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From the Editor

The Star Formation Newsletter has since its inception been available on the web at the European Southern Observatory's web page (<http://www.eso.org/gen-fac/pubs/starform/>). Some years ago, a mirror-site was set up at the University of Massachusetts. However, this site is no longer maintained. For the convenience of those for whom a connection to the USA is faster than one to Europe, I have set up a web site at the University of Colorado, where all issues of the Star Formation Newsletter are available, and which will be updated monthly. It is the intent to continue to maintain also the ESO site. The URL is <http://casa.colorado.edu/reipurth>. In addition to the Newsletter, the new web site will also maintain an updated list of meetings announced in the Newsletter, links to recent PhD's on star formation related matters, catalogues, and many other compilations of interest to the star formation community.

Abstracts of recently accepted papers

High-resolution spectroscopy of ROSAT low-mass pre-main sequence stars in Orion

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High-resolution spectroscopic observations of the lithium-rich stars found on the basis of the ROSAT All-Sky Survey (RASS) in the general direction of the Orion star forming region are presented. Different properties are derived from the spectra and analyzed: i) the equivalent widths of the lithium 6708 Å absorption line have been measured and a revision of spectral types has been performed; ii) radial velocities (RV) and projected rotational velocities, $v \sin i$, have been derived by application of cross-correlation techniques. A relatively large number of spectroscopic binaries and of suspected spectroscopic binary and multiple systems are found among the stars in the sample. Based on the strength of the lithium line with respect to young open cluster ZAMS stars of the same spectral type, the pre-main sequence nature is confirmed for more than 70% of the stars in the sample. The interrelation of the derived observational properties, such as kinematics, lithium abundance, age and projected rotational velocity of the stars in the sample are analyzed also in connection with the spatial location of the objects. In particular, the comparison between the kinematics of the stars and that of the gas, provided by the CO and CS molecular emission observations, reveals different degrees of clustering of the stars with respect to the cloud material and different kinematical groups can be distinguished. The sample of RASS lithium-rich stars found in the general direction of Orion appears to be a mixture of true Orion stars and, possibly, stars belonging to the Gould Belt.

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ISO–SWS Observations of Interstellar Solid $^{13}\text{CO}_2$: Heated Ice and the Galactic $^{12}\text{C}/^{13}\text{C}$ Abundance Ratio

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We present observations of the stretching mode of $^{13}\text{CO}_2$ ice along 13 lines of sight in the Galaxy, using the *Short Wavelength Spectrometer* on board of the *Infrared Space Observatory* (ISO–SWS). Remarkable variations are seen in the absorption band profile in the different lines of sight. The main feature is attributed to $^{13}\text{CO}_2$ mixed with polar molecules such as H_2O , and CH_3OH . The high-mass objects GL 2136, GL 2591, S 140 : IRS1, and W 3 : IRS5 show an additional narrow substructure at 2282 cm^{-1} ($4.382\text{ }\mu\text{m}$), which we attribute to a polar, CH_3OH -containing CO_2 ice, that experienced heating. This heating effect is sustained by a good correlation of the strength of the substructure with dust and CO gas temperatures along the line of sight, and anti-correlation with ice abundances. Thus, our main conclusion is that interstellar CO_2 ices around luminous protostars are subjected to, and altered by, thermal processing and that it may reflect the evolutionary stage of the nearby protostar. In contrast, the ices around low mass protostars and in a quiescent cloud in our sample do not show signs of thermal processing.

Furthermore, we determine for the first time the Galactic $^{12}\text{C}/^{13}\text{C}$ ratio from the solid state as a function of Galactocentric radius. The $^{12}\text{CO}_2/^{13}\text{CO}_2$ ratio for the local ISM (69 ± 15), as well as the dependence on Galactocentric radius, are in good agreement with gas phase (C^{18}O , H_2CO) studies. For the few individual objects for which gas phase values are available, the $^{12}\text{C}/^{13}\text{C}$ ratios derived from CO_2 tend to be higher compared to CO studies (albeit with $\sim 2.5\sigma$ significance only). We discuss the implications of this possible difference for the chemical origin of interstellar CO_2 .

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<http://www.submm.caltech.edu/boogert/publ.html>

Low-mass stars in the massive H II region NGC 3603 — Deep NIR imaging with ANTU/ISAAC

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We have observed NGC 3603, the most massive visible H II region known in the Galaxy, with ANTU(VLT1)/ISAAC in the near-infrared (NIR) J_s , H , and K_s -bands. Our observations are the most sensitive observations made to date of this dense starburst region, allowing us to investigate with unprecedented quality its low-mass stellar population. Our mass limit to stars detected in all three bands is $0.1M_\odot$ for a pre-main sequence star of age 0.7 Myr. The overall age of the pre-main sequence stars in the core region of NGC 3603 has been derived from isochrone fitting in the colour-magnitude diagram, leading to 0.3 – 1.0 Myr. The NIR luminosity functions show that the cluster is populated in low-mass stars at least down to $0.1M_\odot$. Our observations clearly show that sub-solar mass stars do form in massive starbursts.

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HST/WFPC2 and VLT/ISAAC observations of PROPLYDS in the giant HII region NGC 3603

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We report the discovery of three proplyd-like structures in the giant HII region NGC 3603. The emission nebulae are clearly resolved in narrow-band and broad-band HST/WFPC2 observations in the optical and broad-band VLT/ISAAC observations in the near-infrared. All three nebulae are tadpole shaped, with the bright ionization front at the head facing the central cluster and a fainter ionization front around the tail pointing away from the cluster. Typical sizes are 6,000 A.U. \times 20,000 A.U. The nebulae share the overall morphology of the proplyds (“PROto PLANetarY DiskS”) in Orion, but are 20 to 30 times larger in size. Additional faint filaments located between the nebulae and the central ionizing cluster can be interpreted as bow shocks resulting from the interaction of the fast winds from the high-mass stars in the cluster with the evaporation flow from the proplyds.

Low-resolution spectra of the brightest nebula, which is at a projected separation of 1.3 pc from the cluster, reveal that it has the spectral excitation characteristics of an Ultra Compact HII region with electron densities well in excess of 10^4 cm^{-3} . The near-infrared data reveal a point-source superimposed on the ionization front.

The striking similarity of the tadpole shaped emission nebulae in NGC 3603 to the proplyds in Orion suggests that the physical structure of both types of objects might be the same. We present 2D radiation hydrodynamical simulations of an externally illuminated star-disk-envelope system, which was still in its main accretion phase when first exposed to ionizing radiation from the central cluster. The simulations reproduce the overall morphology of the proplyds in NGC 3603 very well, but also indicate that mass-loss rates of up to $10^{-5} M_{\odot} \text{ yr}^{-1}$ are required in order to explain the size of the proplyds.

Due to these high mass-loss rates, the proplyds in NGC 3603 should only survive $\approx 10^5$ yr. Despite this short survival time, we detect three proplyds. This indicates that circumstellar disks must be common around young stars in NGC 3603 and that these particular proplyds have only recently been exposed to their present harsh UV environment.

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Multi-wavelength imaging of the peculiar Vela Molecular Ridge nebula BBW 192E

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We present the first images of the nebula BBW 192E at near- and mid-infrared wavelengths as well as a 1.3 mm continuum map. The nebula BBW 192E is associated with the IRAS point source 08513-4201 which has a luminosity of about $1400 L_{\odot}$ and a strongly rising spectral energy distribution towards mid-infrared wavelengths. The infrared

images show a pronounced bipolar nebula, which is offset by about $10''$ from the known optical emission, as well as several point sources. We interpret this morphology as evidence for an inclined disk-like structure and scattered light emerging from the lobes. This is supported by our near-infrared imaging polarimetry at sub-arcsecond resolution which furthermore indicates that the central energy source is seen directly at near-infrared wavelengths.

At 1.3 millimetre, we detected a cometary shaped source in the dust continuum radiation, $151'' \times 55''$ in size, with a total mass of $180 M_{\odot}$ as well as average hydrogen column and number densities of $4.5 \times 10^{22} \text{ cm}^{-2}$ and $2.6 \times 10^5 \text{ cm}^{-3}$, respectively. This dust cloud is also responsible for the strong spatial variation of the extinction across the nebula.

We discuss the physical properties of the infrared point sources and conclude that some might be young, low-mass pre-main sequence stars. The main energy source of the nebula is an embedded intermediate-mass young stellar object.

These observations are among the first infrared detections of a disk-like system associated with a bipolar nebula surrounding an intermediate-mass young stellar object.

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The structure of protostellar envelopes derived from submillimeter continuum images

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High dynamic range imaging of submillimeter dust emission from the envelopes of eight young protostars in the Taurus and Perseus star-forming regions has been carried out using the SCUBA submillimeter camera on the James Clerk Maxwell Telescope. Good correspondence between the spectral classifications of the protostars and the spatial distributions of their dust emission is observed, in the sense that those with cooler spectral energy distributions also have a larger fraction of the submillimeter flux originating in an extended envelope compared with a disk. This results from the cool sources having more massive envelopes rather than warm sources having larger disks. Azimuthally-averaged radial profiles of the dust emission are used to derive the power-law index of the envelope density distributions, p (defined by $\rho \propto r^{-p}$), and most of the sources are found to have values of p consistent with those predicted by models of cloud collapse. However, the youngest protostars in our sample, L1527 and HH211-mm, deviate significantly from the theoretical predictions, exhibiting values of p somewhat lower than can be accounted for by existing models. For L1527 heating of the envelope by shocks where the outflow impinges on the surrounding medium may explain our result. For HH211-mm another explanation is needed, and one possibility is that a shallow density profile is being maintained in the outer envelope by magnetic fields and/or turbulence. If this is the case star formation must be determined by the rate at which the support is lost from the cloud, rather than the hydrodynamical properties of the envelope, such as the sound speed.

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Preprint available at <http://www.mrao.cam.ac.uk/~cjc/preprints/preprints.html>

Interaction of Infall and Winds in YSOs

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The interaction of a stellar or disk wind with a collapsing environment holds promise for explaining a variety of outflow phenomena observed around young stars. In this paper we present the first simulations of these interactions. The focus here is on exploring how ram pressure balance between wind and ambient gas and post-shock cooling affects the shape of the resulting outflows. In our models we explore the role of ram pressure and cooling by holding the wind speed constant and adjusting the ratio of the inflow mass flux to the wind mass flux (\dot{M}_a/\dot{M}_w). Assuming non-spherical cloud collapse, we find that relatively strong winds can carve out wide, conical outflow cavities and that relatively weak winds can be strongly collimated into jet-like structures. If the winds become weak enough, they can be cut

off entirely by the infalling environment. We identify discrepancies between results from standard snowplow models and those presented here that have important implications for molecular outflows. We also present mass vs. velocity curves for comparison with observations.

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Formation and loss of hierarchical structure in two-dimensional MHD simulations of wave-driven turbulence in interstellar clouds

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Two dimensional compressible magneto-hydrodynamical (MHD) simulations run for ~ 20 crossing times on a 800×640 grid with two stable thermal states show persistent hierarchical density structures and Kolmogorov turbulent motions in the interaction zone between incoming non-linear Alfvén waves. These structures and motions are similar to what is commonly observed in weakly self-gravitating interstellar clouds, suggesting that these clouds get their fractal structures from non-linear magnetic waves generated in the intercloud medium; no internal source of turbulent energy is necessary. The clumps in the simulated clouds are slightly warmer than the interclump medium as a result of magnetic dissipational and compressive heating when the clumps form. Thus the interclump medium has a lower pressure than the clumps, demonstrating that the clumps owe their existence entirely to transient compressive motions, not pressure confinement by the interclump medium. Clump lifetimes increase with size, and are about one sound crossing time.

Two experiments with this model illustrate a possible trigger for star formation during spontaneous cloud evolution driven by self-gravity and increased self-shielding. A first test is of the hypothesis that a low ionization fraction and enhanced magnetic diffusion lead to the disappearance of clumps smaller than an Alfvén wavelength. Two identical models are run that differ only in the magnetic diffusion rate. The results show a significant decrease in the magnetic wave amplitude as the diffusion rate increases, in agreement with expectations for wave damping, but there is virtually no change in the density structure or amplitude of the density fluctuations as a result of this increased diffusion. This is because all of the density fluctuations are essentially sonic in nature, driven by the noise from Alfvén wave motions outside and at the surface of the cloud. These sonic disturbances travel throughout the cloud parallel to the mean field orientation and are not affected by the local magnetic wave dissipation rate. This result implies that low ionization fractions in molecular clouds do not necessarily lead to increased cloud smoothing.

The second experiment tests the hypothesis that enhanced density alone in a self-gravitating cloud leads to wave self-shielding and loss of incident turbulent energy. Three models with identical conditions except for the presence or lack of an imposed plane-parallel gravitational field confirm that externally generated magnetic waves tend to be excluded from the densest regions of self-gravitating clouds, and as a result these clouds show a significant loss of density substructure. This loss of turbulent energy and density substructure may trigger star formation in the relatively quiescent gas pools that contain a thermal Jeans mass or more. Such a model fits well with the hypothesis that the stellar initial mass function comes from the structure of turbulent hierarchical clouds.

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HST/NICMOS Observations of Massive Stellar Clusters Near the Galactic Center

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We report *Hubble Space Telescope* (*HST*) Near-infrared Camera and Multi-object Spectrometer (NICMOS) observations of the Arches and Quintuplet clusters, two extraordinary young clusters near the Galactic Center. For the first time, we have identified main sequence stars in the Galactic Center with initial masses well below $10 M_{\odot}$. We present the first determination of the initial mass function (IMF) for any population in the Galactic Center, finding an IMF slope which is significantly more positive ($\Gamma \approx -0.65$) than the average for young clusters elsewhere in the Galaxy (Γ

≈ -1.4). The apparent turnoffs in the color-magnitude diagrams suggest cluster ages which are consistent with the ages implied by the mixture of spectral types in the clusters; we find $\tau_{\text{age}} \sim 2 \pm 1$ Myr for the Arches cluster, and $\tau_{\text{age}} \sim 4 \pm 1$ Myr for the Quintuplet. We estimate total cluster masses by adding the masses of observed stars down to the 50% completeness limit, and then extrapolating down to a lower mass cutoff of $1 M_{\odot}$. Using this method, we find $\gtrsim 10^4 M_{\odot}$ for the total mass of the Arches cluster. Such a determination for the Quintuplet cluster is complicated by the double-valued mass-magnitude relationship for clusters with ages $\gtrsim 3$ Myr. We find a lower limit of $6300 M_{\odot}$ for the total cluster mass, and suggest a best estimate of twice this value which accounts for the outlying members of the cluster. Both clusters have masses which place them as the two most massive clusters in the Galaxy.

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<http://nemesi.stsci.edu/figer/web/papers.html>

The Effect of Resistivity on the Nonlinear Stage of the Magnetorotational Instability in Accretion Disks

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We present three-dimensional magnetohydrodynamic simulations of the nonlinear evolution of the magnetorotational instability (MRI) with a non-zero Ohmic resistivity. The simulations begin from a homogeneous (unstratified) density distribution, and use the local shearing-box approximation. The evolution of a variety of initial field configurations and strengths is considered, for several values of constant coefficient of resistivity η . For uniform vertical and toroidal magnetic fields we find unstable growth consistent with the linear analyses; finite resistivity reduces growth rates, and, when large enough, stabilizes the MRI. Even when unstable modes remain, resistivity has significant effects on the nonlinear state. The properties of the saturated state depend on the initial magnetic field configuration. In simulations with an initial uniform vertical field, the MRI is able to support angular momentum transport even for large resistivities through the quasi-periodic generation of axisymmetric radial channel solutions rather than through the maintenance of anisotropic turbulence. Reconnective processes rather than parasitic instabilities mediate the resurgent channel solution in this case. Simulations with zero net flux show that the angular momentum transport and the amplitude of magnetic energy after saturation are significantly reduced by finite resistivity, even at levels where the linear modes are only slightly affected. The MRI is unable to sustain angular momentum transport and turbulent flow against diffusion for $Re_M \leq 10^4$, where the Reynolds number is defined in terms of the disk scale height and sound speed, $Re_M = c_s H / \eta$. As this is close to the Reynolds numbers expected in low, cool states of dwarf novae, these results suggest that finite resistivity may account for the low and high angular momentum transport rates inferred for these systems.

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Influence of Magnetic fields on Pulsed, Radiative Jets

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We present results of magnetohydrodynamic simulations of steady and time variable jets for a set of conditions applicable to outflows from young stellar objects (YSOs). As a first step in a detailed study of radiative magnetohydrodynamic jets, we study both steady and pulsed jets with a large scale magnetic field oriented parallel to the jet flow axis. While toroidal components may be present in many jets we have chosen in this initial study to focus solely on pure poloidal initial geometries. The range of magnetic field strengths studied are characterized by the dimensionless parameter $\beta = 8\pi P_{gas} / B^2 = 0.1 \rightarrow 10^7$. The results of our simulations show that the global characteristics are not strongly

dependent on the strength of the magnetic field. Instead, we find that a predominantly poloidal field has more subtle effects, such as inhibiting instabilities, and increasing the “order” in the flow patterns. While the fields act to restrict “turbulent” gas motions, the pulse induced internal shocks increase the likelihood of instabilities, complicate the global flow patterns, and increase the likelihood of magnetic reconnection. We detail the ways in which the magnetic pressure and tension forces affect the kinematics observed in these simulations.

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A cluster of radio sources near GGD 14

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We present sensitive VLA radio continuum observations at 3.6-cm toward the star-forming region GGD 14 (also known as GGD 12/13/14/15, G213.88-11.84, and AF GL890). In addition to the previously known cometary HII region, we report the detection of a cluster of six compact radio sources, all with a nearby 2 μm counterpart. These new sources appear to be ultracompact HII regions ionized by B2 - B3 ZAMS stars. The kinematic age of these six compact radio sources, assuming expansion at 10 km s^{-1} , is less than 25 years, and we conclude that they must be confined by some mechanism. The sources are so compact that they could be gravitationally bound to the star. One of the new detections, the source VLA 7, is located near the center of the CO molecular outflow. We suggest that VLA 7 is associated with the powering source of the molecular outflow and that the infrared sources IRS9M and IRS9E, between which lies VLA 7, could be the lobes of a bipolar reflection nebula tracing the outflow at small scales.

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<http://www.astrosmo.unam.mx/~gocoy/preprints.html>

Rotation in the Orion Nebula Cluster

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Eighteen small (4 arc-min square) fields within the Orion Nebula Cluster (ONC) have been photometrically monitored for one or more observing seasons between 1990 and 1999 with a CCD attached to the 0.6 m telescope at Van Vleck Observatory on the campus of Wesleyan University. Data were obtained exclusively in the Cousins I band on between 25 and 40 nights per season. Results from the first three years of operation of this program were summarized and analyzed by Choi & Herbst (1996). Here we provide an update based on six additional years of observation and the extensive optical and infrared study of the cluster by Hillenbrand (1997) and Hillenbrand et al. (1998). Rotation periods with false alarm probabilities (FAP) $< 1\%$ are now available for 134 members of the ONC. Of these, 67 were detected at multiple epochs with identical periods by us and an additional 15 were confirmed by Stassun et al. (1999) in their study of Ori OB1c/d. Therefore, we have a sample of 82 stars with virtually certain rotation periods and another 52 with highly probable periods, all of which are cluster members. The bimodal period distribution for the ONC reported by CH is confirmed but we also find a clear dependence of rotation period on mass. This phenomenon can be understood as an effect of deuterium burning, which temporarily slows the contraction and, therefore, spin-up of stars with $M \leq 0.25 M_{\odot}$ and ages ~ 1 My. Stars with $M < 0.25 M_{\odot}$ have not had time to bridge the gap in the period distribution at around 4 days. Excess H-K and I-K emission, as well as CaII infrared triplet equivalent widths (Hillenbrand et al. 1998), show weak but significant correlations with rotation period among stars with $M > 0.25 M_{\odot}$. Our results provide new observational support for the importance of disks in the early rotational evolution of low mass stars.

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Available by anonymous ftp from <ftp.astro.wesleyan.edu>. (/pub/bill/ONC.tar.gz)

The far UV spectrum of T Tauri stars.

I. The relevance of the IUE Newly Extracted Spectra (INES).

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The far UV spectrum of the T Tauri Stars (TTSs) provides important clues about the structure of the stellar atmospheres, winds and accretion shocks. The IUE (International Ultraviolet Explorer) Final Archive contains the most complete Data Base for such studies. A new extraction system, the IUE Newly Extracted Spectra (INES), has been developed to overcome the disadvantages of the extraction system used in the IUE Final Archive, the Signal Weighted Extraction Technique (SWET). We have compared the INES spectra of the whole sample of T Tauri stars (TTSs) in the far UV range (1200-2000 Å) with the SWET low resolution spectra available in the IUE Final Archive. Although in most of the cases there is a good agreement between both samples, an important enhancement of the INES line fluxes with respect to the SWET line fluxes is reported for particular spectra. The line fluxes are enhanced by as much as a factor of ~ 2.5 in some objects, which is significant for variability studies of TTSs since the variations of the UV lines are typically of this order. The emission measure distributions built to study the atmospheres of these stars are based on the UV emission line fluxes, so the new system is susceptible to introduce changes in these models. Moreover, the non-linear enhancement of the INES line fluxes produces variations in diagnostic line ratios usually taken as temperature and density tracers in late-type stars. These line ratios can vary as much as a factor of 3 when the INES data are compared to the SWET, with the subsequent variation of the physical parameters derived from them.

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Flickering in FU Orionis

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We analyze new and published optical photometric data of FU Orionis, an eruptive pre-main-sequence star. The outburst consists of a 5.5 mag rise at B with an e -folding timescale of ~ 50 days. The rates of decline at B and V are identical, 0.015 ± 0.001 mag yr⁻¹. Random fluctuations superimposed on this decline have an amplitude of 0.035 ± 0.005 mag at V and occur on timescales of 1 day or less. Correlations between V and the color indices U-B, B-V, and V-R indicate that the variable source has the optical colors of a G0 supergiant. We associate this behavior with small amplitude flickering of the inner accretion disk.

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Star Count Analysis based on the Linear Programming

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A new, efficient method of deriving stellar number density distribution along a line of sight from star count data by using a *Linear Programming* technique is presented. The derived stellar number density distribution is further used to find a distance to a dark globule. In order to validate the algorithm, we select a dark globule Barnard 361 with known stellar number density distribution and distance. Our estimates of stellar density distribution and distance to the globule are in close agreement with previous results. The effects of the choice of the luminosity function and of the general extinction law on the resulting stellar density function are discussed. The algorithm is applied to star

count data for a dark globule, LDN 400, whose distance is unknown. For this purpose, CCD observations were made toward LDN 400 in V band. The stellar number density distribution toward LDN 400 shows two prominent peaks at distances of 1.2 and 2.5 kpc, respectively. The locations of density peaks roughly coincide with the Sagittarius arm and stellar density enhancement of OB stars. The stellar number density distribution is further used to derive the distance to LDN 400. When using the luminosity function of Gilmore & Reid (1983) and the Galaxy model of Bahcall & Soneira (1980), we found a distance to LDN 400 of 450 ± 50 pc and an extinction caused by the cloud is 2.4 ± 0.5 magnitudes in the V band.

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Semiforbidden line profiles in UV spectra of T Tauri stars and the investigation of an accretion zone geometry

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Profiles of Si III 1892 and C III 1909 semiforbidden lines in RU Lup and RY Tau spectra, observed with HST, were investigated for the first time. It was found that FWHM of these optically thin lines exceeds 200 km/s, which excludes definitely the possibility of their formation in chromospheric regions. It seems unlikely that a significant portion of the line fluxes originates in a stellar wind, because the Si III] 1892 line is stronger than the C III] 1909 one. It was demonstrated that it is possible in principle to reproduce the observed profiles in the frame of an accretion shock model, such as only in the case, when the accretion zone velocity field differ significantly from an axisymmetrical one. If so, line profiles should vary periodically and this can be used to find the geometry of TTs accretion zone and magnetic field topology - respective formulae are presented. Periodical variations of the 0.3-0.7 keV X-ray flux should be observed as well.

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Preprints are available via request from lamzin@sai.msu.ru

UV spectra of T Tauri stars from Hubble Space Telescope: RU Lupi

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HST spectra of RU Lupi in UV spectral band are analysed. Mg II h and k lines consist of broad (~ 1400 km/s at the base) symmetrical relative λ_0 emission component, originated at the stellar surface, and strong blueshifted absorption component, which forms in the stellar wind with $V_\infty \sim 300$ km/s. Profiles of Si II] and Si III] 1892 optically thin lines are almost identical and so wide, that they definitely can not form in a stellar chromosphere - I argue they form in the accretion shock, such as infall gas velocity is near 400 km/s. Components of C IV 1550 and Si IV 1400 doublets have nearly equal intensities, indicating that infall gas density is more than $3 \cdot 10^{12} \text{ cm}^{-3}$. Lyman series lines of H₂ molecules were found - apparently they form in the stellar wind. It was estimated from H₂ lines observed flux, that RU Lup luminosity in HI L_α line exceeds $0.1 L_{\text{bol}}$. L_α line radiation pressure onto circumstellar hydrogen atoms can play a significant role in the initial acceleration of stellar wind matter, but the influence of L_α radiation onto the dynamics of molecular gas is negligible.

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Chondrule fine-grained mantle formation by hypervelocity impact of chondrules with a dusty gas

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At some stage during the chondrule (and refractory inclusion) formation process, many of these objects accreted fine-grained mantles of dust. Observations suggest that the mantle thickness is directly proportional to the chondrule-core radius. Following the proposal of Connolly and Love 1998, we demonstrate numerically how this effect can be produced by the hypersonic interaction between a chondrule and mixture of gas and dust. This result is of relevance to the shock and jet models of chondrule formation, and places limits on both models.

In particular, we use this result to constrain our version of the jet theory of chondrule formation, where chondrules are formed at the base of a bipolar solar jet and then ejected to the outer regions of a magnetically confined solar nebula, where they impact at hypersonic speeds into the nebula. We find that the observed linear correlation between mantle thickness and chondrule core radius requires a dust to gas mass ratio of approximately 0.5 - 1.0, provided that the dust-chondrule sticking coefficient, Q , was in the range 0.5 - 1.0. We suggest that the settling of dust ejected from the jet could produce such high ratios in the inner regions of the nebula.

Another constraint on the chondrule formation process is the observed structure of fine-grained rims around igneous rims, but not the other way around. We argue that this observation can be readily explained by the jet model, but poses a challenge for the shock model.

As a consequence of this study, we show that the standard drag coefficient for a sphere moving through rarefied gas is approximately 70% of the physically correct value. We also derive a simple form for the drag coefficient which describes the interaction between dust grains and a macroscopic sphere.

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preprints available from http://taylor.mel.dbce.csiro.au/~kurtl/Papers/Icarus_PP/

Star Formation in the Vela Molecular Clouds IV. Young embedded star clusters towards D-cloud Class I sources

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We study the association between embedded star clusters and young stellar objects believed to be precursors of intermediate mass stars ($2 \lesssim M \lesssim 10 M_{\odot}$), within the Vela Molecular Ridge D-cloud. A sample of 12 IRAS-selected Class I sources belonging to the region was imaged in the near infrared bands JHK and the photometry used in order to gain information on the stellar population around these objects. We find a large fraction of sources with a NIR excess, particularly within fields located towards higher luminosity protostars ($L_{\text{bol}} \gtrsim 10^3 L_{\odot}$, meaning $M \gtrsim 5 M_{\odot}$ according to accretion models), indicative of the presence of a large number of less massive young stellar objects. An analysis of the K -source surface density confirms that the higher luminosity Class I sources are embedded in young clusters of sizes $\sim 0.1 - 0.3$ pc and volume densities $\gtrsim 3000 - 12000$ stars pc^{-3} . Conversely, the lower luminosity Class I sources ($L_{\text{bol}} < 10^3 L_{\odot}$, i. e., $M \lesssim 5 M_{\odot}$) are associated with small groups of young stellar objects or isolated. This indicates that intermediate mass star progenitors lie in clusters whose member richness increases with the progenitor mass itself. The Class I sources appear as the most massive and less evolved objects in the clusters and tend to be located near the star surface density peaks, suggesting a mass and age segregation which may be partly explained by models of competitive accretion. The K luminosity functions of the clusters are indicative of populations of coeval stars $10^5 - 10^6$ yr old roughly distributed according to the field stars initial mass function. A scenario in which clusters are formed by contraction and fragmentation of molecular cores, with less massive stars first leaving the birthline, is proposed.

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<http://www.mporzio.astro.it/massi/papers/clustvela.upd.ps.gz>

A Radiation Hydrodynamic Model for Protostar Collapse II. The Second Collapse and the Birth of a Protostar

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We carry out radiation hydrodynamic calculations to study physical processes in the formation of a $1M_{\odot}$ protostar. Following our previous work, calculations pursue the whole evolution from the beginning of the first collapse to the end of the main accretion phase. The adiabatic core formed after the initial collapse (i.e., the first core) experiences further gravitational collapse triggered by dissociation of molecular hydrogen, which leads to the formation of the second core, or the birth of a protostar. The protostar grows in mass as accreting the infalling material from the circumstellar envelope while the protostar keeps its radius at $\sim 4R_{\odot}$ during the main accretion phase. These typical features in the evolution are in good agreement with previous studies.

We consider two different initial conditions for the density distribution: homogeneous and hydrostatic cloud cores with the same central density of $1.415 \times 10^{-19} \text{g} \cdot \text{cm}^{-3}$. The homogeneous core has the total mass of $1M_{\odot}$ while the hydrostatic core has $3.852M_{\odot}$. For the initially homogeneous model, the accretion luminosity rapidly rises to the maximum value of $25L_{\odot}$ just after the birth of a protostar, and declines gradually as the mass accretion rate decreases. In contrast, the luminosity increases monotonically with time for the initially hydrostatic model. This difference arises because the mass accretion rate varies depending on the inward acceleration at the initial stage, which affects the luminosity curve. A less massive hydrostatic core would possess the similar properties in the luminosity curve to the $3.852M_{\odot}$ case, because a hydrostatic cloud core with mass lower than $3.852M_{\odot}$ can be shown to provide a smaller mass accretion rate after the birth of a protostar and a more gradual rise in the luminosity curve.

Our numerical code is designed to provide the evolution of the SED along with the dynamical evolution in our spherically symmetric calculations. We confirm that the SED evolves from a 10K greybody spectrum to hotter spectra typical for class I and flat spectrum sources. The SED for the class 0 sources corresponds to the age of $2 \times 10^4 \text{yr}$, which is smaller by an order of magnitude than the typical age of class I objects. Considering possible non-spherically-symmetric effects, we suggest that observed class 0 sources should consist of the “genuine” class 0 objects, which are as young as 10^4yr , and more evolved protostars on edge-on view (“class 0-like class I” objects). The contamination of edge-on class I objects into class 0 sources are not negligible because they are abundant than genuine class 0 objects.

Since observations indicate that the class 0 sources are typically more luminous than class I sources, the initially hydrostatic model, where the luminosity increases monotonically with time, does not match the observations. The initially homogeneous model, in contrast, shows a tendency consistent with the observations.

Compiling our results and other theoretical and observational evidence, we illustrate an evolutionary picture of protostar formation. In terms of the evolutionary time and the inclination to an observer, we find that protostellar objects are clearly categorized.

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http://www.ccsr.u-tokyo.ac.jp/~masunaga/index_prs.html

Bipolar molecular outflows driven by hydromagnetic protostellar winds

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We demonstrate that magnetically-collimated protostellar winds will sweep ambient material into thin, radiative, momentum-conserving shells whose observable features reproduce those commonly observed in bipolar molecular outflows. We find the typical position-velocity and mass-velocity relations to occur in outflows in a wide variety of ambient density distributions, regardless of the time histories of their driving winds.

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The Detection of Outflows in the IR-Quiet Molecular Core NGC 6334 I(North)

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We find strong evidence for outflows originating in the dense molecular core NGC 6334 I(North): a 1000 M_{\odot} molecular core distinguished by its lack of H II regions and mid-IR emission. New observations were obtained of the SiO ($2 \rightarrow 1$) and ($5 \rightarrow 4$) lines with the SEST 15-m telescope and the H₂ ($\nu = 1 \rightarrow 0$) S(1) line with the ESO 2.2-m telescope. The line profiles of the SiO transitions show broad wings extending from -50 to 40 km s⁻¹, and spatial maps of the line wing emission exhibit a bipolar morphology with the peaks of the red and blue wing separated by $30''$. The estimated mass loss rate of the outflow is comparable to those for young intermediate to high-mass stars. The near-IR images show eight knots of H₂ emission. Five of the knots form a linear chain which is displaced from the axis of the SiO outflow; these knots may trace shock excited gas along the path of a second, highly collimated outflow. We propose that I(N) is a rare example of a molecular core in an early stage of cluster formation.

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High-excitation CS and C³⁴S towards ultracompact HII regions

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We have used the JCMT telescope to observe the $J=5-4$ and $J=7-6$ rotational transitions of CS and C³⁴S towards 19 ultracompact HII regions. The main goal was to extend the survey of Cesaroni et al. (1991) to a larger sample of sources and to higher energy transitions sensitive to the densest, hottest molecular gas. In all cases we find gas with $n_{\text{H}_2} \simeq 10^5-10^6$ cm⁻³ associated with the ultracompact HII regions, thus confirming that massive stars are born inside dense molecular clumps. In particular, the observed line intensities can be satisfactorily reproduced with a single density model, without the contribution of a radiative field. A comparison between the profiles of different transitions suggests that the regions traced by the CS molecule could be collapsing. Also, higher energy lines seem to trace more turbulent environments: it is shown that turbulence can be an efficient mechanism to confine the expansion of ultracompact HII regions, as proposed by Xie et al. (1996), although confinement by thermal pressure cannot be excluded on the basis of our data. For one of the sources, G10.47+0.03, we present a map in the CS(7-6) transition: this shows that the diameter of the emitting region is comparable to that measured in the lower excitation lines observed by Cesaroni et al. (1991).

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<http://www.arcetri.astro.it/~starform/publ1999.htm>

Production of star-grazing and impacting planetesimals via orbital migration of extra-solar planets

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During orbital migration of a giant extrasolar planet via ejection of planetesimals (Murray et al. 1998), inner mean-motion resonances can be strong enough to cause planetesimals to graze or impact the star. We integrate numerically

the motions of particles which pass through the 3:1 or 4:1 mean-motion resonances of a migrating Jupiter-mass planet. We find that many particles can be trapped in the 3:1 or 4:1 resonances and pumped to high enough eccentricities that they impact the star. This implies that for a planet migrating a substantial fraction of its semi-major axis, a fraction of its mass in planetesimals could impact the star. This process may be capable of enriching the metallicity of the star at a time when the star is no longer fully convective. Upon close approaches to the star the surfaces of these planetesimals will be sublimated. Orbital migration should cause continuing production of evaporating bodies, suggesting that this process should be detectable with searches for transient absorption lines in young stars. The remainder of the particles will not impact the star but can be subsequently ejected by the planet as it migrates further inwards. This allows the planet to migrate a substantial fraction of its initial semi-major axis by ejecting planetesimals.

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Jet driven molecular outflows in Orion

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We present high sensitivity and high angular resolution images of the high velocity ($v_{LSR} > 30 \text{ km s}^{-1}$) CO emission in the $J = 1 \rightarrow 0$ and $J = 2 \rightarrow 1$ lines of the Orion KL region. These results reveal the morphology of the high-velocity CO emission at the most extreme velocities. High velocity emission have been only detected in two regions: BN/KL (IRc2/I) and Orion–S.

The Orion–S region contains a very young (dynamical age of $\sim 10^3$ years), very fast ($\sim 110 \text{ km s}^{-1}$) and very compact ($\lesssim 0.16 \text{ pc}$) bipolar outflow. From the morphology of the high-velocity gas we estimate that the position of the powering source must be $20''$ north of FIR 4. So far, the exciting source of this outflow has not been detected. For the IRc2/I molecular outflow the morphology of the moderate velocity ($\lesssim 60 \text{ km s}^{-1}$) gas shows a weak bipolarity around IRc2/I. The gas at the most extreme velocities does not show any bipolarity around IRc2/I, if any, it is found $\sim 30''$ north from these sources. The blue and redshifted gas at moderate velocities shows similar spatial distribution with a systematic trend for the size of the high-velocity gas to decrease as the terminal radial velocity increases. The same trend is also found for the jet driven molecular outflows L 1448 and IRAS 03282 + 3035. The size-velocity relationship is fitted with a simple velocity law which considers a highly collimated jet and entrained material outside the jet moving in the radial direction. We also find that most of the CO outflowing at moderate velocities is located at the head of the jet. Our results and the spatial distribution and kinematics of the shock tracers in this outflow can be explained if the IRc2/I outflow is driven by a precessing jet oriented along the line of sight. The implication of these findings in the evolution of molecular outflows is discussed.

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Preprints are available on the WWW at: <http://www.oan.es/preprints/lista.html>

Shock excited far-infrared molecular emission around T Tau

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The first complete far-infrared spectrum of T Tau has been obtained with the LWS spectrometer on-board the Infrared Space Observatory (ISO), which detected strong emission from high-J ($J=14-25$) CO, para- and ortho-H₂O and OH transitions over the wavelength range from 40 to 190 μm . In addition the [OI]63 μm , [OI]145 μm and [CII]158 μm atomic lines were also detected. Most of the observed molecular emission can be explained by a single emission region at $T\sim 300-900$ K and $n_{\text{H}_2}\sim 10^{5-6}\text{cm}^{-3}$, with a diameter of about 2-3 arcsec. This corresponds to a very compact region of 300 - 400 AU at the distance of 140 pc. An higher temperature component seems to be needed to explain the highest excitation CO and H₂O lines. We derive a water abundance of $1-7\cdot 10^{-5}$ and an OH abundance of $\sim 3\cdot 10^{-5}$ with respect to molecular hydrogen, implying H₂O and OH enhancements by more than a factor of 10 with respect to the expected ambient gas abundance.

The observed cooling in the various species amounts to $0.04 L_{\odot}$, comparable to the mechanical luminosity of the outflow, indicating that the stellar winds could be responsible of the line excitation through shocks.

In order to explain the observed molecular cooling in T Tau in terms of C-type shock models, we hypothesise that the strong far-ultraviolet radiation field photodissociates water in favour of OH. This would explain the large overabundance of OH observed.

The estimated relatively high density and compactness of the observed emission suggest that it originates from the shocks taking place at the base of the molecular outflow emission, in the region where the action of the stellar winds from the two stars of the binary system is important.

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C¹⁸O Observations of the Dense Cloud Cores and Star Formation in Ophiuchus

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In order to reveal the distribution of the dense gas of $\geq 10^4\text{cm}^{-3}$, C¹⁸O ($J=1-0$) observations have been made toward the molecular clouds in the Ophiuchus region of $\sim 6.4\text{deg}^2$ with the two 4m telescopes of Nagoya University. Forty dense cores have been identified, providing the first complete sample of such dense cores in Ophiuchus. The C¹⁸O dense cores are distributed not only in the active star forming region, ρ Oph cloud core, but also in the North region where star formation is less active. The typical core mass, M_{LTE} , radius, R , and average number density, $n(\text{H}_2)$, of the cores are $90M_{\odot}$, 0.24 pc and $1.7\times 10^4\text{cm}^{-3}$ in the ρ Oph region, respectively, and $14M_{\odot}$, 0.19 pc, and $7.6\times 10^3\text{cm}^{-3}$ in the North region, respectively. Nine of the 40 cores are associated with young stellar objects, and most of the C¹⁸O cores are starless. An analysis of the physical parameters of the C¹⁸O cores show that star forming cores tend to have larger $N(\text{H}_2)$ than the rest by a factor of ~ 3 , although there is no significant trend in the other physical parameters between star forming and starless cores.

We have compared the present C¹⁸O data with the ¹³CO data (Nozawa et al. 1991) and with the associated YSOs, in order to better understand the condensing process from molecular gas with density of $\sim 10^3\text{cm}^{-3}$ to protostars. It is found that 55% of the ¹³CO cores are associated with C¹⁸O cores and that the C¹⁸O cores are typically less massive, smaller and denser by $\sim 34\%$, $\sim 32\%$, and a factor of ~ 3 , respectively, than the ¹³CO cores. It is also found that the C¹⁸O cores have steeper density profiles than the ¹³CO cores; when we fit the density profile by a power law as $\rho\propto r^{-\beta}$, the value of β for C¹⁸O and ¹³CO are estimated as ~ 1.5 and 1.2, respectively. This suggests that the C¹⁸O cores are gravitationally more relaxed than the ¹³CO cores.

In order to investigate the energetics of the cores, the virial mass, M_{VIR} , has been calculated for each core. It is found that most of the ¹³CO cores have M_{VIR} larger than M_{LTE} . On the other hand, 22 out of the 40 C¹⁸O cores have M_{VIR} smaller than M_{LTE} , suggesting that the C¹⁸O cores are more deeply gravitationally bound than the ¹³CO cores.

Further, we have found a correlation between the ratio $M_{\text{VIR}}/M_{\text{LTE}}$ and star formation activity; i.e.; (1) For ¹³CO cores, the fraction of the ¹³CO cores associated with the C¹⁸O cores tend to increase with decreasing $M_{\text{VIR}}/M_{\text{LTE}}$,

and (2) for the C¹⁸O cores, the fraction of the C¹⁸O cores associated with stars tend to increase with decreasing of $M_{\text{VIR}}/M_{\text{LTE}}$. We interpret this to indicate that the gradual dissipation of the internal turbulence leads to formation of denser cores and subsequent star formation. Through the evolution from the ¹³CO cores to the C¹⁸O cores, they should lose the turbulence energy of $\sim 10^{44}$ erg. The supersonic gas motion with the magnetic fields produces shocks and the radiation from the small shocked region may significantly contribute to the cooling. We suggest that the cores have continuous collisions between turbulent eddies to produce the C-shocks. Also the Alfvénic energy loss may be viable as the dissipation mechanism.

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ISO Mid-Infrared Spectra of Reflection Nebulae

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We present 5 – 15 μm imaging spectroscopy of the reflection nebulae vdB17 (NGC 1333), vdB59 (NGC 2068), vdB101, vdB111, vdB133 and vdB135, obtained with the infrared camera and circular variable filter wheel on the *Infrared Space Observatory (ISO)*. These nebulae are illuminated by stars with $T_{\text{eff}} = 3,600 \text{ K} - 19,000 \text{ K}$, implying ultraviolet (UV; $\lambda < 400 \text{ nm}$) to total stellar flux ratios of $F_{(\lambda < 400\text{nm})}/F_{\text{total}} = 0.01 - 0.87$. We detect the infrared emission features (IEFs) at 6.2, 7.7, 8.6, 11.3, and 12.7 μm , broad emission features at 6 – 9 μm and 11 – 13 μm , and 5 – 15 μm continuum emission, from the interstellar medium in vdB17, vdB59, and vdB133 ($F_{(\lambda < 400\text{nm})}/F_{\text{total}} = 0.22 - 0.87$), and place upper limits on the emission from the interstellar medium in vdB101, vdB111, and vdB135 ($F_{(\lambda < 400\text{nm})}/F_{\text{total}} = 0.01 - 0.20$).

Our goal is to test predictions of models attributing the IEFs to polycyclic aromatic hydrocarbons (PAHs). Interstellar models predict PAHs change from singly ionized to neutral as the UV intensity, G_0 , decreases. The ratio of PAH emission at 6 – 10 μm to PAH emission at 10 – 14 μm is expected to be ten times higher in ionized than neutral PAHs.

We observe no spectroscopic differences with varying T_{eff} . We analyze the spectra of vdB17 and vdB59 as a function of distance from the star, to see how the spectra depend on G_0 within each source. The only quantitative difference we find is a *broadening* of the 7.7 μm IEF at $G_0 = 20 - 60$ within vdB17. We observe only a 40% change in the 6 – 10 μm to 10 – 14 μm flux ratio over $G_0 = 20$ to 6×10^4 .

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The ortho-to-para ratio of ammonia in the L1157 outflow

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We have measured the ortho-to-para ratio of ammonia in the blueshifted gas of the L1157 outflow by observing the six metastable inversion lines from $(J, K) = (1, 1)$ to $(6, 6)$. The highly excited $(5, 5)$ and $(6, 6)$ lines were first detected in the low-mass star forming regions. The rotational temperature derived from the ratio of four transition lines from $(3, 3)$ to $(6, 6)$ is 130–140 K, suggesting that the blueshifted gas is heated by a factor of ~ 10 as compared

to the quiescent gas. The ortho-to-para ratio of the NH_3 molecules in the blueshifted gas is estimated to be 1.3–1.7, which is higher than the statistical equilibrium value. This ratio provides us with evidence that the NH_3 molecules have been evaporated from dust grains with the formation temperature between 18 and 25 K. It is most likely that the NH_3 molecules on dust grains have been released into the gas phase through the passage of strong shock waves produced by the outflow. Such a scenario is supported by the fact that the ammonia abundance in the blueshifted gas is enhanced by a factor of ~ 5 with respect to the dense quiescent gas.

Accepted by ApJ Letters

<http://vsop.mtk.nao.ac.jp/~umemoto/preprint.html>

Outflow sources in the Vela region

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We have observed $^{12}\text{CO}(1-0)$, $^{13}\text{CO}(1-0)$, $\text{C}^{18}\text{O}(1-0)$, and $\text{CS}(2-1)$ towards nine sources in the Vela region for which the $^{12}\text{CO}(1-0)$ spectra by Wouterloot & Brand (1989; A&AS 80, 149) suggested the presence of strong line wings (towards two of those sources only CS or ^{12}CO and ^{13}CO were observed). The sources are located in or behind the Vela Molecular Ridge at distances between about 0.6 and 6.7 kpc. In all transitions we made small maps, typically several arcminutes in size.

Towards five sources the ^{12}CO emission is confused by unrelated components at other velocities (not visible in CS and C^{18}O) which we subtracted from the line profiles before analysing the wing emission. The presence of outflow emission was studied by also subtracting the contribution of a central Gaussian line component. We conclude that of the eight sources observed in CO, seven show outflows, one does not. For one of the sources only the blue wing could be studied due to the confusing presence of other strong line components. For the outflow sources we derive the physical parameters. Wing emission has a relative outflow velocity up to about 16 km s^{-1} , but the average (weighted with line intensity) is about 4 km s^{-1} . Masses of the outflows range from 1 to $150 M_{\odot}$.

CS and C^{18}O were detected towards all eight (resp. seven) sources observed in these molecules. Five sources show single clumps in both transitions, two sources show several clumps in one of the transitions (the other was not mapped completely) and one source shows only weak emission (probably due to its distance). Clump masses and radii range from several $10 M_{\odot}$ to about $1000 M_{\odot}$ and 0.2 pc to 2 pc. Five of the sources show a velocity gradient in CS and C^{18}O indicative of rotation.

Accepted by Astron. Astrophys. Suppl.

http://www.ira.bo.cnr.it/~brand/papers/vela_flows.ps.gz

Shock Heated NH_3 in a Molecular Jet Associated with a High-mass Young Star

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We present the discovery of shock excited NH_3 in a well collimated jet associated with an extremely young high-mass star IRAS 20126+4104. The NH_3 (3,3) and (4,4) emission is dominated by three clumps long the SiO jet (Cesaroni et al. 1999). At the end of the jet there exists strong and broad ($\pm 10 \text{ km s}^{-1}$) NH_3 (3,3) emission. With typical brightness temperatures of $> 500 \text{ K}$, the overall emission indicates a weakly inverted population and appears in an arc, consistent with excitation by bow shocks. There are two bright spots in the NH_3 (3,3) with brightness temperatures approximately 2000 K . The narrow linewidth (1.5 km s^{-1} FWHM), the small sizes ($< 0''.3$) and the unusually high brightness temperature of the features are indicative of maser emission. Our observations provide clear evidence that NH_3 (3,3) masers are excited in shock regions in molecular outflows.

Accepted by ApJ Letters

Preprint: <http://cfa-www.harvard.edu/~qzhang>

A search for young solar system analogues with the VLT

Hans Zinnecker¹, Alfred Krabbe², Mark J. McCaughrean¹, Thomas Stanke¹, Bringfried Stecklum³, Wolfgang Brandner⁴, Deborah L. Padgett⁵, Karl R. Stapelfeldt⁶ and Harold W. Yorke⁶

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The VLT/UT1 telescope has been used with its facility near-IR camera ISAAC to obtain 1–2.5 μm wavelength images at 0."4 spatial resolution of six southern young low-luminosity sources associated with extended reflection nebulosity. Two are in the Chamaeleon I dark cloud (Cha IR nebula, Cederblad 110 IRS4), and the other four in the Gum Nebula (HH 46/47, CG 30, Re 4, Re 5). Complex structure is seen, including in most cases bipolar blue and red scattering lobes likely due to the illumination of outflow cavities by the central star(s), hidden by a flattened circumstellar disk or envelope. In one object (Re 4), a double jet appears to be emanating from the central source, suggestive of a binary system with nearly aligned disks. These images, when supplemented by polarimetry maps, will help determine the structure and geometry of the young stellar objects, and will also be compared to 3D radiative transfer models to match both the surface brightness distribution of the extended emission and the spectral energy distribution of the central source. Applied to a series of such objects, these analyses will lead to an improved evolutionary sequence for the formation of solar system analogues.

Accepted by Astronomy & Astrophysics Letters, (VLT special issue)

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, where you can access it at <http://casa.colorado.edu/reipurth> or at <http://www.eso.org/gen-fac/pubs/starform/>.

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.

Dissertation Abstracts

The Birth and Death of Stars

Christopher David Matzner

Thesis work conducted at: The University of California at Berkeley

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Ph.D dissertation directed by: Christopher F. McKee

Ph.D degree awarded: October 1999

We present analytical models for two violent phases of stellar evolution whose effects upon the interstellar medium are most profound: supernova explosions and protostellar outflows. Using models for outflows, we analyze the efficiency and dynamics of a forming stellar cluster.

The distribution of ejecta that expand away from a core-collapse supernova can be predicted once one knows the velocity of the blastwave shock that crossed the stellar envelope. We identify a new model for this shock's velocity that is simple and accurate, with which we construct detailed models relating stellar structures to their ejecta distributions. The shock model also permits us to calculate the observable features of shock emergence, including the energy and duration of the soft-X-ray burst, the upper limit of ejecta velocities, and the mass (if any) of relativistic ejecta. The latter may help to understand weak gamma-ray bursts from supernovae. We also use the structural similarity of red and blue supergiants to approximate their ejecta with simpler, less flexible models.

We show that hydromagnetic winds from accreting protostars will assume a common force distribution at large distances, whether or not the wind emanates from a narrow region of disk radii. In any power-law density distribution, such a wind sweeps ambient gas into thin shells whose features match those commonly observed in bipolar molecular outflows, regardless how the driving wind's intensity varies over time. This implies that prompt entrainment, not turbulence, is responsible for these features. This model predicts the rate of mass ejection from a star-forming region, and thus the efficiency with which a star cluster can form.

Using the energy injection and mass ejection implied by this model, we address the dynamical evolution of a dense clump inside a molecular cloud as it creates a cluster of low-mass stars. We use the virial equation of motion and assume that star formation is limited by ambipolar diffusion. For lower pressures than within starburst nuclei, an equilibrium state is possible if turbulence does not decay extremely rapidly. However, clumps tend to oscillate about their equilibria, and this can cause star formation to proceed in bursts.

Properties of the components in young binary systems

Jens Woitas

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Ph.D dissertation directed by: Christoph Leinert

Ph.D degree awarded: October 1999

Using near-infrared speckle-interferometry we have obtained resolved JHK-photometry for the components of 58 young binary systems. By placing the components into a color-color diagram we identify some unusual red objects that are candidates for infrared companions or substellar objects. We place a subsample that consists of the components of 14 weak-lined TTS systems (where no significant circumstellar excess emission is expected) into a color-magnitude diagram and show that in all these systems the components are coeval within the uncertainties. Particularly this is the case for the triple system HBC 358. Using the J-magnitude as an indicator for the stellar luminosity, the optical spectral type of the system and the previously justified assumption that all components are coeval we can place the components into the HRD and derive their masses by comparison with theoretical pre-main sequence evolutionary tracks. The results are the following: The distribution of mass ratios is neither clustered towards $M_2/M_1 = 1$ nor is it a function of the primary's mass or the components' projected separation. Comparison of these results with predictions of theoretical multiple star formation models suggests that most of the systems have formed by fragmentation during protostellar collapse, and that the components' masses are principally determined by fragmentation and not by the following accretion processes.

Furthermore the infrared source HV Tau C is discussed using new observational data. We show that this source is no Herbig-Haro object, but an active T Tauri star. So the HV Tau-system does not impose a problem on current models of T Tauri stars and their environment.

From relative positions of the components at different epochs we derive their relative velocities and show that in most close systems orbital motion can be proved. The analysis of this orbital motion leads to an empirical mass estimate for T Tauri-stars which is larger than the masses one would expect from the HRD.

We have also used speckle interferometry to obtain the relative astrometry for the components of nearby low-mass binary systems at different epochs. This has led to an improved orbit determination for the visual pair in the nearby M-dwarf triple Gliese 866. We show that all components of this system have masses only close above the hydrogen burning limit. For eight other systems the combination of our relative astrometry with radial velocity data will lead to precise mass determinations for the components of nearby late type binaries in the near future.

New Jobs

Postdoctoral Research Associate in Star Formation

CARDIFF UNIVERSITY,
Department of Physics & Astronomy
5 The Paprade, PO Box 913,
Cardiff, CF2 3YB, Wales,
United Kingdom.

Tel: 44-1222-874798

Fax: 44-1222-874056

E-mail: a.whitworth@astro.cf.ac.uk

URL:<http://www.astro.cf.ac.uk>

Attention: Dr. Anthony Whitworth

Applications are invited for a 3-year post-doc position to work on star formation with Drs. A Whitworth and D Ward-Thompson. The goal is to simulate numerically the collapse and fragmentation of low-mass cores, using real initial conditions (i.e. density, temperature, velocity and magnetic fields derived from observations) and realistic constitutive physics; and to compare the properties of the resulting protostars with observation. Preference will be given to applicants with experience in astrophysical gas dynamics, but the appointee will also be encouraged to participate in our ongoing observational programme aimed at obtaining stronger constraints on the physics of star-forming cores.

The Cardiff Star-Formation Group currently comprises two faculty, two post-docs and five post-grads. The Cardiff Astronomy Programme is also active in the chemical evolution of galaxies, high-redshift galaxies, LSBGs, sub-millimeter instrumentation and gravitational waves. We have excellent in-house computing facilities.

Applicants should send a CV, publications list, and statement of research interests, to reach Dr. Whitworth by 30 November 1999. They should ask three referees to write by the same date. The minimum starting salary is £17,570 (UKPounds). The starting date should be during 2000. Informal enquiries can be made by e-mail (or 'phone) to a.whitworth@astro.cf.ac.uk (44-1222-874798) or d.ward-thompson@astro.cf.ac.uk (44-1222-875314). Cardiff University is an Equal-Opportunity Employer.

ARCETRI ASTROPHYSICAL OBSERVATORY

Florence (Italy)

International Post-Doctoral Fellowships

The Arcetri Astrophysical Observatory (Florence) intends to award two post-doctoral fellowships in order to foster international collaboration. Applicants must have a Ph.D. or equivalent. In the case of Italian citizens, it is required that they have been affiliated with a foreign institution during the last two years.

The fellows will take part in the observational/theoretical research activity of the Arcetri Observatory in one of the following areas:

1. Physics of the Interstellar Medium and Star Formation
2. Solar Physics
3. SN Remnants and Active Galactic Nuclei
4. High Energy Astrophysics and Cosmology

The annual activity report of the Observatory can be found in the web page: <http://www.arcetri.astro.it/>

Applicants should have a strong previous experience in the relevant area. The gross yearly salary will be between 40.000.000 and 50.000.000 Italian Lire. The fellowships will be granted for two years (subject to an evaluation of performance after the first year). The fellowships will not entail social benefits or medical insurance, but each fellow will be requested to cover himself/ herself with basic medical insurance. No special application forms are required. The applicants should send a CV, a list of publications and arrange for two letters of recommendation to be sent directly to the above address. Applications should arrive in Arcetri no later than January 10, 2000. Starting date is April 2000 but different dates can be considered.

e-mail submission address: natta@arcetri.astro.it

e-mail inquiries : natta@arcetri.astro.it

URL: <http://www.arcetri.astro.it/avvisi/1999/Eoct21-00.txt>

Contact information:

Antonella Natta

Osservatorio Astrofisico di Arcetri phone: +39 055 2752239

fax: +39 055 220039

e-mail: natta@arcetri.astro.it

The application deadline is: January 10, 2000.

Research Position in Astronomy

A postdoctoral research position will be available in the Infrared High-Resolution Imaging Group of the Max Planck Institute for Radioastronomy in Bonn, Germany, starting January 1, 2000 or later.

The research of the group is centered on the interpretation and modeling of high-resolution data of *young stellar objects*, stars in late evolutionary phases, and active galactic nuclei (for details see <http://www.mpifr-bonn.mpg.de/div/speckle>). Applicants should have experience in observational or theoretical astrophysics in one of the above fields.

The position is offered initially for two years. The salary will be on the German BAT II scale and depends on age and marital status. Applicants must hold a PhD in astronomy. Interested scientists should send a letter of application with a summary of relevant experience and research interests, a curriculum vitae, a list of publications, and two letters of recommendation to:

Prof. Gerd Weigelt
Max Planck Institute for Radioastronomy
Auf dem Huegel 69
D-53121 Bonn, Germany

Fax: +49 228 525 437
Email: weigelt@mpifr-bonn.mpg.de

Application review will begin December 15, 1999 and continue until the position is filled. The Max Planck Society is an equal opportunity employer.

Schwinger Fellowship

The Department of Physics & Astronomy at the University of California, Los Angeles, is pleased to announce a solicitation of applications for the Julian Schwinger Fellow. The Schwinger Fellow honors the late Professor Schwinger and recognizes his many contributions to the advancement of physics. This year we are seeking an outstanding young scientist in the area *Origins of Solar Systems* (observational or theoretical). The Schwinger Fellow is a three-year, non-renewable appointment at the rank of Adjunct Assistant Professor. The Fellow is expected to teach a reduced load of two courses per academic year (one lecture and one seminar course) and to carry out personal and collaborative research. The appointment can start on or after July 1, 2000.

Facilities available to the Schwinger Fellow include Keck Observatory, Lick Observatory, and the UCLA Infrared Laboratory. UCLA is also a member of NSF's Center of Adaptive Optics in Astronomy & Vision Science, NASA's Astrobiology Institute, and NASA's Stratospheric Observatory For Infrared Astronomy (SOFIA)

Applications should be sent to:

Selection Committee, Schwinger Fellow,
c/o F.V. Coroniti, Chair
UCLA Department of Physics and Astronomy
Los Angeles, CA 90095-1547
by January 1, 2000.

Applications should include a curriculum vitae, a statement of research interests and the names of at least three people who can be contacted for further information. University of California is an affirmative action and equal opportunity employer.

Announcement

DUSTY: A New Version

Željko Ivezić¹, Maia Nenkova² and Moshe Elitzur²

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A new release of the radiative transfer code DUSTY, which models emission from sources in dusty environments, is available at <http://www.pa.uky.edu/~moshe/dusty/>. The new version can handle both spherical and planar geometries, runs much faster and has an improved user interface. Furthermore, DUSTY now allows user control of its wavelength grid, which can be modified to accommodate spectral features of interest.

DUSTY has been tested on a variety of existing platforms. The solution, including dust scattering, absorption and emission, is exact to within the specified numerical accuracy. The code has built in optical properties for the most common types of astronomical dust and is supplied with a library for many others. It supports various analytical forms for input, and can perform a full dynamical calculation for radiatively driven winds around AGB stars. Arbitrary dust optical properties, density distributions and external radiation can be entered in user supplied files. A single DUSTY run can process an unlimited number of models, with each input set producing a run of optical depths, as specified. The user controls the detail level of the output, which can include spectral, imaging and radial properties as well as other quantities of interest.

We welcome user feedback for improving both the program and its manual, and would greatly appreciate comments and suggestions sent to moshe@pa.uky.edu

Meetings

SIRTF Legacy web workshop: 2nd announcement

The SIRTF Legacy web-based workshop has been postponed from November to early December. The workshop is intended to foster community discussion of SIRTF Legacy projects regarding star and planet formation and evolution of circumstellar disks.

Specifics about SIRTF can be found at the SIRTF Science Center Web site: <http://sirtf.caltech.edu>. SIRTF Legacy project proposals will be due in September 2000. More information about the Legacy component of SIRTF science can be found at: http://sirtf.caltech.edu/Observing/Dana_Point/Bicay/index.htm.

The workshop will be held over 3 days, *Wednesday to Friday, Dec. 8-10, 1999*, 'located' at a site within the NASA-Ames Astrobiology Institute's main website, <http://astrobiology.arc.nasa.gov>. The meeting will consist of topical chat rooms, moderated discussions, and a poster session.

Please send email regarding interest in the workshop to backman@cma.arc.nasa.gov. This will put you on a list for further email broadcasts apart from the SF newsletter.

Due date for posters in html format will be 5 pm PST Dec. 1. Address for poster submission and further details about the meeting including its exact address will be in the next (mid-November) Star Formation newsletter. Until then, technical questions about preparation of posters can be addressed to Sarah West at NASA-Ames, swest@mail.arc.nasa.gov, 650-604-6230.

D. Backman, F&M College / NASA-Ames

EUROCONFERENCE ON DISKS, PLANETESIMALS & PLANETS

Puerto de la Cruz, Tenerife, Spain

January 24th - 28th 2000

Second announcement

Visit us at:

<http://www.iac.es/proyect/planet/planet.html>

The recent discoveries of extrasolar planets and the progress in studies of disks around pre-main and main sequence stars highlight the need of a better understanding of the formation and evolution of planetary systems. Many groups and observatories are undertaking significant efforts towards these goals. The allocation for international observations at the Canary Islands Observatories in 1998 was fully devoted to studies related to these topics, making use of spectroscopic, polarimetric and optical to near-IR photometric techniques.

The conference is the frame where the large amount of data collected with the facilities on the Canary Islands will be presented. Moreover contributions from participants addressing theoretical models and observations in all wavelength ranges will provide an updated overview of the field.

The conference will last five days and will consist of sessions with invited and contributed talks and posters. Sessions will devoted to:

(a) PMS objects: circumstellar (protoplanetary) disks around protostellar objects, PMS stars and Vega-type stars; (b) Planetesimals in PMS and MS stellar systems; (c) Planets around stars; (d) Searches for planets; (e) Impact on planetary system studies of future space and ground-based facilities.

Contributed papers can be accepted up to November 7th 1999.

SOC:

E. van Dishoeck, C. Eiroa (chair), R. Ferlet, M. Mayor, A. Natta, F. Paresce, A. Penny, A. Quirrenbach, H. Rauer, L.F. Rodriguez, P.R. Wesselius, D. de Winter

Invited speakers:

A. Boss; S. Ruden; Paul H. Ho; L. Hartmann; A. Dutrey; A. Burkert; C. Grady; V. Grinin; M. van den Ancker; C. Telesco; W. Holland; A. Lecavelier; M. Mayor; G. Gonzalez; T. Guillot; J. Luu; M. Dominik; T. Brown; A. Glindenmann; S. Guilloteau; M. Shao; M. Fridlund; A. Natta

European grants are available for european scientist younger than 35.

Inquiries about the meeting can be e-mailed to the address:

planet@ll.iac.es

or post to:

T. Karthaus; (Disks, Planetesimals & Planets Meeting)

Instituto de Astrofísica de Canarias; c/ Via Lactea s/n; 38200 La Laguna; Tenerife; Spain

Information will be regularly updated on the conference Web pages:

<http://www.iac.es/proyect/planet/planet.html>