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Abstracts of recently accepted papers

Gemini Mid-Infrared Imaging of Massive Young Stellar Objects in NGC 3576

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We present a mid-infrared study of NGC 3576. The high-resolution images were taken at the Gemini South Observatory through narrow and broad band filters centered between 7.9 μm and 18 μm. The nearly diffraction limited images show IRS 1 resolved into 4 sources for the first time in the 10 μm band. The positions of the sources are coincident with massive young stellar objects detected previously in the near infrared. The properties of each object, such as spectral energy distribution, silicate absorption feature, color temperature and luminosities were obtained and are discussed. We also report observations of two other YSO candidates and the detection of a new diffuse MIR source without a NIR counterpart. We conclude that none of these sources contributes significantly to the ionization of the HII region. A possible location for the ionization source of NGC 3576 is suggested based on both radio and infrared data.

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Available at astro-ph/0308180. Full resolution draft available at ftp.astro.iag.usp.br/cassio/paper/Barbosa.ps.gz

Sh 2-128, an H II and star forming region in the galactic outback

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Near-infrared imaging photometry supplemented by optical spectroscopy and narrow-band imaging of the H II region Sh 2-128 and its environment are presented. This region contains a developed H II region and a neighboring compact H II region associated with a pair of water maser sources. Midway between these, the core of a CO cloud is located. The principal ionizing source of Sh 2-128 is an O7 star close to its center. Slit spectroscopy was used to obtain nebular line fluxes, abundances and physical parameters of Sh 2-128. This H II region is optically thin from the optical to the radio and appears to be ionization-bounded. The present JHK_s images show the presence of a number of point sources and nebular emission knots with large near-infrared excesses in the northern Sh 2-128N. One of the three red K_s knots coincides with the compact H II region. A few of the infrared-excess objects are close to known mid- and far-infrared emission peaks. Star counts in J and K_s show the presence of a small cluster of B-type stars, mainly associated with Sh 2-128N. Except for the youngest, reddest, objects, the stars in the whole region are moderately obscured. The JHK_s photometric properties together with the characteristics of the other objects in the vicinity suggest that Sh 2-128 and Sh 2-128N constitute a single complex formed from the same molecular cloud but with ages $\sim 10^6$ and $< 3\,10^5$ years, respectively. A new spectroscopic distance of 9.4 kpc is derived. This implies a galactocentric distance of 13.5 kpc and $z = 550$. No molecular hydrogen emission was detected at 2.12 μm from any part of the surveyed region.

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A parsec-scale flow associated with the IRAS 16547−4247 radio jet

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IRAS 16547−4247 is the most luminous (6.2×10^4 $L_\odot$.) embedded young stellar object known to harbor a thermal radio jet. We report the discovery using VLT-ISAAC of a chain of H_2 2.12 μm emission knots that trace a collimated flow extending over 1.5 pc. The alignment of the H_2 flow and the central location of the radio jet implies that these phenomena are intimately linked. We have also detected using TIMMI2 an isolated, unresolved 12 μm infrared source towards the radio jet . Our findings affirm that IRAS 16547−4247 is excited by a single O-type star that is driving a collimated jet. We argue that the accretion mechanism which produces jets in low-mass star formation also operates in the higher mass regime.

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VLT/NACO adaptive optics imaging of the TY CrA system

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We report the detection of a possible subsolar mass companion to the triple young system TY CrA using the NACO instrument at the VLT UT4 during its commissioning. Assuming for TY CrA a distance similar to that of the close binary system HD 176386, the photometric spectral type of this fourth stellar component candidate is consistent with an ∼M4 star. We discuss the dynamical stability of this possible quadruple system as well as the possible location of dusty particles inside or outside the system.

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SIMBA observations of the R Corona Australis molecular cloud

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We have mapped the R Corona Australis molecular cloud at 1.2 mm with SIMBA on SEST and detected 25 distinct

dust emission peaks. While 7 of them coincide with positions of previously known young stars, 18 are seemingly not associated with any known stellar object. We discuss the nature of individual sources and conclude that there are at least four small concentrations of young objects located along the filamentary shaped cloud. A comparison with $C^{18}O$ data hints towards the depletion of molecules in some of the cores. Our new results yield some conflicting arguments on whether star formation proceeds from north-west to south-east in the R Cr A cloud.

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The spectroscopic signature of hot Jupiters in FU Orionis objects

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We show that if FU Orionis objects harbour hot Jupiters embedded in their discs, the resulting non-axisymmetric dissipation profile in the disc would be manifest as time-dependent distortions in the absorption line profiles of these objects. In order to affect the infrared line profiles, planets must lie within ~ 0.5 au of the central star, whereas only planets within ~ 0.1 au would influence the optical line profiles. The timescale for modulation of the line profiles is relatively short (months) in each case, so that the effect could not have been discovered from published spectra (which combine data taken in different observing seasons). The detection of hot Jupiters in FU Orionis objects would be in line with the expectations of tidal migration theories (which predict a high incidence of close planets around young stars) and would also lend support to models which link the triggering of rapid rise FU Orionis events to the existence of a close massive planet.

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Explaining UXOR variability with self-shadowed disks

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In this Letter we propose a new view on the phenomenon of Algol-type minima in the light curves of UX Orionis stars. The idea is based on the earlier proposal by various authors that UXORs are nearly-edge-on disks in which hydrodynamic fluctuations could cause clumps of dust and gas to cross the line of sight. However, early models of protoplanetary disks were based on the notion that these have a flaring geometry. If so, then it is mostly the outer regions of the disk that obscure the star. The time scales for such obscuration events would be too long to match the observed time scales of weeks to months. Recent 2-D self-consistent models of Herbig Ae/Be protoplanetary disks (Dullemond 2002 henceforth D02; Dullemond & Dominik in prep., henceforth DD03), however, have indicated that for Herbig Ae/Be star disks there exists, in addition to the usual flared disks, also a new class of disks: disks that are fully self-shadowed. For these disks only their puffed-up inner rim (at the dust evaporation radius) is directly irradiated by the star, while the disk at larger radius resides in the shadow of the rim. For these disks there exist inclinations at which the line of sight towards the star skims the upper parts of the puffed-up inner rim, while passing high over the surface of outer disk regions. These outer disk regions therefore do not obscure the star nor the inner disk regions, and small hydrodynamic fluctuations in the puffed-up inner rim could cause the extinction events seen in UXORs. If this idea is correct, it makes a prediction for the shape of the SEDs of these stars. It was shown by D02/DD03 that flared disks have a strong far-IR excess and can be classified as 'Group I' (in the classification of Meeus et al. 2001), while self-shadowed disks have a relatively weak far-IR excess and are classified as 'Group II'. Our model therefore predicts that UXORs belong to the 'Group II' sources. We show that this correlation is indeed found within a sample

of 86 Herbig Ae/Be stars.

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VLA and BIMA observations toward the exciting source of the massive HH 80-81 outflow

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We present high angular resolution VLA and BIMA observations of NH_3, HCO^+, HCN and SO molecular emission and 1.4, 3.5 and 7 mm continuum emission toward the exciting source of the HH 80-81 system. This object is one of the few massive protostars known to be driving a collimated outflow. We report the first detection of SO 5_5–4_4 molecular emission toward the exciting source of HH 80-81, suggesting that this transition may be a good tracer of molecular gas near massive protostars. We also detected toward this source dust continuum emission at 1.4 and 3.5 mm. From the SO molecular emission and the dust emission we roughly estimated that the molecular mass associated with the circumstellar surroundings of the exciting source of the thermal jet is in the range 1 – 3 $M_\odot$. Weak and broad (2,2) ammonia emission was also found in the direction of the jet suggesting the presence of small amounts of molecular gas at high temperatures (> 50 K).

The VLA observations show the presence of three ammonia components toward the HH 80-81 region. The brightest component peaks at $\sim 8''$ to the NE of the thermal jet and is associated with the H_2O maser spots in the region. A second ammonia clump is located about $25''$ to the NE of the jet and is associated with class I methanol masers. The third ammonia component is located $1'$ to the south from the thermal jet and may be a molecular core yet without stellar formation. The BIMA observations show that the strongest emission in the HCO^+ and HCN lines originate close to the H_2O maser, and cover the same spatial region and velocity range as the brightest ammonia component.

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HST/STIS spectrum of RW Aur A. Evidence for an ionized belt-like structure and mass ejection in time scales of few hours.

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Profiles of the UV semiforbidden lines of C III]$_{1908}$ and Si III]$_{1892}$ of RW Aur have been obtained with the HST/STIS. The C III]$_{1908}$ profile shows two high velocity components at $v = \pm 170$ km s^{-1} and a central one. The Si III]$_{1892}$ profile is very broad (FWHM = 293 km s^{-1}) and the high velocity components are unresolved. It is shown that the high velocity components are most probably produced in a rotating belt alike the detected in other sources of bipolar outflows. A radius between 2.7 R_* and the corotation radius (6.1 R_*) is derived and a $\log T_e(K) \simeq 4.7$ and $\log n_e(cm^{-3}) = 11.6$ are estimated. The belt is clumpy and the most likely source of heating is local X-rays radiation, probably associated with the release of magnetic energy.

In addition, profiles of the optical lines of He I, Fe II and Hα retrieved from the HST Archive have been analyzed. The spectra were obtained shifting the STIS slit between exposures in the transverse direction to the flow. Two features vary from one exposure to another: a blueshifted emission feature (detected in the Fe II and He I lines) and

a redshifted absorption feature (detected in Hα) which are observed at the velocity of the blueshifted and redshifted components of the jet, respectively. There is a clear-cut correlation between the equivalent widths of both components. These components are not associated with the flaring activity of the source since they remain estable in time scales of $\simeq$ 40 minutes. They are most likely associated with variations in the stellar/circumstellar environment in time scales of a few ($\simeq$ 5) hours which are consistent with the reported by other authors for variations of the veiling and the appearance of shell signatures in the optical spectrum.

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The physical structure of high-mass star-forming cores

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We present models of the temperature and density structure of the envelopes of ten deeply embedded massive stars associated with ultracompact HII regions. Constraints come from 60–1300 μm photometry including ISO-LWS spectra, maps at 450 and 850 μm, and CS emission line data. Radial profiles extracted from the maps after removing neighbouring sources were modelled taking the chopping process into account. The line data are modelled with a Monte Carlo program and the continuum data with a dust radiative transfer code. For an assumed $n(r) \propto r^{-p}$ density structure, the index p is found to be uniformly distributed between 1.25 and 2.25 for this sample. The density power law index from radial profiles and emission lines agree well (by $\pm$0.25), while the continuum spectrum sometimes deviates (by $\pm$0.5). Reliable models thus require all three kinds of data.

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http://www.mpifr-bonn.mpg.de/staff/mhatchell/

Indications for grain growth and mass decrease in cold dust disks around Classical T Tauri stars in the MBM 12 young association

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We report detection of continuum emission at $\lambda = 850$ and 450 μm from disks around four Classical T Tauri stars in the MBM 12 (L1457) young association. Using a simple model we infer masses of 0.0014–0.012 $M_\odot$ for the disk of LkHα 263 ABC, 0.005–0.021 $M_\odot$ for S18 ABab, 0.03–0.18 $M_\odot$ for LkHα 264 A, and 0.023–0.23 $M_\odot$ for LkHα 262. The disk mass found for LkHα 263 ABC is consistent with the 0.0018 $M_\odot$ inferred from the scattered light image of the edge-on disk around component C. Comparison to earlier ^{13}CO line observations indicates CO depletion by up to a factor 300 with respect to dark-cloud values. The spectral energy distributions (SED) suggest grain growth, possibly to sizes of a few hundred μm, but our spatially unresolved data cannot rule out opacity as an explanation for the SED shape. Our observations show that these T Tauri stars are still surrounded by significant reservoirs of cold material at an age of 1–5 Myr. We conclude that the observed differences in disk mass are likely explained by binary separation affecting the initial value. With available accretion rate estimates we find that our data are consistent with theoretical expectations for viscously evolving disks having decreased their masses by $\sim$ 30%.

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http://talisker.as.arizona.edu/~michiel/pub.html

A Near Infrared Study of the Star Forming Region S269

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The star forming region S269 is studied with deep JHKs and H_2 v=1-0 S(1) images and K-band spectroscopy. The JHKs images reveal a rich embedded cluster at the center of the field; most stars in the cluster are located in two major congregations. The colors of the two congregations as well as of the associated nebulosities are quite different. The color-color diagrams and color-magnitude diagrams of the two sub-groups show that their intrinsic colors are not significantly different, suggesting they could be formed at a similar age. Between the sub-groups there are two near infrared sources, IRS 2e and 2w. Their K-band spectra rise towards longer wavelengths, indicative of dense dusty envelope surrounding them. Strong H_2 and Brγ lines are detected on these two objects. A poorly-collimated bipolar H_2 jet has been detected around IRS 2e and 2w. The morphology of the infrared jet and K-band spectra of the two infrared sources suggest that the jet is likely driven by IRS 2e or 2w, or both. Several lines of evidence suggest IRS 2e and 2w are massive young stellar objects probably younger than most of the stars in the region. Given the facts above, we speculate that lower-mass star forming activities in a stellar cluster could play an important role in the formation of a massive star.

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First Detection of Millimeter Dust Emission From Brown Dwarf Disks

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We report results from the first deep millimeter continuum survey targeting Brown Dwarfs (BDs). The survey led to the first detection of cold dust in the disks around two young BDs (CFHT-BD-Tau 4 and IC348 613), with deep JCMT and IRAM observations reaching flux levels of a few mJy. The dust masses are estimated to be a few Earth masses assuming the same dust opacities as usually applied to T Tauri stars.

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On the universal outcome of star-formation: Is there a link between stars and brown-dwarfs?

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Given the current consensus that stars form from pre-stellar cloud cores that fragment into small$-N$ groups which decay within a few 10^4 yr, and taking the observed properties of about 1 Myr old stars in the Taurus-Auriga (TA) star-forming region as empirical constraints, we suggest a model that describes the multiplicity properties of the

disintegrated groups. This model concisely describes the outcome of star formation in terms of dynamically unevolved binary properties. Two variants of the model are tested against data on very young stars in Taurus-Auriga (TA) and the Orion Nebula cluster (ONC) as well as the older Pleiades and the Galactic-field populations. The *standard model* (SM) assumes that cloud-core fragmentation only produces stellar systems, while the *standard model with brown dwarfs* (SMwBDs) assumes that cloud-core fragmentation proceeds down to sub-stellar mass cores. Brown dwarfs (BDs) enter the SM by being a separate, dynamically unimportant population. The models produce a very high initial binary proportion among stars (SM), and stars and BDs (SMwBDs), and both reproduce the measured initial mass function (IMF) in TA, the ONC and the Pleiades as well as the Galactic field. Concentrating on the SMwBDs, it is shown that the Briceno et al. result that TA appears to have produced significantly fewer BDs per star than the ONC is reproduced almost exactly without calling for a different IMF. The reason is that star–BD and BD–BD binaries are disrupted in the dense ONC. The model, however, fails to reproduce the observed star–star binary period distribution in TA, because it contains too many star–BD pairs. Also, the SMwBDs leads to too many wide star–BD and BD–BD systems. This is a problem if most stars form in clusters because Galactic-field very-low-mass-star and BD binaries have a low binary fraction and do not contain wide systems. The SM, on the other hand, finds excellent agreement with the observed mass-ratio and period distribution among TA and Galactic-field stellar binaries, as well as the observed stellar period distribution in the ONC and the Pleiades. The conclusion of this work is therefore that the SM describes the initial, dynamically unevolved stellar population very well indeed for a large range of star-forming conditions, suggesting (1) a remarkable invariance of the star-formation products, and (2) that BDs (and some very-low-mass stars) need to be added as a separate population with its own kinematical and binary properties. This separate population may vary with star-forming conditions.

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A Ring Shaped Embedded Young Stellar (Proto)Cluster

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We present sub-arcsec (FWHM$\sim$0.5″) J, H, K and L′ images of a young stellar cluster associated with a candidate massive protostar IRAS 22134+5834. The observations reveal a centrally symmetric, flattened cluster enclosing a central dark region. The central dark region is possibly a cavity within the flattened cluster. It is surrounded by a ring composed of 5 bright stars and the candidate massive protostar IRAS 22134+5834. We construct JHKL′ color-color and HK color-magnitude diagrams to identify the young stellar objects and estimate their spectral types. All the bright stars in the ring are found to have intrinsic infrared excess emission and are likely to be early to late B type stars. We estimate an average foreground extinction to the cluster of $A_v\sim5$ mag and individual extinctions to the bright stars in the range $A_v\sim$20-40 mag indicating possible cocoons surrounding each massive star. This ring of bright stars is devoid of any HII region. It is surrounded by an embedded cluster making this an example of a (proto)cluster that is in one of the dynamically least relaxed states. These observations are consistent with the recent non-axisymmetric calculations of Li & Nakamura, who present a star formation scenario in which a magnetically subcritical cloud fragments into multiple magnetically supercritical cores, leading to the formation of small stellar groups.

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preprints: http://www.astro.up.pt/investigacao/publicacoes/main.html
ftp://ftp.astro.up.pt/pub/preprints/144.ps.gz

Interferometric Mapping of Magnetic Fields in Star-forming Regions III. Dust and CO polarization in DR21(OH)

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We present the polarization detections in DR21(OH) from both the thermal dust emission at 1.3 mm and the CO J=2-1 line obtained with the Berkeley-Illinois-Maryland Association (BIMA) array. Our results are consistent with the prediction of the Goldreich-Kylafis effect that the CO polarization is either parallel or perpendicular to the magnetic field direction. The detection of the polarized CO emission is over a more extended region than the dust polarization, while the dust polarization provides an aide in resolving the ambiguity of the CO polarization. The combined results suggest that the magnetic field direction in DR21(OH) is parallel to the CO polarization and therefore parallel to the major axis of DR21(OH). The strong correlation between the CO and dust polarization suggests that magnetic fields are remarkably uniform throughout the envelope and the cores. The dispersion in polarization position angles implies a magnetic field strength in the plane of the sky of about 1 mG, compared with about 0.5 mG inferred for the line-of-sight field from previous CN Zeeman observations. Our CO data also show that both MM1 and MM2 power high-velocity outflows with v >25 km s^{-1} relative to the systematic velocity.

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The Gravitational Radius of an Irradiated Disk

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We derive an updated, analytic formula for the gravitational radius, r_g, of an irradiated, thin disk. For such a disk, the region outside the gravitational radius will produce a thermal wind, while the region interior to the gravitational radius will be stable. We find that $r_g \approx 1.4\,(M_*/M_\odot)\,/\,\left(T_0/10^4\ \mathrm{K}\right)$ AU. The value of 1.4 AU is approximately one fifth of currently used values.

The analysis uses the adiabatic approximation. We argue that the same formula applies for the non-adiabatic, isothermal case.

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ftp://ftp.mel.dbce.csiro.au/pub/downloads/Kurt/Preprint/

Probing the rotation curve of the outer accretion disk in FU Orionis objects with long-wavelength spectroscopy

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Studies of the Spectral Energy Distribution of Young Stellar Objects suggest that the outer disk of FU Orionis objects might be self-gravitating. In this paper we propose a method to test directly whether, in these objects, significant deviations from Keplerian rotation occur. In a first approach, we have used a simplified model of the disk vertical structure that allows us to quickly bring out effects related to the disk self-gravity. We find that the often studied optical and near-infrared line profiles are produced too close to the central object to provide significant evidence for non-Keplerian rotation. Based on parameters relevant for the case of FU Ori, we show that high-resolution long-wavelength spectroscopy, of the far-infrared H_2 pure rotational lines (sometimes observed in "passive" protostellar disks) and sub-mm CO lines, should be well suited to probe the rotation curve in the outer disk, thus measuring to what extent it is affected by the disk self-gravity. The results of the present exploratory paper should be extended soon to a more realistic treatment of the disk vertical structure.

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Spectroscopic estimate of surface gravity for a planetary member in the σ Orionis cluster

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We present intermediate-resolution (R=1500) near-infrared spectroscopy from 1.17 μm to 1.37 μm of the spectral type T planetary candidate member in the σ Ori cluster S Ori 70 reported by Zapatero Osorio et al. (2002). The new data have been obtained with NIRSPEC at the Keck II telescope. The best fit of our mid-resolution spectrum of S Ori 70 with theoretical spectra gives log g=3.5$\pm$0.5 cm s^{-2} and $T_{\rm eff}$=1,100$^{+200}_{-100}$ K. The low gravity of this object derived from spectral synthesis supports its youth and membership to the young σ Ori cluster. Using evolutionary models for an age of 3 Myr, we obtain a mass of 3 M_{Jup} and a radius of 0.16 $R_{\odot}$, independent of the distance to the object. Our analysis confirms that S Ori 70 is the lowest mass cluster planet so far identified in the galaxy.

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The short period multiplicity among T-Tauri stars

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We present the results of high-resolution spectroscopic observations carried out over three years aimed at estimating the short-period (P_{orb} < 100 days) binary frequency of a sample of T-Tauri stars in Oph-Sco, Cha, Lup, CrA star forming regions (SFRs), already observed with high angular resolution techniques by Ghez et al. (1993) and by Ghez et al. (1997) to detect wider components. When combining all four SFRs, the short-period binary frequency is indistinguishable from that found by Duquennoy & Mayor (1991) for the solar-type field stars which is also consistent with the previous result obtained by Mathieu (1992, 1994). When Oph-Sco is analyzed separately, it seems that there is an excess of short-period binaries of a factor 2-2.5. On the contrary, short-period binary systems seem to be absent in the sample containing stars in Cha/Lup/CrA. Such a trend was equally found by Mathieu (1992) in Taurus. An excess of spectroscopic systems among the components of visual multiple systems is also observed.

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preprints available on http://www.sc.eso.org/∼cmelo/ftp/ms3405.ps

An infrared imaging search for low-mass companions to members of the young nearby β Pic and Tucana/Horologium associations

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We present deep high dynamic range infrared images of young nearby stars in the Tucana/Horologium and β Pic associations, all $\sim$ 10 to 35 Myrs young and at $\sim$ 10 to 60 pc distance. Such young nearby stars are well-suited for direct imaging searches for brown dwarf and even planetary companions, because young sub-stellar objects are still self-luminous due to contraction and accretion. We performed our observations at the ESO 3.5m NTT with the normal infrared imaging detector SofI and the MPE speckle camera Sharp-I. Three arc sec north of GSC 8047-0232 in Horologium a promising brown dwarf companion candidate is detected, which needs to be confirmed by proper motion and/or spectroscopy. Several other faint companion candidates are already rejected by second epoch imaging.

Among 21 stars observed in Tucana/Horologium, there are not more than one to five brown dwarf companions outside of 75 AU (1.5″ at 50 pc); most certainly only $\leq 5\%$ of the Tuc/HorA stars have brown dwarf companions (13 to 78 Jupiter masses) outside of 75 AU. For the first time, we can report an upper limit for the frequency of massive planets ($\sim 10\ M_{jup}$) at wide separations (~ 100 AU) using a meaningfull and homogeneous sample: Of 11 stars observed sufficiently deep in β Pic (12 Myrs), not more than one has a massive planet outside of ~ 100 AU, i.e. massive planets at large separations are rare (≤ 9 %).

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A $3-5$ μm VLT spectroscopic survey of embedded young low mass stars I: structure of the CO ice

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Medium resolution ($\lambda/\Delta\lambda = 5\,000 - 10\,000$) VLT-ISAAC M-band spectra are presented of 39 young stellar objects in nearby low-mass star forming clouds showing the 4.67 μm stretching vibration mode of solid CO. By taking advantage of the unprecedentedly large sample, high S/N ratio and high spectral resolution, similarities in the ice profiles from source to source are identified. It is found that excellent fits to all the spectra can be obtained using a phenomenological decomposition of the CO stretching vibration profile at 4.67 μm into 3 components, centered on 2143.7 cm^{-1}, 2139.9 cm^{-1} and 2136.5 cm^{-1} with fixed widths of 3.0, 3.5 and 10.6 cm^{-1}, respectively. All observed interstellar CO profiles can thus be uniquely described by a model depending on only 3 linear fit parameters, indicating that a maximum of 3 specific molecular environments of solid CO exist under astrophysical conditions. A simple physical model of the CO ice is presented, which shows that the 2139.9 cm^{-1} component is indistinguishable from pure CO ice. It is concluded, that in the majority of the observed lines of sight, 60-90% of the CO is in a nearly pure form. In the same model the 2143.7 cm^{-1} component can possibly be explained by the longitudinal optical (LO) component of the vibrational transition in pure crystalline CO ice which appears when the background source is linearly polarised. The model therefore predicts the polarisation fraction at 4.67 μm, which can be confirmed by imaging polarimetry. The 2152 cm^{-1} feature characteristic of CO on or in an unprocessed water matrix is not detected toward any source and stringent upper limits are given. When this is taken into account, the 2136.5 cm^{-1} component is not consistent with the available water-rich laboratory mixtures and we suggest that the carrier is not yet fully understood. A shallow absorption band centered between 2165 cm^{-1} and 2180 cm^{-1} is detected towards 30 sources. For low-mass stars, this band is correlated with the CO component at 2136.5 cm^{-1}, suggesting the presence of a carrier different from XCN at 2175 cm^{-1}. Furthermore the absorption band from solid ^{13}CO at 2092 cm^{-1} is detected towards IRS 51 in the ρ Ophiuchi cloud complex and an isotopic ratio of ^{12}CO/^{13}CO $= 68 \pm 10$ is derived. It is shown that all the observed solid ^{12}CO profiles, along with the solid ^{13}CO profile, are consistent with grains with an irregularly shaped CO ice mantle simulated by a Continuous Distribution of Ellipsoids (CDE), but inconsistent with the commonly used models of spherical grains in the Rayleigh limit.

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A Cluster of Compact Radio Sources in NGC 2024 (Orion B)

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We present deep 3.6 cm radio continuum observations of the H II region NGC 2024 in Orion B obtained using the Very Large Array in its A-configuration, with $0\farcs2$ angular resolution. We detect a total of 25 compact radio sources in a region of $4' \times 4'$. We discuss the nature of these sources and its relation with the infrared and X-ray objects in the region. At least two of the radio sources are obscured proplyds whose morphology can be used to restrict the location of the main ionizing source of the region. This cluster of radio sources is compared with others that have been found in regions of recent star formation.

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Optical spectra of selected Chamaeleon I young stellar objects

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We present optical spectra of eight candidate brown dwarfs and a previously known T Tauri star (Sz 33) of the Chamaeleon I dark cloud. We derived spectral types based on the strength of the TiO or VO absorption bands present in the spectra of these objects as well as on the PC3 index of Martín et al. (1999). Photometric data from the literature are used to estimate the bolometric luminosities for these sources. We apply D'Antona & Mazzitelli (1997) pre-main sequence evolutionary tracks and isochrones to derive masses and ages. Based on the presence of Hα in emission, we confirm that most of the candidates are young objects. Our sample however includes two sources for which we can only provide upper limits for the emission in Hα; whereas these two objects are most likely foreground/background stars, higher resolution spectra are required to confirm their true nature. Among the likely cloud members, we detect one new sub-stellar object and three transition stellar/sub-stellar sources.

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Photometric and Polarimetric Activity of RZ Psc

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We present the results of synchronous photometric and polarimetric $UBVRI$ observations of the irregular variable star RZ Psc, acquired at the Crimean Astrophysical Observatory in 1989-2002. The star's photometric behaviour is characterized by short, sporadic Algol-like dimmings. We observed only one deep minimum, with a V amplitude of about 1.5^m, during the entire observational time. During this minimum, the linear polarization of RZ Psc reached 3.5%. Comparison with polarimetric observations of the star during another deep minimum in 1989 show that the two minima can be described by the same polarization-brightness relation, testifying to an eclipsing nature for the minima. This provides evidence that the optical characteristics of the flattened circumstellar dust envelope that gives rise to the star's intrinsic polarization have remained virtually unchanged over the last 13 years. We argue that the origin of this stability is the presence of a large dust-free cavity in the central region of the circumstellar dust disk of RZ Psc. The cavity could be associated with binarity of the star or the formation of a planetary system, with most of the dust in the central region of the disk being transformed into large bodies - planetesimals and planets.

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Dust Production from collisions in extrasolar planetary systems. The inner β Pictoris disc

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Dust particles observed in extrasolar planetary discs originate from undetectable km-sized bodies but this valuable information remains uninteresting if the theoretical link between grains and planetesimals is not properly known. We outline in this paper a numerical approach we developed in order to address this issue for the case of dust producing collisional cascades. The model is based on a particle-in-a-box method. We follow the size distribution of particles over eight orders of magnitude in radius taking into account fragmentation and cratering according to different prescriptions. A very particular attention is paid to the smallest particles, close to the radiation pressure induced cut-off size R_{pr}, which are placed on highly eccentric orbits by the stellar radiation pressure. We applied our model to the case of the inner (<10 AU) β Pictoris disc, in order to quantitatively derive the population of progenitors needed to produce the small amount of dust observed in this region ($\simeq 10^{22}$ g). Our simulations show that the collisional cascade from kilometre-sized bodies to grains significantly departs from the classical $dN \propto R^{-3.5}dR$ power law: the smallest particles ($R \simeq R_{pr}$) are strongly depleted while an overabundance of grains with size $\sim 2R_{pr}$ and a drop of grains with size $\sim 100R_{pr}$ develop regardless of disc's dynamical excitation, R_{pr} and initial surface density. However, the global dust to planetesimal mass ratio remains close to its $dN \propto R^{-3.5}dR$ value. Our rigorous approach thus confirms the depletion in mass in the inner β Pictoris disc initially inferred from questionable assumptions. We show moreover that collisions are a sufficient source of dust in the inner β Pictoris disc. They are actually unavoidable even when considering the alternative scenario of dust production by slow evaporation of km-sized bodies. We obtain an upper limit of $\sim 0.1\,M_\oplus$ for the total disc mass below 10 AU. This upper limit is not consistent with the independent mass estimate (at least $15\,M_\oplus$) in the frame of the Falling Evaporating Bodies (FEB) scenario explaining the observed transient features activity. Furthermore, we show that the mass required to sustain the FEB activity implies a so important mass loss that the phenomena should naturally end in less than 1 Myr, namely in less than one twentieth the age of the star (at least $2\,10^7$ years). In conclusion, these results might help converge towards a coherent picture of the inner β Pictoris system: a low-mass disc of collisional debris leftover after the possible formation of planetary embryos, a result which would be coherent with the estimated age of the system.

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First detection of doubly deuterated hydrogen sulfide

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This work was carried out with using the Caltech Submillimeter Observatory and presents the observational study of HDS and D_2S towards a sample of Class 0 sources, and dense cores. We report the first detection of doubly deuterated hydrogen sulfide (D_2S) in two dense cores and analyze the chemistry of these molecules aiming to help understand the deuteration processes in the interstellar medium. The observed values of the D_2S/HDS ratio, and upper limits, require an atomic D/H ratio in the accreting gas of 0.1 - 1. The study presented in this Letter supports the hypothesis that formaldehyde, methanol and hydrogen sulfide are formed on the grain surfaces, during the cold pre-stellar core phase, where the CO depleted gas has large atomic D/H ratios. The high values for the D/H ratios are consistent with the predictions of a recent gas-phase chemical model that includes H_3^+ and its deuterated isotopomers, H_2D^+,

D_2H^+ and D_3^+ (Roberts et al. 2003).

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Observations of warm dust near methanol masers

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Continuum emission at 450 and 850 μm from warm dust has been mapped in the fields of 71 methanol masers. Within these fields lie 30 centimetre-wave radio continuum sources and an additional 13 methanol maser sites. Sub-mm emission is detected at all but one of the maser sites, confirming the association of methanol maser emission with deeply embedded objects. Measured bolometric luminosities confirm that methanol maser emission is an excellent signpost of high-mass star formation. Examples of nearby isolated maserless dust cores may be harbouring massive protostars at an earlier evolutionary stage.

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High Resolution Continuum Imaging at 1.3 and 0.7 cm of the W3-IRS5 Region

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High-resolution images of the hypercompact HII regions (HCHII) in W3-IRS5 taken with the VLA at 1.3 cm and 0.7 cm are presented. Four HCHII regions were detected with sufficient signal-to-noise ratio to allow the determination of relevant parameters such as source position, size and flux density. The sources are slightly extended in our $\sim 0.2''$ beams; the deconvolved radii are <240 AU. A comparison of our data with VLA images taken at epoch 1989.1 show proper motions for sources IRS5-a and IRS5-f. Between 1989.1 and 2002.5, we find a proper motion of 210 mas at a position angle of 12° for IRS5-f and a proper motion of 190 mas at a position angle of 50° for IRS5-a. At the assumed distance to W3-IRS5, 1.83±0.14 kpc, these offsets translate to proper motions of $\sim$135 km s^{-1} and $\sim$122 km s^{-1} respectively. These sources are either shock ionized gas in an outflow or ionized gas ejected from high mass stars. We find no change in the positions of IRS5-d1/d2 and IRS5-b; and we show through a comparison with archival NICMOS 2.2 μm images that these two radio sources coincide with the infrared double constituting W3-IRS5. These contain B or perhaps O stars. The flux densities of the four sources have changed compared to the epoch 1989.1 results. In our epoch 2002.5 data, *none* of the spectral indicies obtained from flux densities at 1.3 cm and 0.7 cm are consistent with optically thin free-free emission; IRS5-d1/d2 shows the largest increase in flux density from 1.3 cm to 0.7 cm. This may be an indication of free-free optical depth within an ionized wind, a photoevaporating disk, or an accretion flow. It is less likely that this increase is caused by dust emission at 0.7 cm.

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Model Spectral Energy Distributions of Circumstellar Debris Disks I. Analytic Disk Density Distributions

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We present results of a study aimed at deriving fundamental properties of circumstellar debris disks from observed infrared to submillimeter spectral energy distributions. This investigation is motivated by increasing telescope/detector sensitivity, in particular the expected availability of the *Space Infrared Telescope Facility* (*SIRTF*) followed by the *Stratospheric Observatory for Infrared Astronomy* (*SOFIA*), which will enable detailed studies with large source samples of late stage circumstellar disk and planetary system evolution. We base our study on an analytic model of the disk density distribution and geometry, taking into account existing constraints from observations and results of theoretical investigations of debris disks. We also outline the effects of the most profound characteristics of circumstellar dust including the grain size distribution and dust chemical composition. In particular we find that an increasing iron content in silicates mainly causes an increase of the dust absorption effiency and thus increases the dust reemission continuum. Furthermore, the influence of the sp^2/sp^3 hybridization ratio in carbon grains on the spectral energy distribution is examined. We investigate the influence of various parameters on the resulting dust scattering and absorption/reemission spectral energy distribution and discuss the possibility for distinguishing between different disks from their infrared to submillimeter spectra. The strength and shape of amorphous silicate may be particularly diagnostic of debris disk evolutionary stages. Since the appearance of these features at 10μm and 20μm depends on the relative abundance of small grains - and therefore the minimum grain size and slope of the grain size distribution - they can be used to trace recent collisional processes in debris disks. Thus, debris disk surveys containing statistically large numbers of objects should reveal the likelihood of collisions and therefore the evolution of dust/planetesimals in debris disks. The results of our study underline the importance of knowledge of the stellar photospheric flux, especially in the near to mid-infrared wavelength range, for a proper analysis of debris disk spectral energy distributions: While the quality of subtraction of the direct stellar light at far-infrared wavelengths determines the accuracy of the mass estimate in the disk, our simulations show that the remaining stellar contribution due to scattering at near- to mid-infrared wavelengths constrains the dust grain size and chemical composition, e.g. the iron abundance in silicate grains.

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http://mc.caltech.edu/~swolf/downloads/deb-sed.ps.gz

The Origin of the Galactic Center Nonthermal Radio Filaments: Young Stellar Clusters

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The unusual class of magnetized nonthermal radio filaments (NTF), threads and streaks with their unique physical characteristics are found only within the inner couple of degrees of the Galactic center. Also, a number of young, mass-losing and rare stellar clusters are recognized to lie in the Galactic center region. The latter characteristic of the Galactic center region is used to explain the origin of the nonthermal radio filaments. We consider a mechanism in which the collective winds of massive WR and OB stars within a dense stellar environment produce shock waves that can accelerate particles to relativistic energies. This mechanism is an extension of a model originally proposed by Rosner and Bodo (1996), who suggested that energetic nonthermal particles are produced in a terminal shock of mass-losing stars. The large-scale distribution of the magnetic field in the context of this model is argued to have neither poloidal geometry nor pervasive throughout the Galactic center region.

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Dissertation Abstracts

The Near-Infrared Tracks of Protostellar Outflows

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In this thesis I present an investigation of the manifestations of star formation in different sites. The thesis consists of three major parts in which observations, analysis and the interpretation of contrasting kinds of objects are described. In each case, the technique of near-infrared imaging is used in order to understand the interaction of outflows with the various kinds of environment.

Firstly, this thesis describes a project based on observations of Bok globules which are small clouds containing a single or just a few star formation sites. The aim is to determine how these globules form, evolve and disperse. Observations were obtained using the Omega Prime wide-field infrared camera installed on the 3.5m telescope on Calar Alto, Spain.

The results indicate outflow activity in several large globules and parsec scale outflows in two of them, namely CB34 and CB54. In each case where outflows were detected, the distribution of reddened stars was also determined using JHK photometry. These results, combined with a careful literature review, provide sufficient confidence to construct a hypothetical evolutionary sequence for Bok globules, in which those that display outflow activity are assumed to be in a late evolutionary stage.

The second part describes a project designed to study examples of very bright outflows in the near-infrared using the UFTI high-resolution infrared imager installed on UKIRT, Mauna Kea, Hawaii. The project aims to provide insight into the physics of outflows, with the further aim of identifying the characteristics of the main driving source. These results aid our understanding of parsec-scale outflows observed in Bok globules.

New measurements of the HH 7-11 outflow allow a determination of the proper motions ($\sim$ 40 km/s) of the near-infrared sources, significantly lowering previously reported values but now in agreement with optical measurements. In addition to this dynamical study, a detailed investigation of the HH 7 bow is carried out using imaging with several near-infrared filters such as [FeII] and the 2-1 S(1) line of H_2. In [FeII], an elongated Mach disk structure in HH 7 is found while the H_2 S(1) 1-0/2-1 ratio reveals the excitation levels, which can be used to constrain bow-shock models. The results indicate that motion at 30 degrees from the line of sight with $\sim$ 55 km/s velocity is required. I extend the study to other bright shocks, such as ASR 49 and those found in the S233IR region.

Finally, the thesis describes preliminary results from a new project on the Rho Ophiuchus cloud complex, also seeking to identify the presence of new outflows with the objective of gaining new knowledge concerning the cloud's formation and evolution. The aim is to conduct an unbiased search for shock-excited molecular hydrogen structures within the cloud and to relate them to identified protostars.

This work on Rho Ophiuchus is based on data obtained with the SOFI infrared imager installed on the NTT, La Silla, Chile. A detailed map of over a quarter of the planned survey area was produced, which is 34 square arc-minutes in the K and H_2 bands, confirming the presence of previously known near-infrared HH objects and also identifying new ones. The present sample of observed outflows in the Rho Ophiuchus cloud, however, is insufficient to draw definite conclusions since it remains difficult to relate them to known YSOs in the cloud.

In summary, this investigation demonstrates that near-infrared wide-field studies of star formation "tracks", together with high-resolution studies, can yield significant clues to the underlying driving sources and reveal the on-going physical interaction with their environments.

Structure of accretion discs around low-mass young stars

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Forming stars undergo a phase characterised by circumstellar, disc-shaped orbiting material. It is important that we should study this disc to understand the formation of planetary systems. My main objective is a comparison between radiative transfer model predictions and observables and I base my modelling on a detailed analytical description of this transfer, so that one can point out dominant phenomena. Despite of the approximations made to obtain an analytical formalism, I show that this model compares satisfactorily with corresponding full numerical simulations. The observational diagnosis is quite new and combines spectral energy distributions and optical interferometric data. Such combination appears to bring much better constraints than model fits based on spectral energy distributions only, as I show with the few low-mass young stars already observed by optical interferometers: FU Ori, T Tau, and SU Aur. The model and diagnosis will be a powerful tool to interpret the massive optical visibility data expected from the new generation of instruments, among those the Very Large Telescope Interferometer and the Keck Interferometer.

The thesis is available in electronic format (PDF or per figure) from
http://www-laog.obs.ujf-grenoble.fr/l̃achaume/these/these.html

A Multi-wavelength Study on the X-ray Emissions from Young Stellar Objects in Orion Molecular Cloud 2 and 3

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We made a multi-wavelength study to reveal the variety and to understand the mechanisms of X-ray emissions from young stellar objects (YSOs), selecting Orion molecular cloud (OMC) 2 and 3 as our study field. OMC-2 and OMC-3 are intermediate mass star-forming regions, which contain YSOs at all evolutional classes from class 0 protostars to T Tauri stars in a wide range of mass from early-type stars to brown dwarfs.

We conducted deep observations on OMC-2 and OMC-3 in the X-ray and near-infrared (NIR) band respectively using the *Chandra X-ray Observatory* and the University of Hawaii 88 inch (2.2 m) telescope. In the X-ray band, we detected 385 sources in the Advanced CCD Imaging Spectrometer (ACIS)-I image of 17×17 arcmin^2, which is complete down to $F_{\rm X} \sim 10^{-14.5}$ ergs s^{-1} cm^{-2} with the faintest detected source of $F_{\rm X} \sim 10^{-15.5}$ ergs s^{-1} cm^{-2} in the 0.5–8.0 keV energy range. In the NIR band, we obtained the J- (1.2 μm), H- (1.6 μm), and K-band (2.2 μm) Quick Infrared Camera (QUIRC) images to extract 1448 NIR sources in a 512 arcmin^2 region. The survey is complete down to $J \sim 17.5$, $H \sim 16.5$, and $K \sim 16.0$ mag, matching well with the *Chandra* limit.

Combining the 2MASS (Two Micron All Sky Survey) and our QUIRC data, we identified the NIR counterpart for 278 (∼72%) X-ray sources (NIR-identified [NIR-IDed] X-ray sources). Most of these sources are YSOs that belong to OMC-2 and OMC-3 considering their magnitude and luminosity function in the K band. The rests of the X-ray sources are unidentified with NIR sources (NIR-unidentified [NIR-unIDed] X-ray sources).

For NIR-IDed X-ray sources, we estimated their mass and evolutional class using their J-, H-, K-band flux. We also derived their X-ray flux variability through the X-ray temporal analysis, and their plasma temperature and X-ray luminosity by the X-ray spectral analysis. By comparing the averaged X-ray properties among different mass ranges, we found that YSOs in the intermediate ($2.0\ M_\odot \leq M < 10.0\ M_\odot$), low ($0.2\ M_\odot \leq M < 2.0\ M_\odot$), and very low ($M < 0.2\ M_\odot$) mass ranges have the same X-ray emission properties in contrast to the high mass ($M \geq 10.0\ M_\odot$) sources. We further revealed that the X-ray emissions from intermediate to very low mass YSOs consist of two thin-thermal plasma components of different temperatures ($k_{\rm B}T \sim 1$ keV and 2–3 keV). Based on the time-sliced X-ray spectroscopy of some bright variable sources and on comparison with the sun and other main and pre-main-sequence sources, we proposed that the soft X-ray component is from coronae while the hard component is due to flares.

Most of the NIR-unIDed X-ray sources are background extragalactic sources from their hard X-ray spectra. However, the spatial distribution of these sources has an excess along the ridge of star-forming cloud cores, which indicates that some of the NIR-unIDed X-ray sources are related to star formations. We made follow-up imaging observations using the University of Hawaii 88 inch (2.2 m) telescope, the Subaru telescope, and the Infrared Telescope Facility in the J, H, K, L' (3.8 μm), and H_2 $v = 1 - 0$ S(1) (2.12 μm) bands in addition to the centimeter interferometer imaging observation with Very Large Array (VLA). Four NIR-unIDed X-ray sources are associated with jet and outflow systems and share many multi-wavelength characteristics in common. We proposed that these X-ray emissions can be explained by the high temperature plasma induced by protostellar jets. Other NIR-unIDed X-ray sources along the cloud core do not have such association. However, their heavily absorbed X-ray spectra and the association of some with sub-millimeter cores infer that they are heavily embedded X-ray-emitting YSOs, such as class 0 objects.

This thesis is available at http://www.astro.psu.edu/users/tsujimot/english/publication.html#thesis_en. Hard copies are also available upon request.

New Jobs

Submillimeter studies of southern protostars and disks

PhD student position

Leiden Observatory, University of Leiden, The Netherlands

Deadline: August 25, 2003

A 4-year PhD student position is available starting late 2003 or early 2004 within the Molecular Astrophysics group at Leiden Observatory. The aim of the project is to use new (sub)millimeter single-dish and interferometric facilities to perform a systematic high-frequency study of the envelopes around low-mass protostars and disks around young stars. The data will complement existing VLT and future SIRTF infrared observations of southern star-forming regions (to be obtained within the context of the SIRTF 'c2d' legacy program) and will be important in preparation for future ALMA and HIFI studies. Both line and continuum data will be obtained to investigate the physical and chemical structure of these regions and their evolution to potential planetary systems. The analysis will involve state-of-the-art radiative transfer techniques and chemical-dynamical models. The project is supervised by Prof. E.F. van Dishoeck. See `http://www.strw.leidenuniv.nl/` for further information about Leiden Observatory.

Applications should include a curriculum vitae (with a list of grades for exams), a brief statement of research experience, and the names of two people who can serve as a reference. The deadline for the application is **AUGUST 25, 2003**. The position is open to students of all nationalities with the equivalent of a Masters degree. The starting date for the position is late 2003/early 2004, with some flexibility in the precise date. Please send applications to

Prof. dr. E.F. van Dishoeck,
Leiden Observatory,
P.O. Box 9513,
2300 RA Leiden,
The Netherlands.
Tel: +31-71-5275814
FAX: +31-71-5275819
e-mail: `ewine@strw.leidenuniv.nl`

The position is funded by the Netherlands Organization of Scientific Research (NWO) and a Spinoza award. The research is carried out in the framework of the Netherlands Research School for Astronomy (NOVA), a national association of university astronomy departments, and is part of the Network 2 on 'Birth and Death of Stars and Planets: The Lifecycle of Gas and Dust'. See `http://www.strw.LeidenUniv.nl/nova/` for more information about NOVA.

New Books

Seeing through the Dust
The Detection of H I and the Exploration of the ISM in Galaxies

Edited by A.R. Taylor, T.L. Landecker, and A.G. Willis

These are the proceedings of a conference held at the Herzberg Institute of Astrophysics in Penticton, British Columbia, Canada on 20-25 October 2001. The meeting was held to celebrate the fiftieth anniversary of the first detection of the H I line in the interstellar medium. The H I line remains one of the most important windows on the Universe, and the book reviews the scientific results of H I gas in the Milky Way and other galaxies, discusses the astrophysical impact of the ambitious surveys that are underway, and explores the potential of H I studies for the future and the next generation of telescopes.

The book is dividided into 11 parts:

1. History of H I Research

2. New Observational Advances and Future Prospects

3. Large-Scale Structure and Dynamics of the Galaxy

4. Models of the ISM

5. The Gaseous Disk and Disk-Halo Interactions

6. ISM Phase Relationships and the Star Formation Cycle

7. H I as a Probe of the Formation and Evolution of ISM Structure

8. H I Studies of the ISM in Nearby Galaxies

9. Galaxies and Galaxy Interactions

10. H I, Dark Matter, and Galaxy Dynamics

11. Large-Scale Structure and Redshifted H I

The book contains 81 papers, including the following 9 larger contributions:

The First Twenty Years *V. Radhakrishnan*
Observational Advances in Radio Astronomy *R.D. Ekers*
The Southern Galactic Plane Survey *N.M. McClure-Griffiths*
H I and Galactic Structure *F.J. Lockman*
Numerical Models of the ISM *E. Vázquez-Semadeni*
Scaling of ISM Turbulence: Implications for H I *J. Cho, A. Lazarian, H. Yan*
Cold Atomic Gas in the Milky Way *S.J. Gibson*
H I as a probe of Structure in the Interstellar Medium of External Galaxies *M.S. Oey*
H I Galaxy Dynamics and Dark Matter *S. Coté*

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