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Abstracts of recently accepted papers

The ejection of T Tauri stars from molecular clouds and the fate of circumstellar discs

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We investigate the evolution of circumstellar discs around T Tauri stars that are ejected from small stellar clusters within molecular clouds. In particular, we study how the interaction that leads to ejection may hasten the transition between Classical and Weak-lined T Tauri status. In our models, ejections of T Tauri stars at velocities of 3-10 km/s truncate the accretion disc at radii between 1 and 10 a.u., reducing the viscous evolution time of the disc so that accretion rapidly ceases. The observational appearance of the resulting systems is then dependent on the presence or absence of a stellar magnetic field. For non-magnetic stars we find that a near-infra red excess should persist due to reprocessing of stellar radiation, but that this is greatly diminished for magnetic T Tauri stars by the presence of a magnetosphere extending to corotation. In either case, there is a period when ejected stars should appear as non-accreting systems with detectable circumstellar material at wavelengths of 5 microns and beyond. We discuss the implications of these results for models in which ejected stars contribute to the halo of pre-main-sequence objects discovered from ROSAT observations of star forming regions and the All-Sky Survey.

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http://www.cita.utoronto.ca/∼armitage/ejection/ejection.html

Optical Emission in the Beam of Stellar Jets: a Possible Mechanism

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We propose a mechanism for the optical emission observed in the beam section of stellar jets based on the stability properties of circularly polarized Alfvén waves propagating in the partially ionized medium filling the jet's channel. We first derive the relevant magneto-hydrodynamic equations which include the Hall term for such a partially ionized medium, a term which gives rise to dispersive effects. Quasi–equipartition of thermal and magnetic energies is assumed and the model is developed in the one–dimensional approximation, but keeping the three components of the vectorial fields. Mild compressions or very weak shocks occur in the flow when instabilities develop, depending on the relative sign of the angular momentum of the underlying accretion disk and the external magnetic field. Simulations performed under quite general conditions show that the temperature/density perturbations associated with the instability are consistent with the average luminosity contrast observed in the jet's beam between bright knots and inter-knot regions.

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New Herbig-Haro Flows in L1448 and L1455

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We present a deep narrow-band Hα and [S II] optical survey of a roughly one square degree region containing L1448 and L1455 in the southwestern region of the Perseus molecular cloud. We report the detection of 13 new groups of Herbig-Haro (HH) objects in this region. The L1448 core contains 8 groups of Herbig-Haro objects (HH 193, HH 194, HH 195, HH 196, HH 197, HH 267, HH 268 and HH 277). Many of the new HH objects near L1448 have orientations similar to the L1448C molecular jet and L1448 IRS3 outflow. All four known infrared sources in L1448 power Herbig-Haro objects. L1448 IRS 1 is the likely source of HH 194, HH195E, and possibly HH 268. L1448 IRS 2 drives HH 195, and L1448 IRS 3 may power HH 196 and possibly HH 193. HH 267 and HH 277 lie close to the axes of the IRS 2 and IRS 3 flows and may also be powered by one of these sources. Finally, the Class 0 source L1448C powers HH 197. The L1455 core contains 5 new groups of HH objects (HH 278, HH 279, HH 280, HH 317, and HH 318). L1455 IRS 1 and L1455 IRS 2 are likely to power HH objects but a unique association between each IRAS source and a specific HH object is difficult to make. Both clouds contain some HH objects whose driving sources cannot be conclusively identified. Most of the new HH objects are located near the cloud edges while some are in the interclump medium (ICM) more than one parsec from the nearest cloud core or known young stellar object. These observations provide further evidence that HH flows can extend far beyond the cloud cores containing their sources, and in some cases extend over greater distances than associated high velocity millimeter wavelength CO emission. Herbig-Haro objects associated with the terminal working surfaces of outflows located in the ICM can be used to probe the nature of the interclump gas in molecular clouds. The large number of HH objects found in relatively inactive star forming regions such as L1448 and L1455 indicates that shock heating and acceleration by protostellar outflows plays an important role in determining the ionization state and energetics of the ICM that surrounds low mass star forming regions.

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X-ray Surveys and the Post-T Tauri Problem

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Recent studies using the *ROSAT* All-Sky Survey (RASS) towards nearby star-forming regions have identified a widely dispersed population of X-ray active stars, and have suggested that these objects are older pre-main sequence stars (post-T Tauri stars) located far from the molecular clouds. We argue that the majority of these stars are not pre-main sequence stars, but young main sequence stars of ages up to $\sim 10^8\ yr$. A simple model assuming continuing star formation over the past $10^8\ yr$ quantitatively reproduces the number, surface density, X-ray emission, and optical properties of the RASS sources. Most of these stars are old enough to have dispersed far from their birth sites in molecular clouds, producing a relatively homogeneous spatial distribution of X-ray sources near the galactic plane. We conclude that the RASS results yield little evidence for a post-T Tauri population. We emphasize the importance of recognizing this wide-spread spatial distribution of $10^8\ yr$ stars in searches for possible older weak-emission T Tauri stars among X-ray selected samples in nearby star-forming regions.

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Polarimetry of Young Stellar Objects II: Circular Polarization of GSS 30

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We present results from the first imaging polarimetry measurements of circularly polarized light. These observations, towards the outflow source GSS 30, show degrees of circular polarization in the K_n band of as much as -1.7%, measured in the outflow region, and $\sim$ -0.5% towards the source of the outflow, IRS 1. No circular polarization is measured towards the polarization disc, contrary to expectations from current scattering models.

The detection of circular polarization in the outflow region means that radiation escaping from the central star must be polarized close to the source before entering the reflection nebula. Monte Carlo simulations are used to show that this may occur with a scattering geometry which contains a dusty envelope surrounding the accretion disc.

The relatively high degrees of circular polarization reported here, coupled to our previous linear polarimetry of this object, require that the refractive index of the scattering grains contains an absorptive component, ruling out pure silicates as the only constituent of the grain population.

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This paper is also available as a preprint from http://star.herts.ac.uk/preprints.html

Spectrophotometry of Flares and short time scale Variations in Weak Line, and Classical T Tauri Stars in Chamaeleon

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Results are presented from a monitoring program looking for variations of the equivalent width and flux of Hα, and of the continuum flux, in 18 classical and 18 weak line T Tauri stars, and one Herbig Ae/Be star, on time scales down to 5 minutes. The stars were observed simultaiously for 14 hours using the multiobject-spectrograph FLAIR on the UK Schmidt Telescope. The campaign turned up two events in weak line T Tauri stars. Both events show the characteristics of flares: The increase of the Hα emission is faster than the decline, and the increase of the emission is much larger in Hα than in the continuum. The total energies radiated in Hα are $2.0 \pm 0.7 \times 10^{33}$ erg and $\geq 6 \pm 2 \times 10^{32}$ erg, or roughly 200 to 700 times larger than the largest flares on the Sun. The spectrum of one of these events shows a component of Hα which is blue-shifted by about 600 km^{-1}. We interpret this component as an indication of mass loss, and estimate, if the event is a typical one, that the mass loss rate due to flares would be about $10^{-13}\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$ for a weak line T Tauri star. We derive lower limits to the magnetic flux density of between 10 and 200 G. Although a number of events have been observed in the classical T Tauri stars as well, none of these has shown the strong increase within minutes and decrease in an hour characteristic of a flare. We interpret this result as being due to either an optical thickness effect in Hα, or to the absence of optical flares in classical T Tauri stars, or simply due to failing to catch any flares in classical T Tauri stars.

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The highly veiled T Tauri stars DG Tau, DR Tau, and DI Cep

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We present a series of spectroscopic and photometric observations spanning up to 13 contiguous nights of three highly veiled T Tauri stars: DG Tau, DR Tau, and DI Cep.

DR Tau and DG Tau are so highly veiled that their continuum emission is dominated by the veiling rather than the stellar continuua. All measurements are in agreement with the hypothesis, that the veiling continuum is effectively a pure continuum source.

All three stars show strong night-to-night variations in the equivalent widths of the emission lines and smaller variations on shorter time scales. We can conclude from simultaneous photometry and spectroscopy of DG Tau and DI Cep, that the variations in the equivalent widths during each night are mostly due to line flux variations, whereas the night-to-night variations are mostly due to veiling continuum variations, consistent with the observed anti-correlation between the equivalent widths and the veiling strengths in DG Tau and DR Tau (the two quantities are un-correlated in the weakly-veiled star DI Cep). Thus, the timescale for changes in the veiling continuum are of the order of a day whereas the line fluxes vary on timescales of minutes to hours. The short timescale variability of the line fluxes precludes an origin in a quasi-spherical wind.

The strengths of all major emission lines in the optical spectrum of DR Tau and DG Tau appear to be quasi-periodic in time, with periods similar to photometric periods reported in the literature. The veiling continuum, however, is much more erratic and not at all suggestive of rotational modulation – a fact which may explains why the veiling-*EW* correlations are relatively weak. Unfortunately, we do not have enough data to distinguish between line "flares" of an unknown origin or rotational modulation.

High resolution spectra suggest that the variations of the line profiles are predominately in the blue wing of the Hα and Hβ profiles in DR Tau, and in the red wing in DI Cep.

Lower limits on the area of the Hα emitting regions can be derived from the amount of veiling and the observed line widths by assuming LTE and that the line is optically thick. The areas of the emitting regions must be at least 2-16 times larger than those of the stars. The observed variations of Hα and other strong emission lines lines thus have to be due to changes in the sizes and/or temperatures of the very large emitting regions seen by the observer. The difference between the large emission line and small veiling continuum regions is confirmed by the timescales for line flux and veiling continuum variations: the short-term line flux variations cannot be produced from the site of the veiling continuum production if the later is identified with the accretion region. Interestingly, the same behavior is seen in systems with *very* strong veiling and quasi-periodic line variations (DG Tau and DR Tau) as well as in a system with moderate to weak veiling and no sign of quasi-periodic variations (DI Cep).

These results support the magnetospheric disk accretion model for classical T Tauri stars.

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The Small-Scale Structure of the CO Outflow in B1

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We present aperture synthesis CO (J=1-0) observations of the compact molecular outflow in the dark cloud B1. We have detected strong blueshifted emission having a peak brightness temperature of 14.3 K, while no significant emission in the redshifted velocity range. The most prominent feature in our map is a distinct ring-like structure having a size of 25″ (8700 AU) × 14″ (5000 AU) at velocities blueshifted by 1.9–2.7 km s^{-1} from the systemic velocity. The central hole of the CO ring well coincides with the IRAS position, suggesting that this outflow is driven by the IRAS source, 03301+3057. The CO ring structure is interpreted as a conical outflow lobe with brightened limb observed from its polar direction.

The high velocity gas that is blueshifted more than 4 km s^{-1} shows the V-shaped structure open to the southwest. This structure well delineates the northeast edge of the CO blue lobe observed with the singe-dish, where the CO lobe faces to the dense gas traced by the $C^{18}O$ emission. The strong peak of SiO emission observed by Yamamoto et al. (1992) is located at the interface between the CO outflow and the dense gas traced by the $C^{18}O$ and $H^{13}CO^+$ emission. This suggests that the outflow which emanates from the young star strongly interacts with the dense material and causes shock that propagates into the surrounding cloud.

The presence of strong SiO emission and the cold IRAS spectrum ($\log[F_\nu(60\mu m)/F_\nu(100\mu m)] < -0.76$) suggest that the central source of B1 is a candidate for the protostar in the earliest evolutionary stage having an outflow in a *nearly pole-on configuration.*

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Atomic Carbon in Southern Hemisphere High Latitude Clouds

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We report the detection of atomic carbon in a sample of eight southern hemisphere high galactic latitude molecular clouds, using the Antarctic Submillimeter Telescope and Remote Observatory. The 492 GHz ($^3P_1 \rightarrow ^3P_0$) transition of [CI] was detected in all of the clouds observed. The C/CO column density ratio ranges from 0.4 to 2.5, and is similar to the values previously measured in high latitude clouds MBM 12 and HD 210121. For all ten high latitude clouds observed in [CI], C/CO averages ~ 1.2 and decreases with increasing total gas column density N_H, as predicted by translucent cloud models. Quantitative comparison with chemical models of homogeneous clouds is unsatisfactory, however, and we conclude that the clumpy structure of clouds must be taken into account in order to interpret the data properly.

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A 2000 $M_\odot$ Rotating Molecular Disk Around NGC 6334 A

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We present mm and cm wave spectroscopic observations of the H II region NGC 6334 A. We have mapped the source in several transitions of CO, CS and NH_3. The molecular emission shows a distinct flattened structure in the E-W direction. This structure is probably a thick molecular disk or torus (2.2×0.9 pc) responsible for the bipolarity of the near-infrared and radio continuum emission which extends in two 'lobes' to the north and south of the shell-like H II region. The molecular disk is rotating from west to east ($\omega \approx 2.4$ km s^{-1} pc^{-1}) about an axis approximately parallel to the radio and NIR emission lobes. By assuming virial equilibrium, we find that the molecular disk contains ∼2000 $M_\odot$. Single-component gas excitation model calculations show that the molecular gas in the disk is warmer and denser ($T_k \approx 60$ K, $n \approx 3{,}000$ cm^{-3}) than the gas to the north and south ($T_k \approx 50$ K, $n \approx 400$ cm^{-3}).

High resolution ($\sim 5''$) NH_3 (3,3) images of NGC 6334 A reveal several small (~ 0.1 pc) clumps, one of which lies southwest of the radio continuum shell, and is spatially coincident with a NIR source, IRS 20. A second NH_3 clump is coincident with an H_2O maser and the center of a molecular outflow. The dense gas tracers, CS $J = 5 \rightarrow 4$ and $7 \rightarrow 6$, peak near IRS 20 and the H_2O maser, not at NGC 6334 A. IRS 20 has a substantial FIR luminosity $L_{FIR} \sim 10^5$ $L_\odot$, which indicates the presence of an O7.5 star, but has no detected radio continuum ($F_{6\ cm} < 0.02$ Jy). The combination of dense gas, a large FIR luminosity and a lack of radio continuum can best be explained if IRS 20 is a protostar. A third clump of NH_3 emission lies to the west of IRS 20, but is not associated with any other molecular or continuum features. The star formation activity in the region has moved west of NGC 6334 A, to IRS 20 and the H_2O maser

position. We suggest that NGC 6334 A, IRS 20, and the H_2O maser spot are part of a 'protocluster' of stars which is condensing from the massive molecular disk. The similarity between the structure around NGC 6334 A and other large ($r \sim$1 pc), massive ($M \sim 10^3\ M_\odot$), rotating disks (K3-50A and G10.6-0.4) suggests that this may be a common mechanism by which open clusters form.

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Binaries among Herbig Ae/Be stars

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We have studied the circumstellar environment of 31 Herbig Ae/Be and related stars in the near infrared by means of speckle-interferometry. For the brighter objects we reach or approximate diffraction-limited resolution of $\approx 0.1''$ (typically 100 AU at the object). Of the resolved objects some show halos, some have a companion. Here we restrict ourselves to a discussion of binarity in this sample. Eleven objects have companions, five of which constitute subarcsecond binaries, mostly found by us. Although the sample is small and neither homogeneous nor complete, it indicates a similar high incidence of binaries as found in recent surveys among T Tauri stars. Where the data allow it, we discuss the nature of the companions.

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Thermal methanol emission in the DR 21 complex

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We present interferometric observations with $\sim$ 3.5″ resolution of the $2_k \rightarrow 1_k$ methanol lines towards the methanol masers in the DR 21/DR 21(OH) complex. These transitions are not masing and hence our measurements can be used to place limits on the methanol mass associated with the maser spots. We do not find in general good correlation between the peaks of "non-maser" methanol emission and the positions of Class I methanol masers. In particular, we put an upper limit on $2_k - 1_k$ emission towards the $8_0 - 7_1A^+$ maser DR21(OH)-1 from Plambeck and Menten (1990). We do find however evidence for coincidence between the peak of the $2_1 - 1_1E$ emission in our map with the class I masers towards DR21-West. We conclude that methanol class I masers are likely to originate in a region considerably smaller than our synthesised beam (3.5″) and with methanol column density of order 10^{16} cm^{-2}. It seems reasonable that they might form in regions of diameter 1000 AU and mass 0.01 $M_\odot$. Our data also show differences between the distribution of methanol and that of other species which suggest large spatial variations in the methanol abundance. In particular, we see evidence for high methanol column density towards the submm continuum source DR21(OH)-MM1. In the western lobe of the DR 21 outflow, the thermal methanol emission appears to be "sandwiched" between vibrationally excited H_2 emission, tracing the outflow shock front, and CS emission tracing the dense ambient medium. This is consistent with the idea that methanol can be enhanced in shock regions, where the outflow impinges on the surrounding dense molecular clumps, releasing methanol from dust grain ice mantles.

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Thermal H_2O emission from the Herbig-Haro flow HH 54

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The first detection of thermal water emission from a Herbig-Haro object is presented. The observations were performed with the LWS (Long Wavelength Spectrograph) aboard ISO (Infrared Space Observatory). Besides H_2O, rotational lines of CO are present in the spectrum of HH 54. These high-J CO lines are used to derive the physical model parameters of the FIR (far-infrared) molecular line emitting regions. This model fits simultaneously the observed OH and H_2O spectra for an OH abundance $X(\mathrm{OH}) = 10^{-6}$ and a water vapour abundance $X(\mathrm{H_2O}) = 10^{-5}$.

At a distance of 250 pc, the total CO, OH and H_2O rotational line cooling rate is estimated to be $1.3\,10^{-2}\,\mathrm{L_\odot}$, which is comparable to the mechanical luminosity generated by the $10\,\mathrm{km\,s^{-1}}$ shocks, suggesting that practically all of the cooling of the *weak-shock* regions is done by these three molecular species alone.

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Gravitational Contraction of Rotating Clouds: Formation of Self-Similarly Collapsing Disks

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We investigate isothermal gravitational collapse of rotating interstellar clouds with axisymmetric numerical simulations. The simulations show that a filamentary cloud fragments owing to the gravitational instability and the fragment evolves into a dynamically contracting disk. The disk contraction is followed until the central density increases by a factor 10^{16} at most. The disk evolution shows similarity; the disk structure at a given time is similar to that at another time except for the scale. We construct various models changing the wavelength of the perturbation and the initial rotation velocity, and study the dependences of the disk evolution on these model parameters. The surface density of the disk is proportional to the square of the sound speed, $\Sigma \propto {c_s}^2$ and almost independent of the wavelength of the perturbation imposed, i.e., the mass contained in the fragment. It indicates that the mass of the gravitationally contracting disk is independent of the parent cloud mass. When the initial cloud rotates slowly, the dense part of the fragment is nearly spherical in the early contraction phase and evolves into a disk. When the initial cloud rotates fast, the fragment has a disk shape from the early contraction phase. In the late contraction phase, the surface density and the rotation velocity depend not strongly on the initial rotation velocity and weakly on it when it is small. Although the disk evolution is well understand by similarity collapse, it shows an oscillation around similarity collapse. A new shock wave forms each cycle of oscillation.

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http://www.a.phys.nagoya-u.ac.jp/cgi-bin/matsu/preprint.pl?e

The OMC-1 molecular hydrogen outflow as a fragmented stellar wind bubble

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We present new images of the OMC-1 molecular hydrogen outflow, made using long-slit spectroscopy in order to accurately subtract the underlying continuum emission. These images reveal an extremely clumpy, quasi-spherical inner shell that breaks up at larger radii into bow-shocks and trailing wakes in the north-west, as originally described by Allen & Burton (1993); a fainter counter-finger to the south-east is newly discovered in the present data. While the outflow appears to be broadly bipolar, this is probably due to an interaction between an initially spherical wind from the source and a large-scale density enhancement surrounding it, rather than direct collimation imposed close to the source. The clumpy appearance of the inner shell confirms the prediction of the recent model of Stone, Xu, & Mundy (1995), in which a spherical and time-varying wind fragments a swept-up shell, producing high-velocity shrapnel, which in turn drives bow-shocks into the surrounding gas, resulting in the observed "fingers". As an alternative to the single varying source proposed by Stone et al, we speculate that several young sources in the BN-KL cluster may have been responsible for first sweeping up the shell and then fragmenting it.

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(A preprint version of this paper may be obtained via World Wide Web. Connect to
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and follow the relevant links to this paper.)

BIMA Array Observations of the 107 GHz Methanol Masers in Cepheus A

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BIMA Array observations of the 107 GHz CH_3OH masers in the Cep A star-forming region have been carried out with $2''$ resolution. These are the first interferometric observations of 107 GHz CH_3OH masers. Two masers were observed. They are both projected near (200 and 500 AU) an ultracompact H II region/radio jet, confirming that they are class II masers. While the 107 GHz masers are positionally coincident with the 12.2 GHz CH_3OH masers to within the uncertainties, these two maser groups (both of which belong to class II) are at different velocities indicating that they are not cospatial. This suggests that the pumping requirements of 12.2 and 107 GHz masers are slightly different, and therefore suggests that these masers reside in regions with slightly different physical characteristics.

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Preprints available at http://socrates.caltech.edu/∼dmehring/preprints/cep_a.ps

The Initial Stages of an HH Jet/Cloud Core Collision

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We have chosen a reduced set of 18 ionization rate equations (for ions of H, C, N, O, S and Ne), which allow us to obtain a moderately accurate estimate of the non-equilibrium radiative cooling function. We evaluate the accuracy of this approach by comparing our cooling function with previous calculations, computed with a more extended set of ions, for the case of gas that cools from a high temperature at constant density. We also compute steady, plane shock models, which we find to compare well with models calculated with much more detailed microphysics.

Using our reduced set of rate equations, we present a simulation of a radiative bow shock formed by a supersonic, plane stream impinging on a rigid sphere. The parameters for the calculation are chosen as to approximately represent typical values found for Herbig-Haro objects, and to give a cooling distance to bow shock radius ratio of 1/10. This

simulation is done with an adaptive grid code, which allows a reasonably high resolution (with ≥ 25 points) of the standoff distance between the bow shock and the rigid obstacle.

Contrary to the standard expectation, we find that the bow shock standoff distance in the stagnation region is considerably shorter than the cooling distance behind a plane-parallel shock. Also, the centrifugal pressure is found to play an important role in determining the structure of the recombination region. This appears to partially invalidate previous bow shock models based on a "quasi-1D" approach, at least for the particular parameters chosen for the present simulation.

Finally, we present tabulations of the cooling rates that have been used (for the different species), in order to facilitate the inclusion of this treatment in other gasdynamic codes.

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First results from the ISOCAM parallel mode

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We present first results of a survey being made in a broad-band 6.75 μm filter using the ISOCAM infrared camera in its parallel mode at ~ 6" resolution. So far we have analysed a sky area of ~ 1.375 deg^2 down to a limiting flux of 5 mJy and detected a total of 287 objects. The final survey will cover a sky area of ~ 33 deg^2, most of which will be done in staring mode, to which we have restricted ourselves in the present paper. The final catalogue should reach a typical sensitivity limit of ~ 1 mJy. We estimate that at the detection limit 99% of the objects will have a galactic origin.

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The article is available on: http://isowww.estec.esa.nl:80/ISO/AandA/rs.html

High Resolution Infrared Observations of GGD 27

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We present new high spatial resolution data of the GGD 27 complex, obtained both by speckle interferometry and lunar occultation observations. Additionally, we performed imaging in the wavelength intervals of 8-9μm and 10-13μm. The combination of these data with earlier VLA radio maps of Marti, Rodríguez and Reipurth (1993) yields new hints on the nature of IRS7 (the labeling of infrared sources in this paper follows Tamura et al. 1991). It also confirms the interpretation by Aspin et al. (1991 and 1994) that their GGD27-ILL is the illuminator of as well of the reflection nebula north of IRS2 as of IRS2 itself. By using precise astrometric calibration, we show that IRS7 is detected at all three wavelengths and presumably is an embedded B2 star. IRS1 and IRS17 still appear point-like in the K-band, although the 8.5μm data suggest some extended emission around IRS1, which is suggested to be caused by heated dust. Other objects in the region targeted by lunar occultation observations, as HL17, HL47 (from Hartigan and Lada 1985) and a hitherto anonymous star, hereafter denoted as no. 11, also appear point-like in the K' band. These data

complete our picture of the formation of massive stars in the region of GGD 27.

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ftp://georg.astro.uni-jena.de/pub/stecklum/ggd27-revised.ps.Z

Properties of Vega-like systems – II. Radiative transfer modelling

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Vega-like stars are main sequence stars that exhibit excess infrared emission due to dust grains which are believed to be distributed in circumstellar discs. We have recently published a new observational database for a large sample of candidate Vega-like systems, comprising optical, near-infrared, and mm/submm-wave photometry, and mid-infrared spectra. This paper presents radiative-transfer models of eight of our sources, calculated using an optically-thin code. For some of the sources the observations were unable to constrain the models successfully, while for those with larger fractional excess luminosities, we were able to determine the parameters of the dust discs. Dust masses for the well-constrained models lay in the range (1–70)E−7 Solar masses – considerably less than the derived masses for pre-main sequence discs. The grain-size distributions favoured smaller grains, as is generally found for interstellar and Solar system dust. Large (∼1 mm) grains were found to be abundant around SAO 179815 (HD 98800), but not around SAO 112630 and SAO 140789. The disc densities were found to fall off steeply with distance from the central stars. The derived inner radii of the discs varied from approximately one to several hundred AU.

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Dissertation Abstracts

Observations of Disks Around Pre–Main-Sequence Binary Stars

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This work is an observational study of disks around low-mass, pre–main-sequence binary stars. Its purpose is to study the extent of binary-disk interactions and to determine whether binaries modify the structure of their associated disks.

We present 800 μm continuum photometry of pre–main-sequence binary stars with projected separations $a_p < 150$ AU in the Scorpius-Ophiuchus and Taurus-Auriga star-forming regions. Combining our observations with published 1300 μm continuum photometry, we find that binaries with $1 < a_p < 50$–100 AU have lower submillimeter continuum fluxes than wider binaries or single stars with a confidence level of greater than 99%, implying reduced disk masses. Thus, binary companions with separations less than 50–100 AU significantly influence the nature of associated disks. A simple model suggests that large gaps in disks with surface densities typical of wide-binary or single-star disks can reduce submillimeter fluxes to levels consistent with the observed limits. This model shows that the present submillimeter flux upper limits do not necessarily imply a large reduction in disk surface densities outside of cleared gaps. *IRAS* 60 μm fluxes show that most binaries have at least one circumstellar disk, with typical lower limits of $M_{\rm disk} = 10^{-5}\ M_\odot$. Thus, circumstellar disk surface densities are no more than two orders of magnitude smaller than those of typical disks around single stars. Our upper limits on submillimeter fluxes place upper limits of 0.005 $M_\odot$ on circumbinary disk masses among binaries with $1 < a_p < 50$–100 AU; however, circumbinary disks are found around some binaries with separations less than a few AU.

We then present $\lambda = 1.3$ and 3 mm aperture synthesis imaging of the multiple T Tauri system UZ Tauri. UZ Tau is a hierarchical quadruple composed of a sub-AU spectroscopic binary, UZ Tau E, 530 AU distant from a 50 AU binary, UZ Tau W. Both dust and gas emission from the 50 AU binary are at least a factor of four lower than from the spectroscopic binary. Since UZ Tau E and W have similar stellar masses, luminosities, and ages, we conclude that the mass of dust and gas associated with UZ Tau W is reduced solely by the influence of a companion with a separation comparable to a typical disk radius. The disk emission from UZ Tau E is similar to that from single T Tauri stars. In a $1''$-resolution aperture synthesis map, CO (2→1) emission is elongated with a size of 300 AU; a disk model fit to the continuum spectral energy distribution yields a disk mass of 0.06 $M_\odot$, larger than the "minimum mass solar nebula". In contrast, no CO emission is detected from UZ Tau W, and its 1.3 mm continuum emission is unresolved in a $1''$ (FWHM) beam (corresponding to a 70 AU radius). The small extent of the emission and dynamical considerations imply that the 50 AU binary cannot be surrounded by any appreciable circumbinary disk; its mm-wave emission is from circumstellar disks around one or both components with masses in the range of 0.002–0.04 $M_\odot$.

Finally, we present a study of disk clearing by pre–main-sequence binaries with separations less than 1 AU. Several binaries have spectral energy distributions (SEDs) with little or no infrared excess at $\lambda = 1$–5 μm, requiring that their inner disks be optically thin. In each case the inferred size of the cleared region is comparable to a few times the binary semimajor axis as predicted by theories of binary-disk interactions. Other binaries show large near- and mid-infrared excesses, with little evidence of cleared regions in their disks. The infrared excesses in these binaries can be reproduced by a model in which a gap is cleared by the binary but is partially filled with very low-surface-density dust; this hot, optically-thin dust also reproduces the 9.8 μm silicate emission features observed in two of these systems. Thus, all binaries studied show SEDs which are consistent with the presence of partially- or wholly-cleared regions in their disks at the locations predicted by theories of binary-disk interactions, though in some cases disk clearing is not required by the SED structure. The common presence of near-infrared excesses indicates that circumstellar material either is not rapidly depleted in close binaries or is replenished from outside the binary orbit. Many of the binaries also have circumbinary disks that have sufficient mass to drive significant orbital evolution during the binaries' pre–main-sequence lifetimes.

New Books

The role of dust in the formation of stars

Edited by H.U. Käufl and R. Siebenmorgen

This book, which is published in the early phase of ESA's Infrared Space Observatory mission, provides for a comprehensive summary of the knowledge in this field of astronomy. In a series of invited review talks and numerous contributed papers the role of dust in the formation of stars is described and discussed.

Dust is ubiquitous in star forming regions, protostars, young stellar objects and stars in various pre-main sequence stages up to perfectly 'normal' main sequence stars. Consequently the authors address the topic from rather different viewpoints. Observers describe and analyze signatures of dust in the entire electromagnetic spectrum from the radio to the ultra-violett. Successful modelling of these signatures with radiative transfer codes is demonstrated for a great variety of sources. Astrophysical laboratory researchers report on studies of synthetic prototype samples of interstellar dust. Other topics covered in this book are e.g. dust processing, dust agglomeration, dust coupling to the magnetic field or dust electric charging. Moreover the reader will learn about dust chemical composition, gas-phase chemistry and photo-chemistry. From a mostly theoretical viewpoint the role of dust as a catalytic agent for star formation is described in great detail.

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