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Abstracts of recently accepted papers

Discovery of a very cool object with extraordinarily strong Hα emission

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We report on the finding of an incredibly strong Hα emission – pseudoequivalent width of 705 Å – known so far in a young, late type dwarf. This object, named as S Ori 71, is a substellar candidate member of the 1–8 Myr star cluster σ Orionis. Due to its overluminous location in color-magnitude diagrams, S Ori 71 might be younger than other cluster members, or a binary of similar components. Its mass is in the range 0.021–0.012 $M_{\odot}$, depending on evolutionary models and possible binarity. The broad Hα line of S Ori 71 appears asymmetric, indicative of high velocity mass motions in the Hα forming region. The origin of this emission is unclear at the present time. We discuss three possible scenarios: accretion from a disk, mass exchange between the components of a binary system, and emission from a chromosphere.

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http://xxx.lanl.gov/abs/astro-ph/0208497

A Substellar Mass Function for Alpha Per

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We present a deep, wide-field optical survey of the young stellar cluster Alpha Per, in which we have discovered a large population of candidate brown dwarfs. Subsequent infrared photometric follow-up shows that the majority of them are probable or possible members of the cluster, reaching to a minimum mass of 0.035 $M_{\odot}$. We have used this list of members to derive the luminosity and mass functions of the substellar population of the cluster (α=0.59±0.05, when expressed in the mass spectrum form $\phi \propto M^{-\alpha}$) and compared its slope to the value measured for the Pleiades. This comparison indicates that the two cluster mass functions are, indeed, very similar.

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Comparing SWAS and ISO observations of water in outflows

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We present a detailed comparison of SWAS and ISO observations of H_2O emission in a sample of outflows. By taking into consideration the different methods used to derive the fractional water abundance, we find that, despite the initial apparent discrepancies, there is satisfactory agreement between ISO and SWAS results for the outflows observed by both satellites. Such an agreement is reached by assuming that most of the detected water comes from a single region smaller than both the ISO and SWAS beam apertures and considering temperatures higher (T>100 K) and density lower ($n(H_2)<2\times10^6$ cm^{-3}) than previously adopted. The ratio between the integrated flux of the ortho-H_2O 2_{12}–1_{01} line at 179.5 μm observed by ISO and the fundamental ortho-H_2O 1_{10}–1_{01} line at 538.3 μm observed by SWAS is always smaller (never by more than a factor of 7) than the expected ratio. We propose that the fundamental ortho-H_2O transition has a contribution from a cooler gas component to which SWAS is sensitive but which is not traced by ISO. We conclude that, while ISO and SWAS observations are consistent with chemical models predicting a significant enhancement of water vapor abundance in outflow regions, the explanation for the low water abundance derived from SWAS observations of the cold ISM is still unclear.

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Preprint available at http://orion.ifsi.rm.cnr.it/publ.html

Hard X-ray emission from a young massive star-forming cluster

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We report the detection of hard X-ray emission (> 2 keV) from a number of point sources associated with the very young massive star-forming region IRAS 19410+2336. The X-ray emission is detected from several sources located around the central and most deeply embedded mm continuum source, which remains undetected in the X-ray regime. All X-ray sources have K-band counterparts, and those likely belonging to the evolving massive cluster show near-infrared colors in the 2MASS data indicative of pre-main-sequence stages. The X-ray luminosities around 10^{31} erg s^{-1} are at the upper end of luminosities known for low-mass pre-main-sequence sources, and mass estimates based on the infrared data indicate that at least some of the X-ray detected sources are intermediate-mass objects. Therefore, we conclude that the X-ray emission is due to intermediate-mass pre-main-sequence Herbig Ae/Be stars or their precursors. The emission process is possibly due to magnetic star-disk interaction as proposed for their low-mass counterparts.

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Preprints available at http://www.mpifr-bonn.mpg.de/staff/beuther/

Submm/FIR CO line emission from the disk of the Class I protostar EL 29

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We present observations towards the Class I protostar EL 29 of the CO J=6→5 and J≥15 transitions obtained with JCMT and ISO LWS respectively, and of five H_2 rotational lines obtained with ISO SWS. The simultaneous analysis of these observations reveals the presence of a warm gas component at about 170-250 K, $\sim$ 550 AU in size, and whose density is $\geq 10^6$ cm^{-3}. The mass of the warm gas is $\sim 8 - 24 \times 10^{-4}$ M$_\odot$. These values compare extremely well with the predictions of the temperature and mass of the flaring disk surrounding EL 29, probed by the dust continuum. We propose that the observed FIR CO emission originates in the super-heated layer surface of the disk of EL 29 and discuss its characteristics. We find that the CO abundance in the disk is large, $\geq 10^{-4}$, implying no depletion or photodissociation and we present arguments in favor of the idea that the dust has settled on the midplane disk of EL 29 and it is thermally decoupled from the gas. We compare the characteristics of the El 29 disk with those of the disks observed in other Herbig AeBe stars by recent studies of H_2 rotational line emission. The gas temperature and mass derived for the disk of EL 29 are similar to the disks of the previously studied sample. As in Herbig AeBe stars, also in EL 29 the gas and dust are probably thermally decoupled. Finally, the upper limit on the H_2O emission that we obtain suggests that water is not an important coolant of the disk gas, in agreement with theoretical water abundance predictions. The present study challenges previous claims that the FIR CO line emission observed in sources similar to EL 29 originates in shocks.

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The 2-D structure of dusty disks around Herbig Ae/Be stars I. Models with grey opacities

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In this paper the two-dimensional structure of protoplanetary disks around Herbig Ae/Be stars is studied. This is done by constructing a self-consistent model based on 2-D radiative transfer coupled to the equation of vertical hydrostatics. As a simplifying assumption a grey opacity is used. It is found that the disk can adopt four different structures, dependent on the surface density distribution $\Sigma(R)$ as a function of radius, i.e. on radial- and vertical optical depth of the disk. For the case of high to intermediate vertical optical depth, the temperature and density structures are in agreement with the simple "disk with inner hole" model of Dullemond, Dominik & Natta (2001, henceforth DDN01). At large radii the disk adopts a flaring shape as expected, and near the dust destruction radius (located at about 0.5 AU for most Herbig Ae stars) the disk is superheated and puffs up. The region directly behind this "puffed-up inner dust wall" is shadowed, as predicted by DDN01. For the case of intermediate to low vertical optical depth, but still high radial optical depth, the 2-D models show that the shadow can cover the entire disk. For such competely self-shadowed disks the inner rim emission in the near infrared constitutes the dominant part of the SED, since the flaring component in the mid- and far infrared is suppressed by the self-shadowing effect. When the disk is optically thin even in radial direction, it becomes unshadowed again because the inner rim can no longer block the stellar light. Such disks have relatively weak infrared excess compared to the stellar flux. Finally, for disks that flare at intermediate radii, but become too optically thin at large radii, the outer parts once again become shadowed. But this time the shadowing is caused by the flaring part of the disk, instead of the inner rim. The disk then consists of a bright inner rim, a shadow, a flaring part and finally a (dim) shadowed outer part. Different observational methods of determining the size of the disk (e.g. from the SED, from continuum mapping or from CO mapping) may yield different results.

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Available from http://www.mpa-garching.mpg.de/PUBLICATIONS/DATA/radtrans/grey2d/

On the nature of variations of H_α and Na I D line profiles of FU Ori

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For the first time we investigated variations of profiles of H_α and Na I D lines in the FU Ori spectrum during several successive nights, more precisely from 3 to 8 January 1999. During our observations the lines were similar to profiles observed previously by someone, what gives basis to set up the hypothesis that these variations are periodic.

We argue that the variations are due to the axial rotation of the FU Ori disk and wind, such as the thermal structure of the innermost disk regions and the topology of the wind stream lines have no axial symmetry. The asymmetry could result from the interaction of the stellar magnetic field with the disk outflow. The binarity of FU Ori looks as a less plausible explanation.

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Preprints are available via anonymous ftp from lnfm1.sai.msu.ru pub/PEOPLE/lamzin/fuori.ps

The Stellar Content of Obscured Galactic Giant H II Regions IV.: NGC3576

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We present deep, high angular resolution near–infrared images of the obscured Galactic Giant H II region NGC3576. Our images reach objects to $\sim 3M_\odot$. We collected high signal–to–noise $K-$band spectra of eight of the brightest objects, some of which are affected by excess emission and some which follow a normal interstellar reddening law. None of them displayed photospheric features typical of massive OB type stars. This indicates that they are still enshrouded in their natal cocoons. The $K-$band brightest source (NGC3576#48) shows CO 2.3 μm bandhead emission, and three others have the same CO feature in absorption. Three sources display spatially unresolved H_2 emission, suggesting dense shocked regions close to the stars. We conclude that the remarkable object NGC3576#48 is an early–B/late–O star surrounded by a thick circumstellar disk/envelope. A number of other relatively bright cluster members also display excess emission in the $K-$band, indicative of reprocessing disks around massive stars (YSOs). Such emission appears common in other Galactic Giant H II regions we have surveyed. The IMF slope of the cluster, $\Gamma = -1.62$, is consistent with Salpeter's distribution and similar to what has been observed in the Magellanic Cloud clusters and in the periphery of our Galaxy.

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Chandra X-ray Observation of the Orion Nebula Cluster. I Detection, Identification and Determination of X-ray Luminosities

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In this first of two companion papers on the Orion Nebula Cluster (ONC), we present our analysis of a 63 Ksec *Chandra* HRC-I observation that yielded 742 X-ray detections within the $30' \times 30'$ field of view. To facilitate our interpretation of the X-ray image, here we collect a multi-wavelength catalog of nearly 2900 known objects in the region by combining 17 different catalogs from the recent literature. We define two reference groups: an *infrared sample*, containing all

objects detected in the K band, and an *optical sample* comprising low extinction, well characterized ONC members. We show for both samples that field object contamination is generally low.

Our X-ray sources are primarily low mass ONC members. The detection rate for optical sample stars increases monotonically with stellar mass from zero at the brown dwarf limit to $\sim 100\%$ for the most massive stars but shows a pronounced dip between 2 and 10 solar masses. We determine L_X and L_X/L_{bol} for all stars in our *optical sample* and utilize this information in our companion paper to study correlations between X-ray activity and other stellar parameters.

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For preprints via WWW: http://www.astropa.unipa.it/∼ettoref

Chandra X-ray Observation of the Orion Nebula Cluster. II Relationship between X-ray activity indicators and stellar parameters

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Using the results of our first paper on the *Chandra* HRC observation of the Orion Nebula Cluster (ONC), here we explore the relation between the coronal activity of its 1-Myr-old pre-main sequence population and stellar parameters. We find that median X-ray luminosities of low mass stars ($M/M_\odot < 3$) increase with increasing mass and decreasing stellar age. Brown dwarfs ($0.03 < M/M_\odot < 0.08$) follow the same trend with mass. From $M \sim 0.1$ to $M \sim 0.5\ M_\odot$, median L_X/L_{bol} values increase by about half an order of magnitude and then remain constant at $\sim 10^{-3.5}$ for the mass range from 0.5 to 3.0 $M/M_\odot$. In these same two mass ranges, L_X/L_{bol} remains roughly constant with age, until it drops by more than two orders of magnitudes at the epoch when $\sim 2-4M_\odot$ stars are expected to become fully radiative.

We find a dependence of L_X and L_X/L_{bol} on circumstellar accretion indicators and suggest three possible hypotheses for its origin. In spite of improved X-ray and rotational data, correlations between activity indicators and rotation remain elusive for these stars, possibly indicating that stars for which rotational periods have been measured have reached some saturation level.

Our study of X-ray activity vs. stellar mass leads us to propose that the few HRC X-ray sources not associated with any optical/infrared counterpart trace a yet to be discovered stellar population of deeply embedded, relatively massive ONC members.

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Small-area molecular structures without shielding

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Using the IRAM 30 m telescope two molecular structures have been detected which cover very small areas, $FWHM \leq 1'$. The clouds have velocities of $v_{\rm lsr} \approx 5\,$km/s and linewidth of $\Delta v \approx 0.8\,$km/s; thus they belong most likely to the Milky Way. Applying standard conversion factors one finds that even at the upper distance limit of 2200 pc the structures are low mass objects ($M = (1-6) \times 10^{-4}\,(\frac{d}{100\rm pc})^2 \rm M_\odot$) which are not gravitationally virialized. HI 21cm line data towards the clouds show no prominent HI clouds. The total HI column densities for both structures are below $N(\rm HI) \leq 2.1 \times 10^{20}\,cm^{-2}$, corresponding to $A_{\rm V} \leq 0.2\,$mag, assuming a standard gas-to-dust ratio. IRAS 100μm data towards the structures show also only low emission, consistent with low extinction. Unless there is unseen cold dust associated with the structures this shielding is too low for the structures to survive the interstellar radiation field for a long time. The detection of 2 such structures in a rather limited sample of observations suggests that they could be a rather common feature in the interstellar medium, however, so far not recognized as such due to the weakness of

their lines and their small extent.

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http://www.astro.uni-bonn.de/~heith/sams.ps.gz

Millimeter-wave Searches for Cold Dust and Molecular Gas around T Tauri Stars in MBM 12

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We report results of a sensitive search for cold dust and molecular gas in the disks around 8 T Tauri stars in the high-latitude cloud MBM 12. Interferometric observations of 3 mm continuum emission in 5 fields containing 6 of the objects, and literature values for the remaining two, limit the disk masses to $M_{\rm disk} < 0.04$–0.09 $M_\odot$ (gas+dust), for a gas:dust mass ratio of 100 and a distance of 275 pc. By coadding the 3 mm data of our five fields, we set an upper limit to the average disk mass of $\bar{M}_{\rm disk}(N=5) < 0.03$ $M_\odot$. Simultaneous observation of the CS J=2–1 and the N_2H^+ 1–0 lines show no emission. Single-dish observations of the ^{13}CO 2–1 line limit the disk mass to $(5$–$10)\times10^{-4}$ $M_\odot$ for a standard CO abundance of 2×10^{-4}. Depletion of CO by up to two orders of magnitude, through freezing out or photodissociation, can reconcile these limits. These mass limits lie within the range found in the Taurus-Auriga and ρ Oph star-forming regions (0.001–0.3 $M_\odot$), and preclude conclusions about possible decrease in disk mass over the 1–2 Myr age range spanned by the latter two regions and MBM 12. Our observations can exclude the presence in MBM 12 of T Tauri stars with relatively bright and massive disks such as T Tau, DG Tau, and GG Tau.

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Preprints available at `http://talisker.as.arizona.edu/~michiel/pub.html`

3.4 micron feature on the shoulder of ice band absorptions in three luminous Young Stellar Objects — IRAS 18511+0146, IRAS 21413+5442, & IRAS 04579+4703

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An absorption feature at 3.4 μm has been detected in the long-wavelength wing of the 3.1 μm H_2O ice feature in three young stellar objects: IRAS 18511+0146, IRAS 21413+5442, and IRAS 04579+4703. The profile of the 3.4 μm absorption in IRAS 18511+0146 has distinct subfeatures at 3.38, 3.41, and 3.48 μm and is not similar to those found in molecular clouds but is similar to those in the diffuse interstellar medium, such as the lines of sight toward the Galactic center and Cyg OB2 12. Spectropolarimetry of the 3.4 μm feature in IRAS 18511+0146 shows no excess polarization accompanying the feature, which is consistent with the observation toward the Galactic center source IRS 7 by Adamson et al. (1999). The 3.4 μm absorption in IRAS 18511+0146 probably occurs in the diffuse interstellar medium intervening in the line of sight to the molecular cloud where the H_2O ice absorption occurs. Furthermore, the 3.4 μm absorption carrier seems to reside in a population of nonpolarizing grains in the diffuse interstellar medium, physically separate from other polarizing grains.

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Self-similar Collapse of Rotating Magnetic Molecular Cloud Cores

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We present self-similar solutions that describe the gravitational collapse of rotating, isothermal, magnetic molecular-cloud cores. These solutions make it possible, for the first time, to study the formation of rotationally supported protostellar disks of the type detected around many young stellar objects in the context of a realistic scenario of star formation in magnetically supported, weakly ionized, molecular cloud cores. This work focuses on the evolution after a point mass first forms at the center and generalizes previous results by Contopoulos, Ciolek, & Königl that did not include rotation. Our semianalytic scheme incorporates ambipolar diffusion and magnetic braking and allows us to examine the full range of expected behaviors and their dependence on the physical parameters. We find that, for typical parameter values, the inflow first passes through an ambipolar-diffusion shock (at a radius r_a), where the magnetic flux decouples from the matter, and subsequently through a centrifugal shock (at r_c), inward of which a rotationally supported disk (of mass M_d) is established. By the time ($\sim 10^5$ yr) that the central mass M_c grows to $\sim 1\,M_\odot$, $r_a \gtrsim 10^3$ AU, $r_c \gtrsim 10^2$ AU, and $M_d/M_c \lesssim 0.1$. The derived disk properties are consistent with data on T Tauri systems, and our results imply that protostellar disks may well be Keplerian also during earlier phases of their evolution. We demonstrate that the disk is likely to drive centrifugal outflows that transport angular momentum and mass, and we show how the radially self-similar wind solution of Blandford & Payne can be naturally incorporated into the disk model. We further verify that gravitational torques and magnetorotational instability-induced turbulence typically do not play an important role in the angular momentum transport. For completeness, we also present solutions for the limiting cases of fast rotation (where the collapse results in a massive disk with such a large outer radius that it traps the ambipolar-diffusion front) and strong braking (where no disk is formed and the collapse resembles that of a nonrotating core at small radii), as well as solutions describing the rotational collapse of ideal-MHD and of nonmagnetic model cores.

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CO Outflows from Young Stellar Objects

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We have mapped the CO J=1-0 emission from molecular outflows associated with six young stellar systems using the BIMA array. The systems are all relatively nearby, low luminosity and range from Class 0 to Class II sources. The CO outflows in these systems are complicated, showing multipolar structures, multi cavities and asymmetric lobes. The complicated appearance of the CO outflows may result from the interactions between one or more outflows and the non-uniform ambient cloud. The CO emission typically arises from shell structures around the outflow axis. For some outflows, there are also clumpy and bow-like structures in CO along the outflow axis within the shell. Comparing the observed outflow features to that of jet- and wind-driven models, we find that the outflow systems show some features that are characteristic of the jet-driven model and others characteristic of the wind-driven model. Simple models of jets or winds cannot reproduce the full range of kinematic features found in observed outflows. The jet-driven model requires jet wandering to produce the observed outflow width and momentum content for most of these outflows, while the wind-driven model needs to have a collimated core with strong velocity gradient away from the core to produce the highly collimated outflows and the observed curved internal H_2 bow shock structures.

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Formic Acid in Orion KL from 1 Millimeter Observations with the Berkeley-Illinois-Maryland Association Array

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We present Berkeley-Illinois-Maryland Association array observations of formic acid (HCOOH) at 1 mm toward the Orion KL region. Near the compact ridge, HCOOH emission is spatially resolved; its partial shell morphology is different from that of other complex O-bearing molecules such as methyl formate and dimethyl ether. This unique distribution suggests that HCOOH is located in a layer that delineates the interaction region between the outflow and the ambient quiescent gas. HCOOH is also detected toward the hot core. For both cases, ejection of grain mantles is likely to be responsible for the observed HCOOH. Accepted by Astrophysical Journal

Multitransitional observations of the CS core of L673

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A multitransitional study with the BIMA interferometric array was carried out toward the starless core found in the L673 region, in order to study the small–size structure of the cores detected with previous single–dish observations, which provides us with a test of the predictions of the chemical model of Taylor et al. (1996; 1998). We detected emission in the CS (J=2→1), N_2H^+ (J=1→0), and HCO^+ (J=1→0) lines. Several clumps of size $\lesssim$0.08 pc were found for each line distributed all over the region where previous single-dish emission was found (Morata et al. 1997). Each molecular transition traces differently the clump distribution, although in some cases the detected clumps are coincident. The distribution of the N_2H^+ emission and the single–dish NH_3 emission are coincident and compatible with an origin in the same gas. The large fraction of missing flux measured for the CS (2→1) transition can be explained if the cloud is formed by a clumpy and heterogeneous medium. Four positions were selected to derive the abundance ratios [N_2H^+/CS] and [HCO^+/CS] from the molecular column density determinations, and to compare them with the values predicted by the chemical model. The model was able to explain the interferometric observations, and, in particular, the chemical differentiation of the detected clumps and the coincidence of the NH_3 and N_2H^+ emissions. The lack of HCO^+ towards the two selected positions that trace the more evolved clumps cannot be accounted for by the model, but it is possibly due to strong self-absorption. We propose a classification of the studied clumps according to the stage of chemical evolution indicated by the molecular abundances.

Accepted by Astronomy and Astrophysics

From Massive Protostars to a Giant H II Region: Submillimeter Imaging of the Galactic Mini-starburst W43

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We have carried out a submillimeter continuum and spectroscopic study of the W43 main complex, a massive star-forming region, which harbors a giant H II region. The maps reveal a filamentary structure containing ~ 50 fragments with masses of $40 - 4\,000$ $M_\odot$ and typical diameters of 0.25 pc. Their large sizes, large non-thermal velocities ($\Delta v \sim 5$ km s^{-1}), and high densities ($n_{\rm H2} \sim 10^6$ cm^{-3}) suggest that they are protoclusters and excellent sites to form massive stars. Follow-up observations are necessary, but we have already identified three protoclusters to be very good candidates for containing very young massive protostars. The starburst cluster, that excites the giant H II region

has a large impact on the molecular complex. However, it remains unclear if this first episode of star formation is triggering the formation of new massive stars, through ionization shocks crossing the closeby molecular clouds. W43 is thus an ideal laboratory to investigate massive star formation from the protostellar phase to that of giant H II regions. Moreover, the very active star-forming complex W43 may be considered a Galactic mini-starburst region that could be used as a miniature model of starburst galaxies.

Accepted by Astrophysical Journal

Preprint available at: http://www.submm.caltech.edu/∼motte/papers.html#w43 (1.4 Mb, PS-gzipped)
or at: http://xxx.lanl.gov/abs/astro-ph/0208519

1-2.5μm spectra of jets from young stars: strong FeII emission in HH111, HH240-241 and HH120.

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As part of a 1-2.5μm spectroscopic survey of jets and molecular outflows, we present the spectra of three Herbig Haro chains (HH111, HH240/241, HH120) characterized by strong emission from several FeII transitions originating from the first 13 fine structure levels. Such emission is correlated with optical SII emission and appears to decrease moving away from the driving source. From the analysis of the FeII, lines we have derived electron densities values in the range $3\,10^3$–$2\,10^4$ cm^{-3}, which are systematically larger than those inferred from optical SII line ratios. We suggest that FeII lines, having critical densities higher than the optical SII transitions, trace either regions of the post-shock cooling layers with higher compression, or a section of the jet axis at a higher degree of ionization. Strong H_2 emission lines are also detected along the three flows and their analysis indicates that a combination of different shocks can be responsible for their excitation in the different objects. Consequently the FeII, line emission, which requires the presence of fast dissociative shocks, is completely independent from the excitation mechanism giving rise to the molecular emission. In addition to the FeII and H_2 lines, emission from other species such as CI, SII, NI as well as recombination lines from the Paschen series are detected and have been used as a reference to infer the gas-phase iron abundance in the observed HH objects. We estimate a grain destruction efficiency of about 30-60%: the highest value is found for HH240A, which also shows the highest degree of excitation among the observed objects.

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Preprints available at http://www.mporzio.astro.it/∼bruni/publ.html

Star Formation in Space and Time: Taurus-Auriga

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To understand the formation of stellar groups, one must first document carefully the birth pattern within real clusters and associations. In this study of Taurus-Auriga, we combine pre-main-sequence ages from our own evolutionary tracks with stellar positions from observational surveys. Aided by the extensive, millimeter data on the molecular clouds, we develop a picture of the region's history. Star formation began, at a relatively low level and in a spatially diffuse manner, at least 1×10^7 yr in the past. Within the last few million years, new stars have been produced at an accelerating rate, almost exclusively within a confined group of striated cloud filaments.

The gas both inside and around the filaments appears to be in force balance. Thus, the appearance of the filaments is due to global, quasi-static contraction of the parent cloud material. Gravity drives this contraction and shock dissipation mediates it, but the internal motion of the gas does not appear to be turbulent. The accelerating nature of recent star formation means that the condensation of cloud cores is a threshold phenomenon, requiring a minimum background density. Other, nearby cloud regions, including Lupus and Chamaeleon, contain some locales that have attained this density, and others that have not. In the latter, we find extensive and sometimes massive molecular gas

that is still devoid of young stars.

Accepted by The Astrophysical Journal

Preprint available at http://www.arcetri.astro.it/∼palla/taurus/taurus.ps.gz

Young Stellar Objects in Gy 2-18(IRAS05439+3035

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We present the results of optical and near-IR spectra and mid-infrared images of the star forming region Gy 2-18, which is associated to IRAS05439+3035. Within this region there is a star with strong Hα emission which is illuminating an optical reflection nebula. Optical and near-IR spectra indicate that this star, named Irs 11, is a possible Herbig Be star of spectral type BO–B2 with a strong stellar wind and an infrared excess probably originating in a circumstellar dust disk. The mid-infrared images at 8.7, 9.7 and 12.5 μm show the presence of a second very red source, Irs 9, deeply embedded in the cloud and with a remarkably strong silicate feature in absorption. The estimated bolometric luminosity of 8.6 10^3 $L_\odot$ and the infrared spectral index $\alpha_{\rm IR} = 1.9$ suggest that Irs 9 is a massive protostellar object. These two sources form the core of the young stellar cluster associated to Gy 2-18. The infrared luminosity and spectral index of another member, Irs 13, are estimated to be $\leq$165 $L_\odot$ and $\leq$ 0.44.

Accepted by Astron. J.

Evidence for Time Evolution in the Exciting Source of the Expanding Water Maser Bubble in Cepheus A

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We analyze VLA-A observations made at 6-cm towards the Cepheus A star-forming region in three epochs: 1982.4, 1986.4, and 1990.2. We confirm that the thermal jet Cep A HW2 shows clear time variability in flux density and morphology. The radio-continuum source R5 is located about 0.″6 south of Cep A HW2 and seems to be the exciting source of the expanding bubble of H_2O masers detected with the VLBA. Our maps of the region suggest that the source R5 was considerable weaker in 1982.4 than in the other two epochs, showing for the first time evidence of its time variability. This variability is consistent with that expected for an expanding H II region. We speculate that the "turn on" of the source R5 between 1982.4 and 1986.4 may be related with an enhancement in the mass loss of the nearby thermal jet Cep A HW2 during the same epoch.

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http://www.astrosmo.unam.mx/~luisfr/publ.html

Water Masers as Tracers of Protostellar Disks and Outflows in the Intermediate Mass Star Forming Region NGC 2071

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We have mapped the water maser emission associated with the infrared centers IRS1 and IRS3 of the NGC 2071IR star forming region at four epochs over ~ 4 months with the Very Long Baseline Array (VLBA). We detected 269 maser features with ~ 1 km s^{-1} linewidths and measured 30 proper motions. In each infrared center, the water maser emission appears to trace parts of a protostellar disk and collimated outflow. The disk components are ~ 9 and ~ 17 AU long, in IRS 3 and IRS 1 respectively, and ~ 2 AU wide. They are identified as disks by their compact size, elongation parallel to the direction of known IR polarization, central location in the maser maps, small internal proper motions, and proximity to $\lambda 1.3$ cm continuum emission. The outflows have axes perpendicular to the disks and exhibit proper motions of up to ~ 42 km s^{-1}. They are outlined by maser emission up to ~ 260 AU from the protostars. The IRS 3 outflow appears to be conical on one side, while the IRS 1 outflow comprises a narrowly collimated bipolar flow surrounded by outward-facing, funnel-shaped cavities. The detection of water maser emission tracing such compact disk components and specifically conical or funnel-shaped structures is unusual. The fact that the distributions are similar in IRS 3 and IRS 1 may indicate the two infrared centers are roughly coeval. NGC 2071IR provides a rare opportunity to resolve the structures and dynamics of disks and outflows together, and to do so for two protostars that are only ~ 2000 AU apart (in projection) in a deeply embedded star forming region of intermediate luminosity.

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Self-Similar Champagne Flows in H II Regions

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We consider the idealized expansion of an initially self-gravitating, static, singular, isothermal cloud core. For $t \geq 0$, the gas is ionized and heated to a higher uniform temperature by the formation of a luminous, but massless, star in its center. The approximation that the mass and gravity of the central star is negligible for the subsequent motion of the H II region holds for distances r much greater than ~ 100 AU and for the massive cloud cores that give rise to high-mass stars. If the initial ionization and heating is approximated to occur instantaneously at $t = 0$, then the subsequent flow (for $r \gg 100$ AU) caused by the resulting imbalance between self-gravity and thermal pressure is self-similar. Because of the steep density profile ($\rho \propto r^{-2}$), pressure gradients produce a shock front that travels into the cloud, accelerating the gas to supersonic velocities in what has been called the "champagne phase." The expansion of the inner region at $t > 0$ is connected to the outer envelope of the now ionized cloud core through this shock whose strength depends on the temperature of the H II gas. In particular, we find a modified Larson-Penston (L-P) type of solution as part of the linear sequence of self-similar champagne outflows. The modification involves the proper insertion of a shock and produces the right behavior at infinity ($v \to 0$) for an outflow of finite duration, reconciling the long-standing conflict on the correct (inflow or outflow) interpretation for the original L-P solution.

For realistic heating due to a massive young central star which ionizes and heats the gas to $\sim 10^4$ K, we show that even the self-gravity of the ionized gas of the massive molecular cloud core can be neglected. We then study the self-similar solutions of the expansion of H II regions embedded in molecular clouds characterized by more general power-law density distributions: $\rho \propto r^{-n}$ with $3/2 < n < 3$. In these cases, the shock velocity is an increasing function of the exponent n, and diverges as $n \to 3$. We show that this happens because the model includes an origin, where the pressure driving the shock diverges because the enclosed heated mass is infinite. Our results imply that the continued photoevaporation of massive reservoirs of neutral gas (e.g., surrounding disks and/or globules) nearby to the embedded ionizing source is required in order to maintain over a significant timescale the emission measure observed in champagne flows.

Accepted by The Astrophysical Journal

The Mass Function of the Arches Cluster from Gemini Adaptive Optics Data

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We have analysed high resolution adaptive optics (AO) science demonstration data of the young, massive stellar cluster Arches near the Galactic Center, obtained with the Gemini North telescope in combination with the University of Hawai'i AO system Hokupa'a. The AO H and K' photometry is calibrated using HST/NICMOS observations in the equivalent filters F160W and F205W obtained by Figer et al. (1999, ApJ, 525, 750). The calibration procedure allows a detailed comparison of the ground-based adaptive optics observations against diffraction limited space-based photometry. The spatial resolution as well as the overall signal-to-noise ratio of the Gemini/Hokupa'a data is comparable to the HST/NICMOS data. The low Strehl ratio of only a few percent is the dominant limiting factor in the Gemini AO science demonstration data as opposed to space-based observations. After a thorough technical comparison, the Gemini and HST data are used in combination to study the spatial distribution of stellar masses in the Arches cluster. Arches is one of the densest young clusters known in the Milky Way, with a central density of $\sim 3 \cdot 10^5\, M_\odot\, \mathrm{pc}^{-3}$ and a total mass of about $10^4\, M_\odot$. A strong colour gradient is observed over the cluster field. The visual extinction increases by $\Delta A_V \sim 10$ mag over a distance of $15''$ from the cluster core. Extinction maps reveal a low-extinction cavity in the densest parts of Arches ($R \leq 5''$), indicating the depletion of dust due to stellar winds or photo-evaporation. We correct for the change in extinction over the field and show that the slope of the mass function is strongly influenced by the effects of differential extinction. We obtain present-day mass function slopes of $\Gamma \sim -0.8 \pm 0.2$ in the mass range $6 < M < 65\ M_\odot$ from both data sets. The spatial analysis reveals a steepening of the mass function slope from close to zero in the cluster center to $\Gamma \sim -1.7 \pm 0.7$ at $R > 10''$, in accordance with a Salpeter slope ($\Gamma = -1.35$). The bias in the mass function towards high-mass stars in the Arches center is a strong indication for mass segregation. The dynamical and relaxation timescales for Arches are estimated, and possible mass segregation effects are discussed with respect to cluster formation models.

Accepted by A&A.

Preprints available at http://xxx.lanl.gov/abs/astro-ph/0208321

Numerical methods for non-LTE line radiative transfer: Performance and convergence characteristics

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Comparison is made between a number of independent computer programs for radiative transfer in molecular rotational lines. The test models are spherically symmetric circumstellar envelopes with a given density and temperature profile. The first two test models have a simple power law density distribution, constant temperature and a fictive 2-level molecule, while the other two test models consist of an inside-out collapsing envelope observed in rotational transitions of HCO^+. For the 2-level molecule test problems all codes agree well to within 0.2%, comparable to the accuracy of the individual codes, for low optical depth and up to 2% for high optical depths (τ=4800). The problem of the

collapsing cloud in HCO^+ has a larger spread in results, ranging up to 12% for the J=4 population. The spread is largest at the radius where the transition from collisional to radiative excitation occurs. The resulting line profiles for the HCO^+ J=4–3 transition agree to within 10%, i.e., within the calibration accuracy of most current telescopes. The comparison project and the results described in this paper provide a benchmark for future code development, and give an indication of the typical accuracy of present day calculations of molecular line transfer.

Accepted by Astronomy & Astrophysics

Available from `http://www.strw.leidenuniv.nl/~radtrans/`

Accretion-Ejection Instability in magnetized disks: Feeding the Corona with Alfvén Waves

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We present a detailed calculation of the mechanism by which the Accretion-Ejection Instability can extract accretion energy and angular momentum from a magnetized disk, and redirect them to its corona. In a disk threaded by a poloidal magnetic field of the order of equipartition with the gas pressure, the instability is composed of a spiral wave (analogous to galactic ones) and a Rossby vortex. The mechanism detailed here describes how the vortex, twisting the footpoints of field lines threading the disk, generates Alfvén waves propagating to the corona. We find that this is a very efficient mechanism, providing to the corona (where it could feed a jet or a wind) a substantial fraction of the accretion energy.

Accepted by A&A

http://fr.arXiv.org/ps/astro-ph/0208120

Completion of a SCUBA survey of Lynds dark clouds and implications for low-mass star formation

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We have carried out a survey of optically-selected dark clouds using the bolometer array SCUBA on the James Clerk Maxwell Telescope, at $\lambda = 850$ μm. The survey covers a total of 0.5 square degrees and is unbiased with reference to cloud size, star formation activity, or the presence of infrared emission. Several new protostars and starless cores have been discovered; the protostars are confirmed through the detection of their accompanying outflows in CO(2–1) emission. The survey is believed to be complete for Class 0 and Class I protostars, and yields two important results regarding the lifetimes of these phases. First, the ratio of Class 0 to Class I protostars in the sample is roughly unity, very different from the 1:10 ratio that has previously been observed for the ρ Ophiuchi star-forming region. Assuming star formation to be a homogeneous process in the dark clouds, this implies that the Class 0 lifetime is similar to the Class I phase, which from infrared surveys has been established to be $\sim 2 \times 10^5$ yr. It also suggests there is no rapid initial accretion phase in Class 0 objects. A burst of triggered star formation some $\sim 10^5$ yr ago can explain the earlier results for ρ Ophiuchus. Second, the number of starless cores is approximately twice that of the total number of protostars, indicating a starless core lifetime of $\sim 8 \times 10^5$ yr. These starless cores are therefore very short-lived, surviving only two or three free-fall times. This result suggests that, on size scales of $\sim 10^4$ AU at least, the dynamical evolution of starless cores is probably not controlled by magnetic processes.

Accepted by AJ

Preprint available at http://www.nrao.edu/~cchandle/preprints/preprints.html

Large-scale Vortices in Protoplanetary Disks: On the observability of possible early stages of planet formation

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We investigate the possibility of mapping large-scale anti-cyclonic vortices, resulting from a global baroclinic instability, as pre-cursors of planet formation in proto-planetary disks with the planned Atacama Large Millimeter Array (ALMA). On the basis of three-dimensional radiative transfer simulations, images of a hydrodynamically calculated disk are derived which provide the basis for the simulation of ALMA. We find that ALMA will be able to trace the theoretically predicted large-scale anti-cyclonic vortex and will therefore allow testing of existing models of this very early stage of planet formation in circumstellar disks.

Accepted by ApJ (Letters section)

Preprint: http://spider.ipac.caltech.edu/staff/swolf/homepage/public/preprints/vortex.ps.gz

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/ .

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New Jobs

Faculty Position(s) in Star Formation

UNIVERSITY OF MICHIGAN

Pending approval, the Department of Astronomy at the University of Michigan seeks to hire up to 3 tenure track faculty, to start as early as September 1, 2003. The department has prioritized the intellectual areas of *star formation*, compact object/high energy astrophysics, and extragalactic astronomy. There is some preference that at least one appointee will contribute to the astronomical instrumentation activities in the department.

Research facilities available to the successful applicant include the twin Magellan 6.5 meter telescopes in Chile, the MDM 1.3 meter and 2.4 meter telescopes on Kitt Peak, the 26 meter UM radio telescope and the departmental computing network. Current Michigan faculty members active in star formation research include Fred Adams, Ray Jayawardhana and John Monnier.

Applicants should provide a vita, bibliography and a statement of research interests, and secure at least three letters of recommendation. Applications received prior to 15 November 2002 will receive first consideration. Please indicate prominently in the application which intellectual area you are most identified with, and whether you are involved in instrument development. Please address all applications and recommendations to Ms. Shanna Thorson at the address below. Email inquiries may also be directed to Department Chair Douglas Richstone (dor@umich.edu). The University of Michigan is an Equal Opportunity/Affirmative Action Employer.

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University of Exeter, United Kingdom
Postdoctoral position in hydrodynamical modelling of star formation

A PPARC funded research fellowship is available, for up to 3 years, from 1st January 2003, or as soon as possible thereafter, to conduct hydrodynamical modelling of star formation in turbulent molecular clouds. Candidates should have, or be about to obtain, a relevant PhD, familiarity with the field, and experience of numerical hydrodynamical modelling techniques would be an advantage. Salary on scale 17,626 pa to 26,491 pa (under review) depending on qualifications and experience.

Information available from Dr M R Bate, School of Physics, University of Exeter, EX4 4QJ e-mail mbate@astro.ex.ac.uk to whom applications (CV, statement of research interests & list of publications, plus the names and contact details of three referees) should be sent by **30 September 2002** quoting reference number R4452. See www.astro.ex.ac.uk for information on the group's activities.

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New Books

Solar System Evolution
A New Perspective

by Stuart Ross Taylor

This is the second edition of a well known book about the solar system. It has been completely rewritten to take into account the numerous results of the last decade. As is evident from the list of chapters below, the book is not just a catalogue of facts about the solar system, but is concerned about the physical processes that have shaped the planetary system since its origin. Particular efforts are made to place the solar system into a larger context by bridging various disciplines from astrophysics to meteoritics to planetology. The level of the book suggests that it will be useful as a textbook for a graduate course. But it will also serve as an excellent guide for astronomers working in the field of star formation to understand the processes involved in planet formation. The book contains the following chapters:

1. A brief history 1.1 The pre-Copernican view - 1.2 The Copernican revolution - 1.3 Laplace and his followers - 1.4 Tidal theories - 1.5 Solar accretion theories - 1.6 Nebular theories

2. The universe 2.1 The scale and structure of the universe - 2.2 Element synthesis

3. Stars 3.1 Star formation - 3.2 Early violent stellar activity - 3.3 The formation of the Sun

4. The solar nebula 4.1 The initial concept - 4.2 Molecular clouds and interstellar dust - 4.3 Presolar material - 4.4 Separation of nebulae - 4.5 Dust disks around stars - 4.6 Nebular collapse, nebular lifetime, and angular momentum - 4.7 Nebular structure and temperature

5. Composition and chemical evolution of the solar nebula 5.1 CI chondrites and the primitive nebula - 5.2 Volatile elements - 5.3 Homogeneity or heterogeneity? - 5.4 Gass loss from the inner nebula - 5.5 Volatile-element depletion in the early inner nebula

6. The evidence from meteorites 6.1 The most-ancient samples - 6.2 Refractory or calcium-aluminum inclusions (CAIs) - 6.3 The matrix of chondrites - 6.4 Chondrules - 6.5 Models for the origin of chondrules and CAIs - 6.6 Chondrites and other primitive meteorites - 6.7 Chronology - 6.8 Fractionated meteorites and parent bodies

7. Building planets 7.1 The collapse of clockwork solar systems - 7.2 Differences between the inner and outer planets - 7.3 Formation of the giant planets by the planetesimal hypothesis - 7.4 The inner solar system - 7.5 Planetesimals - 7.6 Accretion of planetesimals - 7.7 The long-term stability of the solar system

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Meetings

TOWARD OTHER EARTHS
DARWIN/TPF AND THE SEARCH FOR EXTRASOLAR PLANETS

22-25 April 2003
Heidelberg, Germany

We are planning to host an international scientific conference, to be held on 22-25 April 2003, in Heidelberg, Germany. This will be the first major meeting of the DARWIN/TPF community. The conference will be sponsored by ESA/NASA.

The conference will include an introductory lecture, invited talks, contributed talks and posters on the major scientific topics listed below, and a public talk. Anyone interested in participating is encouraged to pre-register at the conference web-site. Pre-registration will start in September.

SCIENTIFIC TOPICS:

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DARWIN and TPF Mission

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IAU Symposium 221
Star Formation at High Angular Resolution

One of the symposia selected for the IAU General Assembly in 2003 will be on the theme of star formation: *IAU Symposium 221—Star Formation at High Angular Resolution*. The GA will take place in Darling Harbour in Sydney. This was a major venue for the Olympic Games in 2000 and is adjacent to the Central Business District of the city. The GA runs from 13–26 July, 2003 and IAU 221 will be on 22–25 July. There are five other Symposia, 21 Joint Discussions, 4 Special Sessions and 3 Invited Discourses.

In this Symposium we aim to review what has been learnt about the star formation process through high angular resolution observations, and to discuss the prospects for progress with the wide variety of instruments that will become available over the next decade. The program will include the following sessions:

- Molecular clouds to protostellar cores
- Massive star formation
- Extra-galactic star formation
- Low mass star formation
- Jets and Outflows
- Disks
- The influence of planets during star formation

In addition, the opening and closing plenary sessions will summarise the field of star formation and discuss its future progress. There will also be a session on the first results from new facilities operating at high angular resolution.

Further information on the Symposium can be found from

http://www.phys.unsw.edu.au/iau221

Registration, and further information about the General Assembly, can be found from the GA website at

http://www.astronomy2003.com

The registration and abstract submission deadline is February 15, 2003. There will be discounts for early registration. Specific enquiries about the scientific content of Symposium 221 can be made to iau221@phys.unsw.edu.au.

Michael Burton
Chair of SOC and LOC for IAU Symposium 221.