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Abstracts of recently accepted papers

The Trumpler 14 Photodissociation Region in the Carina Nebula

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We report the results of observations of the fine-structure emission lines [CII] 158 μm and [OI] 63 μm using FIFI on the Kuiper Airborne Observatory (KAO) and the Long Wavelength Spectrometer (LWS) on board ISO, towards the molecular cloud associated with the stellar cluster Trumpler 14 (Tr 14) in the Carina Nebula. These data are compared with selected CO and CS transitions obtained with the SEST as well as IRAS and *MSX* images to produce a detailed view of the morphology and the physical conditions prevailing in the photodissociation region (PDR) at the interface between the ionized gas and the molecular dust lane. The relative intensity distribution observed for the various tracers is consistent with the stratification expected for a molecular cloud seen edge-on and exposed to a radiation field of $\approx 10^4$ G_0, which is dominated by the most massive stars of Tr 14. The grain photoelectric heating efficiency, ϵ, is estimated to be $\approx 5 \times 10^{-3}$ and is comparable to other galactic PDRs. The molecular gas has a complicated velocity structure with a high velocity dispersion resulting from the impact of the stellar winds arising from Tr 14. There is evidence of small-scale clumping with a very low volume filling factor. Despite the rich concentration of massive O stars in Tr 14 we find that the parameters of the PDR are much less-extreme than those of the Orion and M 17 massive star-forming regions.

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An analytic model for the motion of the head of a variable jet

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We present a model for the motion of the head of a variable jet which conserves both mass and momentum. Our model is in principle applicable for an ejection variability of arbitrary form. However, we present full solutions for only two cases : sinusoidal velocity variability+constant mass loss rate and sinusoidal velocity variability+constant ejection density.

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Star Formation in Transient Molecular Clouds

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We present the results of a numerical simulation in which star formation proceeds from an initially unbound molecular cloud core. The turbulent motions, which dominate the dynamics, dissipate in shocks leaving a quiescent region which becomes gravitationally bound and collapses to form a small multiple system. Meanwhile, the bulk of the cloud escapes due to its initial supersonic velocities. In this simulation, the process naturally results in a star formation efficiency of $\sim 50\%$. The mass involved in star formation depends on the gas fraction that dissipates sufficient kinetic energy in shocks. Thus, clouds with larger turbulent motions will result in lower star formation efficiencies. This implies that globally unbound, and therefore transient giant molecular clouds (GMCs), can account for the low efficiency of star formation observed in our Galaxy without recourse to magnetic fields or feedback processes. Observations of the dynamic stability in molecular regions suggest that GMCs may not be self-gravitating, supporting the ideas presented in this letter.

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The unusual infrared colors of a faint object in the Chamaeleon I star forming region

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We present deep near-infrared (J_SHK_S) imaging observations carried out with the ESO Very Large Telescope (VLT) of a field in the Chamaeleon I star forming region in an attempt to identify possible members with masses comparable to, or below, the mass of Jupiter. We focus on an object, ChaI J110814.2-773649, which stands out as an outlier in color-color and color-magnitude diagrams of the field, with $H = 22.16^{+0.21}_{-0.17}$, $H - K_S = -0.01^{+0.26}_{-0.24}$, $J_S - H = 2.00^{+\infty}_{-0.62}$. H-band spectroscopy of this object shows that the unusual colors are not due to emission lines in that region, and even provide a clear detection of its continuum. Assuming membership in Chamaeleon I and an age of 2 Myr like for the bulk of the members of that region, the blue $H - K_S$ color and the absolute magnitude are consistent with model predictions for a cool, sub-Jupiter mass object with strong dust depletion in the atmosphere. However, the very red $J_S - H$ color implied by the marginal detection in the J_S band is unexpected in an object with such atmospheric properties. We speculate that this might be due to differences in the properties of dust and its depletion under the photosphere with respect to field objects (T dwarfs) with a similar temperature, resulting from both the youth and the low surface gravity of a low mass member of a star forming region. We also consider the alternative possibility that ChaI J110814.2-773649 might actually be a high redshift object, whose red $J_S - H$ color could result from absorption of the flux bluewards of Lyman α in the J band. We find that such possibility would be marginally compatible with the J_SHK_S photometry of ChaI J110814.2-773649 if it were an unreddened starburst at $8.5 < z < 11$.

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`http://www.eso.org/~fcomeron/yipmo.ps`

The dependence of the sub-stellar IMF on the initial conditions for star formation

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We have undertaken a series of hydrodynamical simulations of multiple star formation in small turbulent molecular clouds. Our goal is to determine the sensitivity of the properties of the resulting stars and brown dwarfs to variations in the initial conditions imposed. In this paper we report on the results obtained by applying two different initial turbulent velocity fields. The slope of the turbulent power-law spectrum α is set to -3 in half of the calculations and to −5 in the other half. We find that, whereas the stellar mass function seems to only be weakly dependent on the value of α, the sub-stellar mass function turns out to be more sensitive to the initial slope of the velocity field. We argue that, since the role of turbulence is to create substructure from which gravitational instabilities may grow, variations in other initial conditions that also determine the fragmentation process are likely to affect the shape of the sub-stellar mass function as well. The absence of many planetary mass *free-floaters* in our simulations, especially in the mass range $1 - 10$ M_J, suggests that, if these objects are abundant, they are likely to form by similar mechanisms to those thought to operate in quiescent accretion discs, instead of via instabilities in gravitationally unstable discs. We also show that the distribution of orbital parameters of the multiple systems formed in our simulations are not very sensitive to the initial conditions imposed. Finally, we find that multiple and single stars share comparable kinematical properties, both populations being able to attain velocities in the range $1 - 10$ km s^{-1}. From these values we draw the conclusion that only low-mass star-forming regions such as Taurus-Auriga or Ophiuchus, where the escape speed is low, might have suffered some depletion of its single and binary stellar population.

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An Interstellar Origin for the Beryllium 10 in CAIs

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Beryllium 10 is a short-lived radionuclide ($t_{1/2} = 1.5\,\mathrm{Myr}$) that was incorporated live into calcium-rich, aluminum-rich inclusions (CAIs) at the birth of our solar system. Beryllium 10 is unique among the short-lived radionuclides in that it is only formed by spallation reactions and not by nucleosynthesis, e.g. in a supernova. Previous work [McKeegan et al. (2000), *Science*, 289, 1334; Gounelle et al. (2001), *Ap.J.*, 548, 1051] has stated that the high initial abundance of ^{10}Be in CAIs ($^{10}\mathrm{Be}/^{9}\mathrm{Be} \approx 1 \times 10^{-3}$) cannot be attributed to galactic cosmic rays (GCRs), and therefore concluded that the spallation reactions must have occurred within the solar nebula itself, due to energetic particles emitted by the early Sun.

In this paper we re-examine this conclusion. We calculate the contributions of GCRs to the ^{10}Be abundance in a molecular cloud core as it collapses to form a protostar and protoplanetary disk. We constrain the flux of protons and ^{10}Be GCRs in the Sun's molecular cloud core 4.5 Gyr ago. We use numerical magnetohydrodynamic simulations of star formation to model the time evolution of the magnetic field strength and column density of gas in a collapsing cloud core. We account for magnetic focusing and magnetic mirroring and the anisotropic distribution of GCR pitch angles in the cloud core. We calculate the rates at which GCR protons and α particles induce spallation reactions producing ^{10}Be atoms, and the rates at which GCR ^{10}Be nuclei are trapped in the cloud core. Accounting also for the decay of ^{10}Be over the evolution of the cloud core, we calculate the time-varying $^{10}\mathrm{Be}/^{9}\mathrm{Be}$ ratio. We find that at the time of protostar formation $^{10}\mathrm{Be}/^{9}\mathrm{Be} \approx 1 \times 10^{-3}$, with an uncertainty of about a factor of three. Spallation reactions account for 20% of the ^{10}Be in CAIs, while trapped GCR ^{10}Be nuclei account for the other 80%. The initial abundance of ^{10}Be in CAIs is therefore entirely attributable to cosmic rays. We discuss the implications of this finding to the origin of other short-lived radionuclides, and to the use of ^{10}Be as a chronometer.

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Preprints downloadable from `http://www.journals.uchicago.edu/ApJ/future.html`

He I λ10830 as a Probe of Winds in Accreting Young Stars

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He I $\lambda 10830$ profiles acquired with Keck's NIRSPEC for 6 young low mass stars with high disk accretion rates (AS 353A, DG Tau, DL Tau, DR Tau, HL Tau and SVS 13) provide new insight into accretion-driven winds. In 4 stars the profiles have the signature of resonance scattering, and possess a deep and broad blueshifted absorption that penetrates more than 50% into the 1 μm continuum over a continuous range of velocities from near the stellar rest velocity to the terminal velocity of the wind, unlike inner wind signatures seen in other spectral features. This deep and broad absorption provides the first observational tracer of the acceleration region of the inner wind and suggests that this acceleration region is situated such that it occults a significant portion of the stellar disk. The remaining 2 stars also have blue absorption extending below the continuum although here the profiles are dominated by emission, requiring an additional source of helium excitation beyond resonant scattering. This is likely the same process that produces the emission profiles seen at He I $\lambda 5876$.

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Preprint available at www.earth.smith.edu/preprint/ms10830.ps

IRAS 23385+6053: a candidate protostellar massive object

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We present the results of a multi-line and continuum study towards the source IRAS 23385+6053, performed with the IRAM-30m telescope, the Plateau de Bure Interferometer, the Very Large Array Interferometer and the James Clerk Maxwell Telescope. We have obtained single-dish maps in the $C^{18}O$ (1–0), $C^{17}O$ (1–0) and (2–1) rotational lines, interferometric maps in the CH_3CCH (13–12) line, NH_3 (1,1) and (2,2) inversion transitions, and single-pointing observations of the CH_3CCH (6–5), (8–7) and (13–12) rotational lines. The new results confirm our earlier findings, namely that IRAS 23385+6053 is a good candidate high-mass protostellar object, precursor of an ultracompact H_{II} region. The source is roughly composed of two regions: a molecular core $\sim 0.03 \div 0.04$ pc in size, with a temperature of ~ 40 K and an H_2 volume density of the order of 10^7 cm^{-3}, and an extended halo of diameter $\leq$0.4 pc, with an average kinetic temperature of ~ 15 K and H_2 volume density of the order of 10^5 cm^{-3}. The core temperature is much smaller than what is typically found in molecular cores of the same diameter surrounding massive ZAMS stars. From the continuum spectrum we deduce that the core luminosity is between 150 and $1.6 \times 10^4 L_\odot$, and we believe that the upper limit is near the "true" source luminosity. Moreover, by comparing the H_2 volume density obtained at different radii from the IRAS source, we find that the halo has a density profile of the type $n_{H_2} \propto r^{-2.3}$. This suggests that the source is gravitationally unstable. The latter hypothesis is also supported by a low virial-to-gas mass ratio ($M_{VIR}/M_{gas} \leq$0.3). Finally, we demonstrate that the temperature at the core surface is consistent with a core luminosity of 10^3 $L_\odot$ and conclude that we might be observing a protostar still accreting material from its parental cloud, whose mass at present is $\sim 6 M_\odot$.

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Far-infrared photometry of deeply embedded outflow sources

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We present far-infrared maps and spectroscopy for a number of deeply embedded protostellar objects (Cep E, HH 211-MM, IC 1396 W, L 1157, L 1211, and RNO 15 FIR) from data that we acquired with the ISO instruments PHOT and LWS. Several previously undetected deeply embedded sources are found in the vicinity of our targets. We determine temperatures and luminosities of seven objects and locate them on a L_{bol}-T_{bol} diagram – the equivalent to a Hertzsprung-Russell diagram for protostars. Their masses and ages, according to their location on tracks taken from our evolutionary model, are derived. L 1211 and Cep E appear to be intermediate mass objects which will reach final masses of about $3\,M_\odot$, while the other sources are in or below the solar mass range. The derived ages of 15000 to 30000 yr are consistent with their current Class 0 state. A comparison of the luminosity of the associated outflows in the 1 − 0 S(1) line of molecular hydrogen with the source properties (bolometric luminosity, bolometric temperature, and envelope mass) of 16 Class 0 sources shows no statistically significant correlations. Nevertheless, the data are consistent with a scheme in which the outflow strength and protostar evolve simultaneously. We show that the relationship is partially disguised, however, by the local properties of the surrounding material, the extinction, and short-term flux variability.

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preprint: http://www.dias.ie/dias/cosmic/astrophysics/general/Staff/homepages/df/

A Giant Flare on A T Tauri Star Observed at Millimeter Wavelengths

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We have conducted multi-epoch synthesis imaging of λ =2 and 3 millimeter (mm) continuum emission and near infrared K band (2.2 μm) imaging of a flare event in January 2003 that occurred on the young stellar object GMR-A which is suggested to be a weak-line T Tauri star in the Orion cluster. Our mm data showed that the flare activity lasted at least over 13 days, whereas the K-band magnitude did not change during this event. In addition, we have succeeded in detecting short time variations of flux on the time scales of 15 minutes. The total energy of the flare is estimated to be $\sim 10^{35-36}$ erg, which makes it one of the most energetic flares reported to date. Comparing the mm continuum luminosities with reported X-ray luminosities, we conclude that the mm flare was similar in nature to solar and other stellar flares. Our results will be a crucial step toward understanding magnetically induced stellar surface activities in T Tauri stars.

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http://www.astro.caltech.edu/~rsf/publication.html

A large X-ray flare from the Herbig Ae star V892 Tau

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We report the XMM-*Newton* observation of a large X-ray flare from the Herbig Ae star V892 Tau. The apparent low mass companion of V892 Tau, V892 Tau NE, is unresolved by XMM-*Newton*. Nevertheless there is compelling evidence from combined XMM-*Newton* and *Chandra* data that the origin of the flare is the Herbig Ae star V892 Tau.

During the flare the X-ray luminosity of V892 Tau increases by a factor of ~ 15, while the temperature of the plasma increases from $kT \simeq 1.5$ keV to $kT \simeq 8$ keV. From the scaling of the flare event, based on hydrodynamic modeling, we conclude that a 500 G magnetic field is needed in order to confine the plasma. Under the assumptions that a dynamo mechanism is required to generate such a confining magnetic field and that surface convection is a necessary ingredient for a dynamo, our findings provide indirect evidence for the existence of a significant convection zone in the stellar envelope of Herbig Ae stars.

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Monte Carlo radiative transfer in molecular cloud cores

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We present the results of a three-dimensional Monte Carlo radiative transfer code for starless molecular cloud cores heated by an external isotropic or non-isotropic interstellar radiation field. The code computes the dust temperature distribution inside model clouds with specified but arbitrary density profiles. In particular we examine in detail spherical (Bonnor-Ebert) clouds, axisymmetric and non-axisymmetric toroids, and clouds heated by an external stellar source in addition to the general interstellar field. For these configurations, the code also computes maps of the emergent intensity at different wavelengths and arbitrary viewing angle, that can be compared directly with continuum maps of prestellar cores. In the approximation where the dust temperature is independent of interactions with the gas and where the gas is heated both by collisions with dust grains and ionization by cosmic rays, the temperature distribution of the gas is also calculated. For cloud models with parameters typical of dense cores, the results show that the dust temperature decreases monotonically from a maximum value near the cloud's edge (14–15 K) to a minimum value at the cloud's center (6–7 K). Conversely, the gas temperature varies in a similar range, but, due to efficient dust-gas coupling in the inner regions and inefficient cosmic-ray heating in the outer regions, the gradient is non-monotonic and the gas temperature reaches a maximum value at intermediate radii. The infrared emission computed for these models (at 350 μm and 1.3 mm) shows that deviations from spherical symmetry in the density and/or temperature distributions are generally reduced in the simulated intensity maps (even without beam convolution), especially at the longer wavelengths.

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The NH_3 / N_2H^+ abundance ratio in dense cores

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We have observed the dense cores Barnard 217 (B217) and LDN 1262 (L1262) in the $(J, K) = (1, 1)$ and $(2, 2)$ inversion lines of ammonia and in the $J = 1$–0 rotational line of diazenylium. The two cores are morphologically similar, in the sense that both contain a Class-I young stellar object (YSO) 1–2′ away from the core centre. The NH_3 and N_2H^+ column densities show the same pattern in both cores: The average NH_3 / N_2H^+ abundance ratios are 140–190 in the starless main bodies of the cores, while they drop to about 60–90 in the regions around the YSOs. Comparison with the dust continuum emission of B217 suggests that this pattern is due to an enhanced fractional ammonia abundance in the quiescent part of the core, where we find $N(\mathrm{NH_3})/N(\mathrm{H_2}) = 5 \times 10^{-8}$. On the outskirts of the core the fractional ammonia abundance is about 3×10^{-8}, in accordance with our previous results. We discuss these findings in the light of recent chemical models including molecular depletion. The rest frequency of the $N_2H^+(J = 1$–$0)$ transition is found to be $\nu(F_1, F = 2, 3 \rightarrow 1, 2) = 93173797 \pm 3$ kHz.

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http://www.astro.helsinki.fi/~hotzel/preprint.ps

The impact of shocks on the chemistry of molecular clouds: high resolution images of chemical differentiation along the NGC1333-IRAS2A outflow

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This paper presents a detailed study of the chemistry in the outflow associated with the low-mass protostar NGC 1333-IRAS2A down to 3″ (650 AU) scales. Millimeter-wavelength aperture-synthesis observations from the Owens Valley and Berkeley-Illinois-Maryland-Association interferometers and (sub)millimeter single-dish observations from the Onsala Space Observatory 20 m telescope and Caltech Submillimeter Observatory are presented. The interaction of the highly collimated protostellar outflow with a molecular condensation ∼15000 AU from the central protostar is clearly traced by molecular species such as HCN, SiO, SO, CS, and CH_3OH. Especially SiO traces a narrow high velocity component at the interface between the outflow and the molecular condensation. Multi-transition single-dish observations are used to distinguish the chemistry of the shock from that of the molecular condensation and to address the physical conditions therein. Statistical equilibrium calculations reveal temperatures of 20 and 70 K for the quiescent and shocked components, respectively, and densities near 10^6 cm^{-3}. The line-profiles of low- and high-excitation lines are remarkably similar, indicating that the physical properties are quite homogeneous within each component. Significant abundance enhancements of two to four orders of magnitude are found in the shocked region for molecules such as CH_3OH, SiO and the sulfur-bearing molecules. HCO^+ is seen only in the aftermath of the shock consistent with models where it is destroyed through release of H_2O from grain mantles in the shock. N_2H^+ shows narrow lines, not affected by the outflow but rather probing the ambient cloud. The overall molecular inventory is compared to other outflow regions and protostellar environments. Differences in abundances of HCN, H_2CO and CS are seen between different outflow regions and are suggested to be related to differences in the atomic carbon abundance. Compared to the warm inner parts of protostellar envelopes, higher abundances of in particular CH_3OH and SiO are found in the outflows, which may be related to density differences between the regions.

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On the origin of brown dwarfs and free-floating planetary mass objects

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Briceno et al. report a significantly smaller number of brown dwarfs (BDs) per star in the Taurus-Auriga (TA) pre-main sequence stellar groups than in the central region of the Orion Nebula cluster (ONC). Also, BDs have binary properties that are not compatible with a star-like formation history. It is shown here that these results can be understood if BDs are produced as ejected embryos with a dispersion of ejection velocities of about 2 km/s and if the number of ejected embryos is about one per four stars born in TA and ONC. The Briceno et al. observation is thus compatible with a universal BD production mechanism and a universal IMF, but the required number of BDs per star is much too small to account for the one BD per star deduced to be present in the Galactic field. There are two other mechanisms for producing BDs and free-floating planetary-mass objects (FFLOPs), namely the removal of accretion envelopes from low-mass proto-stars through photo-evaporation through nearby massive stars, and hyperbolic collisions between proto-stars in dense clusters. The third BD flavour, the collisional BDs, can be neglected in the ONC. It is shown that the observed IMF with a flattening near $0.5\,M_\odot$ can be re-produced via photo-evaporation of proto-stars if they are distributed according to a featureless Salpeter MF above the sub-stellar mass limit, and that the photo-evaporated

BDs should have a smaller velocity dispersion than the stars. The number of photo-evaporated BDs per star should increase with cluster mass, peaking in globular clusters that would have contained many stars as massive as $150\,M_\odot$. The required number of embryo-ejected BDs in TA and the ONC can be as low as 6 ejected BDs per 100 stars if the central ONC contains 0.23 photo-evaporated BDs per star. Alternatively, if the assumption is discarded that embryo ejection must operate equally in all environments, then it can be argued that TA produced about one ejected BD per star leading to consistency with the Galactic-field observations. The dispersion of ejection velocities would be about 3 km/s. In the central ONC the number of ejected BDs per star would then be at most 0.37, or less if photo-evaporated BDs contribute. This non-universal scenario would thus imply that the Galactic-field BD population may mostly stem from TA-like star formation or modest clusters, the ONC not being able to contribute more than about 0.25 ± 0.04 BDs per star.

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A Resolved Circumstellar Disk around the Herbig Ae Star HD 100546 in the Thermal Infrared

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We present mid-infrared nulling interferometric and direct imaging observations of the Herbig Ae star HD 100546 obtained with the Magellan I (Baade) 6.5 m telescope. The observations show resolved circumstellar emission at 10.3, 11.7, 12.5, 18.0, and 24.5 microns. Through the nulling observations (10.3, 11.7 and 12.5 microns), we detect a circumstellar disk, with an inclination of 45 +- 15 degrees with respect to a face-on disk, a semimajor axis position angle of 150 +- 10 degrees (E of N), and a spatial extent of about 25 AU. The direct images (18.0 and 24.5 microns) show evidence for cooler dust with a spatial extent of 30-40 AU from the star. The direct images also show evidence for an inclined disk with a similar position angle as the disk detected by nulling. This morphology is consistent with models in which a flared circumstellar disk dominates the emission. However, the similarity in relative disk size we derive for different wavelengths suggests that the disk may have a large inner gap, possibly cleared out by the formation of a giant protoplanet. The existence of a protoplanet in the system also provides a natural explanation for the observed difference between HD 100546 and other Herbig Ae stars.

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Search for HH objects and emission-line stars in the star forming regions. II. The region of GM1-61 and V453 Ori nebulae

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The results of the observations of the objects, embedded in the dark cloud L1582A, in which the cometary nebulae GM1-61 and V453 Ori are located, are presented. Five new HH objects are discovered in this field. They probably form several flows. The morphology of the nebulae is analyzed and the probable sources of the outflows are discussed. One more reflection nebula, visible mainly in the infrared, is found.

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Spectroscopic identification of DENIS-selected brown dwarf candidates in the Upper Scorpius OB association

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We present low-resolution (R=900) optical (576.1–1,051.1 nm) spectroscopic observations of 40 candidate very low-mass members in the Upper Scorpius OB association. These objects were selected using the I, J and K photometry available in the DENIS database. We have derived spectral types and we have measured Hα and NaI doublet (at 818.3 and 819.5 nm) equivalent widths. We assess the youth of the objects by comparing them to their older counterparts of similar spectral type in the Pleiades cluster and the field. Our analysis indicates that 28 of our targets are young very low-mass objects, and thus they are strong candidate members of the OB association. The other 12 DENIS sources are foreground M dwarfs or background red giants. Our sample of spectroscopic candidate members includes 18 objects with spectral types in the range M6.5 and M9, which are likely young brown dwarfs. We classify these candidates as accreting/non accreting using the scheme proposed by Barrado y Navascués & Martín (2003). We find 5 substellar-mass candidate cluster members that are still undergoing mass accretion, indicating that the timescale for accretion onto brown dwarfs can be as long as 5 Myr in some cases.

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Parsec-scale Herbig-Haro Outflows from Intermediate Mass Stars

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While there are many parsec-scale Herbig-Haro (HH) outflows known to be driven by low-mass young stars, few are associated with their intermediate mass counterparts. Here we present the discovery of five such bipolar outflows. Of these, LkHα 198, 1548C27 IRS 1, LkHα 233 and LkHα 234 were previously known to possess small-scale HH flows, while no such activity was observed before near IRAS 19395+2313. The largest of the newly discovered outflows are seen in the vicinity of LkHα 234 and 1548C27 IRS 1, and stretch (in projection) 8 pc and 7.5 pc respectively. LkHα 233 which was previously known to power a spectroscopically detected small-scale ($\leq$10 arcsec) jet is now seen to drive a 3 pc outflow and LkHα 198 is shown here to power a 2 pc outflow. Two HH objects in the vicinity of IRAS 19395+2313 lead us to suggest that it may also be responsible for a 5 pc outflow. In total, 27 new HH objects/complexes were discovered. Examination of these parsec-scale outflows show that they have similar lengths, morphologies, and dynamical timescales as those from low-mass sources. Many appear to have blown out of the parent cloud, suggesting that their total lengths are much greater than optically observed. The degree of collimation of these outflows is similar to those from low-mass sources suggesting that the transition to more poorly-collimated outflows must occur at higher masses than the sources observed here.

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

Very compact radio emission from high-mass protostars. I. CRL 2136: Continuum and water maser observations

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We report 5–43 GHz radio observations of the CRL 2136 region at 0.6–6″ resolution. We detect weak (mJy intensity) radio emission from the deeply embedded high-mass protostar IRS 1, which has an optically thick spectrum up to frequencies of 22 GHz, flattening at higher frequencies, which might be explained by emission from a jet. Water maser mapping shows that the strong emission observed redshifted relative to the systemic velocity is spatially coincident with the optically thick continuum emission. The H_2O maser emission from this object (and others we know of) seems to have a different origin than most of these masers, which are frequently tracing bipolar high-velocity outflows. Instead, the CRL 2136 H_2O emission arises in the close circumstellar environment of the protostar (within 1000 AU). We speculate that most of it is excited in the hot, dense infalling gas after the accretion shock, although this cannot explain *all* the H_2O emission. An accretion shock nature for the continuum emission seems unlikely.

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Unveiling the Inner Disk Structure of T Tauri Stars

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We present near-infrared spectra of the excess continuum emission from the innermost regions of classical T Tauri disks. In almost all cases, the shape of the excess is consistent with that of a single-temperature blackbody with $T \sim 1400$ K, similar to the expected dust sublimation temperature for typical dust compositions. The amount of excess flux roughly correlates with the accretion luminosity in objects with similar stellar properties. We compare our observations with the predictions of simple disk models having an inner rim located at the dust sublimation radius, including irradiation heating of the dust from both the stellar *and* accretion luminosities. The models yield inner rim radii in the range 0.07-0.54 AU, increasing with higher stellar and accretion luminosities. Using typical parameters that fit our observed sample, we predict a rim radius ~ 0.2 AU for the T Tauri star DG Tau, which agrees with recent Keck near-infrared interferometric measurements. For large mass accretion rates, the inner rim lies beyond the corotation radius at or within which magnetospheric accretion flows are launched, which implies that pure gaseous disks must extend inside the dust rim. Thus, for a significant fraction of young stars, dust cannot exist in the innermost disk, calling into question theories in which solid particles are ejected by a wind originating at the magnetospheric radius.

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A study of the Galactic star forming region IRAS 02593+6016 / S 201 in infrared and radio wavelengths

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We present infrared and radio continuum observations of S 201 star forming region. A massive star cluster is observed in this region, which contains different classes of young stellar objects. The near-infrared colour-colour and colour-magnitude diagrams are studied to discuss the nature of these sources. We have discovered the knots of molecular hydrogen emission at 2.122 μm in the central region of S 201. These knots are clearly seen along the diffuse emission in north–west direction which are probably the obscured Herbig-Haro objects. High sensitivity and high resolution radio continuum images from GMRT observations at 610 and 1280 MHz show an interesting arc-shaped structure due to the interaction between the HII region and the adjacent molecular cloud. The ionization front at the interface between the HII region and the molecular cloud is clearly seen by comparing the radio, molecular hydrogen and Brγ images. The emission from the carriers of Unidentified Infrared Bands in the mid-infrared 6–9 μm (possibly due to PAHs) as extracted from the Midcourse Space Experiment survey (at 8, 12, 14 and 21 μm) is compared with the radio emission. The HIRES processed IRAS maps at 12, 25, 60, and 100 μm, have also been used for comparison. The spatial distribution of the temperature and the optical depth of the warm dust component around S 201 region, has

been generated from the mid-infrared images.

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Preprint available to download at http://www.tifr.res.in/∼ojha/S201.html

An L′-band survey for circumstellar disks around low-mass stars in the young σ Orionis cluster

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We present new K- and L′-band imaging of a representative sample of members of the young 3−5 Myr old σ Orionis cluster. We identified objects with $(K-L')$ excess by analysing colour-colour diagrams and comparing the observations with empirical main-sequence colours. The derived disk frequency depends on the method used: (54±15)% if measured directly from the $JHKL'$ colour-colour diagram; or (46±14)% if excesses are computed with respect to predicted photospheric colours (according to the objects spectral types, 2-σ excess detections). We compare the $(K-L')$ excess with other indicators and show that this is a robust and reliable disk indicator. We also compare the derived disk frequency with similarly aged clusters and discuss possible implications for disk lifetimes. The computed age of the σ Ori cluster is very important: a cluster age of 3 Myr would support the overall disk lifetime of 6 Myr proposed in the literature, while an age >4 Myr would point to a slower disk destruction rate.

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VLA observations of 6-cm excited OH

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The VLA was used to determine precise positions for 4765-MHz OH maser emission sources toward star-forming regions which had been observed about seven months earlier with the Effelsberg 100-meter telescope. The observations were successful for K3-50, DR21EX, W75N, and W49A. No line was detectedAstron. J. toward S255: this line had decreased to less than 5 per cent of the flux density observed only seven months earlier. The time-variability of the observed features during the past 30 years is summarised. In addition, to compare with the Effelsberg observations, the 4750-MHz and 4660-MHz lines were observed in W49A. These lines were found to originate primarily from an extended region which is distinguished as an exceptional collection of compact continuum components as well as by being the dynamical centre of the very powerful H_2O outflow.

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First detection of triply-deuterated methanol

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We report the first detection of triply-deuterated methanol, with 12 observed transitions, towards the low-mass protostar IRAS 16293-2422, as well as multifrequency observations of $^{13}CH_3OH$, used to derive the column density of the main isotopomer CH_3OH. The derived fractionation ratio $[CD_3OH]/[CH_3OH]$ averaged on a 10" beam is 1.4%. Together with previous CH_2DOH and CHD_2OH observations, the present CD_3OH observations are consistent with a formation of methanol on grain surfaces, if the atomic D/H ratio is 0.1 to 0.3 in the accreting gas. Such a high atomic ratio can be reached in the frame of gas-phase chemical models including all deuterated isotopomers of H_3^+.

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Angular Momentum Transfer in Star-Discs Encounters: The Case of Low-Mass Discs

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A prerequisite for the formation of stars and planetary systems is that angular momentum is transported in some way from the inner regions of the accretion disc. Tidal effects may play an important part in this angular momentum transport. Here the angular momentum transfer in an star-disc encounter is investigated numerically for a variety of encounter parameters in the case of low mass discs. Although good agreement is found with analytical results for the entire disc, the loss *inside* the disc can be up to an order of magnitude higher than previously assumed. The differences in angular momentum transport by secondaries on a hyperbolic, parabolic and elliptical path are shown, and it is found that a succession of distant encounters might be equally, if not more, successful in removing angular momentum than single close encounter.

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Evidence for grain growth in T Tauri disks

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In this article we present the results from mid-infrared spectroscopy of a sample of 14 T Tauri stars with silicate emission. The qualitative analysis of the spectra reveals a correlation between the strength of the silicate feature and its shape similar to the one which was found recently for the more massive Herbig Ae/Be stars by van Boekel et al. (2003). The comparison with theoretical spectra of amorphous olivine ($[Mg,Fe]_2SiO_4$) with different grain sizes suggests that this correlation is indicating grain growth in the disks of T Tauri stars. Similar mechanisms of grain processing appear to be effective in both groups of young stars.

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A variable velocity, precessing jet model for HH 32

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HH 32 has a bright, strongly red-shifted lobe with a system of scattered condensations. We propose that these condensations correspond to internal working surfaces in a variable ejection velocity, precessing jet. From a 3D numerical simulation, we obtain predictions of [O II] 3726+29, [O III] 5007, [O I] 6300, Hα, [N II] 6583, and [S II] 6716+31 intensity maps, for an orientation angle of $\sim 70°$ between the outflow axis and the plane of the sky (as appropriate for HH 32). We also obtain predictions of radial velocity channel maps. These predictions are then compared with previously published observations of HH 32, and the strengths and weaknesses of the model are discussed.

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Herbig-Haro jets emerging from a neutral cloud into a H II region

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We present numerical simulations of a Herbig-Haro flow that bursts out of a dense cloud core into a surrounding H II region. Such blow-out's from cloud cores have recently been imaged in various star-forming regions, and we here explore the properties of such outflows by varying selected input parameters to the models. We present time-series of temperature, density, ionization fraction, and Hα emission. We find that the Hα emission of the outflows is mostly controlled by the impinging ionizing photon field rather than by the intrinsic properties of the outflows.

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Hiding the high excitation in the head of a fast Herbig-Haro jet

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We propose that some low excitation HH objects might correspond to the head of a pulsed jet moving into a dense environment. We develop an analytic model showing that the head of such a jet will move slowly, producing a low excitation bow shock. At the times at which the successive pulses catch up with the jet head, high excitation emission will be produced, lasting for a time of the order of the cooling timescale of the material heated in the pulse/jet head interaction. In this way, the jet head has "flashes" of high excitation emission superimposed on a "quiescent", low excitation emission.

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The giant pillars of the Carina Nebula

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Results are presented from a multi-wavelength study of the giant pillars within the Carina Nebula. Using near-IR data from 2MASS, mid-IR data from *MSX*, 843 MHz radio continuum maps from the MOST, and molecular line and continuum observations from the SEST, we investigate the nature of the pillars and search for evidence of ongoing star formation within them. Photodissociation regions (PDRs) exist across the whole nebula and trace the giant pillars, as well as many ridges, filaments and condensations ($A_v > 7$ mag). Morphological similarities between emission features at 21 μm and 843 MHz adjacent to the PDRs, suggests that the molecular material has been carved by the intense stellar winds and UV radiation from the nearby massive stars. In addition, star forming cores are found at the tips of several of the pillars. Using a stellar density distribution, several candidate embedded clusters are also found. One is clearly seen in the 2MASS images and is located within a dense core (G287.84-0.82). A search for massive young stellar objects and compact H II regions using mid-IR colour criteria, reveal twelve candidates across the complex. Grey-body fits to SEDs for four of these objects are suggestive of OB-stars. We find that massive star formation in the Carina Nebula is occurring across the whole complex and confirm it has been continuous over the past 3 Myrs.

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Stellar Rotation in Young Clusters: The First 4 Million Years

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To investigate what happens to angular momentum during the earliest observable phases of stellar evolution, we searched the literature for periods (P), projected rotational velocities (vsini), and supporting data on K5-M2 stars (corresponding to masses 0.25 to 1 $M_\odot$) from the Orion Nebula Cluster and environs, ρ Oph, TW Hydra, Taurus-Auriga, NGC 2264, Chamaeleon, Lupus, and η Cha. We combine these measures of rotation with the stellar R (as determined from L_{bol} and T_{eff}) to compare the data with two extreme cases: conservation of stellar angular velocity and conservation of stellar angular momentum. Analysis of the P dataset suggests that the frequency distribution of periods among the youngest and oldest stars in the sample is indistinguishable, while the vsini dataset reveals a decrease in mean vsini as a function of age. Both results suggest that a significant fraction of all PMS stars must evolve at nearly constant angular velocity during the first ∼3-5 million years after they begin their evolution down convective tracks. Hence, the angular momenta of a significant fraction of PMS stars must be tightly regulated during the first few million years after they first become observable.

This result seems surprising at first glance, because observations of young main sequence stars reveal a population (30-40%) of rapidly rotating stars that must begin to spin up at ages $t << 5$ Myr. To determine whether these apparently contradictory results are reconcilable, we use simple models along with our dataset to place limits on (a) the fraction of PMS stars that must be regulated, and (b) the complementary fraction that could spin up as a function of time, but escape statistical detection given the broad distribution of stellar rotation rates. These models include (a) instantaneous release at the stellar birthline of a given fraction of stars, with the remaining fraction regulated for 10 Myr; (b) all stars regulated initially, with the released fraction varying linearly with time, and timescales for release of half the stars varying from 0.5 to 5 Myr (i.e., all released by 1 and 10 Myr); and (c) a hybrid model that invokes assumptions (a) and (b). In all cases, we find that a modest population (30-40%) of PMS stars could be released within the first 1 Myr and still produce period distributions statistically consistent with the observed data. This population is large enough to account for the rapid rotators observed among young main sequence stars of comparable mass. The limits placed by our models on the fraction of regulated and released stars as a function of time are also consistent with the lifetime of accretion disks as inferred from near-IR excesses, and hence with the hypothesis that disk locking accounts for rotation regulation during early PMS phases.

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http://spider.ipac.caltech.edu/staff/rebull/research.html

Radio Continuum Jets from Protostellar Objects

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We have carried out a deep 3.6 cm radio continuum survey of young outflow sources using the Very Large Array in its A-configuration providing sub-arcsecond resolution. The eight regions observed are Haro 6-10 and L1527 IRS in Taurus, Haro 5a/6a in OMC 2/3, NGC 2023 MMS, NGC 2264 IRS1, HH 108 IRAS/MMS in Serpens, L1228, and L1251A. In combination with our similar and previously published maps of 8 other star forming regions, we find only one region with a single source, while the other 15 regions have on average 3.9 nearby sources. This supports the view that isolated star formation is rare. We have selected 21 objects, which are all young mostly Class I sources, and find a binary frequency of 33% in the separation range from 0.5 to 12 arcsec. This is within the uncertainties comparable to the observed binary frequency among T Tauri stars in a similar separation range. Seven of the 21 sources drive giant Herbig-Haro flows. Four of these 7 are known to have companions (3 are triple systems), corresponding to 57%. We discuss these results in relation to the hypothesis that giant Herbig-Haro flows are driven by disintegrating multiple systems.

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Substellar companions and isolated planetary mass objects from protostellar disc fragmentation

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Self-gravitating protostellar discs are unstable to fragmentation if the gas can cool on a time scale that is short compared to the orbital period. We use a combination of hydrodynamic simulations and N-body orbit integrations to study the long term evolution of a fragmenting disc with an initial mass ratio to the star of $M_{\rm disc}/M_* = 0.1$. For a disc which is initially unstable across a range of radii, a combination of collapse and subsequent accretion yields substellar objects with a spectrum of masses extending (for a Solar mass star) up to $\approx 0.01\ M_\odot$. Subsequent gravitational evolution ejects most of the lower mass objects within a few million years, leaving a small number of very massive planets or brown dwarfs in eccentric orbits at moderately small radii. Based on these results, systems such as HD 168443 – in which the companions are close to or beyond the deuterium burning limit – appear to be the best candidates to have formed via gravitational instability. If massive substellar companions originate from disc fragmentation, while lower-mass planetary companions originate from core accretion, the metallicity distribution of stars which host massive substellar companions at radii of $\sim$ 1au should differ from that of stars with lower mass planetary companions.

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http://star-www.st-and.ac.uk/astronomy/Welcome

Hydrodynamic simulations of molecular outflows driven by fast-precessing protostellar jets

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The structure of protostellar jets and outflows is determined by both the nature of the driving protostar and the enveloping environment. To deduce protostellar evolution from the outflow evolution, we need to distinguish between these influences. Here, we employ three dimensional numerical simulations to investigate how outflow properties evolve as the jet direction precesses. We limit this study to wide-angled fast precession of molecular jets through half-angles of 5°, 10°, and 20°. We employ a code that includes molecular hydrogen cooling, dissociation and reformation as well as other cooling functions and chemistry appropriate for the high densities assumed. The jet bores out an annulus of increasing radius but constant width, with strong molecular cooling acting to reduce the drag on the impact region. Nevertheless, the expansion decelerates the outflow advance sufficiently that we predict highly precessing molecular jets can reach 1 parsec in size between 30,000 – 100,000 years. Even on the relatively short (500 yr) timescale of the simulations, the leading edge of the annulus disrupts into numerous bow shocks and some linear shock structures.

Images, position-velocity diagrams and channel maps for H_2 and CO transitions are analysed. Testable predictions for the upcoming generation of high-resolution sub-millimetre and far-infrared telescopes are made. The distributions of both mass and CO emission line flux with radial velocity are predicted and compared to observations. A clear dependence of the slope of the mass-velocity (or luminosity-velocity) distribution on the precession angle is found that may help interpret the variety of reported line profiles.

We compute the evolution of radiative emission relative to the mean jet power for these simulations and previous molecular jet simulations in this series. The H_2 1–0 S(1) emission is roughly a factor of 0.001 of the mean power in the dense jets and 0.01 in the light jets, consistent with the kinetic energy of the light jets being more efficiently radiated.

Accepted by MNRAS

NGC 2264 IRS1: the central engine and its cavity

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We present a high–resolution study of NGC 2264 IRS1 in CS 2→1 and in the 3-mm continuum using the IRAM Plateau de Bure Interferometer. We complement these radio data with images taken at 2.2 μm, 4.6 μm, and 11.9 μm. The combined information allow a new interpretation of the closest environment of NGC 2264 IRS1. No disk around the B–type star IRS1 was found. IRS1 and its low–mass companions are located in a low–density cavity which is surrounded by the remaining dense cloud core which has a clumpy shell–like structure. Strong evidence for induced on–going star formation was found in the surroundings of IRS1. A deeply embedded very young stellar object 20″ to the north of IRS1 is powering a highly collimated bipolar outflow. The object 8 in the closer environment of IRS1 is a binary surrounded by dusty circumbinary material and powering two bipolar outflows.

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http://www.astro.uni-jena.de/Users/martin/publi.html

Discovery of a Massive Protostar near IRAS 18507+0121

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We have observed the massive star forming region, IRAS 18507+0121, at millimeter wavelengths in 3 mm continuum emission and $H^{13}CO^+$(J=1–0) and SiO(v=0, J=2–1) line emission, and at near-infrared wavelengths between 1.2 and 2.1 μm. Two compact molecular cores are detected: one north and one south separated by $\sim 40''$. The northern molecular core contains a newly discovered, deeply embedded, B2 protostar surrounded by several hundred solar

masses of warm gas and dust, G34.4+0.23 MM. Based on the presence of warm dust emission and the lack of detection at near-infrared wavelengths, we suggest that G34.4+0.23 MM may represent the relatively rare discovery of a massive protostar (e.g. analogous to a low-mass "Class 0" protostar). The southern molecular core is associated with a near-infrared cluster of young stars and an ultracompact (UC) HII region, G34.4+0.23, with a central B0.5 star. The fraction of near-infrared stars with excess infrared emission indicative of circumstellar material is greater than 50% which suggests an upper limit on the age of the IRAS 18507+0121 star forming region of 3 Myrs.

Accepted by ApJ

Preprints available at http://www.aoc.nrao.edu/∼dshepher/science.shtml

Searching for signs of triggered star formation toward IC 1848

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We have carried out an in-depth study of three bright-rimmed clouds SFO 11, SFO 11NE and SFO 11E associated with the HII region IC 1848, using observations carried out at the James Clerk Maxwell Telescope (JCMT) and the Nordic Optical Telescope (NOT), plus archival data from IRAS, 2MASS and the NVSS. We show that the overall morphology of the clouds is reasonably consistent with that of radiative-driven implosion (RDI) models developed to predict the evolution of cometary globules. There is evidence for a photoevaporated flow from the surface of each cloud and, based upon the morphology and pressure balance of the clouds, it is possible that D-critical ionisation fronts are propagating into the molecular gas. The primary O star responsible for ionising the surfaces of the clouds is the 06V star HD17505. Each cloud is associated with either recent or ongoing star formation: we have detected 8 sub-mm cores which possess the hallmarks of protostellar cores and identify YSO candidates from 2MASS data. We infer the past and future evolution of the clouds and demonstrate via a simple pressure-based argument that the UV illumination may have induced the collapse of the dense molecular cores found at the head of SFO 11 and SFO 11E.

Accepted by A&A

preprint available as: astro-ph/0311034

A Compact Array imaging survey of southern bright-rimmed clouds

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We have carried out a radio-wavelength imaging survey of 45 bright-rimmed clouds (BRCs), using the Australia Telescope Compact Array to characterise the physical properties in their ionised boundary layers. We detected radio emission from a total of 25 clouds and using a combination of Digitised Sky Survey and mid-infrared MSX 8μm images classified the emission into that associated with the ionised cloud rims, that associated with embedded possible massive YSOs and that unlikely to be associated with the clouds at all. A total of 18 clouds display radio emission clearly associated with the cloud rim and we determine the ionising photon flux illuminating these clouds and the electron density and pressure of their ionised boundary layers. Using a global estimate for the interior molecular pressure of these clouds we show that the majority are likely to be in pressure equilibrium and hence are currently being shocked by photoionisation-induced shocks. We identify those clouds where the predicted ionising photon flux is inconsistent with that derived from the observations and show that either the spectral types of the stars illuminating the BRCs are earlier than previously thought or that there must be additional ionising sources within the HII regions. Finally, we identify the radio sources embedded within the clouds with infrared stellar clusters and show that they contain late O and early B-type stars, demonstrating that a number of BRCs are intimately involved with high to intermediate-mass star formation.

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preprint available as: astro-ph/0311041

Evidence for Evolution of the Outflow Collimation in Very Young Stellar Objects

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We present Very Long Baseline Array proper-motion measurements of water masers toward two young stellar objects (YSOs) of the W75N star-forming region. We find that these two objects are remarkable for having a similar spectral type, being separated by 0.7″ (corresponding to 1400 AU), and sharing the same environment, but with a strikingly different outflow ejection geometry. One source has a collimated, jet-like outflow at a 2000 AU scale, while the other has a shell outflow at a 160 AU scale expanding in multiple directions with respect to a central compact radio continuum source. This result reveals that outflow collimation is not only a consequence of ambient conditions but is something intrinsic to the individual evolution of stars and brings to light the possibility of noncollimated outflows in the earliest stages of YSOs

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Sulphur-bearing species in the star forming region L1689N

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We report observations of the expected main S-bearing species (SO, SO_2 and H_2S) in the low-mass star forming region L1689N. We obtained large scale ($\sim 300''$x$200''$) maps of several transitions from these molecules with the goal to study the sulphur chemistry, i.e. how the relative abundances change in the different physical conditions found in L1689N. We identified eight interesting regions, where we carried out a quantitative comparative study: the molecular cloud (as reference position), five shocked regions caused by the interaction of the molecular outflows with the cloud, and the two protostars IRAS16293-2422 and 16293E. In the cloud we carefully computed the gas temperature and density by means of a non-LTE LVG code, while in other regions we used previous results. We hence derived the column density of SO, SO_2 and H_2S, together with SiO and H_2CO - which were observed previously - and their relevant abundance ratios. We find that SiO is the molecule that shows the largest abundance variations in the shocked regions, whereas S-bearing molecules show more moderate variations. Remarkably, the region of the brightest SiO emission in L1689N is undetected in SO_2, H_2S and H_2CO and only marginally detected in SO. In the other weaker SiO shocks, SO_2 is enhanced with respect to SO. We propose a schema in which the different molecular ratios correspond to different ages of the shocks. Finally, we find that SO, SO_2 and H_2S have significant abundance jumps in the inner hot core of IRAS16293-2422 and discuss the implications of the measured abundances.

Accepted by Astronomy & Astrophysics

http://www.obs.u-bordeaux1.fr/public/radio/VWakelam/aea-L1689N-sulphur.pdf

Evidence for a fundamental stellar upper mass limit from clustered star formation

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The observed masses of the most massive stars do not surpass about $150\,M_\odot$. This may either be a fundamental upper mass limit which is defined by the physics of massive stars and/or their formation, or it may simply reflect the increasing sparsity of such very massive stars so that observing even higher-mass stars becomes unlikely in the Galaxy and the Magellanic Clouds. It is shown here that if the stellar initial mass function (IMF) is a power-law with a Salpeter exponent ($\alpha = 2.35$) for massive stars then the richest very young cluster R136 seen in the Large Magellanic Cloud (LMC) should contain stars with masses larger than $750\,M_\odot$. If, however, the IMF is formulated by consistently incorporating a fundamental upper mass limit then the observed upper mass limit is arrived at readily even if the IMF is invariant. An explicit turn-down or cutoff of the IMF near $150\,M_\odot$ is not required; our formulation of the problem contains this implicitly. We are therefore led to conclude that a fundamental maximum stellar mass near $150\,M_\odot$ exists, unless the true IMF has $\alpha > 2.8$.

Accepted by MNRAS

http://xxx.lanl.gov/abs/astro-ph/0310860

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

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

The Star Formation Newsletter is available on the World Wide Web at http://www.ifa.hawaii.edu/∼reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .

Dissertation Abstracts

Radiative Feedback and Massive Star Formation

Richard Edgar

Thesis work conducted at: Institute of Astronomy, Cambridge

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Ph.D dissertation directed by: Cathie Clarke

Ph.D degree awarded: October 2003

In this thesis, I develop a new method of treating the problem of radiative transfer around a forming massive star. This new method addresses the failings of grey radiative transfer through dusty gas, while avoiding the computational cost of frequency dependent transfer algorithms. The grey approximation fails because of the implied assumption of thermal equilibrium between the radiation field and the dusty gas. At the inner edge of the dust shell, radiation streaming from the protostar, $T \sim 10^4 K$, encounters dust which is evaporating at $\sim 2000K$. This mismatch causes the the grey approximation to miss a very sharp deceleration of the flow (equivalent to the input of L/c worth of momentum) at the inner edge of the dust shell. I split the radiation field into direct and thermalised components, and attenuating the direct component with frequency dependent opacities. The attenuated energy is then put into the thermalised field, which is solved using the diffusion approximation. My new algorithm is validated by comparison with previous frequency dependent calculations.

This method is then applied to collapses of spherically symmetry gas clouds. I use this to show that there is no absolute radiative limit to stellar masses. Radiative feedback on the dusty inflow will cause a star to stop accreting, but this does not occur at any particular fixed mass. More massive clouds give rise to more massive stars. Adjusting the dust abundance does alter the efficiency of process, but not enough to suppress the formation of stars $> 10M_{\odot}$.

However, applying my new method to the Bondi–Hoyle geometry (likely to be found in a competitively accreting stellar cluster), I show that radiative feedback can still cause great difficulties in forming massive stars. The decreased central concentration, and presence of centrifugal support mean that radiative feedback can disrupt the Bondi–Hoyle flow. Although lack of time prevented me from exploring much parameter space, I am able to suggest the regions which might be fruitfully explored in the future.

Young massive stars: traffic lights for nearby star formation

Jill M. Rathborne

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Ph.D dissertation directed by: Michael G. Burton

Ph.D degree awarded: October 2003

While formation processes are well understood for low-mass stars, developing theories for high-mass stars are hindered by the rapid timescales and cluster environments within which they form. Stellar winds and radiation fields from young massive stars have a profound impact on the environment and star formation within a giant molecular cloud (GMC), possibly to the extent of halting further formation. Conversely, evidence also exists to suggest these processes may instead trigger star formation. To investigate the effect young massive stars have on subsequent star formation within their GMC, two massive star forming regions were studied:- the Carina Nebula and NGC 6334. A multiwavelength study was undertaken, combining infrared (IR), molecular line and radio continuum data. These datasets were obtained using ground- and space-based telescopes, including an IR system at the South Pole. Emission from PAH molecules at 3.29- and 8-μm were used to trace the photodissociation regions (PDRs). Emission at 21-μm and 843-MHz trace heated dust and ionization gas within H II regions and deeply embedded objects. The morphology of the PDRs and ionization fronts across the Carina Nebula suggest the interactions from the massive star clusters are carving giant pillars from the remnant GMC. For NGC 6334, the PDRs have a complex morphology and are concentrated around the isolated sites of massive star formation. Young sources were identified across these complexes using near- and mid-IR colour-colour diagrams. A census of sources containing circumstellar disks was compiled using JHK$_s$L diagrams; the results clearly demonstrate the advantage of including L-band observations. Massive young stellar objects (MYSOs) were identified through their 8–21μm colours. Candidate MYSOs were found within both the Carina Nebula and NGC 6334. The identification of young sources within the Carina Nebula suggests that star formation is ongoing within this nebula, contrary to previous conclusions. In addition, the star formation occurs over a larger extent of this nebula compared to NGC 6334, where the activity is nearby to the massive stars. The relative location of the star formation activity is consistent with influences from the massive stars that comprise these two complexes.

New Jobs

Postdoctoral Research Position – Star Formation

UNIVERSITY OF MICHIGAN

Applications are invited for a postdoctoral research position at the University of Michigan, to start anytime in the next year. The successful candidate will work with Prof. Edwin Bergin on observational and theoretical studies of the physics and chemistry of star formation. Applicants should have experience in observational studies of star-forming cores and/or protoplanetary disks at centimeter, millimeter, submillimeter and/or infrared wavelengths. Applicants with knowledge of astrochemistry, radiative transfer techniques, and/or ISM physics are encouraged to apply. The successful candidate will have the option of working with Dr. Bergin on several ongoing projects including: probing the initial conditions of star formation, developing predictive models of chemistry and emission in star forming cores and protoplanetary disks, the detection of new molecules in protoplanetary disks, and on probing the physics and chemistry of interstellar shock waves using the IRS instrument on the newly launched SIRTF observatory.

The position is for two years, with extension to a third year possible, and includes research support. Applicants with a Ph.D. should send a curriculum vitae, a description of research interests, and a list of publications, and should arrange for three letters of recommendation to be sent directly to the address below. Please indicate the preferred starting date. Applications received prior to 15 January 2002 will receive first consideration.

Women and Minorities are encouraged to apply. The University is responsive to the needs of dual career couples. The University of Michigan is a non-discriminatory/affirmative action employer.

Department of Astronomy
University of Michigan
501 E. University
830 Dennison Building
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U.S.A.
attn: Katie Delano, Academic Secretary

Email Submission Address: kdelano@umich.edu
Email Inquiries: ebergin@umich.edu
Department Web page: http://www.astro.lsa.umich.edu

Two Month Postdoc at Armagh Observatory: Jet Simulations

Applications are invited for a two month postdoctoral research position to work with Dr. Michael D. Smith on the interpretation of astrophysical jets. Specifically, a comparison of supercomputer simulations of protostellar jets with observations is to be made. The overall aim of the project is to trace the evolution of protostars through simulations of inflow and outflow, with emphasis on supersonic jets and turbulence. Experience in the fields of star formation and/or fluid dynamics would be an advantage.

The post is a PPARC-funded research position available immediately and to end on or before 29/2/2004. Further information is available by e-mail to mds@arm.ac.uk. Further information about Armagh Observatory may be obtained by consulting the Observatory web-site at http://www.arm.ac.uk.

Applications arriving before 15 November 2003 will be given full consideration. Email a curriculum vitae and bibliography, including the names and contact details of two potential referees, to mds@arm.ac.uk

Meetings

ASTRONOMICAL POLARIMETRY
CURRENT STATUS AND FUTURE DIRECTIONS
15-19 March 2004
Waikoloa Beach Marriott, Kailua, Hawaii

Second Announcement

We are pleased to confirm the holding of a conference on optical - infrared - mm/submm (OIM) Astronomical Polarimetry, in the wonderful surroundings on the South Kohala coast of the Big Island of Hawaii in March 2004. The aim of the meeting is to bring together workers in all areas of OIM astronomical polarimetry to discuss the most recent results in this exciting and crucial field, and to consider the potential for polarimetry in the era of eight- and ten-metre optical/infrared telescopes and new and future mm/submm facilities.

The meeting will concentrate on ground-based polarization measurements, and will include a session devoted to new and novel instrumentation and techniques. The remaining sessions will be organized according to the astronomical source rather than wavelength regime or specific technique. Neither Radio Polarimetry (beyond the mm regime) nor Solar Polarimetry are within the conference remit, however, each will be the subject of dedicated review talks.

SCIENCE AREAS: Sessions will be divided into two, with approximately 80% of the time guaranteed for current results and 20% for presentations on future directions, facilities etc. Proceedings, including posters, will be published. Details of the division between oral and poster presentations will be given once the relative demands are known. The web site gives details of expected sessions, each of which will consist of an invited review and a number of contributed talks. The following science areas will be covered: Techniques, Instrumentation and Data Analysis - Theory and Modelling - Star Formation - Extrasolar Circumstellar matter - Ejecta - Interstellar Dust and Gas - Stars, CVs, Magnetic Stars - Galaxies, Radio Galaxies and AGN - High-Redshift and Cosmological Polarimetry

INVITED REVIEWERS (with provisional titles):

(Confirmed:) Jim Hough: Observational Techniques in Ground-based Polarimetry - Jane Greaves: Techniques in the millimetre and far infrared - Brenda Matthews: Polarimetry and Star formation in the submillimetre - Francois Menar: Circumstellar disks in YSOs - Tim Gledhill: Ejecta and the late stages of stellar evolution - Dave Aitken: Dust and infrared polarization signatures - Nadine Manset : Polarimetry of binary stars - Clive Tadhunter : Polarimetry of AGN - Angelica de Oliveira-Costa : Cosmological polarimetry - the CMB - Motohide Tamura : Circumstellar disks in PMS and T Tauri stars - Alex Lazarian : Dust Alignment mechanisms - (To be confirmed:) Alyssa Goodman: Polarimetric observations of the ISM in molecular clouds - (Additional reviews:) Haosheng Lin: Solar polarimetry measurements - Tim Cawthorne : High-resolution radio polarimetry

CONFERENCE SUMMATION: Dr. Roger Hildebrand of the Department of Astronomy and Astrophysics, University of Chicago has kindly agreed to provide a summation of the conference at the end of the last session of the week. Roger has long been a world-leader in astronomical polarization research, in particular the study of magnetic fields via far-infrared and sub-mm polarimetry. We are honored to include Dr. Hildebrand in our conference program.

DATES AND DEADLINES:
End of Early Registration: 1-Dec-2003 – Abstract Deadline: 1-Jan-2004 – Late Registration Deadline: 1-Feb-2004

SPONSORING ORGANIZATIONS: - Joint Astronomy Centre - Subaru Telescope - Canada-France Hawaii Telescope - Gemini Observatory - University of Hawaii Institute for Astronomy - W.M.Keck Observatory - Caltech Submillimetre Observatory

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Contact email address: pol2004@jach.hawaii.edu
Web site: http://www.jach.hawaii.edu/JACpublic/JAC/pol2004

Short Announcements

NINTH SYNTHESIS IMAGING SUMMER SCHOOL

15-22 June 2004, Socorro, NM, USA

The Ninth Summer School in Synthesis Imaging will take place from June 15 (Tuesday) through June 22 (Tuesday) of 2004. The Summer School will be hosted by the National Radio Astronomy Observatory (NRAO) and by the New Mexico Institute of Mining and Technology, and will be held in the Workman center on the Tech campus in Socorro, New Mexico. The Summer School will cover the fundamentals of radio interferometry, including both connected element and very long baseline interferometers, and some advanced lectures on specialized topics. Data reduction tutorials at the Array Operations Center of the NRAO will give attendees "hands-on" experience with data calibration and imaging for both VLA and VLBA data. The range of subjects will be similar to past Summer Schools, and can be reviewed by consulting "Synthesis Imaging in Radio Astronomy II", the published collection of lectures from the 6th NRAO Synthesis Imaging Summer School (ASP Conference Series, Volume 180, 1999). The lectures will be given at a level appropriate for graduate students in astrophysics. There will be ample time for questions and discussion following each lecture and at the end of each day.

Attendance at the Summer School will be limited to a total of 150 people. There will be a registration fee of $120, which includes a copy of "Synthesis Imaging in Radio Astronomy II", transportation to and from Albuquerque airport on June 14 and on June 22/23, daily transportation to/from local hotels, a tour of the VLA, and several other events. The possibility of providing some financial assistance is being investigated, and further details will be described in the second announcement. Rooms will be blocked out at Socorro motels for the school, and information on these motels will be sent to registered participants in February 2004. The daily cost of a single room currently ranges from $56-73$ and sharing a double from $28-39$ per person including tax. Motel reservations will be the responsibility of the attendees.

To indicate your interest in attending the Summer School and to receive future mailings, please pre-register electronically by following the directions at http://www.aoc.nrao.edu/events/synthesis/2004/.

Claire Chandler

On behalf of the local organizing committee: Claire Chandler, Greg Taylor, Terry Romero, Michelle Creech-Eakman, Skip Lagoyda, and Terry Lopez.

Moving ... ??

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