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Short Announcements

Julian W. McNeil II, an amateur astronomer from Paducah, Kentucky, reports the appearance of a new cometary reflection nebula 1.1 arcminutes in diameter in the Lynds 1630 cloud in Orion. The nebula was found on several images taken on 2004 Jan 23 UT with a 7.6-cm Takahashi refractor + CCD, and it is not present on seven sky survey images from POSS-I, POSS-II and UKSTU taken between 1951 and 1991. Coordinates for the new optical nebula are: R.A. = $5^h46^m14^s$, Dec = -00^{o}05'.8 (J2000). McNeil's Nebula is apparently associated with IRAS 05436-0007, which consequently may have erupted. The new nebula surrounds the Herbig-Haro object HH 22, which however seems unrelated to the IRAS source. McNeil's Nebula appears very reddened towards the IRAS source, as commonly seen in cometary nebulae. Subsequent CCD images and infrared photometry/spectroscopy obtained at Mauna Kea confirm the emergence of this new nebula, and shows the brightening of a faint optical counterpart to the IRAS source, which displays an emission line spectrum akin to those seen in EXor eruptions. Observers are urged to monitor the development of this rare event before Orion disappears in the evening twilight.

Bo Reipurth

Abstracts of recently accepted papers

The Irradiated Herbig-Haro Jets Near σ Orionis

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We present high-resolution echelle spectra of the irradiated Herbig-Haro jets HH 444, 445, 446, and 447 from the Keck I telescope. The structural, kinematic, and physical properties of the jets near their sources are analyzed in detail. In particular, spatio-kinematic electron density variations and evidence for excited, low-velocity entrained material are found. Despite their proximity to the massive stars in the σ Orionis system, the inner portions of these jets generally exhibit low excitation conditions, consistent with shadowing from circumstellar material. The outflow sources show Hα and forbidden line emission on top of late-type photospheric spectra and strong lithium absorption, indicative of typical classical T Tauri stars. These spectroscopic data are discussed in the context of theoretical models which attempt to account for the generation of outflows. Additionally, narrowband *Hubble Space Telescope* WFPC2 images of HH 444 and 445 are presented and compared with the spectroscopic data. Besides the jets, the images of both sources reveal extended emission structures which point directly away from σ Ori, and are therefore interpreted as photoevaporating proplyds.

Accepted by the Astrophysical Journal

Preprint available at http://www.ifa.hawaii.edu/publications/preprints/04preprints/Andrews_04-003.pdf

The association between masers and outflows in massive star forming regions

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We report the results of a single-dish survey of molecular outflows towards a homogeneous sample of 136 ultracompact H II regions for which we had previously obtained observations in the methanol 6.7 GHz and water 22.2 GHz maser lines. The line profiles of the ^{13}CO $J = 1$–0 and 2–1 transitions have been compared to those of the corresponding lines of the C^{18}O isotopomer to reveal the occurrence of line wings and hence of molecular outflows. We found 53 outflows resulting in an overall detection rate of ∼39%. The probability to have an outflow increases to about 50% in regions with maser emission, whereas it is about 25% in those without masers. If we consider just the outflow sources, the chance to find a maser is very high: 74%, without a significant difference between H_2O and CH_3OH. These results strongly confirm from a statistical point of view that both types of masers are closely associated with the evolutionary phase when outflows occur.
The temperatures and optical depths of the molecular cloud hosting the ultracompact H II regions and the comparison between the detection rates suggest a tentative evolutionary scheme for massive star forming regions: the earliest phase is associated with maser emission and with an outflow not yet developed enough to be detected with single-dish observations; then maser emission disappears while the outflow is still present; and finally, only the ultracompact H II region without masers or outflows is present.

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http://www.arcetri.astro.it/∼codella/co-uc.ps.gz

Spectroscopy of Molecular Hydrogen Emission from KH 15D

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We report infrared spectroscopy of the unusual eclipsing pre-main sequence object KH 15D, obtained using NIRSPEC on Keck II. During eclipse, observations using low spectral resolution ($\lambda/\delta\lambda \sim 1000$) reveal the presence of prominent molecular hydrogen emission in 5 lines near 2 μm. The relative line strengths are consistent with thermal excitation at $T \sim 2800 \pm 300K$. Observations out of eclipse, at both low and high spectral resolution ($\lambda/\delta\lambda \sim 2 \times 10^4$), show reduced contrast with the stellar continuum. The change in contrast for the strongest line, 1-0 S(1), is consistent with an approximately constant emission line superposed on a variable stellar continuum. Emission in the 1-0 S(1) line is observed to extend by ≥ 4 arc-sec both east and west of the stellar point spread function (≥ 3000 AU). Observed at high spectral resolution, the velocity and intensity structure of the 1-0 S(1) profile are both asymmetric. East of the stellar PSF (by $1.1 - 2.3$ arc-sec) the emission is blueshifted (-63 km sec^{-1}), and has significantly greater intensity than the marginally redshifted component ($+2$ km sec^{-1}, $\sim$ consistent with zero) which dominates west of the stellar PSF. The spatial extent of the emission, and the excitation temperature, suggest shock-excitation of ambient gas by a bipolar outflow from the star and/or disk. However, it is difficult to account for the observed radial velocity unless the outflow axis is inclined significantly to the plane of the sky.

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A multi-wavelength scattered light analysis of the dust grain population in the GG Tau circumbinary ring

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We present the first 3.8 μm image of the dusty ring surrounding the young binary system GG Tau, obtained with the W. M. Keck II 10 m telescope's adaptive optics system. This is the longest wavelength at which the ring has been detected in scattered light so far, allowing a multi-wavelength analysis of the scattering properties of the dust grains present in this protoplanetary disk in combination with previous, shorter wavelengths, *HST* images. We find that the scattering phase function of the dust grains in the disk is only weakly dependent on the wavelength. This is inconsistent with dust models inferred from observations of the interstellar medium or dense molecular clouds. In particular, the strongly forward-throwing scattering phase function observed at 3.8 μm implies a significant increase in the population of large ($>\sim 1\,\mu$m) grains, which provides direct evidence for grain growth in the ring. However, the grain size distribution required to match the 3.8 μm image of the ring is incompatible with its published 1 μm polarization map, implying that the dust population is not uniform throughout the ring. We also show that our 3.8 μm scattered light image probes a deeper layer of the ring than previous shorter wavelength images, as demonstrated by a shift in the location of the inner edge of the disk's scattered light distribution between 1 and 3.8 μm. We therefore propose a stratified structure for the ring in which the surface layers, located $\sim$ 50 AU above the ring midplane, contain dust grains that are very similar to those found in dense molecular clouds, while the region of the ring located $\sim$ 25 AU from the midplane contains significantly larger grains. This stratified structure is likely the result of vertical dust settling and/or preferred grain growth in the densest parts of the ring.

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Preprints are available at http://xxx.lanl.gov/abs/astro-ph/0401560

Flaring vs. self-shadowed disks: the SEDs of Herbig Ae/Be stars

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Isolated Herbig Ae stars can be divided into two groups (Meeus et al. 2001): those with an almost flat spectral energy distribution in the mid-infrared ('group I'), and those with a strong decline towards the far-infrared ('group II'). In this paper we show that the group I vs. II distinction can be understood as arising from flaring vs. self-shadowed disks. We show that these two types of disks are natural solutions of the 2-D radiation-hydrostatic structure equations. Disks with high optical depth turn out to be flaring and have a strong far-IR emission, while disks with an optical depth below a certain threshold drop into the shadow of their own puffed-up inner rim and are weak in the far-IR. In spite of not having a directly irradiated surface layer, self-shadowed disks still display dust features in emission, in agreement with observations of group II sources. We propose an evolutionary scenario in which a disk starts out with a flaring shape (group I source), and then goes through the process of grain growth, causing the optical depth of the disk to drop and the disk to become self-shadowed (group II source). We show that this scenario predicts that the (sub-)millimeter slope of the disk changes from steep (small grains) to Rayleigh-Jeans-like (large grains) in the early stages of evolution, so that all group II sources are expected to have Rayleigh-Jeans-like slopes, while some group I sources may still have steep (sub-)millimeter slopes.

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http://www.mpa-garching.mpg.de/∼dullemon/radtrans/flareshadow/

PV Ceph: Young Star Caught Speeding?

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Three independent lines of evidence imply that the young star PV Ceph is moving at roughly 20 km s^{-1} through the interstellar medium. The first, and strongest, suggestion of motion comes from the geometry of the HH knots in the "giant" Herbig-Haro (HH) flow associated with PV Ceph. Bisectors of lines drawn between pairs of knots at nearly equal distances from PV Ceph imply an E-W motion of the source, and a plasmon model fit to the knot positions gives a good fit of 22 km s^{-1} motion for the star. The second bit of damning evidence comes from a redshifted "trail" of molecular gas, pointing in the *same E-W direction* implied by the HH knot geometry. The third exhibit we offer in accusing PV Ceph of speeding involves the tilt apparent in the high-velocity molecular jet now emanating from the star. This tilt is best explained if the true, current, jet direction is N-S, as it is in HST WFPC2 images, and the star is moving —again at roughly 20 km s^{-1}.

Tracing the motion of PV Ceph backward in time, to the nearest cluster from which it might have been ejected, we find that it is very likely to have been thrown out of the massive star-forming cluster NGC 7023 —more than 10 pc away. PV Ceph and NGC 7023 are at similar distances, and the backward-trace of PV Ceph's motion is astonishingly well-aligned with a dark, previously unexplained, rift in NGC 7023. We propose that PV Ceph was ejected, at a speed large enough to escape NGC 7023, at least 100,000 years ago, but that it did not enter the molecular cloud in which it now finds itself until more like 35,000 years ago. Our calculations show that currently-observable molecular outflow associated with PV Ceph is about 10,000 years old, so that the flow has had plenty of time to form while in its current molecular cloud. But, the question of what PV Ceph was doing, and what gas/disk it took along with it in the time it was traveling through the low-density region between NGC 7023 and its current home is open to question.

Recent numerical simulations have suggested that condensed objects should be ejected at high velocity before they have "finished" forming in a cluster. Prior to this work, a handful of pre-main-sequence stars have been shown to be moving at speeds > 10 km s^{-1}. To the best of our knowledge, though, the analysis of PV Ceph and NGC 7023 described here is the first observational work associating a speeding young star with a distant ancestral cluster. These high-speed ejections from clusters will create a class of rapidly-moving young stars in molecular clouds. If these ejections are at all common, their existence confounds both calculations of clouds' star-forming efficiency and theories of star formation that do not allow for stars to move rapidly through a reservoir of star-forming material while they form.

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http://cfa-www.harvard.edu/ agoodman/Presentations/aas04PVCeph/
http://arxiv.org/abs/astro-ph/0401486

Modelling ambipolar diffusion with two-fluid smoothed particle hydrodynamics

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We describe a fully three-dimensional, Lagrangian magnetohydrodynamics code which is able to treat self-gravitating gas dynamics and to take account of ambipolar diffusion. The ion density is given as a function of the local neutral density, using an expression derived from models of ionisation balance in molecular clouds. In turn, the ion density determines the strength of the coupling between the ionised and neutral fluids.

The code is tested by modelling the evolution of a dense core which is initially thermally supercritical but magnetically subcritical. The core steadily loses its magnetic support through ambipolar diffusion, and eventually becomes unstable against collapse. Our results agree well with those obtained by Fiedler and Mouschovias, who modelled the same system using a two-dimensional finite-difference code.

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Fragmentation of magnetized cloud cores

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Using a fully three-dimensional, Lagrangian two-fluid magnetohydrodynamics code, we simulate the collapse and fragmentation of a rotating molecular cloud core. The code used is able to describe the dynamics of partially-ionised fluids, and takes account of ambipolar diffusion and magnetic braking.

We model both magnetised and non-magnetised cores. The magnetised cores are chosen to be initially thermally supercritical, but magnetically subcritical. Therefore, before they can collapse, magnetic support must be lost through ambipolar diffusion.

Our results imply that magnetic braking is so effective in removing angular momentum that fragmentation is inhibited. These results cast doubt on the suggestion by Boss that the likelihood of core fragmentation is increased by a magnetic field.

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Peering into the heart of a high-mass star forming region: bispectrum speckle interferometry of the ultracompact H II region K3-50 A

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We present K'-band bispectrum speckle interferometry of the ultracompact H II region K3-50A. Our image resolves the central $1'' \times 1''$ region into at least 7 point-like objects. We find K'-band counterparts for all but one of the N-band sources discovered by Okamoto et al. (2003), and there are additional K'-band sources which were unresolved in the N-band images. Our reconstructed image also reveals the fine-structure of the cone-shaped nebulosity extending to the south. The brightest K'-band source is located exactly at the tip of the cone-shaped nebulosity. The nebula shows several arcs and the orientation of its main axis agrees very well with the direction of the CO outflow from K3-50A. This nebulosity therefore very likely represents the clumpy inner surface of a partially evacuated cavity excavated by the strong outflows.

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Preprints are available at http://www.mpifr-bonn.mpg.de/div/ir-interferometry/publications.html

IRAS 18317−0757: A Cluster of Embedded Massive Stars and Protostars

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We present high resolution, multiwavelength continuum and molecular line images of the massive star-forming region IRAS 18317−0757. The global infrared through millimeter spectral energy distribution can be approximated by a two temperature model (25K and 63K) with a total luminosity of approximately $\log(L/L_\odot) = 5.2$. Previous submillimeter imaging resolved this region into a cluster of five dust cores, one of which is associated with the ultracompact HII region G23.955+0.150, and another with a water maser. In our new 2.7mm continuum image obtained with BIMA, only the UCHII region is detected, with total flux and morphology in good agreement with the free-free emission in the VLA centimeterwave maps. For the other four objects, the non-detections at 2.7mm and in the MSX mid-infrared bands are consistent with cool dust emission with a temperature of 13-40K and a luminosity of 1000-40000 $L_\odot$. By combining single-dish and interferometric data, we have identified over two dozen virialized $C^{18}O$ cores in this region which contain $\approx 40\%$ of the total molecular gas mass present. While the overall extent of the $C^{18}O$ and dust emission is similar, their emission peaks do not correlate well in detail. At least 11 of the 123 infrared stars identified by 2MASS

in this region are likely to be associated with the star-forming cluster. Two of these objects (both associated with the UCHII) were previously identified as O stars via infrared spectroscopy. Most of the rest of the reddened stars have no obvious correlation with the $C^{18}O$ cores or the dust continuum sources. In summary, our observations indicate that considerable fragmentation of the molecular cloud has taken place during the time required for the UCHII region to form and for the O stars to become detectable at infrared wavelengths. Additional star formation appears to be ongoing on the periphery of the central region where up to four B-type (proto)stars have formed amongst a substantial number of $C^{18}O$ cores.

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Tracing the shock precursors in the L1448–mm/IRS3 outflows

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We present the detection of the SiO ν=0 J=2–1 and J=3–2 lines, and of the HCO 1_{01}–0_{00} J=3/2–1/2 F=2–1 line at ambient velocities towards the molecular outflows in L1448–mm and L1448–IRS3. This is the first detection of HCO in a dark cloud. We have also measured lines of $H^{13}CO^+$, $H^{13}CN$, $HN^{13}C$, CH_3OH, and N_2H^+. While the HCO and the SiO lines have the narrowest profiles with linewidths of $\sim$0.5 km s^{-1}, the other lines have widths of $\sim$1 km s^{-1}. Towards L1448–mm, all lines except those of SiO and HCO, show two distinct velocity components centered at 4.7 and 5.2 km s^{-1}. HCO is only observed in the 4.7 km s^{-1} cloud, and SiO in the 5.2 km s^{-1} component. The SiO abundance is $\sim10^{-11}$ in the 5.2 km s^{-1} clouds, one order of magnitude larger than in the 4.7 km s^{-1} component and in other dark clouds. The HCO abundance is $\sim10^{-11}$, similar to that predicted by the ion–molecule reactions models for the quiescent gas in dark clouds. The large change in the SiO/HCO abundance ratio (>150) from the 4.7 to the 5.2 km s^{-1} component, and the distribution and kinematics of the SiO emission towards L1448–mm suggest that the ambient SiO is associated with the molecular outflows. We propose that the narrow linewidths and the abundances of SiO in the ambient gas are produced by the interaction of the magnetic and/or radiative precursors of the shocks with the clumpy pre–shocked ambient gas.

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Detecting the Dusty Debris of Terrestrial Planet Formation

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We use a multiannulus accretion code to investigate debris disks in the terrestrial zone, at 0.7–1.3 AU around a 1 $M_\odot$ star. Terrestrial planet formation produces a bright dusty ring of debris with a lifetime of at least 10^6 yr. The early phases of terrestrial planet formation are observable with current facilities; the late stages require more advanced instruments with adaptive optics.

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preprints: http://xxx.lanl.gov/abs/astro-ph/0401343

additional information at: http://cfa-www.harvard.edu/~kenyon/pf/terra/td1/

An excitation study of bow shocks driven from protostars in S233IR

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We present narrow-band near-infrared images of the high-mass star formation region S233IR. We detect several groups of molecular hydrogen knots aligned with known outflows. Images in vibrationally-excited H_2 and [FeII] reveal the excitation distributions across the main two conspicuous bow shocks. Emission from the [FeII] line is strong and located at the apex of both bow shocks as well as other locations within the northern bow where we distinguish a compact Mach disk through its [FeII] emission. The H_2 emission is not restricted to the bow wings but distinct components are detected near the bow apices. The data are broadly comparable to steady bow shocks of speed 60–80 $\mathrm{km\,s^{-1}}$ possessing dissociative caps and C-type flanks. Nevertheless, non-steady bow shock behavior is essential to interpret all aspects of the bow structures. In this respect, the S233 bow caps may be in the neutral transformation stage from J-type to C-type.

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Preprints are available from http://www.mpia-hd.mpg.de/homes/khtig/publications.html

The Global Baroclinic Instability in Accretion Disks. II: Local Linear Analysis.

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This paper contains a local linear stability analysis for accretion disks under the influence of a global radial entropy gradient $\beta = -d\log T/d\log r$ for constant surface density. Numerical simulations suggested the existence of an instability in two- and three-dimensional models of the solar nebula. The present paper tries to clarify, quantify, and explain such a global baroclinic instability for two-dimensional flat accretion disk models. As a result linear theory predicts a transient linear instability that will amplify perturbations only for a limited time or up to a certain finite amplification. This can be understood as a result of the growth time of the instability being longer than the shear time which destroys the modes which are able to grow. So only non-linear effects can lead to a relevant amplification. Nevertheless, a lower limit on the entropy gradient $\propto \beta \approx 0.22$ for the transient linear instability is derived, which can be tested in future non-linear simulations. This would help to explain the observed instability in numerical simulations as an ultimate result of the transient linear instability, i.e. the Global Baroclinic Instability.

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The IC 2118 association: new T Tauri stars in high-latitude molecular clouds

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We identified new pre-main sequence stars in the region of high-latitude molecular clouds associated with the reflection

nebula IC 2118, around $l \sim 208^{\rm o}$ and $b \sim -27^{\rm o}$. The stars were selected as T Tauri candidates in objective prism plates obtained with the Schmidt telescope of Konkoly Observatory. Results of spectroscopic follow-up observations, carried out with the FLAIR spectrograph installed on the UK Schmidt and with ALFOSC on Nordic Optical Telescope, are presented in this paper. Based on spectral types, presence of emission lines and lithium absorption line, we identified five classical T Tauri stars and a candidate weak-line T Tauri star projected on the molecular clouds, as well as two candidate pre-main sequence stars outside the nebulous region. Using the near infrared magnitudes obtained from the 2MASS All Sky Catalog (IPAC 2003) we determined the masses and ages of these stars. We found that the five classical T Tauri stars projected on the clouds are physically related to them, whereas the other stars are probably background objects. Adopting a distance of 210 pc for IC 2118 (Kun et al. 2001) and using Palla & Stahler's (1999) evolutionary tracks we derived an average age of 2.5×10^6 yrs and a mass interval of 0.4–1.0 $\rm M_\odot$ for the members of the IC 2118 association.

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HD 77407 and GJ 577: two new young stellar binaries detected with the Calar Alto Adaptive Optics system ALFA

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We present the first results from our search for close stellar and sub-stellar companions to young nearby stars on the northern sky. Our infrared imaging observations are obtained with the 3.5 m Calar Alto telescope and the AO system ALFA. With two epoch observations which were separated by about one year, we found two co-moving companion candidates, one close to HD 77407 and one close to GJ 577. For the companion candidate near GJ 577, we obtained an optical spectrum showing spectral type M4.5; this candidate is a bound low-mass stellar companion confirmed by both proper motion and spectroscopy. We estimate the masses for HD 77407 B and GJ 577 B to be ~ 0.3 to $0.5\,M_\odot$ and ~ 0.16 to $0.2\,M_\odot$, respectively. Compared to Siess al. (2000) models, each of the two pairs appears co-eval with HD 77407 A,B being 10 to 40 Myrs and GJ 577 A,B being ≥ 100 Myrs old. We also took multi-epoch high-resolution spectra of HD 77407 to search for sub-stellar companions, but did not find any with $3\,M_{Jup}$ as upper mass ($m \sin i$) limit (for up to 4 year orbits); however, we detected a long-term radial velocity trend in HD 77407 A, consistent with a $\sim 0.3\,\rm M_\odot$ companion at ~ 50 AU separation, i.e. the one detected by the imaging. Hence, HD 77407 B is confirmed to be a bound companion to HD 77407 A. We also present limits for undetected, but detectable companions using a deep image of HD 77407 A and B, also observed with the Keck NIRC2 AO system; any brown dwarfs were detectable outside of 0.5 arcsec (17 AU at HD 77407), giant planets with masses from ~ 6.5 to $12\,\rm M_{Jup}$ were detectable at ≥ 1.5 arcsec.

Astronomy and Astrophysics

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

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We present new mid-infrared observations of objects in the vicinity of the O-star σ Orionis, obtained with TIMMI-

2 at ESO. By constraining their near- and mid-infrared spectral energy distributions, we established the nature of previously known IRAS sources and identified new mid-infrared sources as young stellar objects with circumstellar disks, likely massive members of the σ Ori cluster. For two of these objects we have obtained spectroscopy in the 8–13 μm range in order to investigate the chemistry of the dust grains. TX Ori exhibits a typical silicate emission feature at 10 μm, with a feature at about 11.2 μm that we identify as due to crystalline olivine. The IRAS 05358−0238 spectrum is very unusual, with a weak silicate feature and structure in the range 10–12 μm that may be explained as due to self-absorbed forsterite. We also provide the first evidence for the presence of circumstellar disks in the jet sources Haro 5-39/HH 447, V510 Ori/HH 444 and V603 Ori/HH 445.

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The 2D Continuum Radiative Transfer Problem: Benchmark Results for Disk Configurations

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We present benchmark problems and solutions for the continuum radiative transfer (RT) in a 2D disk configuration. The reliability of three Monte-Carlo and two grid-based codes is tested by comparing their results for a set of well-defined cases which differ for optical depth and viewing angle. For all the configurations, the overall shape of the resulting temperature and spectral energy distribution is well reproduced. The solutions we provide can be used for the verification of other RT codes. We also point out the advantages and disadvantages of the various numerical techniques applied to solve the RT problem.

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A Circumstellar Disc in a High-Mass Star Forming Region

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We present an edge-on Keplerian disc model to explain the main component of the 12.2 and 6.7 GHz methanol maser emission detected toward NGC7538-IRS1 N. The brightness distribution and spectrum of the line of bright masers are successfully modeled with high amplification of background radio continuum emission along velocity coherent paths through a maser disc. The bend seen in the position-velocity diagram is a characteristic signature of differentially rotating discs. For a central mass of 30 solar masses, suggested by other observations, our model fixes the masing disc to have inner and outer radii of about 350 AU and 1000 AU.

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Chandra X-ray observations of Young Clusters I. NGC2264 Data.

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We present results of a Chandra observation of a field in NGC 2264. The observations were taken with the ACIS-I camera with an exposure time of 48.1 ks. We present a catalog of 263 sources, which includes X-ray luminosity, optical and infrared photometry and X-ray variability information. We found 41 variable sources, 14 of which have a flare-like light curve, and 2 of which have a pattern of a steady increase or decrease over a 10 hour period. The optical and infrared photometry for the stars identified as X-ray sources are consistent with most of these objects being pre-main sequence stars with ages younger than 3 Myr.

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On the origin of H_2CO abundance enhancements in low-mass protostars

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High angular resolution H_2CO 218 GHz line observations have been carried out toward the low-mass protostars IRAS 16293–2422 and L1448–C using the Owens Valley Millimeter Array at $\sim 2 arcsec$ resolution. Simultaneous 1.37 mm continuum data reveal extended emission which is compared with that predicted by model envelopes constrained from single-dish data. For L1448–C the model density structure works well down to the 400 AU scale to which the interferometer is sensitive. For IRAS 16293–2422, a known proto-binary object, the interferometer observations indicate that the binary has cleared much of the material in the inner part of the envelope, out to the binary separation of ∼800 AU. For both sources there is excess unresolved compact emission centered on the sources, most likely due to accretion disks $\leq$200 AU in size with masses of $\geq$0.02 $M_\odot$ (L1448–C) and $\geq$0.1 $M_\odot$ (IRAS 16293–2422). The H_2CO data for both sources are dominated by emission from gas close to the positions of the continuum peaks. The morphology and velocity structure of the H_2CO array data have been used to investigate whether the abundance enhancements inferred from single-dish modelling are due to thermal evaporation of ices or due to liberation of the ice mantles by shocks in the inner envelope. For IRAS 16293–2422 the H_2CO interferometer observations indicate the presence of large scale rotation roughly perpendicular to the large scale CO outflow. The H_2CO distribution differs from that of $C^{18}O$, with $C^{18}O$ emission peaking near MM1 and H_2CO stronger near MM2. For L1448–C, the region of enhanced H_2CO emission extends over a much larger scale $>1''$ than the radius of $50-100$ K ($0.6-0.15$ arcsec) where thermal evaporation can occur. The red-blue asymmetry of the emission is consistent with the outflow; however the velocities are significantly lower. The H_2CO $3_{22}-2_{21}/3_{03}-2_{02}$ flux ratio derived from the interferometer data is significantly higher than that found from single-dish observations for both objects, suggesting that the compact emission arises from warmer gas. Detailed radiative transfer modeling shows, however, that the ratio is affected by abundance gradients and optical depth in the $3_{03}-2_{02}$ line. It is concluded that a constant H_2CO abundance throughout the envelope cannot fit the interferometer data of the two H_2CO lines simultaneously on the longest and shortest baselines. A scenario in which the H_2CO abundance drops in the cold dense part of the envelope where CO is frozen out but is undepleted in the outermost region provides good fits to the single-dish and interferometer data on short baselines for both sources. Emission on the longer baselines is best reproduced if the H_2CO abundance is increased by about an order of magnitude from $\sim 10^{-10}$ to $\sim 10^{-9}$ in the inner parts of the envelope due to thermal evaporation when the temperature exceeds ∼50 K. The presence of additional H_2CO abundance jumps in the innermost hot core region or in the disk cannot be firmly established, however, with the present sensitivity and resolution. Other scenarios, including weak outflow-envelope interactions and photon heating of the envelope, are discussed and predictions for future generation interferometers are presented, illustrating their potential in distinguishing these competing scenarios

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www.astro.su.se/∼fredrik/papers.html

Reduction of chemical networks. II. Analysis of the fractional ionisation in protoplanetary discs

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We analyse the chemical evolution of the fractional ionisation in a steady-state protoplanetary disc over a time interval of 10^6 yr. We consider a disc model with a vertical temperature gradient and with gas-grain chemistry including surface reactions. The ionisation due to stellar X-rays, stellar and interstellar UV radiation, cosmic rays, and radionuclide decay is taken into account. Using our reduction schemes as a tool for the analysis, we isolate small sets of chemical reactions which reproduce the evolution of the ionisation degree at representative disc locations with an accuracy of 50%–100%. On the basis of fractional ionisation, the disc can be divided into three distinct layers. In the dark dense midplane the ionisation degree is sustained by cosmic rays and radionuclides only and is very low, $la10^{-12}$. This region corresponds to the so-called "dead zone" in terms of the angular momentum transport driven by MHD turbulence. The ionisation degree can be accurately reproduced by chemical networks with about 10 species and a similar number of reactions. In the intermediate layer the chemistry of the fractional ionisation is driven mainly by the attenuated stellar X-rays and (inter-) stellar UV and is far more complicated. For the first time, we argue that surface hydrogenation of long carbon chains can be of crucial importance for the evolution of the ionisation degree in protoplanetary discs. Therefore, in the intermediate layer reduced networks contain more than a 100 species involved in hundreds of reactions. Finally, in the unshielded low-density surface layer of the disc the chemical life cycle of the ionisation degree comprises a restricted set of photoionisation-recombination processes. It is sufficient to keep about 20 species and reactions in reduced networks. Furthermore, column densities of key molecules are calculated and compared to the results of other recent studies and observational data. The relevance of our results to the MHD modelling of protoplanetary discs is discussed.

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On the possible variability of magnetic field of T Tauri

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We observed T Tau and AS 507 with the 6 m telescope of the Special Astrophysical Observatory on January 16, 18 and February 15 2003. The Main Stellar Spectrograph equipped with the polarimetric analyzer was used to measure longitudinal component $B_\parallel$ of photospheric magnetic field of these stars. We found only upper limits of $B_\parallel$ for both stars: $+15 \pm 30$ G for T Tau and -70 ± 90 G for AS 507.

The magnetic field of AS 507 was not measured before, but the value of T Tau's $B_\parallel$ is less than Smirnov et al.(2003) found from 1996 and 2002 yr observations ($B_\parallel \simeq 150 \pm 50$ G), so we concluded that longitudinal component of T Tau's photospheric magnetic field is variable.

We also have measured longitudinal component of T Tau's magnetic field in the He I 5876 emission line formation region. It was found that $B_\parallel \simeq +650$ G, $\simeq +350$ G and $\simeq +1100$ G January 16, 18 and February 15 2003 respectively. January 18 and February 15 observations were carried out at practically the same phases of the stellar rotation period, but profiles of He I 5876 line at these moments differ significantly. It is why we suppose that three times differnce in $B_\parallel$ observed at these two nights is not the result of observational errors. Possible reasons of the variability of $B_\parallel$ in the photosphere and magnitosphere of T Tau is discussed.

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HH 666: The Axis of Evil in the Carina Nebula

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We report the discovery of the iniquitous parsec-scale outflow HH 666 — the first protostellar jet in the Carina Nebula — as well as the infrared identification of its embedded driving source. The HH 666 jet emanates from a bright-rimmed molecular globule (G287.57-0.91) at the head of a dust pillar in the southern part of Carina. Optical and near-infrared images reveal structures that resemble bow shocks and internal working surfaces in other Herbig-Haro (HH) jets, and which are especially bright in [Fe II] λ16435. Except for extended bow shock wings, all features lie within a few degrees of a single axis oriented roughly southeast to northwest, with a remarkable highly-collimated flow breaking out of the natal globule. Long-slit echelle spectra reveal only redshifted velocities toward the southeast of the globule, and blueshifted velocities toward the northwest. The observed features conspire to form a single, coherent bipolar jet with a total projected length of over 4.5 arcmin or more than 3 pc. Doppler shifts as high as $\pm$250 km s^{-1} are seen, indicating that the jet axis has a significant tilt from the plane of the sky, and the total length of the jet may be closer to 4 or 5 pc. HH 666 is therefore among the longest HH jets known. Condemned to toil in the inferno of the Carina Nebula, scorched by UV radiation from the hot stars that power the H II region, much of the jet is influenced by radiative excitation. Infrared images reveal a reddened star embedded within the molecular globule lying along the jet axis. We identify this evildoer (HH 666 IRS) as the likely driving source of the jet. The infrared spectral energy distribution of HH 666 IRS is consistent with that of a Class I protostellar object, with a luminosity of a few hundred to 10^3 L$_\odot$, and a probable main-sequence mass of a few to 8 M$_\odot$. This Class I object associated with a prominent bipolar jet constitutes the first direct evidence of ongoing active star formation by accretion in the Carina Nebula.

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X-ray emission from a metal depleted accretion shock onto the classical T Tauri star TW Hya

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We present the X-ray spectrum of TW Hya observed at high and intermediate spectral resolution with the Reflection Grating Spectrometer (RGS) and the European Photon Imaging Camera (EPIC) onboard the *XMM-Newton* satellite. TW Hya is the first classical T Tauri star for which simultaneous X-ray data with both high spectral resolution and high sensitivity were obtained, thus allowing to probe the X-ray emission properties of stars in the early pre-main sequence phase. Despite TW Hya's high X-ray luminosity in excess of 10^{30} erg/s its X-ray spectrum is dominated by emission lines from rather cool plasma (T $\approx$ 3 MK), and only little emission measure is present at high temperatures (T $\approx$ 10 MK). We determine photon fluxes for the emission lines in the high resolution spectrum, confirming the earlier result from *Chandra* that the predominant emission is from neon and oxygen, with comparatively weak iron lines. Further, the line ratios of He-like triplets of nitrogen, oxygen and neon require densities of $n_{\rm e} \sim 10^{13}\,{\rm cm}^{-3}$, about two orders of magnitude higher than for any other star observed so far at high spectral resolution. Finally, we find that nearly all metals are underabundant with respect to solar abundances, while the abundances of nitrogen and neon are enhanced. The high plasma density, the (comparatively) low temperature, and peculiar chemical abundances in the X-ray emitting region on TW Hya are untypical for stellar coronae. An alternative X-ray production mechanism is therefore called for and a natural explanation is an accretion column depleted of grain forming elements. The metal depletion could be either due to the original molecular cloud that formed TW Hya or due to a settling of dust in the circumstellar disk of TW Hya.

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`http://www.astropa.unipa.it/~stelzer/publications.html`

N_2H^+ Observations of Molecular Cloud Cores in Taurus

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N_2H^+ observations of molecular cloud cores in Taurus with the Nobeyama 45 m radio telescope are reported. We compare "cores with young stars" with "cores without young stars". The differences in core radius, linewidth, and core mass are small. Linewidth is dominated by thermal motions in both cases. N_2H^+ maps show that the intensity distribution does not differ much between cores without stars and those with stars. This is in contrast to the result previously obtained in $H^{13}CO^+$ toward Taurus molecular cloud cores. Larger degree of depletion of $H^{13}CO^+$ in starless cores will be one possible explanation for this difference. We studied the physical state of molecular cloud cores in terms of "critical pressure" for the surface (external) pressure. There is no systematic difference between starless cores and cores with stars in this analysis. Both are not far from the critical state for pressure equilibrium. We suggest that molecular cloud cores in which thermal support is dominated evolve toward star formation by keeping close to the critical state. This result is in contrast with that obtained in the intermediate-mass star forming region OMC-2/3, where molecular cloud cores evolve by decreasing the critical pressure appreciably. We investigate the radial distribution of the integrated intensity. Cores with stars are found to have shallow (-1.8 to -1.6) power-law density profiles.

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http://alma.mtk.nao.ac.jp/∼kt/ktpreprint.html

H_2 Emission Nebulosity Associated with KH 15D

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An H_2 emission filament is found in close proximity to the unique object KH 15D using the adaptive optics system of the Subaru Telescope. The morphology of the filament, the presence of spectroscopic outflow signatures observed by Hamilton et al., and the detection of extended H_2 emission from KH 15D by Deming, Charbonneau, & Harrington suggest that this filament arises from shocked H_2 in an outflow. The filament extends about 15″ to the north of KH 15D.

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The Stellar Composition of the Star Formation Region CMa R1 – III. A new outburst of the Be star component in Z CMa

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We report on a recent event in which, after more than a decade of slowly fading, the visual brightness of the massive young binary Z CMa suddenly started to rise by about 1 magnitude in December 1999, followed by a rapid decline to its previous brightness over the next six months. This behaviour is similar to that exhibited by this system around its eruption in February 1987. A comparison of the intrinsic luminosities of the system with recent evolutionary calculations shows that Z CMa may consist of a 16 $M_\odot$ B0 IIIe primary star and a $\sim$3 $M_\odot$ FUor secondary with a common age of $\sim 3 \times 10^5$ yr. We also compare new high-resolution spectra obtained in Jan. and Feb. 2000, during the recent rise in brightness, with archive data from 1991 and 1996. The spectra are rich in emission lines, which originate from the envelope of the early B-type primary star. The strength of these emission lines increased strongly with the brightness of Z CMa. We interpret the collected spectral data in terms of an accretion disc with atmosphere around the Herbig B0e component of Z CMa, which has expanded during the outbursts of 1987 and 2000. A high resolution profile of the 6300 Å [O I] emission line, obtained by us in March 2002 shows an increase in flux and a prominent blue shoulder to the feature extending to ~ -700 km s^{-1}, which was much fainter in the pre-outburst spectra. We propose that this change in profile is a result of a strong change in the collimation of a jet, as a result of the outburst at the start of this century.

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Deep Imaging Surveys of Star-Forming Clouds II. A New Giant Herbig-Haro Flow in L1451

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We report the discovery of a new giant Herbig-Haro flow near the L1451 region of the Perseus Molecular Cloud. The East–West oriented flow contains two known HH objects (HH 280 and HH 317), two new HH objects (HH 492 and HH 493), and is 2.1 pc long. The flow is driven by the Class-I protostar IRAS 03235+3004 embedded in a bright-rimmed, sharp-edged cometary cloud facing northeast. The flow source is embedded in a West-facing conical reflection nebula. The cometary cloud appears to have been shaped by O and B stars in the Per OB2 association, including the B0.5 star 40 Per, located along the well defined symmetry axis of the cloud and with a projected separation of 26 pc. A soft-UV induced photo-ablation model is proposed to explain the properties of the cometary cloud.

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A Search for Warm Circumstellar Disks in the TW Hydrae Association

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A search for previously undetected optically thin disks around stars in the nearby, young, TW Hydrae Association was conducted around sixteen stars with sensitive 12 and 18 μm photometry. The survey could detect Zodiacal-like dust,

with temperature 200–300 K, at levels of $L_{IR}/L_{\star}=7\times10^{-3}$. Possible mid-infrared excess emission from TWA 17 was detected at the 2σ level, but none of the other stars showed evidence for circumstellar dust. The rapid disappearance of large amounts of dust around the K and M-type stars in this sample may mean that any planet formation in the terrestrial planet region was completed very quickly. There appears to be a bi-modal distribution of dust disks in TWA with stars having either copious or negligible warm dust.

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The Circumstellar Environments of High-Mass Protostellar Objects I: Submillimetre Continuum Emission

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We present maps of the 850 μm and 450 μm continuum emission seen towards a sample of 68 high-mass protostellar candidates with luminosities ranging from $10^{2.5}$ $L_{\odot}$ to $\sim 10^5$ $L_{\odot}$. Most of these candidate high-mass stars are in the earliest stages of evolution, and have not yet developed an ultra-compact HII region. We observe a variety of continuum emission morphologies, from compact symmetric sources through to multiple cores embedded in long filaments of emission. We find on average there is a 65% probability of an IRAS point-source having a companion detection at submillimetre wavelengths. The ratio of integrated flux to peak flux for our detections shows no strong dependence on distance, suggesting the emission we have observed is primarily from scale-free envelopes with power-law density structures. Assuming a near kinematic distance projection, the clumps we detect vary in mass from $\sim$1 $M_{\odot}$ to over 1000 $M_{\odot}$, with a mean clump mass of 330 $M_{\odot}$, column density of 9×10^{23} cm^{-2} and diameter of ~ 0.6 pc. The high luminosity and low mass of the smallest clumps suggests they are accompanied by a minimal number of stellar companions, while the most massive clumps may be examples of young protogroups and protoclusters. We measure the spectral index of the dust emission (α) and the spectral index of the dust grain opacity (β) towards each object, finding clumps with morphologies suggestive of strong temperature gradients, and of grain growth in their dense inner regions. We find a mean β of 0.9, significantly smaller than observed towards UCHII regions.

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Preprints available from http://saturn.phy.umist.ac.uk:8000/~tjm/hmpoI.ps.gz

Dissertation Abstracts

Multiple Star Formation in Molecular Cloud Cores

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Ph.D degree awarded: December 2003

The purpose of this thesis has been to investigate numerically the process of multiple star formation in molecular cloud cores, in the context of low-mass star formation. The numerical models have been performed using the smoothed particle hydrodynamics (SPH) technique, in an implementation that makes use of sink particles to model protostars and includes the notion of opacity limit for fragmentation via a barotropic equation of state.

The models described in this thesis may be divided in two groups, in terms of the initial conditions and methodology applied. The first group of simulations are simple models involving small clusters of $N = 5$ protostars (modelled by sink particles inserted at the outset) in a homogeneous background of gas. Two processes are dominant: competitive accretion between the stellar seeds and dynamical interactions in unstable multiple systems. The effect of these processes on the multiplicity properties of the resulting stars and brown dwarfs is studied. The main conclusion from these models refers to the resulting IMF, which resembles the broad features of the observed IMF if a power-law mass function with Salpeter or nearly-Salpeter slope is used to parameterise the small-N clusters mass function. Therefore, I speculate that the results by Motte et al. (1998) on the similarity of the core mass function and the IMF cannot be used to disproof the hypothesis that most stars arise in small non-hierarchical multiples.

The second group of models are intended to be a more realistic approach to the investigation of multiple star formation in molecular cloud cores. To achieve this goal, initial conditions which result naturally in the collapse and fragmentation of molecular clouds, and in the formation of accretion discs, must be imposed. Perturbations generated by a supersonic turbulent velocity field in a homogeneous gas cloud fulfil all these requirements. In addition to realistic initial conditions, the thermal behaviour of the gas is also considered. This has been accomplished by using a barotropic equation of state, which switches between an isothermal gas and a polytropic gas at a critical density chosen to match accurately radiative transfer calculations of the collapse of a cloud core.

Ten calculations of 5 $M_\odot$ turbulent gas clouds were performed, five with turbulent power spectrum slope of -5 (more kinetic power in large scales) and five with slope of -3 (more kinetic power in small scales). From these simulations I conclude that multiple star formation is a major channel for star formation in turbulent flows. The incidence of multiple systems is high, but in agreement with the photometric width of the main sequence of young clusters (like e.g. Praesepe). I find that *the slope of the sub-stellar IMF is sensitive to the slope of the initial velocity power spectrum*, whereas the stellar IMF does not change substantially. Few objects with masses below ≈ 0.01 $M_\odot$ are formed, despite the minimum fragment mass being $10\times$ smaller. I also find that single and binary stars attain comparable velocities in the range $1 - 10$ km s^{-1}. Higher-order multiples have lower velocity dispersions. Thus, low-mass, loose star forming regions like Taurus or Ophiuchus might have an overabundance of $N > 2$ multiples, as lower-N systems may easily escape the potential well of these associations. Also I find that, as expected, denser cores produce a longer tail of high-speed escapers. Finally, it is found that very low mass stars and brown dwarfs can remain bound in multiples but at very large separations. My simulations can accommodate the existence of systems with brown dwarfs as wide companions but only *if the primaries of these systems are themselves multiple systems.*

The comparison with observational data has also highlighted some shortcomings of these simulations: very low mass binary stars and brown dwarf binaries are under-produced, as low-binding energy pairs are unlikely to survive in the dense stellar environments produced by the simulations. Pure wide binaries, and low mass ratio systems are also scarce. The effect of the initial angular momentum of the clouds on the production of these systems remains to be investigated.

A copy of this thesis is available from ftp://ftp.astro.su.se/edelgado/thesis.ps

Methanol Masers as Signposts of Star Formation

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Ph.D dissertation directed by: Prof. Roy Booth Ph.D degree awarded: February 2004

Using a consistent survey of the galactic plane at 6.7 GHz as a starting point, this thesis reports on the observational as well as theoretical results achieved by extensively studying of the phenomenon of class II methanol masers.

The general catalogue of 6.7 GHz methanol masers in the Milky Way, gathers all known sources discovered since 1991, including the 4 new sources detected during the Onsala Blind Survey of the galactic plane. Their spatial distribution in the Galaxy follows the distribution of OB-associations hosting massive star formation, suggesting that methanol masers arise where massive stars form. Statistical considerations are presented with the aim of estimating the luminosity function of the masers.

Dust continuum observations of methanol maser sites not uniquely associated to known infrared sources, were used to trace the Spectral Energy Distribution (SED) of these sites, yielding dust temperatures and enclosed masses. This study confirmed that many of 6.7 GHz methanol maser sources host large amounts of cold dust, making further evidence for classifying them as sites of (massive) star formation in an early stage. VLBI observations of strong 6.7 GHz methanol masers conducted for the first time including short baseline spacings showed that there is a considerably large, low brightness emission that was systematically resolved out at the usual spatial resolution. Various scenarios for the nature of this emission are presented as the basis for the investigation toward an explanation to this phenomenon.

Theoretical work on modelling a circumstellar disc traced by methanol masers gave estimates for the mass of the central object and the extent of the masing disc in NGC7538-IRS1 N. The model fits both the spectrum and the integrated brightness profile using two parameters, the line of sight velocity gradient and the ratio between inner and outer radius.

As a side project, results of 3.6 cm-continuum global VLBI observations of the young active stars YZ CMi, AD Leo and T Tauri Sb (first detection at this frequency and resolution) are presented, where size and polarisation of the coronal emission as well as accurate positions of all targets were measured. The emission mechanism for the corona could be non-thermal, and particularly for T Tauri Sb, an electron cyclotron maser is proposed to explain the flaring activity.

http://www.oso.chalmers.se/∼michele/Thesis.htm

New Jobs

Star and planet formation/Evolution of circumstellar dust disks to planetary systems Ph.D. Student Position

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Tel: 0049-6221-528283
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Attention: Personnel Department, Ingrid Apfel

A position for a Ph.D. student is available in the new Emmy Noether Research Group "Evolution of circumstellar dust disks to planetary systems" at the Max Planck Institute for Astronomy in Heidelberg, Germany. **It is initially for 2 years with a possible extension to a total of 4 years.**

The Emmy Noether Research Group, when fully established in mid-2004, will consist of the group leader, a Postdoc, a Ph.D. student and possibly several diploma students. It is embedded in the department "Star and Planet Formation" at the MPIA. The successful applicant is expected to perform observational and theoretical studies on the evolution of circumstellar disks from young massive gas/dust disks to possibly planet-harbouring debris disks.

Applicants should hold the equivalent of an MSc in astronomy or physics and ideally should have first experience with astronomical research (numerical simulations / analysis of astronomical observations).

The position is available on the German BAT federal public service scale (BAT IIa/2).

Interested students are invited to send an application including a curriculum vitae, copies of University degrees/records, and two letters of recommendation to the adress above to Dr. Sebastian Wolf.

Applications received **before March 15, 2004** will receive fullest consideration. Later applications will be considered on the basis of availability. This position will be open until a suitable candidate is found.

The MPIA is an equal opportunity employer and particularly welcomes applications from women and minorities.

Numerical Modelling and/or Star/Planet Formation Postdoctoral Position

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Attention: Personnel Department, Ingrid Apfel

The MPIA department "Star and Planet Formation" invites applications for a postdoctoral position in the Emmy Noether Research Group "Evolution of Circumstellar Dust Disks to Planetary Systems". **The position is initially for 2 years with a possible extension to a total of 4 years.**

We are searching for an internationally recognized scientist working in the area of circumstellar disk evolution and planet formation with significant knowledge and experience in numerical modelling techniques. The successful candidate is expected to investigate various phases of the planet formation in circumstellar disks on the basis of predominantly hydrodynamic and/or N-particle/SPH simulations. In addition to the general computing facilities of the MPIA, the successful candidate will have access to special computers including a multiprocessor workstation, an ORIGIN 2000 system, and a cluster of special hardware devices (GRAPE-5/6) connected to local PC clusters. The MPIA has access to two computing centers with several parallel systems: At the IPP Computing Center Garching: a 4.0 TFlop/s IBM pSeries "Regatta" system and a vector NEC SX-5/3C supercomputer at the GWDG (society for scientific computing) in Goettingen: a 422 GigaFlop/s Regatta System and a 55 node linux cluster (2 x 3 GHz XEON each).

The position is available on the German BAT scale (BAT IIa).

Prerequisites:
- PhD in astrophysics, physics, or related field by the start of the appointment;
- Profound experience in numerical modelling, in particular in hydrodynamic simulations and/or N-particle/SPH simulations.

The application should briefly describe research experience and interests, and should include a complete curriculum vitae and bibliography. At least two letters of recommendation should be sent directly to the address above. Applications received **before March 15, 2004** will receive fullest consideration. Later applications will be considered on the basis of availability. This position will be open until a suitable candidate is found.

We encourage applications from women, minorities and disabled persons.

New Books

Cosmic Masers: From Protostars to Black Holes

Edited by V. Migenes and M.J. Reid

These are the proceedings of IAU Symposium No. 206 held in Angra dos Reis, Rio de Janeiro, Brazil on 5-10 March 2001. The book offers a detailed examination of the large amount of data and the significant progress in our understanding of masers in different environments that has been accumulated since the previous symposium on the subject in 1992. The book is dividided into 9 parts, of which the first one on star formation is by far the largest, filling half the book.

1. Star Formation
1a. H_2O Masers
1b. OH Masers
1c. CH_3OH Masers
1d. Supernova Remnants
1e. Radio Recombination Lines
1f. Thermal Molecular Emission in Star Forming Regions

2. Stellar Masers
2a. SiO Masers
2a. H_2O Masers
2a. OH Masers
2a. HCN Masers

3. Protoplanetary Nebulae

4. Polarization and Magnetic Fields

5. Extragalactic Nuclear Masers
5a. H_2O Masers
5b. OH Masers

6. Comets

7. Maser Theory

8. Telescopes, Observatories and Projects

9. Conference Summary

The book contains 100 papers and poster papers, and includes the following larger presentations and reviews:

Star formation: relationship between the maser species *J.L. Caswell*
Stellar masers: a review *P.J. Diamond*
Extragalactic H_2O masers *L. Greenhill*
OH Megamasers *C.J. Lonsdale*
Maser emission from comets *P. Colom, D. Bockelée-Morvan, J. Crovisier, E. Gérard*
Topics in basic maser theory *M. Elitzur*
Theory and extragalactic masers *W.D. Watson*
Conference summary *M.J. Reid*

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E-mail: catalog@astrosociety.org – Web site: www.astrosociety.org

Meetings

ALMA Science Workshop

University of Maryland Conference Center May 14-15, 2004

In October 1999, a meeting was held in Washington, D. C. to bring together scientists working on the development of what would become ALMA to review the scientific program planned for the array and how that program interacted with the science goals of other astronomical facilities contemporaneous with it. The results of that meeting were published in *Science with ALMA*, ASP Conference Series Volume 235. Much of the research planned for ALMA at that meeting has appeared in the ALMA Design Reference Science Plan, a collection of experiments planned for the fully operational ALMA which was recently presented by the ALMA Project and which may be inspected at www.alma.nrao.edu.

Construction of ALMA has begun, and planning for its operation continues. The North American ALMA Science Center, under construction in Charlottesville, will be the center of interaction between the telescope and the American user. The 14-15 May 2004 workshop at the University of Maryland will focus on ALMA science and on this interaction between ALMA and the user. Early Science is expected from a subset of ALMA telescopes by 2008. Astronomers are invited to discuss the present state of plans for ALMA, ALMA's scientific goals and how best to enable them, what science goals might be accomplished during the ALMA Early Science Phase and the face ALMA presents to its scientists users. For further details please visit the ALMA web site at www.alma.nrao.edu

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

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

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

Moving ... ??

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