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Abstracts of recently accepted papers

Migration of Extrasolar Planets: Effects from X-Wind Accretion Disks

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Magnetic fields are dragged in from the interstellar medium during the gravitational collapse that forms star/disk systems. Consideration of mean field magnetohydrodynamics (MHD) in these disks shows that magnetic effects produce subkeplerian rotation curves and truncate the inner disk. This letter explores the ramifications of these predicted disk properties for the migration of extrasolar planets. Subkeplerian flow in gaseous disks drives a new migration mechanism for embedded planets and modifies the gap opening processes for larger planets. This subkeplerian migration mechanism dominates over Type I migration for sufficiently small planets ($m_P \leq 1 M_{Earth}$) and/or close orbits ($r \leq 1$AU). Although the inclusion of subkeplerian torques shortens the total migration time by only a moderate amount, the mass accreted by migrating planetary cores is significantly reduced. Truncation of the inner disk edge (for typical system parameters) naturally explains final planetary orbits with periods $P \sim 4$ days. Planets with shorter periods $P \sim 2$ days can be explained by migration during FU-Ori outbursts, when the mass accretion rate is high and the disk edge moves inward. Finally, the midplane density is greatly increased at the inner truncation point of the disk (the X-point); this enhancement, in conjunction with continuing flow of gas and solids through the region, supports the in situ formation of giant planets.

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First Spectroscopic Identification of Massive Young Stellar Objects in the Galactic Center

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We report the detection of several molecular gas-phase and ice absorption features in three photometrically-selected young stellar object (YSO) candidates in the central 280 pc of the Milky Way. Our spectra, obtained with the Infrared Spectrograph (IRS) onboard the *Spitzer Space Telescope*, reveal gas-phase absorption from CO_2 (15.0μm), C_2H_2 (13.7μm) and HCN (14.0μm). We attribute this absorption to warm, dense gas in massive YSOs. We also detect strong and broad 15μm CO_2 ice absorption features, with a remarkable double-peaked structure. The prominent long-wavelength peak is due to CH_3OH-rich ice grains, and is similar to those found in other known massive YSOs. Our IRS observations demonstrate the youth of these objects, and provide the first spectroscopic identification of massive YSOs in the Galactic Center.

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Episodic accretion at early stages of evolution of low mass stars and brown dwarfs: a solution for the observed luminosity spread in HR diagrams?

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We present evolutionary models for young low mass stars and brown dwarfs taking into account episodic phases of accretion at early stages of the evolution, a scenario supported by recent large surveys of embedded protostars. An evolution including short episodes of vigorous accretion ($\dot{M} \geq 10^{-4} M_\odot \mathrm{yr}^{-1}$) followed by longer quiescent phases ($\dot{M} < 10^{-6} M_\odot \mathrm{yr}^{-1}$) can explain the observed luminosity spread in HR diagrams of star forming regions at ages of a few Myr, for objects ranging from a few Jupiter masses to a few tenths of a solar mass. The gravitational contraction of these accreting objects strongly departs from the standard Hayashi track at constant $T_{\rm eff}$. The best agreement with the observed luminosity scatter is obtained if most of the accretion shock energy is radiated away. The obtained luminosity spread at 1 Myr in the HR diagram is equivalent to what can be misinterpreted as a $\sim$ 10 Myr age spread for non-accreting objects. We also predict a significant spread in radius at a given $T_{\rm eff}$, as suggested by recent observations. These calculations bear important consequences on our understanding of star formation and early stages of evolution and on the determination of the IMF for young ($\leq$ a few Myr) clusters. Our results also show that the concept of a stellar birthline for low-mass objects has no valid support.

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http://stacks.iop.org/1538-4357/702/L27 and http://arxiv.org/pdf/0907.3886

Multiple low-turbulence starless cores associated with intermediate- to high-mass star formation

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Context: Characterizing the gas and dust properties prior to and in the neighborhood of active intermediate- to high-mass star formation.
Methods: Two Infrared Dark Clouds (IRDCs) – IRDC 19175-4 and IRDC 19175-5 – that are located in the vicinity of the luminous massive star-forming region IRAS 19175+1357, but that remain absorption features up to 70 μm wavelength, were observed with the Plateau de Bure Interferometer in the 3.23 mm dust continuum as well as the N_2H^+(1–0) and ^{13}CS(2–1) line emission.
Results: While IRDC 19175-4 is clearly detected in the 3.23 mm continuum, the second source in the field, IRDC 19175-5, is only barely observable above the 3σ continuum detection threshold. However, the N_2H^+(1–0) observations reveal

17 separate sub-sources in the vicinity of the two IRDCs. Most of them exhibit low levels of turbulence ($\Delta v \leq 1\,\mathrm{km\,s^{-1}}$), indicating that the fragmentation process in these cores may be dominated by the interplay of thermal pressure and gravity, but not so much by turbulence. Combining the small line widths with the non-detection up to $70\,\mu$m and the absence of other signs of star formation activity, most of these 17 cores with masses between sub-solar to $\sim$10 $\mathrm{M_\odot}$ are likely still in a starless phase. The N_2H^+ column density analysis indicates significant abundance variations between the cores. Furthermore, we find a large CS depletion factor of the order 100. Although the strongest line and continuum peak is close to virial equilibrium, its slightly broader line width compared to the other cores is consistent with it being in a contraction phase potentially at the verge of star formation. Based on the 3.23 mm upper limits, the other cores may be gravitationally stable or even transient structures. The relative peak velocities between neighboring cores are usually below $1\,\mathrm{km\,s^{-1}}$, and we do not identify streaming motions along the filamentary structures. Average densities are between 10^5 and $10^6\,\mathrm{cm^{-3}}$ (one to two orders of magnitude larger than for example in the Pipe nebula) implying relatively small Jeans-lengths that are consistent with the observed core separations of the order 5000 AU. Environmental reasons potentially determining these values are discussed.
Conclusions: These observations show that multiple low- to intermediate-mass low-turbulence starless cores can exist in the proximity of more turbulent active intermediate- to high-mass star-forming regions. While masses and levels of turbulence are consistent with low-mass starless core regions, other parameters like the densities or Jeans-lengths differ considerably. This may be due to environmental effects. The quest for high-mass starless cores prior to any star formation activity remains open.

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http://www.mpia.de/homes/beuther/papers.html

A Spatial Study of the Mid-IR Emission Features in Four Herbig Ae/Be Stars

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Context. Infrared (IR) spectroscopy and imaging provide a prime tool to study the characteristics of polycyclic aromatic hydrocarbon (PAH) molecules and the mineralogy in regions of star formation. Herbig Ae/Be stars are known to have varying amounts of natal cloud material present in their vicinity.
Aims. Our aim is to study the characteristics of the mid-IR emission originating in Herbig Ae/Be stars, especially the extent of the emission and how this relates to the (proto-)stellar characteristics.
Methods. Today's powerful ground- and space-based telescopes provide images and spectra at unprecedented spectral and spatial resolution. We analyse the images and spectra from four Herbig Ae/Be stars (IRAS 06084-0611 , CD-42 11721 , TY CrA , and HD 176386), as obtained with TIMMI2 on the ESO 3.6 m telescope and VISIR on the VLT. These observations are supplemented with data from ISO-SWS and Spitzer-IRAC.
Results. We find evidence for large-scale structure and extended emission in all four sources, except for HD 176386, which only shows silicate emission, all sources show PAH emission in their spectra. In addition, a spatially resolved silicate and PAH spectrum could be extracted for TY CrA.
Conclusions. The variety in emission scales distinguishes two classes. In the first, the morphology and spectral characteristics resemble those of reflection nebulae. In the second, the characteristics are in-line with Herbig A stars. This separation simply reflects a difference in stellar characteristics (e.g. luminosity). In Herbig B stars, dust emission from the surroundings dominates, where for Herbig A stars, the disk dominates the emission. In this scheme, IRAS 06084-0611 and CD-42 11721 resemble reflection nebulae and HD 176386 a more typical Herbig Ae/Be star. TY CrA shows characteristics common to both genuine reflection nebulae and Herbig B stars. We propose a geometry for TY

CrA, with most notably, a ∼70 AU inner gap in the 340 AU circumtertiary disk cleared by a fourth stellar companion.

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Evidence of warm and dense material along the outflow of a high-mass YSO

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Context. Outflow cavities in envelopes of young stellar objects (YSOs) have been predicted to allow far-UV (FUV) photons to escape far from the central source, with significant observable effects, especially if the protostar is a forming high-mass star suspected of emitting a copious amount of FUV radiation. Indirect evidence of this picture has been provided by models and unresolved single-dish observations, but direct high-resolution data are necessary for confirmation. Previous chemical modeling has suggested that CS and HCN are good probes of the local FUV field, so make good target species.
Aims. We directly probe the physical conditions of the material in the outflow walls to test this prediction.
Methods. Interferometric observations of the CS(7-6) and HCN(4-3) rotational lines in the high-mass star-forming region AFGL 2591 are carried out in the compact and extended configuration of the SubMillimeter Array (SMA). The velocity structure was analyzed, and integrated maps compared to K-band near-IR observations. A chemical model predicts abundances of CS and HCN for a gas under protostellar X-ray and FUV irradiation, and was used in conjunction with the data to distinguish between physical scenarios.
Results. CS and HCN emission was found in spatial coincidence in extended sources displaced up to $7''$ from the position of the young star. Their line widths are small, excluding major shocks. Chemical model calculations predict an enhanced abundance of the two molecules in warm, dense, and FUV irradiated gas. Hot dust observed between the molecular emission and the outflow accounts for the necessary attenuation to prevent photodissociation of the molecules.
Conclusions. The SMA data suggest that the outflow walls are heated and chemically altered by the FUV emission of the central high-mass object, providing the best direct evidence yet of large-scale direct irradiation of outflow walls.

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http://www.astro.phys.ethz.ch/staff/simonbr/sma-letter.pdf

Turbulent Driving Scales in Molecular Clouds

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Context. Supersonic turbulence in molecular clouds is a dominant agent that strongly affects the clouds' evolution and star formation activity. Turbulence may be initiated and maintained by a number of processes, acting at a wide range of physical scales. By examining the dynamical state of molecular clouds, it is possible to assess the primary candidates for how the turbulent energy is injected.
Aims. The aim of this paper is to constrain the scales at which turbulence is driven in the molecular interstellar medium, by comparing simulated molecular spectral line observations of numerical magnetohydrodynamic (MHD) models and molecular spectral line observations of real molecular clouds.
Methods. We use principal component analysis, applied to both models and observational data, to extract a quantitative measure of the driving scale of turbulence.
Results. We find that only models driven at large scales (comparable to, or exceeding, the size of the cloud) are

consistent with observations. This result applies also to clouds with little or no internal star formation activity.
Conclusions. Astrophysical processes acting on large scales, including supernova-driven turbulence, magnetorotational instability, or spiral shock forcing, are viable candidates for the generation and maintenance of molecular cloud turbulence. Small scale driving by sources internal to molecular clouds, such as outflows, can be important on small scales, but cannot replicate the observed large-scale velocity fluctuations in the molecular interstellar medium.

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The Physical Conditions in Gomez's Hamburger (IRAS 18059-3211), a Pre-MS Rotating Disk

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Aims. We aim to study the structure, dynamics, and physical conditions of Gomez's Hamburger (IRAS 18059-3211; GoHam), and in particular confirm that GoHam mainly consists of a flaring disk in Keplerian rotation around a young, probably pre-MS star.
Methods. We present high resolution SMA maps of ^{12}CO J = 2-1, ^{13}CO J = 2-1, ^{12}CO J = 3-2, and C^{17}O J = 3-2, as well as data on ^{12}CO J = 6-5 and the continuum flux at these wavelengths. Spatial resolutions as high as $1''$ are attained. Except for the C17O data, the dynamical ranges are larger than 10. The maps are compared with a numerical model, which simulates the emission of a rotating disk with the expected general properties of such objects, and a very satisfactory fitting of our maps is obtained. The meaning and reliability of our results are thoroughly discussed.
Results. Our observations allow measurement of the main properties of GoHam on scales of between $\sim 1''$($\sim$5 $\times$ 10^{15} cm, for the assumed distance, 300 pc) and the total extent of the nebula, $14''$. We are able to measure the global structure of the gas-rich disk, which is found to be flaring, and its dynamics, which is clearly dominated by Keplerian rotation, with a small degree of turbulence. The combination of different lines, in particular of different opacities, allows us to estimate reasonably the distributions of gas temperature and density. We clearly find a significant and sharp increase in temperature at large distances from the equator, accompanied by a decrease in density of the same order. Finally, we identify a condensation in the southern part of the disk that has no counterparts in the northern nebula. This condensation is quite extended (about 5 $\times$ 10^{15} cm), contains a significant amount of mass (roughly, $\sim$ 6 $\times$ 10^{-3} $M_\odot$), and seems to be associated with a detectable distortion of the global rotation kinematics. We discuss several possible interpretations of that feature.

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Measuring anti-clustering in triggered star formation

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Statistical methods for quantifying clustering have not been tested against anti-clustered data. Here we investigate the performance of the normalised correlation length and $\mathcal{Q}$ when applied to anti-clustered data, both simulated and recently published observations. The normalised correlation length successfully distinguishes anticlustered data in simulations and indicates anticlustering in an area where it is speculated that triggered star formation has occurred. The existence of radial anticlustering can cause the $\mathcal{Q}$ clustering analysis method to malfunction. Users of $\mathcal{Q}$ should therefore use the normalised correlation length to rule out anticlustering before applying $\mathcal{Q}$.

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Deep JHK_S and *Spitzer* Imaging of Four Isolated Molecular Cloud Cores

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We present observations in eight wavebands from 1.25 to 24 μm of four dense cores: L204C-2, L1152, L1155C-2, and L1228. Our goals are to study the young stellar object (YSO) population of these cores and to measure the mid-infrared extinction law. With our combined near-infrared and *Spitzer* photometry, we classify each source in the cores as, among other things, background stars, galaxies, or embedded YSOs. L1152 contains three YSOs and L1228 has seven, but neither L204C-2 nor L1155C-2 appear to contain any YSOs. We estimate an upper limit of 7×10^{-5} to 5×10^{-4} $L_\odot$ for any undiscovered YSOs in our cores. We also compute the line-of-sight extinction law toward each background star. These measurements are averaged spatially, to create χ^2 maps of the changes in the mid-infrared extinction law throughout our cores, and also in different ranges of extinction. From the χ^2 maps, we identify two small regions in L1152 and L1228 where the outflows in those cores appear to be destroying the larger dust grains, thus altering the extinction law in those regions. On average, however, our extinction law is relatively flat from 3.6 to 24 μm for all ranges of extinction and in all four cores. From 3.6 to 8 μm, this law is consistent with a dust model that includes larger dust grains than the diffuse interstellar medium, which suggests grain growth has occurred in our cores. At 24 μm, our extinction law is two to four times higher than predicted by dust models. However, it is similar to other empirical measurements.

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The H_2 velocity structure of inner knots in HH 212 : asymmetries and rotation

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High-resolution R$\sim$50 000 long-slit spectroscopy of the inner knots of the highly symmetrical protostellar outflow HH 212 was obtained in the 1-0 S(1) line of H_2 at 2.12 μm with a spatial resolution of $\sim 0\farcs45$. At the resulting velocity resolution of $\sim 6\,\mathrm{km\,s^{-1}}$, multiple slit oriented observations of the northern first knot NK1 clearly show double-peaked line profiles consistent with either a radiative bow shock or dual (forward and reverse) shocks. In contrast, the velocity distribution of the southern first knot SK1 remains single-peaked, suggesting a significantly lower jet velocity and possibly a different density variation in the jet pulses in the southern flow compared to the northern flow. Comparison with a semi-empirical analytical model of bow shock emission allows us to constrain parameters such as the bow inclination to the line of sight, the bow shock and jet velocities for each flow. Although a few features are not reproduced by this model, it confirms the presence of several dynamical and kinematical asymmetries between opposite sides of the HH 212 bipolar jet. The position-velocity diagrams of both knots exhibit complex dynamics that are broadly consistent with emission from a bow shock and/or jet shock, which does not exclude jet rotation, although a clear signature of jet rotation in HH 212 is missing. Alternative interpretations of the variation of radial velocity across these knots, such as a variation in the jet orientation, as well as for the velocity asymmetries between the flows, are also considered. The presence of a correlation between flow velocity and collimation in each flow is suggested.

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Physical structure and water line spectrum predictions of the Intermediate Mass protostar OMC2-FIR4

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Aims. Intermediate Mass (IM) stars are an important component of our Galaxy, as they significantly contribute to the interstellar FUV field and, consequently, play an important role in the energy balance of the ISM. Despite their importance, very little is known about their formation process and only a few studies have been devoted to characterize the first phases in the evolution of intermediate mass protostars. Here we consider in great detail the case of the brightest and closest known young IM protostar: FIR4 in the OMC2 component of the Orion molecular cloud complex.
Methods. We analyzed the available continuum emission (maps and SED) through one-dimensional dust radiative transfer calculations. We ran large grids of models to find the envelope model that best fits the data. The derived dust density and temperature profiles have been then used to compute the gas temperature profile, equating gas cooling and heating terms across the envelope. Last, we computed the water line spectrum for various possible values of water abundance.
Results. The luminosity of FIR4 has been reevaluated to 1000 $L_\odot$, making FIR4 definitively an Intermediate Mass protostar. The envelope surrounding FIR4 has a relatively shallow density power law index, ~ 0.6. The most surprising result is that the gas and dust are thermally decoupled in the interior of the envelope, where the dust ices sublimate at 100 K. This has important consequences in the interpretation of the line data. We provide the predictions for the water spectrum, and discuss in detail the lines which will be observed by the Herschel Space Observatory .

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Multi-color Optical Survey of the Orion Nebula Cluster. I. The Catalog

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We present U, B, V, I broadband, 6200 Å TiO mediumband, and Hα narrowband photometry of the Orion Nebula Cluster (ONC) obtained with the WFI imager at the ESO/MPI 2.2 telescope at La Silla Observatory. The nearly simultaneous observations cover the entire ONC in a field of about 34×34 arcmin. They enable us to determine stellar colors avoiding the additional scatter in the photometry induced by stellar variability typical of pre-main-sequence stars. We identify 2612 point-like sources in the I band; 58%, 43%, and 17% of them are also detected in V, B, and U, respectively. 1040 sources are identified in the Hα band. In this paper we present the observations, the calibration techniques adopted, and the resulting catalog. We show the derived color-magnitude diagram of the population and discuss the completeness of our photometry. We define a spectrophotometric TiO index that takes into account the fluxes in the V, I, and TiO bands. Comparing it with spectral types of ONC members in the literature, we find a correlation between the index and the spectral type valid for M-type stars, which is accurate to better than 1 spectral subclass for M3-M6 types and better than 2 spectral subclasses for M0-M2 types.. This allows us to newly classify 217 stars. In a similar way, we subtract from our Hα photometry the photospheric continuum at its wavelength, deriving calibrated line excess for the full sample. This represents the largest Hα star catalog obtained to date on the ONC. This data set enables a full re-analysis of the properties of the pre-main-sequence population in the Orion Nebula

Cluster to be presented in an accompanying paper.

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Hierarchical Star Formation in the Milky Way Disk

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Hierarchical star formation leads to a progressive decrease in the clustering of star clusters both in terms of spatial scale and age. Consistently, statistical analysis of the positions and ages of clusters in the Milky Way disk strongly suggests that a correlation between the duration of star formation in a region and its size does exist. The average age difference between pairs of open clusters increases with their separation as the ∼0.16 power. In contrast, for the Large Magellanic Cloud, Efremov & Elmegreen found that the age difference scales with the ∼0.35 power of the region size. This discrepancy may be tentatively interpreted as an argument in support of intrinsically shorter (faster) star formation timescales in smaller galaxies. However, if both the effects of cluster dissolution and incompleteness are taken into consideration, the average age difference between cluster pairs in the Galaxy increases with their separation as the ∼0.4 power. This result implies that the characteristic timescale for coherent, clustered-mode star formation is nearly 1 Myr. Therefore, the overall consequence of ignoring the effect of cluster dissolution is to overestimate the star formation timescale. On the other hand, in the Galactic disk and for young clusters separated by less than three times the characteristic cluster tidal radius (10 pc), the average age difference is 16 Myr, which suggests common origin. A close pair classification scheme is introduced and a list of 11 binary cluster candidates with physical separation less than 30 pc is compiled. Two of these pairs are likely primordial: ASCC 18/ASCC 21 and NGC 3293/NGC 3324. A triple cluster candidate in a highly hierarchical configuration is also identified: NGC 1981/NGC 1976/Collinder 70 in Orion. We find that binary cluster candidates seem to show a tendency to have components of different sizeevidence for dynamical interaction.

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Hierarchical Star Formation: Stars and Stellar Clusters in the Gould Belt

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We perform a study of the spatial and kinematical distribution of young open clusters in the solar neighbourhood, discerning between bound clusters and transient stellar condensations within our sample. Then, we discriminate between Gould Belt (GB) and local Galactic disc (LGD) members, using our previous estimate of the structural parameters of both systems obtained from a sample of O-B6 Hipparcos stars. Single membership probabilities of the clusters are also calculated in the separation process. Using this classified sample, we analyse the spatial structure and the kinematic behaviour of the cluster system in the GB. The two star formation regions that dominate and give the GB its characteristic-inclined shape show a striking difference in their content of star clusters: while Ori OB1 is richly populated by open clusters, not a single one can be found within the boundaries of Sco OB2. This is mirrored in the velocity space, translating again into an abundance of clusters in the region of the kinematic space populated by the members of Ori OB1, and a marginal number of them associated with Sco OB2. We interpret all these differences by characterizing the Orion region as a cluster complex typically surrounded by a stellar halo, and the Sco-Cen region as an OB association in the outskirts of the complex. In the light of these results, we study the nature of the GB with respect to the optical segment of the Orion Arm, and we propose that the different content of star clusters, the different heights over the Galactic plane and the different residual velocities of Ori OB1 and Sco OB2 can be explained in terms of their relative position to the density maximum of the Local Arm in the solar neighbourhood. Although morphologically intriguing, the GB appears to be the result of our local and biased view of a larger star

cluster complex in the Local Arm, that could be explained by the internal dynamics of the Galactic disc.

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Evidence for Dust Evolution Within the Taurus Complex from Spitzer Images

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We present *Spitzer* images of the Taurus Complex (TC). We take advantage of the sensitivity and the spatial resolution of the observations to characterize the diffuse infrared (IR) emission across the cloud. This work highlights evidence of dust evolution within the translucent sections of the archetype reference for studies of quiescent molecular clouds. We combine the *Spitzer* 160 μm and IRAS 100 μm observations to produce a dust temperature map and a far-IR (FIR) dust opacity map at $5'$ resolution. The average dust temperature is about 14.5 K with a dispersion of ±1 K across the cloud. The FIR dust opacity is tightly correlated with the extinction derived from Two Micron All Sky Survey stellar colors and is a factor of 2 larger than the average value for the diffuse interstellar medium. This opacity increase and the attenuation of the radiation field both contribute to account for the lower emission temperature of the large grains. The structure of the TC significantly changes in the mid-IR (MIR) images that trace emission from polycyclic aromatic hydrocarbons (PAHs) and very small grains (VSGs). We focus our analysis of the MIR emission to a range of ecliptic latitudes away from the zodiacal bands and where the zodiacal light residuals are small. Within this cloud area, there are no 8 and 24 μm counterparts to the brightest 160 μm emission features. Conversely, the 8 and 24 μm images reveal filamentary structure that is strikingly inconspicuous in the 160 ?m and extinction maps. The IR colors vary over subparsec distances across this filamentary structure. We compare the observed colors with model calculations quantifying the impact of the radiation field intensity and the abundance of stochastically heated particles on the dust spectral energy distribution. To match the range of observed colors, we have to invoke variations by a factor of a few of both the interstellar radiation field and the abundance of PAHs and VSGs. We conclude that within this filamentary structure a significant fraction of the dust mass cycles in and out the small-size end of the dust size distribution.

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The Flared Inner Disk of the Herbig Ae Star AB Aurigae Revealed by VLTI/MIDI in the N-Band

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Aims. We aim at using the long baselines of the VLT Interferometer and the mid-IR combiner MIDI (8-13 μm) to

derive the morphology of the protoplanetary disk surrounding the Herbig Ae star AB Aurigae
Methods. We present the first N-band analysis of AB Aur performed with a maximum angular resolution of 17 mas (2.5 AU at the Taurus-Auriga distance). We used the radiative transfer code MC3D and a silicate-dominated dust grain mixture to fit the spectral energy distribution (SED), together with the N-band dispersed visibilities ($\lambda/\delta\lambda \sim 30$) and to constrain the inner-disk spatial structure.
Results. The silicate band is prominent in the $\sim$ 300 mas FOV of the MIDI instrument, the emission reaches 70 to 90% of the total flux measured by ISO. The circumstellar emission (CSE) is resolved even at the shortest baselines. The spectrally dispersed visibilities show a steep drop between 8 and 9.5 μm, followed by a plateau between 10 and 13 μm. Our modelling shows that the observed SED and visibilities can be reproduced with a simple passive disk model. For such a weakly inclined disk ($i \sim 30$ deg), the mid-IR visibilities can directly determine the flaring index, while the scale height can be subsequently and unambiguously derived from the combination of the spectral and interferometric constraints. The modelling yields typical values for the scale height of about 8 AU at a radial distance of 100 AU and a flaring index in the range 1.25-1.30 for the explored range of model input parameters.
Conclusions. The radial structure of the circumstellar inner disk around AB Aur is directly determined by MIDI. The radiative transfer modelling demonstrates the powerful synergy of interferometry and spectro-photometry to alleviate the degeneracy, which may hamper determining the disk morphology. Our analysis supports the classification of AB Aur among the flared disks of the first group in the Meeus classification.

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High Velocity Outflow in CO $J = 7 - 6$ from the Orion Hot Core

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Using the Caltech Submillimeter Observatory 10.4-meter telescope, we performed sensitive mapping observations of ^{12}CO $J = 7 - 6$ emission at 807 GHz towards Orion IRc2. The image has an angular resolution of 10 arcsec, which is the highest angular resolution data toward the Orion Hot Core published for this transition. In addition, thanks to the on-the-fly mapping technique, the fidelity of the new image is rather high, particularly in comparison to previous images. We have succeeded in mapping the northwest-southeast high-velocity molecular outflow, whose terminal velocity is shifted by $\sim 70 - 85$ km s^{-1} with respect to the systemic velocity of the cloud. This yields an extremely short dynamical time scale of $\sim$900 years. The estimated outflow mass loss rate shows an extraordinarily high value, on the order of 10^{-3} $M_\odot$ yr^{-1}. Assuming that the outflow is driven by Orion IRc2, our result agrees with the picture so far obtained for a 20 $M_\odot$ (proto)star in the process of formation.

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Preprint is available at http://subarutelescope.org/staff/rsf/publication.html

Revealing the Structure of a Pre-Transitional Disk: The Case of the Herbig F Star SAO 206462 (HD 135344B)

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SAO 206462 (HD 135344B) has previously been identified as a Herbig F star with a circumstellar disk with a dip in its infrared excess near 10 μm. In combination with a low accretion rate estimated from Br γ, it may represent a gapped, but otherwise primordial or "pre-transitional" disk. We test this hypothesis with Hubble Space Telescope coronagraphic imagery, FUV spectroscopy and imagery and archival X-ray data, and spectral energy distribution (SED) modeling constrained by the observed system inclination, disk outer radius, and outer disk radial surface brightness (SB) profile using the Whitney Monte Carlo Radiative Transfer Code. The essentially face-on (i $<\sim 20°$) disk is detected in scattered light from 0.4″ to 1.15″ (56-160 AU), with a steep ($r^{-9.6}$) radial SB profile from 0.6″ to 0.93″. Fitting the SB data requires a concave upward or anti-flared outer disk, indicating substantial dust grain growth and settling by 8 $\pm$ 4 Myr. The warm dust component is significantly variable in near to mid-IR excess and in temperature. At its warmest, it appears confined to a narrow belt from 0.08 to 0.2 AU. The steep SED for this dust component is consistent with grains with $a \leq 2.5$ μm. For cosmic carbon to silicate dust composition, conspicuous 10 μm silicate emission would be expected and is not observed. This may indicate an elevated carbon to silicate ratio for the warm dust, which is not required to fit the outer disk. At its coolest, the warm dust can be fit with a disk from 0.14 to 0.31 AU, but with a higher inclination than either the outer disk or the gaseous disk, providing confirmation of the high inclination inferred from mid-IR interferometry. In tandem, the compositional and inclination difference between the warm dust and the outer dust disk suggests that the warm dust may be of second-generation origin, rather than a remnant of a primordial disk component. With its near face-on inclination, SAO 206462's disk is a prime location for planet searches.

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Star formation history of CMa R1: I. Wide-field X-ray study of the young stellar population

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The CMa R1 star-forming region contains several compact clusters as well as many young early-B stars. It is associated with a well-known bright rimmed nebula, the nature of which is unclear (fossil HII region or supernova remnant). To help elucidate the nature of the nebula, our goal was to reconstruct the star-formation history of the CMa R1 region, including the previously unknown older, fainter low-mass stellar population, using X-rays. We analyzed images obtained with the *ROSAT* satellite, covering $\sim$ 5 sq. deg. Complementary VRI photometry was performed with the *Gemini* South telescope. Colour-magnitude and colour-colour diagrams were used in conjunction with pre-main sequence evolutionary tracks to derive the masses and ages of the X-ray sources. The *ROSAT* images show two distinct clusters. One is associated with the known optical clusters near Z CMa, to which $\sim$ 40 members are added. The

other, which we name the "GU CMa" cluster, is new, and contains ~ 60 members. The *ROSAT* sources are young stars with masses down to $M_\star \sim 0.5 M_\odot$, and ages up to 10 Myr. The mass functions of the two clusters are similar, but the GU CMa cluster is older than the cluster around Z CMa by at least a few Myr. Also, the GU CMa cluster is away from any molecular cloud, implying that star formation must have ceased; on the contrary (as already known), star formation is very active in the Z CMa region.

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ftp://www.astro.iag.usp.br/pub/jane/cma/cmax_paper.pdf

Diagnostic Line Emission from EUV and X-ray Illuminated Disks and Shocks around Low Mass Stars

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Extreme ultraviolet (EUV, 13.6 eV $< h\nu \lesssim 100$ eV) and X-rays in the 0.1-2 keV band can heat the surfaces of disks around young, low mass stars to thousands of degrees and ionize species with ionization potentials greater than 13.6 eV. Shocks generated by protostellar winds can also heat and ionize the same species close to the star/disk system. These processes produce diagnostic lines (e.g., [NeII] 12.8 μm and [OI] 6300 Å) that we model as functions of key parameters such as EUV luminosity and spectral shape, X-ray luminosity and spectral shape, and wind mass loss rate and shock speed. Comparing our models with observations, we conclude that either internal shocks in the winds or X-rays incident on the disk surfaces often produce the observed [NeII] line, although there are cases where EUV may dominate. Shocks created by the oblique interaction of winds with disks are unlikely [NeII] sources because these shocks are too weak to ionize Ne. Even if [NeII] is mainly produced by X-rays or internal wind shocks, the neon observations typically place upper limits of $\lesssim 10^{42}$ s^{-1} on the EUV photon luminosity of these young low mass stars. The observed [OI] 6300 Å line has both a low velocity component (LVC) and a high velocity component. The latter likely arises in internal wind shocks. For the former we find that X-rays likely produce more [OI] luminosity than either the EUV layer, the transition layer between the EUV and X-ray layer, or the shear layer where the protostellar wind shocks and entrains disk material in a radial flow across the surface of the disk. Our soft X-ray models produce [OI] LVCs with luminosities up to 10^{-4} L$_\odot$, but may not be able to explain the most luminous LVCs.

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Structure and evolution of pre-main sequence circumstellar disks

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We present new sub-arcsecond (0.7") Combined Array for Research in Millimeter-wave Astronomy (CARMA) observations of the 1.3 mm continuum emission from circumstellar disks around 11 low and intermediate mass pre-main sequence stars. High resolution observations for 3 additional sources were obtained from literature. In all cases the disk emission is spatially resolved. We adopt a self consistent accretion disk model based on the similarity solution for the disk surface density and constrain the dust radial density distribution on spatial scales of about 40 AU. Disk surface densities appear to be correlated with the stellar ages where the characteristic disk radius increases from 20 AU to 100 AU over about 5 Myr. This disk expansion is accompanied by a decrease in the mass accretion rate, suggesting that our sample disks form an evolutionary sequence. Interpreting our results in terms of the temporal evolution of a viscous α-disk, we estimate (i) that at the beginning of the disk evolution about 60% of the circumstellar material was located inside radii of 25–40 AU, (ii) that disks formed with masses from 0.05 to 0.4 M$_\odot$ and (iii) that the viscous timescale at the disk initial radius is about 0.1-0.3 Myr. Viscous disk models tightly link the surface density $\Sigma(R)$ with the radial profile of the disk viscosity $\nu(R) \propto R^\gamma$. We find values of γ ranging from -0.8 to 0.8, suggesting that the viscosity dependence on the orbital radius can be very different in the observed disks. Adopting the α parameterization for the viscosity, we argue that α must decrease with the orbital radius and that it may vary between 0.5 and 10^{-4}. (abridged)

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No Transition Disk? Infrared Excess, PAH, H_2, and X-rays from the Weak-Lined T Tauri Star DoAr 21

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As part of a program to understand disk dispersal and the interplay between circumstellar disks and X-ray emission, we present new high-resolution mid-infrared imaging, high-resolution optical spectroscopy, and *Chandra* grating X-ray spectroscopy of the weak-lined T Tauri star DoAr 21. DoAr 21 (age $< 10^6$ yr and mass ~ 2.2 $M_\odot$ based on evolutionary tracks) is a strong X-ray emitter, with conflicting evidence in the literature about its disk properties. It shows weak but broad Hα emission (reported here for the first time since the 1950s); polarimetric variability; PAH and H_2 emission; and a strong, spatially-resolved 24-μm excess in archival *Spitzer* photometry. Gemini sub-arcsecond-resolution 9–18 μm images show that there is little or no excess mid-infrared emission within 100 AU of the star; the excess emission is extended over several arcseconds and is quite asymmetric. The extended emission is bright in the UV-excited $\lambda = 11.3$ μm PAH emission feature. A new high-resolution X-ray grating spectrum from *Chandra* shows that the stellar X-ray emission is very hard and dominated by continuum emission; it is well-fit by a multi-temperature thermal model, typical of hard coronal sources, and shows no evidence of unusually high densities. A flare during the X-ray observation shows a temperature approaching 10^8 K. We argue that the far-ultraviolet emission from the transition region is sufficient to excite the observed extended PAH and continuum emission, and that the H_2 emission may be similarly extended and excited. While this extended emission may be a disk in the final stages of clearing, it also could be more akin to a small-scale photodissociation region than a protoplanetary disk, highlighting both the very young ages ($< 10^6$ yr) at which some stars are found without disks, and the extreme radiation environment around even late-type pre–main-sequence stars.

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The Inner Rim Structures of Protoplanetary Discs

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The inner boundary of protoplanetary discs is structured by the dramatic opacity changes at the transition from the dust-containing to a dust-free zone. This paper explores the variety and limits of inner rim structures in passively heated dusty discs. For this study, we implemented detailed sublimation physics in a fast Monte Carlo radiative transfer code. We show that the inner rim in dusty discs is not an infinitely sharp wall but a diffuse region which may be narrow or wide. Furthermore, high surface densities and large silicate grains as well as iron and corundum grains decrease the rim radius, from a 2.2 AU radius for small silicates around a 47 Solar luminosity Herbig Ae star typically to 0.4 AU and as close as 0.2 AU. A passive disc with grain growth and a diverse dust composition must thus have a small inner rim radius. Finally, an analytical expression is presented for the rim location as a function of dust, disc and stellar properties.

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Triggered Star Formation in a Double Shell Near W51A

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We present Heinrich Hertz Telescope CO observations of the shell structure near the active star-forming complex W51A to investigate the process of star formation triggered by the expansion of an H II region. The CO observations confirm that dense molecular material has been collected along the shell detected in *Spitzer* IRAC images. The CO distribution shows that the shell is blown out toward a lower density region to the northwest. Total hydrogen column density around the shell is high enough to form new stars. We find two CO condensations with the same central velocity of 59 km s^{-1} to the east and north along the edge of the IRAC shell. We identify two young stellar objects in early evolutionary stages (Stage 0/I) within the densest molecular condensation. From the CO kinematics, we find that the H II region is currently expanding with a velocity of 3.4 km s^{-1}, implying that the shell's expansion age is $\sim$1 Myr. This timescale is in good agreement with numerical simulations of the expansion of the H II region (Hosokawa & Inutsuka). We conclude that the star formation on the border of the shell is triggered by the expansion of the H II region.

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Mid-Infrared Spectra of Transitional Disks in the Chamaeleon I Cloud

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We present 5-40 μm *Spitzer* Infrared Spectrograph spectra of a collection of transitional disks, objects for which the spectral energy distribution (SED) indicates central clearings (holes) or gaps in the dust distribution, in the Chamaeleon I star-forming region. Like their counterparts in the Taurus-Auriga star-forming region that we have previously observed, the spectra of these young objects (1-3 Myr old) reveal that the central clearings or gaps are very sharp-edged, and are surrounded by optically thick dusty disks similar to those around other classical T Tauri stars in the Chamaeleon I association. Also like the Taurus transitional disks, the Chamaeleon I transitional disks have extremely large depletion factors for small dust grains in their gaps, compared to the full accretion disks whose SEDs are represented by the median SED of Class II objects in the region. We find that the fraction of transitional disks in the Chamaeleon I cloud is somewhat higher than that in the Taurus-Auriga cloud, possibly indicating that the frequency of transitional disks, on average, increases with cluster age. We also find a significant correlation between the stellar mass and the radius of the outer edge of the gap. We discuss the disk structures implied by the spectra and the constraints they place on gap-formation mechanisms in protoplanetary disks.

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Rotation of the Warm Molecular Gas Surrounding Ultracompact HII Regions

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We present molecular line and 1.4 mm continuum observations towards five massive star forming regions at arcsecond resolution using the Submillimeter Array (SMA). We find that the warm molecular gas surrounding each HII region (as traced by SO2 and OCS) appears to be undergoing bulk rotation. From the molecular line emission and thermal component of the continuum emission, we independently derived gas masses for each region which are consistent with each other. From the free-free component of the continuum emission we estimate the minimum stellar mass required to power the HII region and find that this mass, when added to the derived gas mass, is a significant fraction of the dynamical mass for that region.

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On the Relationship Between Debris Disks and Planets

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Dust in debris disks is generated by collisions among planetesimals. The existence of these planetesimals is a consequence of the planet-formation process, but the relationship between debris disks and planets has not been clearly established. Here we analyze Spitzer/MIPS 24 and 70 μm data for 150 planet-bearing stars, and compare the incidence of debris disks around these stars with a sample of 118 stars around which planets have been searched for, but not found. Together they comprise the largest sample ever assembled to deal with this question. The use of survival analysis techniques allows us to account for the large number of non-detections at 70 μm. We discovered 10 new debris disks around stars with planets and one around a star without known planets. We found that the incidence of debris disks is marginally higher among stars with planets, than among those without, and that the brightness of the average debris disk is not significantly different in the two samples. We conclude that the presence of a planet that has been detected via current radial-velocity techniques is not a good predictor for the presence of a debris disk detected at infrared wavelengths.

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Table 2 is available in machine readable form in the online journal. It can also be queried at the VizieR Service from: http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=J/ApJ/700/L73.

The Dynamics of Radiation Pressure-Dominated HII Regions

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We evaluate the role of radiation pressure in the dynamics of H II regions. We first determine under what conditions radiation pressure is significant in comparison to gas pressure and show that, while radiation pressure is generally unimportant for H II regions driven by a handful of massive stars, it is dominant for the larger H II regions produced by the massive star clusters found near the Galactic center and in starburst environments. We then provide a solution for the problem of how H II regions expand when radiation pressure influences their behavior. Finally, we compare radiation-dominated H II regions to other sources of stellar feedback, and argue that H II regions are probably the primary mechanism for regulating the formation of massive star clusters.

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On the Absence of High Metallicity-High Column Density Damped Lyman α Systems: Molecule Formation in a Two-Phase Interstellar Medium

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We argue that the lack of observed damped Lyman α (DLA) systems that simultaneously have high H I columns densities and high metallicities results naturally from the formation of molecules in the cold phase of a two-phase atomic medium in pressure balance. Our result applies equally well in diffuse systems where the ultraviolet radiation field is dominated by the extragalactic background and in dense star-forming ones, where the local radiation field is likely to be orders of magnitude higher. We point out that such a radiation-insensitive model is required to explain the absence of high column - high metallicity systems among DLAs observed using gamma-ray burst afterglows, since these are likely subjected to strong radiation fields created by active star formation in the GRB host galaxy. Moreover, we show that the observed relationship between the maximum atomic gas column in DLAs sets a firm upper limit on the fraction of the mass in these systems that can be in the warm, diffuse phase. Finally, we argue that our result explains the observed lack of *in situ* star formation in DLA systems.

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The Initial Core Mass Function due to Ambipolar Diffusion in Molecular Clouds

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We show that the ambipolar-diffusion–initiated fragmentation of molecular clouds leads simply and naturally to an initial core mass function (CMF) which is very similar to the initial stellar mass function (IMF) and in excellent agreement with existing observations. This agreement is robust provided that the three (input) free parameters remain within their range of values suggested by observations. Other, observationally testable, predictions are made.

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The California Molecular Cloud

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We present an analysis of wide-field infrared extinction maps of a region in Perseus just north of the Taurus-Auriga dark cloud complex. From this analysis we have identified a massive, nearby, but previously unrecognized, giant molecular cloud (GMC). Both a uniform foreground star density and measurements of the cloud's velocity field from CO observations indicate that this cloud is likely a coherent structure at a single distance. From comparison of foreground star counts with Galactic models we derive a distance of 450 $\pm$ 23 parsecs to the cloud. At this distance the cloud extends over roughly 80 pc and has a mass of $\approx 10^5$ $M_\odot$, rivaling the Orion (A) Molecular Cloud as the largest and most massive GMC in the solar neighborhood. Although surprisingly similar in mass and size to the more famous Orion Molecular Cloud (OMC) the newly recognized cloud displays significantly less star formation activity with more than an order of magnitude fewer Young Stellar Objects (YSOs) than found in the OMC, suggesting that

both the level of star formation and perhaps the star formation rate in this cloud are an order of magnitude or more lower than in the OMC. Analysis of extinction maps of both clouds shows that the new cloud contains only 10% the amount of high extinction ($A_K > 1.0$ mag) material as is found in the OMC. This, in turn, suggests that the level of star formation activity and perhaps the star formation rate in these two clouds may be directly proportional to the total amount of high extinction material and presumably high density gas within them and that there might be a density threshold for star formation on the order of $n(H_2) \approx$ a few $\times 10^4$ cm^{-3}.

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The Super-Alfvenic Model of Molecular Clouds: Predictions for Mass-to-Flux and Turbulent-to-Magnetic Energy Ratios

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Recent measurements of the Zeeman effect in dark-cloud cores provide important tests for theories of cloud dynamics and prestellar core formation. In this Letter we report results of *simulated* Zeeman measurements, based on radiative transfer calculations through a snapshot of a simulation of supersonic and super-Alfvénic turbulence. We have previously shown that the same simulation yields a relative mass-to-flux ratio (core versus envelope) in agreement with the observations (and in contradiction with the ambipolar-drift model of core formation). Here we show that the mass-to-flux and turbulent-to-magnetic-energy ratios in the simulated cores agree with observed values as well. The mean magnetic field strength in the simulation is very low, $\bar{B} = 0.34\ \mu$G, presumably lower than the mean field in molecular clouds. Nonetheless, high magnetic field values are found in dense cores, in agreement with the observations (the rms field, amplified by the turbulence, is $B_{\rm rms} = 3.05\ \mu$G). We conclude that a strong large-scale *mean* magnetic field is not required by Zeeman effect measurements to date, although it is not ruled out by this work.

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Dispersal of Protoplanetary Disks by Central Wind Stripping

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We present a model for the dispersal of protoplanetary disks by winds from either the central star or the inner disk. These winds obliquely strike the flaring disk surface and strip away disk material by entraining it in an outward radial-moving flow at the wind-disk interface, which lies several disk scale heights above the midplane. The disk dispersal time depends on the entrainment velocity, $v_d = \epsilon c_s$, at which disk material flows into this turbulent shear layer interface, where ϵ is a scale factor and c_s is the local sound speed in the disk surface just below the entrainment layer. If $\epsilon \sim 0.1$, a likely upper limit, the dispersal time at 1 AU is ∼6 Myr for a disk with a surface density of 10^3 g cm^{-2}, a solar mass central star, and a wind with an outflow rate $\dot{M}_w = 10^{-8}\ M_\odot$ yr^{-1} and terminal velocity $v_w = 200$ km s^{-1}. When compared with photoevaporation and viscous evolution, wind stripping can be a dominant mechanism only for the combination of low accretion rates ($<\sim 10^{-8}\ M_\odot$ yr^{-1}) and wind outflow rates approaching these accretion rates. This case is unusual since generally outflow rates are $<\sim 0.1$ of accretion rates.

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Does sub-cluster merging accelerate mass segregation in local star formation?

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The nearest site of massive star formation in Orion is dominated by the Trapezium subsystem, with its four OB stars and numerous companions. The question of how these stars came to be in such close proximity has implications for our understanding of massive star formation and early cluster evolution. A promising route toward rapid mass segregation was proposed by McMillan et al. (2007), who showed that the merger product of faster-evolving sub-clusters can inherit their apparent dynamical age from their progenitors. In this paper we briefly consider this process at a size and time scale more suited for local and perhaps more typical star formation, with stellar numbers from the hundreds to thousands. We find that for reasonable ages and cluster sizes, the merger of sub-clusters can indeed lead to compact configurations of the most massive stars, a signal seen both in Nature and in large-scale hydrodynamic simulations of star formation from collapsing molecular clouds, and that sub-virial initial conditions can make an un-merged cluster display a similar type of mass segregation. Additionally, we discuss a variation of the minimum spanning tree mass-segregation technique introduced by Allison et al. (2009).

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Mid-Infrared Size Survey of Young Stellar Objects: Description of Keck Segment-Tilting Experiment and Basic Results

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The mid-infrared properties of pre-planetary disks are sensitive to the temperature and flaring profiles of disks for the regions where planet formation is expected to occur. In order to constrain theories of planet formation, we have carried out a mid-infrared ($\lambda = 10.7$ μm) size survey of young stellar objects using the segmented Keck telescope in a novel configuration. We introduced a customized pattern of tilts to individual mirror segments to allow efficient sparse-aperture interferometry, allowing full aperture synthesis imaging with higher calibration precision than traditional imaging. In contrast to previous surveys on smaller telescopes and with poorer calibration precision, we find that most objects in our sample are partially resolved. Here, we present the main observational results of our survey of five embedded massive protostars, 25 Herbig Ae/Be stars, 3 T Tauri stars, 1 FU Ori system, and five emission-line objects of uncertain classification. The observed mid-infrared sizes do not obey the size-luminosity relation found at near-infrared wavelengths and a companion paper will provide further modeling analysis of this sample. In addition, we report imaging results for a few of the most resolved objects, including complex emission around embedded massive protostars, the photoevaporating circumbinary disk around MWC 361A, and the subarcsecond binaries T Tau, FU Ori, and MWC 1080.

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Search of HH Objects and Emission-Line Stars in the Star Forming Regions. VI. Herbig-Haro Objects and Emission Stars in the Vicinity of GM 1-64 and GM 2-4 Nebulae

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3 new HH objects and 12 emission-line stars, mainly of T Tau type, are found in the direction of the galactic anticenter in the vicinity of GM 1-64 and GM 2-4 nebulae. These two nebulae are of cometary nature, being illuminated by emission stars. The central star of GM 2-4 is surrounded by dense dust envelope and is visible only in IR. In the same area two bright IR stellar sources are located, which can belong to young stars of Class 1. One of them (CPM 19) is surrounded by compact group of fainter PMS objects. It is found that CPM 19 is well visible in the optical range and demonstrates significant brightness variations.

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Quantification of segregation dynamics in ice mixtures

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Context. The observed presence of pure CO_2 ice in protostellar envelopes, revealed by a double peaked 15 μm band, is often attributed to thermally induced ice segregation. The temperature required for segregation is however unknown because of lack of quantitative experimental data and this has prevented the use of ice segregation as a temperature probe. In addition, quantitative segregation studies are needed to characterize diffusion in ices, which underpins all ice dynamics and ice chemistry.
Aims. This study aims to quantify the segregation mechanism and barriers in different H_2O:CO_2 and H_2O:CO ice mixtures.
Results. The investigated ice mixtures cover a range of astrophysically relevant ice thicknesses and mixture ratios. The ices are deposited at 16–50 K under (ultra-)high vacuum conditions. Segregation is then monitored, at 40–70 K in the CO_2 mixtures and at 23–27 K in the CO mixtures, through infrared spectroscopy. The CO_2 and CO band shapes are distinctly different in pure and mixed ices and can thus be used to measure the fraction of segregated ice as a function of time. The segregation barrier is determined using rate equations and the segregation mechanism is investigated through Monte Carlo simulations.
Discussion. Thin (8–37 ML) H_2O ice mixtures, containing either CO_2 or CO, segregate sequentially through surface processes, followed by an order of magnitude slower bulk diffusion. Thicker ices (>100 ML) segregate through a bulk process, which is faster than even surface segregation in thin ices. The thick ices must therefore be either more porous or segregate through a different mechanism, e.g. a phase transition, compared to the thin ices. The segregation dynamics of thin ices are reproduced qualitatively in Monte Carlo simulations of surface hopping and pair swapping. The experimentally determined surface-segregation rates follow the Ahrrenius law with a barrier of 1080 ± 190 K for H_2O:CO_2 ice mixtures and 300 ± 100 K for H_2O:CO mixtures. Though the barrier is constant with ice mixing ratio, the segregation rate increases with CO_2 concentration.
Conclusions. Dynamical ice processes can be quantified through a combination of experiments and different model techniques and they are not scale independent as previously assumed. The derived segregation barrier for thin H_2O:CO_2 ice mixtures is used to estimate the surface segregation temperature during low-mass star formation to be 30 ± 5 K. Both surface and bulk segregation is proposed to be a general feature of ice mixtures when the average bond strengths of the mixture constituents in pure ice exceeds the average bond strength in the ice mixture.

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Formation rates of complex organics in UV irradiated CH_3OH-rich ices I: Experiments

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Context. Gas-phase complex organic molecules are commonly detected in the warm inner regions of protostellar envelopes, so-called hot cores. Recent models show that photochemistry in ices followed by desorption may explain the observed abundances. There is, however, a general lack of quantitative data on UV-induced complex chemistry in ices.
Aims. This study aims to experimentally quantify the UV-induced production rates of complex organics in CH_3OH-rich ices under a variety of astrophysically relevant conditions.
Results. The ices are irradiated with a broad-band UV hydrogen microwave-discharge lamp under ultra-high vacuum conditions, at 20–70 K, and then heated to 200 K. The reaction products are identified by reflection-absorption infrared spectroscopy (RAIRS) and temperature programmed desorption (TPD), through comparison with RAIRS and TPD curves of pure complex species, and through the observed effects of isotopic substitution and enhancement of specific functional groups, such as CH_3, in the ice.
Discussion. Complex organics are readily formed in all experiments, both during irradiation and during the slow warm-up of the ices after the UV lamp is turned off. The relative abundances of photoproducts depend on the UV fluence, the ice temperature, and whether pure CH_3OH ice or CH_3OH:CH_4/CO ice mixtures are used. C_2H_6, CH_3CHO, CH_3CH_2OH, CH_3OCH_3, $HCOOCH_3$, $HOCH_2CHO$ and $(CH_2OH)_2$ are all detected in at least one experiment. Varying the ice thickness and the UV flux does not affect the chemistry. The derived product-formation yields and their dependences on different experimental parameters, such as the initial ice composition, are used to estimate the CH_3OH photodissociation branching ratios in ice and the relative diffusion barriers of the formed radicals. At 20 K, the pure CH_3OH photodesorption yield is $2.1(\pm1.0) \times 10^{-3}$ per incident UV photon, the photo-destruction cross section $2.6(\pm0.9) \times 10^{-18}$ cm^2.
Conclusions. Ice photochemistry in CH_3OH ices is efficient enough to explain the observed abundances of complex organics around protostars. Some complex molecules, such as CH_3CH_2OH and CH_3OCH_3, form with a constant ratio in our ices and this can can be used to test whether complex gas-phase molecules in astrophysical settings have an ice-photochemistry origin. Other molecular ratios, e.g. HCO-bearing molecules versus $(CH_2OH)_2$, depend on the initial ice composition and temperature and can thus be used to investigate when and where complex ice molecules form.

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CCH in prestellar cores

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Aims. We study the abundance of C_2H in prestellar cores both because of its role in the chemistry and because it is a potential probe of the magnetic field. We also consider the non-LTE behaviour of the N=1−0 and N=2−1 transitions of C_2H and improve current estimates of the spectroscopic constants of C_2H.
Methods. We used the IRAM 30m radiotelescope to map the N=1−0 and N=2−1 transitions of C_2H towards the prestellar cores L1498 and CB246. Towards CB246, we also mapped the 1.3 mm dust emission, the J=1−0 transition of N_2H^+ and the J=2−1 transition of $C^{18}O$. We used a Monte Carlo radiative transfer program to analyse the C_2H observations of L1498. We derived the distribution of C_2H column densities and compared with the H_2 column densities inferred from dust emission.
Results. We find that while non-LTE intensity ratios of different components of the N=1−0 and N=2−1 lines are present, they are of minor importance and do not impede C_2H column density determinations based upon LTE analysis. Moreover, the comparison of our Monte-Carlo calculations with observations suggest that the non-LTE deviations can be qualitatively understood. For extinctions less than 20 visual magnitudes, we derive toward these two cores (assuming LTE) a relative abundance $[C_2H]/[H_2]$ of $(1.0 \pm 0.3) \times 10^{-8}$ in L1498 and $(0.9 \pm 0.3) \times 10^{-8}$ in CB246 in reasonable agreement with our Monte-Carlo estimates. For L1498, our observations in conjunction with the Monte Carlo code imply a C_2H depletion hole of radius 9×10^{16} cm similar to that found for other C-containing species.

We briefly discuss the significance of the observed C_2H abundance distribution. Finally, we used our observations to provide improved estimates for the rest frequencies of all six components of the C_2H (1−0) line and seven components of C_2H (2−1). Based on these results, we compute improved spectroscopic constants for C_2H. We also give a brief discussion of the prospects for measuring magnetic field strengths using C_2H.

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A Break in the Gas and Dust Surface Density of the Disc Around the T Tauri Star IM Lupi

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Aims. We study the distribution and physical properties of molecular gas in the disc around the T Tauri star IM Lup on scales close to 200 AU. We investigate how well the gas and dust distributions compare and work towards a unified disc model that can explain both gas and dust emission.
Methods. ^{12}CO, ^{13}CO, and C^{18}O J=2-1 line emission, as well as the dust continuum at 1.3 mm, is observed at 1.8″ resolution towards IM Lup using the Submillimeter Array. A detailed disc model based on the dust emission is tested against these observations with the aid of a molecular excitation and radiative transfer code. Apparent discrepancies between the gas and dust distribution are investigated by adopting simple modifications to the existing model.
Results. The disc is seen at an inclination of 54° ± 3° and is in Keplerian rotation around a 0.8-1.6 $M_\odot$ star. The outer disc radius traced by molecular gas emission is 900 AU, while the dust continuum emission and scattered light images limit the amount of dust present beyond 400 AU and are consistent with the existing model that assumes a 400 AU radius. Our observations require a drastic density decrease close to 400 AU with the vertical gas column density at 900 AU in the range of 5×10^{20}-10^{22} cm^{-2}. We derive a gas-to-dust mass ratio of 100 or higher in disc regions beyond 400 AU. Within 400 AU from the star our observations are consistent with a gas-to-dust ratio of 100 but other values are not ruled out.

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Exploring pre-main sequence variables of ONC: The new variables

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Since 2004, we have been engaged in a long-term observing program to monitor young stellar objects in the Orion Nebula Cluster. We have collected about two thousands frames in V, R, and I broad-band filters on more than two hundred nights distributed over five consecutive observing seasons. The high-quality and time-extended photometric data give us an opportunity to address various phenomena associated with young stars. The prime motivations of this project are *i)* to explore various manifestations of stellar magnetic activity in very young low-mass stars; *ii)* to search for new pre-main sequence eclipsing binaries; and *iii)* to look for any EXor and FUor like transient activities associated with YSOs. Since this is the first paper on this program, we give a detailed description of the science drivers, the observation and the data reduction strategies as well. In addition to these, we also present a large number of new periodic variables detected from our first five years of time-series photometric data. Our study reveals that about 72% of CTTS in our FOV are periodic, whereas, the percentage of periodic WTTS is just 32%. This indicates that inhomogeneity patterns on the surface of CTTS of the ONC stars are much more stable than on WTTS. From our multi-year monitoring campaign we found that the photometric surveys based on single-season are incapable of identifying all periodic variables. And any study on evolution of angular momentum based on single-season surveys must be carried out with caution.

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Infrared Dark Cloud Cores in the SCUBA Legacy Catalogue

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We present an investigation of candidate Infrared Dark Cloud cores as identified by Simon et al. (2006) located within the SCUBA Legacy Catalogue. After applying a uniform noise cut to the Catalogue data we identify 154 Infrared Dark Cloud cores that were detected at 850 μm and 51 cores that were not. We derive column densities for each core from their 8 μm extinction and find that the IRDCs detected at 850 μm have higher column densities (a mean of $1.7 \times 10^{22}\,\mathrm{cm}^{-2}$) compared to those cores not detected at 850 μm (a mean of $1.0 \times 10^{22}\,\mathrm{cm}^{-2}$). Combined with sensitivity estimates, we suggest that the cores not detected at 850 μm are low mass, low column density and low temperature cores that are below the sensitivity limit of SCUBA at 850 μm. For a subsample of the cores detected at 850 μm those contained within the MIPSGAL area) we find that two thirds are associated with 24 μm sources. Cores not associated with 24 μm emission are either "starless" IRDC cores that perhaps have yet to form stars, or contain low mass YSOs below the MIPSGAL detection limit. We see that those "starless" IRDC cores and the IRDC cores associated with 24 μm emission are drawn from the same column density population and are of similar mass. If we then assume the cores without 24 μm embedded sources are at an earlier evolutionary stage to cores with embedded objects we derive a statistical lifetime for the quiescent phase of a few 10^3–10^4 years. Finally, we make conservative predictions for the number of observed IRDCs that will be observed by the Apex Telescope Galactic Plane Survey (ATLASGAL), the Herschel Infrared Galactic Plane Survey (Hi-GAL), the JCMT Galactic Plane Survey (JPS) and the SCUBA-2 "All Sky" Survey (SASSy).

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Evidence for Disk Photoevaporation Driven by the Central Star

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The lifetime of isolated protoplanetary disks is thought to be set by the combination of viscous accretion and photoevaporation driven by stellar high-energy photons. Observational evidence for magnetospheric accretion in young sun-like stars is robust. Here we report the first observational evidence for disk photoevaporation driven by the central star. We acquired high-resolution (R$\sim$30,000) spectra of the [Ne II] 12.81μm line from 7 circumstellar disks using VISIR on Melipal/VLT. We show that the 3 transition disks in the sample all have [Ne II] line profiles consistent with those predicted by a photoevaporative flow driven by stellar extreme UV photons. The $\sim$6 km/s blue-shift of the line from the almost face-on disk of TW Hya is clearly inconsistent with emission from a static disk atmosphere and convincingly points to the presence of a photoevaporative wind. We do not detect any [Ne II] line close to the stellar velocity from the sample of classical optically thick (non-transition) disks. We conclude that most of the spectrally unresolved [Ne II] emission in these less evolved systems arises from jets/outflows rather than from the disk. The pattern of the [Ne II] detections and non-detections suggests that extreme UV-driven photoevaporation starts only at a later stage in the disk evolution.

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Wind-Swept Clouds and Possible Triggered Star Formation Associated with the Supernova Remnant G357.7+0.3

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We present evidence for interaction between the supernova remnant (SNR) G357.7+0.3 and nearby molecular clouds, leading to the formation of wind-swept structures and bright emission rims. These features are not observed at visual wavelengths, but are clearly visible in mid-infrared mapping undertaken using the Spitzer Space Telescope. Analysis of one of these clouds, the bright cometary structure G357.46+0.60, suggests that it contains strong polycyclic aromatic hydrocarbon emission features in the 5.8 and 8.0 μm photometric bands, and that these are highly variable over relatively small spatial scales. The source is also associated with strong variations in electron density; a far-infrared continuum peak associated with dust temperatures of ∼30 K; and has previously been observed in the 1720 MHz maser transition of OH, known to be associated with SNR shock excitation of interstellar clouds. This source also appears to contain a young stellar object (YSO) within the bright rim structure, with a steeply rising spectrum between 1.25 and 24 μm. If the formation of this star has been triggered recently by the SNR, then YSO modelling suggests a stellar mass ∼5-10 $M_{\odot}$, and luminosity $L_{\rm YSO} \sim 10^2$-2×10^3 $L_{\odot}$.
Finally, it is noted that a further, conical emission region appears to be associated with the Mira V1139 Sco, and it is suggested that this may represent the case of a Mira outflow interacting with a SNR. If this is the case, however, then the distance to the SNR must be ∼half of that determined from CS J= 21 and 32 line radial velocities.

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Physical Structure and Dust Reprocessing in a sample of HH Jets

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Context. Stellar jets are an essential ingredient of the star formation process and a wealth of information can be derived from their characteristic emission-line spectra.
Aims. We investigate the physical structure and dust reprocessing in the shocks along the beam of a number of classical Herbig-Haro (HH) jets in the Orion and Lupus molecular cloud (HH 111, HH 1/2, HH 83, HH 24 M/A/E/C, Sz68). The parameters describing the plasma conditions, as well as the dust content, are derived as a function of the distance from the source and, for HH 111, of the gas velocity.
Methods. Spectral diagnostic techniques are applied to obtain the jet physical conditions (the electron and total density, n_e and n_H, the ionisation fraction, x_e, and the temperature, T_e) from the ratios between selected forbidden lines. The presence of dust grains is investigated by estimating the gas-phase abundance of calcium with respect to its Solar value.
Results. We find the electron density varies between 0.05-4 10^3 cm^{-3}, the ionisation fraction x_e is 0.01-0.7, the temperature ranges between 0.6-3 10^4 K, and the hydrogen density between 0.01-6 10^4 cm^{-3}. Interestingly, in the HH 111 jet, n_e, x_e, and T_e, peak in the High Velocity Interval (HVI) of the strongest working surfaces, confirming the prediction from shocks models. Calcium turns out to be depleted with respect to its Solar value, but its gas-phase abundance is higher than that estimated in the interstellar medium in Orion. The depletion is high (up to 80%) along the low-excited jets, while low or no depletion is measured in the jets which show higher excitation conditions. Moreover, in HH 111 the depletion is lower in the HVI of the faster shock.
Conclusions. Our results confirm the shock structure predicted by models and indicate that the shocks occurring along the jets, and presumably those present in the launch zone, are partially destroying the dust grains and that the efficiency of dust reprocessing strongly depend on shock velocity. However, the high Ca gas-phase abundance estimated in some of the knots, is not well justified by existing models of dust reprocessing in shocks, and indicates

that the dust must have been partially reprocessed in the region where the flow originates.

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Discovery of Extremely High Velocity "Molecular Bullets" in the HH 80-81 High-Mass Star-Forming Region

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We present Submillimeter Array 1.3 mm waveband continuum and molecular line observations of the HH 80-81 high-mass star-forming region. The dust continuum emission reveals two dominant peaks MM1 and MM2, and line emission from high-density tracers suggests the presence of another core MC. Molecular line emission from MM1, which harbors the exciting source of the HH 80-81 radio jet, yields a hot molecular core at a gas temperature of 110 K. The two younger cores MM2 and MC both appear to power collimated CO outflows. In particular, the outflow arising from MM2 exhibits a jet-like morphology and a broad velocity range of 190 km/s. The outflow contains compact and fast moving molecular clumps, known as "molecular bullets" first discovered in low-mass class 0 protostellar outflows. These "bullets" cannot be locally entrained or swept up from the ambient gas, but are more likely ejected from the close vicinity of the central protostar. The discovery of this remarkable outflow manifests an episodic, disk-mediated accretion for massive star formation.

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2MASS J171123182724315: A Deeply Embedded Low-mass Protostellar System in the B59 Molecular Cloud

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We present near-infrared observations of the low-mass deeply embedded Class 0/I system 2MASS J17112318-2724315 (2M171123) in the B59 molecular cloud. Bright scattered light nebulosity is observed toward this source in the K_S images, that seems to trace the edges of an outflow cavity. We report the detection of a low-luminosity protostar 2M17112255-27243448 (2M17112255) that lies $\sim 8''$ ($\sim$1000 AU) from 2M171123. This is a Class I system, as indicated by its 2-8 μm slope and Infrared Array Camera colors, with an estimated internal luminosity of $\sim 0.3\ L_\odot$. We estimate a mass of $\sim$0.12-0.25 $M_\odot$ for this source, at an age of 0.1-1 Myr. Also presented is detailed modeling of the 2M171123 system. The best-fit parameters indicate a large envelope density of the order of $\sim 10^{-13}$ g cm^{-3}, and an intermediate inclination between 53° and 59°. The observed K_S -band variability for this system could be explained by slight variability in the mass infall rate between 2.5E-5 and 1.8E-5 $M_\odot$ yr^{-1}. The protostar 2M171123 exhibits a rarely observed absorption feature near 11.3 μm within its 10 μm silicate band. We find a strong correlation between the strength in this 11.3 μm "edge" and the H_2O-ice column density, indicating the origin of this feature in the thickness of the ice mantle over the silicate grains.

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The Bolocam Galactic Plane Survey – II. Catalog of the Image Data

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We present a catalog of 8358 sources extracted from images produced by the Bolocam Galactic Plane Survey (BGPS). The BGPS is a survey of the millimeter dust continuum emission from the northern Galactic plane. The catalog sources are extracted using a custom algorithm, Bolocat, which was designed specifically to identify and characterize objects in the large-area maps generated from the Bolocam instrument. The catalog products are designed to facilitate follow-up observations of these relatively unstudied objects. The catalog is 98% complete from 0.4 Jy to 60 Jy over all object sizes for which the survey is sensitive ($< 3.5'$). We find that the sources extracted can best be described as molecular clumps – large dense regions in molecular clouds linked to cluster formation. We find the flux density distribution of sources follows a power law with $dN/dS \propto S^{-2.4\pm0.1}$ and that the mean Galactic latitude for sources is significantly below the midplane: $\langle b \rangle = (-0.095 \pm 0.001)^\circ$.

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http://irsa.ipac.caltech.edu/data/BOLOCAM_GPS/

Millimeter-wave Interferometric Study of Dust and CO Disks Around Late Spectral Type Stars in Taurus-Auriga

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We present a new millimeter survey of 23 pre-main-sequence stars in the Taurus-Auriga star-forming region. The main goal of the project was to identify circumstellar disks around stars of late spectral types ($M_* <\sim 0.7\ M_\odot$). We used the IRAM Plateau de Bure Interferometer to obtain observations at 1.3 mm, 2.7 mm, and the CO J = 1-0 and J = 2-1 lines. We detected eight sources in continuum emission, with new detections of CIDA-1 and CIDA-8 at 1.3 mm. Overall, we find that circumstellar disks around stars with spectral types later than M2 tend to have smaller millimeter continuum fluxes than those around earlier type stars. We also present four detections of disks in their CO line emission (LkHα 358, GO Tau, Haro 6-13, IRAS 04385+2550). By mapping the rotation of the resolved CO emission from the circumstellar disks, we obtain estimates of the dynamical mass of the central stars.

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Thermal instability and the effects of cosmic-ray diffusion

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We study the dynamical effects of cosmic rays (CRs) on thermal instability in the linear regime. CRs and the thermal plasma are treated as two different interacting fluids, in which CRs can diffuse along the magnetic field lines. We show

that the growth rate of the magnetothermal condensation mode is reduced because of the existence of CRs, and this stabilizing effect depends on the diffusion coefficient and the ratio of CR pressure to gas pressure. Thus, a slower rate of structure formation via thermal instability is predicted when CRs are considered.

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Excitation and abundance study of CO^+ in the interstellar medium

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Context: Observations of CO^+ suggest column densities on the order 10^{12} cm^{-2} that can not be reproduced by many chemical models. CO^+ is more likely to be destroyed than excited in collisions with hydrogen. An anomalous excitation mechanism may thus have to be considered when interpreting CO^+ observations. Other uncertainties in models are the chemical network, the gas temperature or the geometry of the emitting source. Similar is true for other reactive ions that will be observed soon with the Herschel Space Observatory.
Aims: Chemical constraints are explored for observable CO^+ abundances. The influence of an anomalous excitation mechanism on CO^+ line intensities is investigated. Model results are compared to observations.
Methods: Chemical models are used to perform a parameter study of CO^+ abundances. Line fluxes are calculated for $N(CO^+) = 10^{12}$ cm^{-2} and different gas densities and temperatures using a non–LTE escape probability method. The chemical formation and destruction rates are considered explicitly in the detailed balance equations of the radiative transfer. In addition, the rotational levels of CO^+ are assumed to be excited upon chemical formation according to a *formation temperature*. Collisional excitation by atomic and molecular hydrogen as well as by electrons is studied for conditions appropriate to dense photon-dominated regions (PDRs) and star-forming environments.
Results: Chemical models are generally able to produce high fractional CO^+ abundances ($x(CO^+) \approx 10^{-10}$). In a far-ultraviolet (FUV) dominated environment, however, high abundances of CO^+ are only produced in regions with a Habing field $G_0 > 100$ and $T_{\rm kin} > 600$ K, posing a strong constraint on the gas temperature. For gas densities $< 10^6$ cm^{-3} and temperatures > 600 K, the combination of chemical and radiative transfer analysis shows little effect on intensities of CO^+ lines with upper levels $N_{\rm up} \leq 3$. Significantly different line fluxes are calculated with an anomalous excitation mechanism, however, for transitions with higher upper levels and densities $> 10^6$ cm^{-3}. The Herschel Space Observatory is able to reveal such effects in the terahertz wavelength regime. Ideal objects to observe are protoplanetary disks with densities $> 10^6$ cm^{-3} . It is finally suggested that the CO^+ chemistry may be well understood and that the abundances observed so far can be explained with a high enough gas temperature and a proper geometry.

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The role of thermodynamics in disc fragmentation

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Thermodynamics play an important role in determining the way a protostellar disc fragments to form planets, brown dwarfs and low-mass stars. We explore the effect that different treatments of radiative transfer have in simulations of fragmenting discs. Three prescriptions for the radiative transfer are used, (i) the diffusion approximation of Stamatellos et al. (2007a), (ii) the barotropic equation of state (EOS) of Goodwin et al. (2004a), and (iii) the barotropic EOS of Bate et al. (2003). The barotropic approximations capture the general evolution of the density and temperature at the centre of each proto-fragment but (i) they do not make any adjustments the particular circumstances of a proto-fragment forming in the disc, and (ii) they do not take into account thermal inertia effects that are important for fast-forming proto-fragments in the outer disc region. As a result, the number of fragments formed in the disc and their properties are different, when a barotropic EOS is used. This is important not only for disc studies but also for simulations of collapsing turbulent clouds, as in many cases in such simulations stars form with discs that subsequently fragment. We also examine the difference in the way proto-fragments condense out in the disc at different distances from the central star using the diffusion approximation and following the collapse of each proto-fragment until the formation of the second core ($\rho \simeq 10^{-3}$ g cm^{-3}). We find that proto-fragments forming closer to the central star tend to form earlier and evolve faster from the first to the second core than proto-fragments forming in the outer disc region. The former have a large pool of material in the inner disc region that they can accrete from and grow in mass. The latter accrete more slowly and they are hotter because they generally form in a quick abrupt event.

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http://www.astro.cardiff.ac.uk/pub/Dimitrios.Stamatellos/publications/

The Bimodality of Accretion In T Tauri Stars and Brown Dwarfs

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We present numerical solutions of the collapse of prestellar cores that lead to the formation and evolution of circumstellar disks. The disk evolution is then followed for up to three million years. A variety of models of different initial masses and rotation rates allows us to study disk accretion around brown dwarfs and low-mass T Tauri stars, with central object mass $M_* < 0.2\,M_\odot$, as well as intermediate and upper-mass T Tauri stars ($0.2\,M_\odot < M_* < 3.0\,M_\odot$). Our models include self-gravity and allow for nonaxisymmetric motions. In addition to the self-consistently generated gravitational torques, we introduce an effective turbulent α-viscosity with $\alpha = 0.01$, which allows us particularly to model accretion in the low-mass regime where disk self-gravity is diminishing. A range of models with observationally-motivated values of the initial ratio of rotational to gravitational energy yields a correlation between mass accretion rate $\dot{M}$ and M_* that is relatively steep, as observed. Additionally, our modeling reveals evidence for a bimodality in the $\dot{M}$–M_* correlation, with a steeper slope at lower masses and a shallower slope at intermediate and upper masses, as also implied by observations. Furthermore, we show that the neglect of disk self-gravity leads to a much steeper $\dot{M}$–M_* relation for intermediate and upper-mass T Tauri stars. This demonstrates that an accurate treatment of global self-gravity is essential to understanding observations of circumstellar disks.

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Hot and Cool Water in Herbig Ae Protoplanetary Disks: A Challenge for Herschel

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The spatial origin and detectability of rotational H_2O emission lines from Herbig Ae type protoplanetary disks beyond 70 μm is discussed. We use the recently developed disk code PRODIMO to calculate the thermo-chemical structure of a Herbig Ae type disk and apply the non-LTE line radiative transfer code RATRAN?to predict water line profiles and intensity maps. The model shows three spatially distinct regions in the disk where water concentrations are high, related to different chemical pathways to form the water: (1) a big water reservoir in the deep midplane behind the inner rim, (2) a belt of cold water around the distant icy midplane beyond the "snowline" $r \geq 20$ AU, and (3) a layer of irradiated hot water at high altitudes $z/r = 0.1 \ldots\ 0.3$, extending from about 1 AU to 30 AU, where the kinetic gas temperature ranges from 200 K to 1500 K. Although region 3 contains only little amounts of water vapour ($\sim 10^{-4}\ M_{\rm Earth}$), it is this warm layer that is almost entirely responsible for the rotational water emission lines as observable with Herschel. Only one ortho and two para H_2O lines with the lowest excitation energies <100 K are found to originate partly from region 2. We conclude that observations of rotational water lines from Herbig Ae disks probe first and foremost the conditions in region 3, where water is predominantly formed via neutral-neutral reactions and the gas is thermally decoupled from the dust $T_{\rm gas} > T_{\rm dust}$. The observation of rotational water lines does not allow for a determination of the snowline, because the snowline truncates the radial extension of region 1, whereas the lines originate from the region 3. Different line transfer approximations (LTE, escape probability, Monte Carlo) are discussed. A non-LTE treatment is required in most cases, and the results obtained with the escape probability method are found to underestimate the Monte Carlo results by 2%-45%.

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The Massive Star Forming Region Cygnus OB2. I. Chandra catalogue of association members

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We present a catalogue of 1696 X-ray sources detected in the massive star forming region (SFR) Cygnus OB2 and extracted from two archival Chandra observations of the center of the region. A deep source extraction routine, exploiting the low background rates of Chandra observations was employed to maximize the number of sources extracted. Observations at other wavelengths were used to identify low count-rate sources and remove likely spurious sources. Monte Carlo simulations were also used to assess the authenticity of these sources. We used a Bayesian technique to identify optical or near-IR counterparts for 1501 (89%) of our sources, using deep observations from the INT Photometric H-alpha Survey, the Two Micron All Sky Survey, and the UKIRT Infrared Deep Sky Survey-Galactic plane Survey. 755 (45%) of these objects have six-band r', H-alpha, i', J, H, and K optical and near-IR photometry. From an analysis of the Poisson false-source probabilities for each source we estimate that our X-ray catalogue includes < 1% of false sources, and an even lower fraction when only sources with optical or near-IR associations are considered. A Monte Carlo simulation of the Bayesian matching scheme allows this method to be compared to more simplified matching techniques and enables the various sources of error to be quantified. The catalogue of 1696 objects presented here includes X-ray broad band fluxes, model fits, and optical and near-IR photometry in what is one of the largest X-ray catalogue of a single SFR to date. The high number of stellar X-ray sources detected from relatively shallow observations confirms the status and importance of Cygnus OB2 as one of our Galaxy's most massive SFRs.

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Star Formation in the Central 400 pc of the Milky Way: Evidence for a Population of Massive YSOs

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The central kpc of the Milky Way might be expected to differ significantly from the rest of the Galaxy with regard to gas

dynamics and the formation of young stellar objects (YSOs). We probe this possibility with mid-infrared observations obtained with IRAC and MIPS on Spitzer and with MSX. We use color-color diagrams and spectral energy distribution (SED) fits to explore the nature of YSO candidates (including objects with 4.5μm excesses possibly due to molecular emission). There is an asymmetry in the distribution of the candidate YSOs, which tend to be found at negative Galactic longitudes; this behavior contrasts with that of the molecular gas, approximately 2/3 of which is at positive longitudes. The small scale height of these objects suggests that they are within the Galactic center region and are dynamically young. They lie between two layers of infrared dark clouds (IRDCs) and may have originated from these clouds. We identify new sites for this recent star formation by comparing the mid-IR, radio, submillimeter, and methanol maser data. The methanol masers appear to be associated with young, embedded YSOs characterized by 4.5μm excesses. We use the SEDs of these sources to estimate their physical characteristics; their masses appear to range from ~ 10 to ~ 20 solar mass. Within the central 400×50 pc ($|l| < 1.3^0$ and $|b| < 10'$) the star formation rate based on the identification of Stage I evolutionary phase of YSO candidates is about 0.14 solar mass per year. Given that the majority of the sources in the population of YSOs is classified as Stage I objects, we suggest that a recent burst of star formation took place within the last 10^5 years. This suggestion is also consistent with estimates of star formation rates within the last $\sim 10^7$ years showing a peak around 10^5 years ago. Lastly, we find that the Schmidt-Kennicutt Law applies well in the central 400 pc of the Galaxy. This implies that star formation does not appear to be dramatically affected by the extreme physical conditions in the Galactic center region.

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Postdoc, computational and observational studies of star formation with ALMA and Herschel

Effective immediately, a two-year postdoctoral position is available at Leiden Observatory, in connection with the ASTRONET-funded project ARTIST: Adaptable Radiative Transfer Innovations for Submillimeter Telescopes. The primary tasks of the postdoc will be to develop and test interfaces between existing theoretical descriptions of low-mass star formation and the modeling tools designed within ARTIST. Throughout, comparison to data form existing telescopes (such as JCMT, APEX, CARMA, SMA, and Herschel) will be used to apply the developed tools.

The ARTIST project is a collaboration between Leiden Observatory, the Argelander Institute for Astronomy at the University of Bonn, and the Institut de Ciencies de l'Espa, Barcelona (see http://www.astro.uni-bonn.de/ARC/artist). The project aims to develop the next generation modeling suite for comprehensive multi-dimensional radiative transfer calculations of dust and line emission, and is specifically designed for ALMA and Herschel. Low-mass star formation is explicitly taken as a research inspiration for ARTIST, although wider applicability is foreseen.

A demonstrated background in star formation studies is required. The postdoc will have ample opportunity to pursue her/his own research, including collaborations with members of the network.

Leiden Observatory is at the forefront of astronomical research and has a strong international character. We offer a competitive salary and excellent benefits. All research facilities of Leiden Observatory are available to the postdoc.

Applicants should send a CV, publication list, a statement of research interests, and three letters of recommendation to Dr. M.R. Hogerheijde at michiel *at* strw.leidenuniv.nl. Evaluation of the applications starts October 1 2009 and continues until the position is filled.

INAF - Arcetri Astrophysical Observatory - Florence (Italy) International Post-Doctoral Fellowship on High-Mass Star Formation

The INAF - Arcetri Astrophysical Observatory (Florence) intends to award a post-doctoral fellowship in the field of star formation. The fellow is expected to focus his/her activity on observations of OB star forming regions. In particular, he/she will participate in the investigation of high-mass star formation in the Galaxy by means of large scale surveys at (sub)mm and IR wavelengths, complemented by more focused, higher angular resolution observations of selected regions. Experience with radio single-dish and interferometric observations and data analysis is requested, from centimeter to sub-millimeter wavelengths.

Applicants must have a Ph.D. or equivalent at the starting date of the fellowship. The gross yearly salary will be 33,000 Euro. The fellowship will be granted for two years, conditional to a positive evaluation of the research activity carried out during the first year, and will not entail social benefits or medical insurance. No special application forms are required. The applicants should send a CV and a list of publications to the above submission address and should arrange for two letters of recommendation to be sent separately to the same address. E-mail submission is accepted. Applications should arrive in Arcetri no later than October 15, 2009. The starting date will be as early as possible but is negotiable.

Application deadline: October 15, 2009

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The Crowded Universe

Alan Boss

Alan Boss, who is well known for his research into star and planet formation, has written an account of the development of the field of exoplanets. Four interweaving strands go through the book. One follows the ever more frequent ground-based discoveries of extrasolar planets and the ever-shifting records for different types of planets: largest, smallest, hottest, coolest, etc. Another outlines NASA's and ESA's friendly competition to launch increasingly sophisticated satelittes to discover Earth-like planets, and the shifting fortunes, delays or cancellations of different projects. The Kepler mission is followed through this political minefield until launch. A third strand covers the human dimension, with glimpses of the people behind the projects and the discoveries. And finally a fourth relates the observations to the two main competing theories of planet formation – core accretion and disk instability – and recounts how different groups of researchers interpret their observations in favor of one or another of these formation scenarios. The book, which is written in an easy flowing prose, follows in chronological order all these various developments from 1995 to 2009.

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