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## *Abstracts of recently accepted papers*

### **New molecules found in comet C/1995 O1 (Hale-Bopp) – Investigating the link between cometary and interstellar material**

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We present millimetre and submillimetre observations of comet C/1995 O1 (Hale-Bopp) undertaken near perihelion with the Caltech Submillimeter Observatory and the 30-m telescope and Plateau-de-Bure interferometer of the Institut de Radioastronomie Millimétrique. From a spectral molecular survey, six new cometary molecular species have been identified for the first time in a comet: SO, SO<sub>2</sub>, HC<sub>3</sub>N, NH<sub>2</sub>CHO, HCOOH, and HCOOCH<sub>3</sub>. Relative abundances with respect to water are 0.3% (SO), 0.2% (SO<sub>2</sub>), 0.02% (HC<sub>3</sub>N), 0.01–0.02% (NH<sub>2</sub>CHO), 0.09% (HCOOH), and 0.08% (HCOOCH<sub>3</sub>). Several rotational transitions of OCS and HNCO, whose first identifications were made previously in comet C/1996 B2 (Hyakutake), have also been detected, confirming that these molecular species are ubiquitous compounds of cometary atmospheres. Inferred abundances of OCS and HNCO relative to water in comet Hale-Bopp are 0.4% and 0.1%, respectively. During this observational campaign, we also observed rotational lines of HCN, HNC, CH<sub>3</sub>CN, CO, CH<sub>3</sub>OH, H<sub>2</sub>CO, H<sub>2</sub>S, and CS. In combination with results of other observations, a comprehensive view of the volatile composition of the coma of comet Hale-Bopp is obtained. A quantitative comparison shows that chemical abundances in comet Hale-Bopp parallel those inferred in interstellar ices, hot molecular cores and bipolar flows around protostars. This suggests that the processes at work in the interstellar medium, in particular grain surface chemistry, played a major role in the formation of cometary ices. It supports models in which cometary volatiles formed in the interstellar medium and suffered little processing in the Solar Nebula.

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Preprint available at <ftp://iram.fr/dist/papers/halebopp.ps.gz>

## Carbon Dioxide in Star Forming Regions

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We consider the gas phase chemistry of CO<sub>2</sub> molecules in active regions. We show that CO<sub>2</sub> molecules evaporated from dust in hot cores cannot be efficiently destroyed, and are in fact copiously produced in cooler gas. When CO<sub>2</sub>-rich ices are sputtered in strong MHD shock waves the increase in atomic hydrogen, due to H<sub>2</sub> dissociation by ion-neutral streaming, means that CO<sub>2</sub> can be depleted by factors of  $\sim 500$  from its injected abundance. We find a critical shock speed exists at higher preshock densities below which CO<sub>2</sub> molecules can be efficiently sputtered but survive in the postshock gas. These calculations offer an explanation for the low gas/solid CO<sub>2</sub> ratios detected by ISO in star-forming cores as being due to shock destruction followed by partial reformation in warm gas. The presence of high abundances of CO<sub>2</sub> in the strongly-shocked Galactic Centre clouds Sgr B2 and Sgr A also find a tentative explanation in this scenario. Shock activity plays an important role in determining the chemistry of star-forming regions and we suggest that most hot cores are in fact shocked cores.

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## T Tauri stars: the UV/X-Ray connection

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We have analysed newly calibrated IUE and ROSAT data for three T Tauri stars from different subclasses: TW Hya, V410 Tau and CS Cha, a Classical T Tauri star (CTTS), a Weak T Tauri star (WTTS) and a T Tauri star intermediate between CTTS and WTTS, respectively. In the ultraviolet the continuum seems to be well explained by the sum of the stellar black body emission plus a hydrogenic component with temperature in the range  $1.4$  to  $5 \times 10^4$  K. TW Hya requires additionally a third component at 7900 K covering approximately 5% of the stellar surface. Using UV line fluxes, we have also analysed the energy emitted by these stars up to temperatures of  $10^5$  K. All three stars show emission strongly enhanced relatively to the Sun and peaking at temperatures characteristic of the transition region. In this respect the behaviour of the three stars seems to extend in a harmonic way from the ultraviolet into the X-ray band. The X-ray spectral analyses are consistent with emission from a two-temperature, optically thin plasma in collisional equilibrium. The lowest temperature plasma is at about  $10^6$  K while the highest reaches  $10^7$  K. We have also checked for and found no evidence for flaring activity in our sources at the time of the observations. Nevertheless, some level of variability is present for the stars in the sample. The ROSAT datasets for V410 Tau show a variation in terms of count rate on timescales of months to years.

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Preprints available at: <http://www.astro.up.pt/investigacao/indice.html>

## Models of the dust structures around Vega-excess stars

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We present models of the submillimetre dust emission around four Vega-excess stars. The results are adjusted to

simultaneously fit the spectral energy distribution from millimetre through to optical wavelengths, as well as the sub-mm image. The combination of spatially-resolved images with continuum fluxes over a range of wavelengths can remove some of the previous ambiguities in estimating the dust emission characteristics and circumstellar distributions.

Fomalhaut shows the brightest and best-resolved sub-mm image, and so gives the most unambiguous fit. Both the imaging and photometric results can best be modelled by an edge-on thick torus, of inner radius 100 au, outer radius 140 au, and thickness of  $\sim 120$  au. The observed sharp outer boundary cannot be fit by a reasonable power law density distribution. Furthermore, inside 100 au the density also drops abruptly, by at least a factor of 10.

The structures of both Vega and  $\epsilon$  Eri are also best modelled by radially-thin rings rather than discs, in both case viewed almost pole-on. However, there are clearly clumps in their morphologies which cannot be explained by simple axisymmetric models.

The sub-mm disc in  $\beta$  Pic can be adequately fit by the same model as that used to account for the extended structure seen in scattered light. However, the additional southwestern emission component, if it lies in the  $\beta$  Pic system, must have a dust mass comparable with that of the whole visible disc.

In all cases, the spectral energy distribution can be fit by a single ring or disc-like structure. Grain sizes of a few tens of  $\mu\text{m}$  and  $\beta = 0.8 - 1.1$  provide the best fits, and we place limits on the dust size distribution.

The dust temperatures are too low and there is too much temperature variation between the sources for grain sublimation to be effective at creating the central holes. All rings are dominated by grain-grain collisions, and we discuss methods of creating and sustaining the observed structures. Most likely they arise from a mechanism such as planet shepherding. The outer cutoff may arise in a similar way, although external stripping of material is not discounted.

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## A Search for Extended Disks around Weak-lined T Tauri Stars

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We present the results of a search for dust and gas emission around T Tauri stars in the Taurus-Auriga region, conducted with the IRAM interferometer in CO, HCO<sup>+</sup> and the adjacent continua at 1.3 and 3.4 mm. We studied a sample of young stars with and without the near-infrared spectral signature of disks, to learn whether young stars with little or no evidence of inner accretion disks are surrounded by extensive outer disks providing reservoirs of cold gas and dust.

Our sample comprises 3 classical T Tauris (TTs) and 12 weak-lined T Tauris (WTs). We detect the thermal emission indicative of the presence of a disk around the TTs: IP Tau, LkCa 15 and HP Tau. We resolve the continuum emission of the dust disk of LkCa 15. We also resolve the CO and HCO<sup>+</sup> emission of a large rotating disk at LkCa 15. We do not detect any millimeter continuum or CO emission from the WT, with the notable exception of V836 Tau, a borderline WT presenting evidence of accretion activity.

Our detection limits place stringent upper bounds on the amount of circumstellar gas and dust left around the WT. Our detection of all the TTs and non-detection of all the WT indicate that the disappearance of disks in TTs, and the corresponding time scale for this disappearance, customarily derived from infrared observations that sample the hot inner part of circumstellar disks ( $R \leq 5$  AU), concerns in reality the entire disk, including the outer regions ( $R \geq 50 - 500$  AU) to which our observations are more sensitive.

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A preprint is available under <http://laog.obs.ujf-grenoble.fr/activites/starform/formation.html>

## Star Formation in a Crossing Time

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Observations suggest that star formation occurs in only one or two crossing times for a range of scales spanning a factor of  $\sim 1000$ . These observations include (1) measurements of embedded cluster ages in comparison with the cloud core dynamical times, (2) measurements of the age difference versus separation for clusters in the Large Magellanic Clouds in comparison with the crossing time versus size correlation for molecular clouds, (3) hierarchical structure of embedded young clusters, and (4) the high fraction of dense clouds that contain star formation.

Such a short overall time scale for star formation implies that sources of turbulent energy or internal feedback are not required to explain or extend cloud lifetimes, and that star and protostar interactions cannot be important for the stellar initial mass function. Stars appear in a cloud as if they freeze out of the gas, preserving the turbulent-driven gas structure in their birth locations. The galaxy-wide star formation rate avoids the Zuckerman-Evans catastrophe, which has long been a concern for molecular clouds that evolve this quickly, because the multifractal structure of interstellar gas ensures that only a small fraction of the mass is able to form stars. Star formation on large scales operates slower than on small scales, but in most cases the whole process is over in only a few dynamical times.

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## High Veiling at Near Infrared Wavelengths in Classical T Tauri Stars

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The near infrared veiling (the ratio of any non-photospheric excess flux to the photospheric flux) is studied for a sample of 50 mainly Classical T Tauri stars (CTTS), mostly from the Taurus-Auriga complex, based on high resolution spectra ( $R \sim 20,500$ ) of wavelength regions in the J and K wavebands (near  $\text{Pa}\beta$  -  $1.28215 \mu\text{m}$  - and near  $\text{Br}\gamma$  -  $2.16611 \mu\text{m}$  respectively). The method used to compute the veiling at these wavelengths is independent of any assumptions about reddening/extinction towards the studied objects.

Photospheric absorption lines are identified in the spectra of 73% of the CTTS observed at J and in 71% at K. For these stars the veiling in the J ( $r_J$ ) and K ( $r_K$ ) wavebands was determined. Average values for all the stars are  $\langle r_J \rangle = 0.57$  and  $\langle r_K \rangle = 1.29$ . Considering only stars with veilings determined to better than  $3\sigma$  these means are  $\langle r_J \rangle = 0.97$  and  $\langle r_K \rangle = 1.76$ . For the remaining 27% of the stars observed at J and 29% at K, for which no photospheric lines were identified, lower limits were obtained for  $r_J$  and  $r_K$ . Considering only those stars with lower limits the mean lower limits are  $\langle r_J \rangle > 1.34$  and  $\langle r_K \rangle > 2.4$ . Our results indicate high veiling of these stars in the NIR. The NIR veilings deduced are considerably greater than expected from extrapolation of the veilings measured in the optical, assuming that they result from an accretion shock, and are also bigger than the expected veiling from an accretion disk. Although the origin of this large NIR veiling is not clear one possibility deserving further study is that it partially arises within shocks at the base of magnetospheric accretion columns which cover a large fraction of the stellar surface. The possibility that the near infrared veiling of photospheric lines is not caused by a continuum, but is rather due to non-photospheric line emission from the disk or from a shock at the base of the accretion columns, should also be investigated by detailed modelling including the Ti, Fe, Si & Mn lines as opacity sources.

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<http://www.astro.up.pt/users/dfmf/nirveil.ps.gz>

## RW Aur A, a close binary?

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We have discovered periodic changes in velocity and equivalent width of a number of different spectral features of RW Aur A, a T Tauri star with a jet, broad emission lines and substantial excess continuous emission. In particular, the photospheric lines vary in radial velocity with an amplitude of  $5.7 \text{ km s}^{-1}$  over a period of 2.77 days, which appears to have been stable over at least 18 years.

The present *Letter* focusses *solely* on one straightforward interpretation, namely that RW Aur A is a single-lined spectroscopic binary. However, other spectral features vary in or out of phase with the same or the double period. Interpretations, other than a binary model, should be considered but must await the more extended report on our large observational material.

In the binary case, the small amplitude leads to a mass function of only  $5 \cdot 10^{-5} M_{\odot}$ , by far the smallest observed for young binaries. The jet velocity and extent restrict the range of inclinations (if the orbital axis is aligned with the jet), implying a close binary with a secondary at the brown dwarf limit. Further restrictions follow if the primary rotates synchronously.

Narrow emission components of HeI and HeII vary in anti-phase with the photospheric absorption lines. We show that it is unlikely that these lines reflect the motion of the secondary.

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## V633 Cassiopeiae (LkH $\alpha$ 198) and V628 Cassiopeiae (MWC 1080) Revisited!

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We present the results of mm observations carried out at the James Clerk Maxwell telescope (JCMT) on August 1993 and August 1994 of two Herbig Ae/Be stars, namely V633 Cas and V628 Cas. We follow up on the reported discovery of a probable protostellar object  $20''$  North -West of V633 Cas by Hajjar & Bastien (1994), also reported later by Sandell & Weintraub (1994). It is the main source of emission in the region at mm wavelengths, and probably the major contributor in the submm up to  $100 \mu\text{m}$ . We estimate a total mass of  $0.12 M_{\odot}$  with a dust emissivity index of  $0.35 \pm 0.21$ . As seen in maps from Nakano *et al* (1990), V633 Cas C is at the center of a  $^{13}\text{CO}$  cavity and at the position of observed molecular concentrations. Since it also falls at the center of a flattened structure seen in  $\text{HCO}^+$ , it is most probably the source of the large scale CO outflow (Levreault 1988). From the dimension of the CO cavity, we estimate an age of  $3 \times 10^4$  years for the object. Based on a first estimate of its SED, we find a ratio of  $L_{\text{bol}}/L_{1.3\text{mm}} > 2 \times 10^4$ . Based on all these facts, we conclude that V633 CasC is *not* a Class 0 but an extreme Class I object. The dust emission from MWC 1080 is extended and flat with some features correlated with the optical ones. It is not evident that the grains we are sampling are directly related to the stellar environment.

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## Large X-ray Flare from a Herbig Be star, MWC297

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Hard X-ray emissions from a Herbig Be star MWC297 were discovered in three separate observations spanning 5 days in April 1994 with the Advanced Satellite for Cosmology and Astrophysics (ASCA). An X-ray flare was found at the beginning of the second observation with a maximum luminosity of  $\approx 4.9 \times 10^{32}$  ergs/s, which is five times larger than that of the quiescent phase (the first observation). It then declined with an  $e$ -folding time of  $\approx 5.6 \times 10^4$  sec to the pre-flare level in the third observation. The X-ray spectra are explained by absorbed thin-thermal plasma models. The temperature in the quiescent phase of  $\approx 2.7$  keV is significantly higher than that of main-sequence OB stars and similar to low mass young stellar objects (YSOs) and other Herbig Ae/Be stars observed with ASCA. The temperature increased in the flare phase to about 6.7 keV at the flux maximum, then decreased to 3.2 keV in the decay phase.

These facts strongly suggest that X-rays from Herbig Ae/Be stars, at least for MWC297, are attributable to magnetic activity similar to low mass YSOs. Since no theory predicts surface convection zone in massive stars like MWC297, our results may require a mechanism other than the conventional stellar dynamo theory. Possible magnetic activity could be either the stellar interior shear or the inherited magnetic field from the parent molecular cloud.

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Preprints available at <http://www-cr.scphys.kyoto-u.ac.jp/member/kenji/index.html>

## The distribution of OH in Taurus Molecular Cloud-1

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The column density of the OH radical in Taurus Molecular Cloud-1 (TMC-1), reaches its maximum close to the cyanopolyne peak. A comparison with previously published maps of other molecules shows that OH has a similar distribution as HC<sub>3</sub>N and CCS, but differs largely from CS, SO, NH<sub>3</sub> and N<sub>2</sub>H<sup>+</sup>. The OH/C<sup>18</sup>O column density ratio is, however, almost constant along the dense ridge of TMC-1, suggesting that the fractional OH abundance does not change much, the derived value being about  $10^{-7}$ . This high number confirms that in dense gas OH is mainly formed by the electron recombination of H<sub>3</sub>O<sup>+</sup>. The approximate constancy of the fractional OH abundance is in accordance with a flat density distribution as has been derived recently (Pratap et al. 1997, ApJ 486, 862).

Previous SO/CS maps together with some recent modelling results seem to be in conflict with the idea that the cyanopolyne peak in the southeastern part of the cloud would be chemically less evolved than the ammonia maximum in the northwest. Therefore we discuss the possibility that the OH maximum represents the so called ‘radical peak’, which occurs when freezing on to grain surfaces starts to be the dominant factor controlling the chemical composition and reactions (Brown & Millar 1989, MNRAS 237, 661). It turns out that the greater part of the data accumulated so far, including the present OH observations, fit the ‘old’ picture where a slightly higher density and a more advanced chemical state prevail in the northwestern part of the TMC-1 ridge.

The ‘satellite’ lines towards two locations in the cloud show enhanced 1612 MHz emission. We suggest that this is due to non-thermal excitation by far-infrared radiation from dust, heated by the embedded young stars in the neighbourhood of the TMC-1 ridge.

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## **ROSAT PSPC observations of T Tauri stars in MBM12**

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We present the *ROSAT* PSPC pointed and *ROSAT* All-Sky Survey (RASS) observations and the results of our low and high spectral resolution optical follow-up observations of the T Tauri stars (TTS) and X-ray selected T Tauri star candidates in the region of the high galactic latitude dark cloud MBM12 (L1453-L1454, L1457, L1458). Previous observations have revealed 3 “classical” T Tauri stars and 1 “weak-line” T Tauri star along the line of sight to the cloud. Because of the proximity of the cloud to the sun, all of the previously known TTS along this line of sight were detected in the 25 ks *ROSAT* PSPC pointed observation of the cloud. We conducted follow-up optical spectroscopy at the 2.2-meter telescope at Calar Alto to look for signatures of youth in additional X-ray selected T Tauri star candidates. These observations allowed us to confirm the existence of 4 additional TTS associated with the cloud and at least 2 young main sequence stars that are not associated with the cloud and place an upper limit on the age of the TTS in MBM12  $\sim 10$  Myr.

The distance to MBM12 has been revised from the previous estimate of  $65 \pm 5$  pc to  $65 \pm 35$  pc based on results of the *Hipparcos* satellite. At this distance MBM12 is the nearest known molecular cloud to the sun with recent star formation. We estimate a star-formation efficiency for the cloud of 2–24%.

We have also identified a reddened G9 star behind the cloud with  $A_v \sim 8.4$ –8.9 mag. Therefore, there are at least two lines of sight through the cloud that show larger extinctions ( $A_v > 5$  mag) than previously thought for this cloud. This higher extinction explains why MBM12 is capable of star-formation while most other high-latitude clouds are not.

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<http://xxx.lanl.gov/abs/astro-ph/9911244>

## **Massive young stellar objects with molecular outflows**

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We studied three members of the sample of 31 cold and luminous southern IRAS sources, which was compiled by Osterloh et al. (1997). These young stellar objects are characterized by extremely red IRAS colours [ $S_\nu(100\mu\text{m}) > S_\nu(60\mu\text{m}) > S_\nu(25\mu\text{m}) > 20 \times S_\nu(12\mu\text{m})$ ]. Based on their strong CO line wings found in previous observations, the three objects IRAS 12091–6129, IRAS 12405–6238, and IRAS 16019–4903 were selected in order to investigate their nature and the outflow structure in more detail.

The mapping in the CO  $J = 2 \rightarrow 1$  line as well as the  $\lambda 1.3$  mm continuum dust emission show that all three sources are deeply embedded in dense cloud cores. Strong CO line wings and their mapping indicate the presence of bipolar gas outflows in all three cases.

$N$ - and  $Q$ -band imaging resolve some substructures inside the  $\lambda 1.3$  mm maps and give evidence for deeply embedded young stellar objects which seem to drive the observed outflows. The comparison of the FIR imaging with the results in  $K$  imply that most of the  $K$ -band nebulosities are reprocessed radiation escaping through inhomogeneities in a dense cloud.

We derived physical parameters such as  $\text{H}_2$  column densities and cloud core masses from the CO and the bolometer measurements, and we compared the properties of the outflows and of the surrounding clouds with those found for well-known high-, intermediate- and low-mass objects. This comparison showed that the newly detected outflow systems belong to the most energetic outflows in our galaxy observed so far.

Accepted by Astron. & Astrophys., Main Journal

## Rotation and X-ray emission from protostars

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The ASCA satellite has recently detected variable hard X-ray emission from two Class I protostars in the  $\rho$  Oph cloud, YLW15 (IRS43) and WL6, with a characteristic time scale  $\sim 20$ h. In YLW15, the X-ray emission is in the form of quasi-periodic energetic flares, which we explain in terms of strong magnetic shearing and reconnection between the central star and the accretion disk. The flare modelling, based on the solar analogy, gives us access to the size of the magnetic structures, which in turn allows to calculate the rotation parameters of the star and the disk. In WL6, X-ray flaring is rotationally modulated, and appears to be more like the solar-type magnetic activity ubiquitous on T Tauri stars. On the basis of these observations, we find that YLW15 is a fast rotator (near break-up), while WL6 rotates with a significantly longer period. We thus use X-ray flaring as a “clock” to measure the rotation of protostars. With the help of the mass-radius relation on the stellar “birthline”, we derive a mass  $M_\star \sim 2M_\odot$  and  $\lesssim 0.4M_\odot$  for the central stars of YLW15 and WL6 respectively. YLW15 thus appears as a future A star. On the long term, the magnetic interactions between the star and the disk results in magnetic braking and angular momentum loss of the star. The compared rotation behavior of YLW15 and WL6 confirms that for solar-mass stars their magnetic braking takes place on time scales  $t_{br} \sim$  a few  $10^5$  yrs, i.e., of the same order as the estimated duration of the Class I protostar stage. The main parameter determining  $t_{br}$  turns out to be the stellar mass, so that close to the birthline there must be a mass-rotation relation,  $t_{br} \propto M_\star$ , such that stars with  $M_\star \gtrsim 1 - 2M_\odot$  are fast rotators, while their lower-mass counterparts have had the time to spin down and reach synchronous rotation with the inner surrounding accretion disk. The rapid rotation and strong star-disk magnetic interactions of YLW15 also naturally explain the observation of “superflares” of X-ray luminosities as high as  $L_X \gtrsim 10^{33-34}$  erg s<sup>-1</sup> during a few hours, while at the WL6 stage the lower X-ray luminosities are likely to be of purely stellar origin. The mass-rotation relation through magnetic braking may also explain why so few Class I protostars have been detected in X-rays to date, and why they all lie in clusters. In the case of YLW15, and perhaps also of other protostars, a hot coronal wind ( $T \sim 10^6$  K) may be responsible for the VLA thermal radio emission. This paper thus proposes the first clues to the magnetic properties of protostars, which govern their rotation status and evolution.

Accepted by The Astrophysical Journal (April 10, 2000 Part 1 issue)

Preprint available at <http://xxx.lanl.gov/abs/astro-ph/9911379>

## Modeling the Near-Infrared Luminosity Functions of Young Stellar Clusters

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We present the results of numerical experiments designed to evaluate the usefulness of near-infrared luminosity functions for constraining the Initial Mass Function (IMF) of young stellar populations. We test the sensitivity of the near-infrared K band luminosity function (KLF) of a young stellar cluster to variations in the underlying IMF, star forming history, and pre-main sequence mass-to-luminosity relations. Using Monte Carlo techniques, we create a suite of model luminosity functions systematically varying each of these basic underlying relations. From this numerical modeling, we find that the luminosity function of a young stellar population is considerably more sensitive to variations in the underlying initial mass function than to either variations in the star forming history or assumed pre-main-sequence (PMS) mass-to-luminosity relation. Variations in a cluster’s star forming history are also found to produce significant changes in the KLF. In particular, we find that the KLFs of young clusters evolve in a systematic manner with increasing mean age. Our experiments indicate that variations in the PMS mass-to-luminosity relation, resulting from differences in adopted PMS tracks produce only small effects on the form of the model luminosity functions and that these effects are mostly likely not detectable observationally.



To illustrate the potential effectiveness of using the KLF of a young cluster to constrain its IMF, we model the observed K band luminosity function of the nearby Trapezium cluster. With knowledge of the star forming history of this cluster obtained from optical spectroscopic studies, we derive the simplest underlying IMF whose model luminosity function matches the observations. Our derived mass function for the Trapezium spans two orders of magnitude in stellar mass ( $5 > M_{\odot} > 0.02$ ) and has a peak near the hydrogen burning limit. Below the hydrogen burning limit, the mass function steadily decreases with decreasing mass throughout the brown dwarf regime. Comparison of our IMF with that derived by optical and spectroscopic methods for the entire Orion Nebula Cluster suggests that modeling the KLF is indeed a useful tool for constraining the mass function in young stellar clusters particularly at and below the hydrogen burning limit.

Accepted by *Astrophys. J.*

## A Near Infrared Imaging Survey of the Lupus 3 Dark Cloud : A Modest Cluster of Low-Mass PMS stars

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We present the first report on results of a near-infrared imaging survey of the Lupus 3 dark cloud. This cloud is known to be associated with a modest cluster of T Tauri stars from a previous optical H $\alpha$  emission-line star survey. The survey covers  $7' \times 11'$ , which corresponds to a projected area of  $\sim 0.35 \text{ pc} \times 0.55 \text{ pc}$  at a distance of 150 pc. Mapping was carried out at  $J$ ,  $H$ , and  $K_s$ , to  $10\sigma$  limiting magnitudes of  $J=17.0$ ,  $H=16.5$ , and  $K_s=15.5$ . A total of 229 sources brighter than  $K_s < 15.8$  were detected at all bands with a 90% completeness limit. Source classification is performed based on the near-infrared colors. Ten sources are candidates of Lada's class II pre-main-sequence (PMS) stars, as they have a color excess which cannot be explained by reddening due to interstellar dust. We also identified 11 class I-like candidates which were not detected at  $J$  and have a large color-excess ( $H - K_s \geq 2$ ) which is unlikely to arise from extinction in the Lupus dark cloud. There are four subclusters in this survey area of which three are embedded and mainly consist of the class I-like candidates. The average density of PMS stars is around  $500 \text{ pc}^{-3}$ , suggesting the presence of a modest cluster of embedded PMS stars. We estimate masses of the class II candidates with an aid of an evolutionary model of PMS stars. Ten out of them have masses less than  $0.08 M_{\odot}$ , if we assume their age to be  $10^6$  yr. Hence, we consider them as candidates of young brown dwarfs (YBDs). The relative population of YBDs in the Lupus 3 dark cloud is larger than in the Taurus.

Accepted by *Astron. J.* (vol.119, February 2000)

<http://www.z.phys.nagoya-u.ac.jp/~nakajima/e-research.html>

## On the Effects of Projection on Morphology

Bárbara Pichardo<sup>1</sup>, Enrique Vázquez-Semadeni<sup>1</sup>, Adriana Gazol<sup>1</sup>, Thierry Passot<sup>2</sup> and Javier Ballesteros-Paredes<sup>1</sup>

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We study the effects of projection of three-dimensional (3D) data onto the plane of the sky by means of numerical simulations of turbulence in the interstellar medium including the magnetic field, parameterized cooling and diffuse and stellar heating, self-gravity and rotation. We compare the physical-space density and velocity distributions with their representation in position-position-velocity (PPV) space ("channel maps"), noting that the latter can be interpreted in two ways: either as maps of the column density's spatial distribution (at a given line-of-sight (LOS) velocity), or as maps of the spatial distribution of a given value of the LOS velocity (weighted by density). This ambivalence appears related to the fact that the spatial and PPV representations of the data give significantly different views. First, the morphology in the channel maps more closely resembles that of the spatial distribution of the LOS velocity component

than that of the density field, as measured by pixel-to-pixel correlations between images. Second, the channel maps contain more small-scale structure than 3D slices of the density and velocity fields, a fact evident both in subjective appearance and in the power spectra of the images. This effect may be due to a pseudo-random sampling (along the LOS) of the gas contributing to the structure in a channel map: the positions sampled along the LOS (chosen by their LOS velocity) may vary significantly from one position in the channel map to the next.

Accepted by Astrophysical Journal

<http://xxx.lanl.gov/abs/astro-ph/9911043>

## **New VLA Observations of the HH 1-2 Region: Evidence for Density Enhancements Moving Along the Axis of the VLA 1 Radio Jet**

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Using the Very Large Array, we have carried out new, sensitive radio continuum observations at 6 and 3.6 cm of the HH 1-2 region. The comparison between the 6-cm maps made from data taken in 1986.2 and 1992.9 indicates that VLA 1, the exciting source of the HH 1-2 flow, has suffered a morphological change that is attributed to the motion of a symmetric pair of knots along the axis of the radio jet. The proper motion of these knots, that are observed within one arc sec from the embedded star, are consistent with the values found for optical and near-IR jets several arc seconds away. We tentatively propose that one of the knots observed in the 1986.2 radio data has emerged out of the heavily obscured region around VLA 1 as a near-infrared knot in the 1998.2 data of Reipurth et al. (2000). This result supports the interpretation that the knots are formed by intrinsic processes in the acceleration and collimation of the flow or by shocks caused by a variable jet running into itself, and not by instabilities or shear with the surrounding medium. The source VLA 3, associated with an H<sub>2</sub>O maser and powering a molecular outflow, also shows morphological changes that we attribute to the turning-on of a new, faint component. Our sensitive 3.6-cm map reveals the presence of a new source, VLA 4, that coincides positionally with the infrared Source 3 of Reipurth et al. (1993). Finally, we derive a proper motion for HH 1F that agrees closely with the optical values. In the case of HH 2 the complexity of the source hampers a detailed comparison with the optical proper motions.

Accepted by Astronomical Journal

<http://www.astrosmo.unam.mx/~luisfr/>

## **Accretion-Induced Lithium Line Enhancements in Classical T Tauri Stars: RW Aur**

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It is widely accepted that much of the stochastic variability of T Tauri stars is due to accretion by a circumstellar disk. The emission line spectrum as well as the excess continuum emission are common probes of this process. In this communication, we present additional probes of the circumstellar environment in the form of resonance lines of low ionization potential elements. Using a set of 14 high resolution echelle observations of the classical T Tauri star (CTTS), RW Aur, taken between 1986 and 1996, we carefully measure the continuum veiling at each epoch by comparing more than 500 absorption lines with those of an appropriate template. This allows us to accurately subtract out the continuum emission and to recover the underlying photospheric spectrum. In doing so, we find that selected photospheric lines are enhanced by the accretion process, namely the resonance lines of LiI and KI. A

resonance line of TiI and a low excitation potential line of CaI also show weak enhancements. Simple slab models and computed line bisectors lead us to propose that these line enhancements are markers of cool gas at the beginning of the accretion flow which provides an additional source of line opacity. These results suggest that published values of surface lithium abundances of classical T Tauri stars are likely to be overestimated. This would account for the various reports of surface lithium abundances in excess of meteoritic values among the extreme CTTS. Computing LTE lithium abundances of RW Aur in a low and then high accretion state yields abundances which vary by one order of magnitude. The low accretion state lithium abundance is consistent with theoretical predictions for a star of this age and mass while the high accretion state spectrum yields a super-meteoritic lithium abundance.

Accepted by Astrophysical Journal

<http://www.daf.on.br/natalie/publications.html>

## **X-Ray Flares from an H $\alpha$ Emission Line Star in the Orion Region, Kiso A0904-105**

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We analyzed ASCA data including the reflection nebula NGC 2023 and discovered two X-ray flares from an H $\alpha$  emission line star, Kiso A0904-105, located at  $\sim 30'$  to the southwest of NGC 2023. The separation time between the two flares was  $\sim 4$  hr. The temperature of the first and the second flares reached  $(5-7)\times 10^7$  K and the luminosities around the flare peaks were  $\sim 10^{33}$  erg s $^{-1}$  (0.5–10.0 keV energy band, assuming the distance of 400 pc) which are comparable to those of the giant X-ray flares from T Tauri stars. After the flare peaks, X-ray intensity exhibited an exponential decay. Comparing the flares with those from T Tauri stars, we found that physical parameters in the flaring plasma were within the range of those obtained from T Tauri stars.

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*Dissertation Abstracts*

**Physical and Statistical Properties of Clouds in Numerical Simulations  
of the Interstellar Medium**

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Thesis work conducted at: Instituto de Astronomía, Universidad Nacional Autónoma de México, México

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Ph.D dissertation directed by: Enrique Vázquez Semadeni

Ph.D degree awarded: November 1999

The present work focuses on determining and understanding the physical and statistical properties of interstellar clouds, primarily employing numerical simulations of the turbulent ISM by Vázquez-Semadeni, Passot, & Pouquet (1995a, 1996); Passot, Vázquez-Semadeni y Pouquet (1995), and comparing the properties of the clouds arising in those simulations with observational data. The most important results are:

1. The clouds in the numerical simulations have comparable kinetic, magnetic and gravitational energies (Ballesteros-Paredes, & Vázquez-Semadeni 1995) in spite of not being in equilibrium. Thus, energy equipartition does not necessarily imply virial equilibrium.
2. The clouds in the numerical simulations are not “virialized” (i.e., are not in virial equilibrium) (Ballesteros-Paredes & Vázquez-Semadeni 1997), but have in general non-zero values of the second time-derivative of their moment of inertia. In the simulations, the clouds are dynamical entities, changing their shapes and exchanging mass, energy and momentum with their surrounding medium.
3. The clouds in the numerical simulations reproduce the velocity dispersion-size relationship observed in real clouds (Larson 1981), but do not follow the mean density-size relationship. This result supports the suggestion that the former relationship may originate directly as a consequence of the energy spectrum of the turbulence, while the observational density-size relationship may be an artifact of sensitivity limitations of observational surveys (Vázquez-Semadeni, Ballesteros-Paredes, & Rodríguez 1997).
4. The clouds in the numerical simulations also seem to reproduce the mass spectrum of the clouds (Vázquez-Semadeni, Ballesteros-Paredes & Rodríguez 1997).
5. Both super-Alfvénic and sub-Alfvénic velocities are found in the clouds in the numerical simulations (Ballesteros-Paredes, Vázquez-Semadeni, & Scalo 1999), contrary to the standard assumption that motions within molecular clouds are sub-Alfvénic.
6. The clouds in the simulations do not have sharp boundaries. Instead, the density field is continuous and the velocity field does not show shocks at the edges of the clouds (Ballesteros-Paredes, Vázquez-Semadeni, & Scalo 1999).
7. The clouds in the simulations are turbulent density fluctuations, i.e., the density peaks are due to the advection of mass produced by the velocity field (Ballesteros-Paredes, Vázquez-Semadeni, & Scalo 1999). It is also suggested that the apparently sharp boundaries of the interstellar clouds are due to a phase transition between the atomic and molecular regimes, as has been suggested by other authors (e.g., Blitz 1991).
8. It is also predicted that the magnetic field must have reversals within clouds as a consequence of the advection of the magnetic field (Ballesteros-Paredes, Vázquez-Semadeni, & Scalo 1999).
9. For an effectively polytropic gas, gravitational collapse triggered by the external turbulence cannot be stopped unless the effective polytropic index  $\gamma_{\text{eff}}$  changes during the process. This may not occur until proto-stellar densities are reached (Ballesteros-Paredes, Vázquez-Semadeni, & Scalo 1999).
10. Cloud formation by larger-scale stream collisions may cause simultaneous compression along elongated regions, which, based only on their internal velocity dispersion, might appear to be causally disconnected. This process has been invoked as a possible solution of the so-called Post-T-Tauri problem in Ballesteros-Paredes, Hartmann, & Vázquez-Semadeni (1999).

Thesis available through <http://www.astroscu.unam.mx/turbulence>

## *New Jobs*

### Preliminary Announcement

## **The Formation and Evolution of Young Stellar Clusters** A European Commission Research Training Network

We have recently been notified of the success of our proposal to the European Commission to fund a Research Training Network under the Fifth Framework Programme entitled “The Formation and Evolution of Young Stellar Clusters”, involving the following teams:

- Astrophysikalisches Institut Potsdam, Germany  
(Network coordinator: Mark McCaughrean, [mjm@aip.de](mailto:mjm@aip.de))
- Osservatorio Astrofisico di Arcetri, Firenze, Italy  
(Contact: Daniele Galli, [galli@arcetri.astro.it](mailto:galli@arcetri.astro.it))
- Institute of Astronomy, Cambridge, England  
(Contact: Cathie Clarke, [cclarke@ast.cam.ac.uk](mailto:cclarke@ast.cam.ac.uk))
- Department of Physics and Astronomy, University of Cardiff, Wales  
(Contact: Ant Whitworth, [Anthony.Whitworth@astro.cf.ac.uk](mailto:Anthony.Whitworth@astro.cf.ac.uk))
- Laboratoire d’Astrophysique de l’Observatoire de Grenoble, France  
(Contact: Jérôme Bouvier, [Jerome.Bouvier@obs.ujf-grenoble.fr](mailto:Jerome.Bouvier@obs.ujf-grenoble.fr))
- Observatório Astronómico de Lisboa, Portugal  
(Contact: Joao-Lin Yun, [yun@oal.ul.pt](mailto:yun@oal.ul.pt))
- CEA Saclay, Service d’Astrophysique, France  
(Contact: Philippe André, [pandre@discovery.saclay.cea.fr](mailto:pandre@discovery.saclay.cea.fr))

The network will start in early 2000 and last for three years. We anticipate hiring a total of seven postdoctoral scientists and three predoctoral students in two- and three-year positions respectively, distributed around the network. There will also be considerable funding for travel between the teams in order to foster the network collaboration, and we will hold a series of joint workshops and conferences over the lifetime of the network.

Broadly speaking, the young scientists employed by the network should be under 35 at the time of hiring, should be a national of an EC member or associated state or have lived in the EC for a minimum of five years before taking up a network position, and should not be a national of the state in which they would be appointed.

For an overview of the science goals of the network, both observational and theoretical, and more detailed information including the precise EC hiring rules and the likely timescales, please contact the network coordinator, Mark McCaughrean (phone: +49 331 749 9525, fax: +49 331 749 9267), and/or any of the team coordinators listed above. When the network details are finalised with the EC, the available positions will be announced via the Star Formation Newsletter and other normal channels.

## *New Books*

### **IUE-INES Guide No.1: Herbig-Haro Objects**

**Prepared by Ana I. Gómez de Castro and Angel Robles**

Scientific Coordinator for the INES Access Guides: W. Wamsteker

The book presents background information on the Herbig-Haro nebulosities observed with the International Ultraviolet Explorer satellite until the end of the mission. The log of observations and the ultraviolet spectrum is provided for all the objects. This information is completed with basic data on the individual sources. The book consists of two parts:

- **Part I** contains a general description of the ultraviolet properties of the Herbig-Haro objects as well as a summary of the major achievements in this research field made with the IUE. A list with all the objects observed with the IUE as well as a summary of the information provided in the Part II is included.
- **Part II** contains a set of tables and figures where the information obtained with the IUE satellite is described.

European Space Agency 1999, 166 pages

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Fax: +31 71 565 5433

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Price: 30 Euros  
Printed in: The Neetherlands

### **IUE-ULDA Access Guide No.8: T Tauri Stars**

**Prepared by Ana I. Gómez de Castro and Merche Franqueira**

Scientific Coordinator for the ULDA Access Guides: W. Wamsteker

The book presents background information on the T Tauri stars observed with the International Ultraviolet Explorer until the end of 1994. The log of observations and the UV spectrum are provided for all the objects as well as the FES light curves until November 1992. This information is completed with basic data on the individual sources. The book consists of two parts:

- **Part I** contains a general description of the ultraviolet properties of the T Tauri stars as well as a summary of the major achievements in this research field made with the IUE. A list with all the objects observed with the IUE as well as a summary of the information provided in the Part II is included.

- **Part II** contains a set of tables and figures where the information obtained with the IUE satellite is described.

European Space Agency 1997, 358 pages

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## *Meetings*

### REMINDER

## IAU Symposium 200: The Formation of Binary Stars

April 10–15, 2000: Potsdam, Germany

**Deadline for registration: December 15 1999**

As announced in the Star Formation Newsletter no. 83, IAU Symposium 200 on “The Formation of Binary Stars” will take place from April 10–15, 2000, in Potsdam, about 30 km southwest of the centre of Berlin, at the Telegraphenberg site of the Astrophysical Institute Potsdam (AIP).

We have recently sent out posters announcing the meeting, which should be pinned up in your libraries soon. The most important point to note is the deadline for registration, December 15th.

Thus, we urge all those interested in attending to visit the symposium website (<http://www.aip.de/IAU200>) and register before the deadline. Full details on the symposium, registration, and arranging accommodation can be found there.

If you have any additional questions, please contact Hans Zinnecker at:  
Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany;  
Phone: +49 (0)331 7499 347; Fax: +49 (0)331 7499 267; e-mail: [hzinnecker@aip.de](mailto:hzinnecker@aip.de)

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://casa.colorado.edu/reipurth> or at <http://www.eso.org/gen-fac/pubs/starform/>.