adopted physical conditions. Logarithmic abundances of simple molecules vary within 0.5–1. As the number of atoms in a molecule becomes greater, the scatter in abundances significantly increases as well. A simple method is suggested, which allows to single out reactions that are most important for the evolution of a given species. The method is based on the investigation of correlations between the species abundance and reaction rate constants and allows to estimate how the increased accuracy of the rate constant for a particular reaction will decrease the uncertainty in the species abundance.

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The Structure of Brown Dwarf Circumstellar Disks

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We present synthetic spectra for circumstellar disks that are heated by radiation from a central brown dwarf. Under the assumption of vertical hydrostatic equilibrium, our models yield scaleheights for brown dwarf disks in excess of three times those derived for classical T Tauri (CTTS) disks. If the near-IR excess emission observed from brown dwarfs is indeed due to circumstellar disks, then the large scaleheights we find could have a significant impact on the optical and near-IR detectability of such systems. Our radiation transfer calculations show that such highly flared disks around brown dwarfs will result in a large fraction of obscured sources due to extinction of direct starlight by the disk over a wide range of sightlines. The obscured fraction for a 'typical' CTTS is less than 20%. We show that the obscured fraction for brown dwarfs may be double that for CTTS, but this depends on stellar and disk mass. We also comment on possible confusion in identifying brown dwarfs via color-magnitude diagrams: edge-on CTTS display similar colors and magnitudes as a face-on brown dwarf plus disk systems.

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http://arxiv.org/abs/astro-ph/0403276

Formation of Chondritic Refractory Inclusions: The Astrophysical Setting

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This study attempts to identify the astrophysical setting in which properties of the Ca,Al-rich inclusions (CAIs) found in chondritic meteorites are best understood. Importance is attached to the short time period in which most or all of the CAIs were formed (¡ 0.5 Myr, corresponding to the observed dispersion of values of initial 26Al/27Al about the canonical value of 5e-05), a constraint that has been overlooked. This period is dissimilar to the time scale of evolution of T Tauri stars, 10 Myr; it corresponds instead to the time scale of Class 0 and Class I young stellar objects, protostars as they exist during the massive infall of interstellar material that creates stars. The innermost portion of the sunpidly-accreting nebular disk, kept hot during that period by viscous dissipation, is the most plausible site for CAI formation. Once condensed, CAIs must be taken out of that hot zone fairly promptly in order to preserve their specialized mineralogical compositions, and they must be transported to the radial distance of the asteroid belt to be available for accretion into the chondrites that contain them today. Though this paper is critical of some aspects of the x-wind model of CAI formation, something akin to the x-wind may be the best way of understanding this extraction and transport of CAIs.

Accepted by Geochim. Cosmochim. Acta

A pdf preprint can be downloaded from http://cfa-www.harvard.edu/~jwood/

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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New Jobs

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New Worlds in the Cosmos - The Discovery of Exoplanets

Michel Mayor and Pierre-Yves Frei

This is the personal account of the quest for extrasolar planets as told by the discoverer of the first exoplanet. In 1995, Michel Mayor and Didier Queloz announced that 51 Pegasi is orbited by a planet. Since then more than a hundred exoplanets have been discovered. In this charming book, aimed at a general readership, the long road from speculation to fact is described, ending with a discussion of expectations for future studies and the possibility of one day finding life on other planets.

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http://www.cambridge.org

Low-mass stars and brown dwarfs: IMF, accretion and activity

A 3 days workshop to be held on October 17-19, 2004 in Volterra, Tuscany, Italy

Recently, new observational facilities (e.g Chandra, XMM, Spitzer and large ground based telescopes) have started to provide a wealth of observational results. They are expected to constrain theories of formation and early evolution of low-mass stars, brown-dwarfs and planetary mass objects. The goal of this workshop is to bring together a small number of experts in the field, both theorists and observers to discuss the recent progress in this area and the perspective in the near future. The workshop venue and format are designed to stimulate discussions among the participants in a friendly and lively setting.

The workshop is organized within a network program between italian groups working in this field, supported by the italian Ministry of Research.

Volterra is an ancient etrurian city in the heart of Tuscany, famous for alabaster and the beautiful countryside. More information on Volterra can be found at http://www.volterratur.it

Attached below is a first sketch of the topics we wish to cover. Please let us know if you can attend the Volterra workshop and to which topics you would like to contribute.

More informations on the workshop, including the pre-registration form, details on the accomodation and facilities are available on the web page: http://www.arcetri.astro.it/∼volt04

Note the pre-registration deadline: May 10, 2004.

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Scientific Program:

I - The IMF and the search for low-mass objects

II - Formation Mechanisms: theories and observational tests

III - Disks: statistics and properties

IV - Accretion-related activity

V - Jets, winds and outflows