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Abstracts of recently accepted papers

Discovery of magnetic fields in the very young, massive stars W601 (NGC 6611) and OI 201 (NGC 2244)

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Context. Recent spectropolarimetric observations of Herbig Ae/Be stars have yielded new arguments in favour of a fossil origin for the magnetic fields of intermediate mass stars.

Aims. To study the evolution of these magnetic fields, and their impact on the evolution of the angular momentum of these stars during the pre-main sequence phase, we observed Herbig Ae/Be members of young open clusters of various ages.

Methods. We obtained high-resolution spectropolarimetric observations of Herbig Ae/Be stars belonging to the young open clusters NGC 6611 (<6 Myr), NGC 2244 (∼1.9 Myr), and NGC 2264 (∼8 Myr), using ESPaDOnS at the Canada-France-Hawaii Telescope.

Results. Here we report the discovery of strong magnetic fields in two massive pre-main sequence cluster stars. We detected, for the first time, a magnetic field in a pre-main sequence rapid rotator: the 10.2 $M_\odot$ Herbig B1.5e star W601 (NGC 6611; $v \sin i \simeq 190$ km s^{-1}). Our spectropolarimetric observations yield a longitudinal magnetic field larger than 1 kG, and imply a rotational period shorter than 1.7 days. The spectrum of this very young object (age ~ 0.017 Myr) shows strong and variable lines of He and Si. We also detected a magnetic field in the 12.1 $M_\odot$ B1 star OI 201 (NGC 2244; $v \sin i = 23.5$ km s^{-1}). The Stokes V profile of this star does not vary over 5 days, suggesting a long rotational period, a pole-on orientation, or aligned magnetic and rotation axes. OI 201 is situated near the Zero-Age Main Sequence on the HR diagram, and exhibits normal chemical abundances and no spectrum variability.

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Deep near-IR variability survey of pre-main-sequence stars in ρ Ophiuchi

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Context. Variability is a common characteristic of pre-main-sequence stars (PMS). Near-IR variability surveys of

young stellar objects (YSOs) can probe stellar and circumstellar environments and provide information about the dynamics of the on going magnetic and accretion processes. Furthermore, variability can be used as a tool to uncover new cluster members in star formation regions.
Aims. We hope to achieve the deepest near-IR variability study of YSOs targeting the ρ Ophiuchi cluster.
Methods. Fourteen epochs of observations were obtained with the Wide Field Camera (WFCAM) at the UKIRT telescope scheduled in a manner that allowed the study of variability on timescales of days, months, and years. Statistical tools, such as the multi-band cross correlation index and the reduced chi-square, were used to disentangle signals of variability from noise. Variability characteristics are compared to existing models of YSOs in order to relate them to physical processes, and then used to select new candidate members of this star-forming region.
Results. Variability in the near-IR is found to be present in 41% of the known population of ρ Ophiuchi recovered in our sample. The behaviours shown are several and can be associated with the existence of spots on the stellar surface, variations in circumstellar extinction, or changes in the geometry of an accretion disc. Using variability, a new population of objects has been uncovered that is believed to be part of the ρ Ophiuchi cluster.

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http://lanl.arxiv.org/abs/0804.1548

The Structure of the DoAr 25 Circumstellar Disk

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We present high spatial resolution ($\lesssim$0.3$''$ $\approx$ 40 AU) Submillimeter Array observations of the 865 μm continuum emission from the circumstellar disk around the young star DoAr 25. Despite its bright millimeter emission, this source exhibits only a comparatively small infrared excess and low accretion rate, suggesting that the material and structural properties of the inner disk may be in an advanced state of evolution. A simple model of the physical conditions in the disk is derived from the submillimeter visibilities and the complete spectral energy distribution using a Monte Carlo radiative transfer code. For the standard assumption of a homogeneous grain size distribution at all disk radii, the results indicate a shallow surface density profile, $\Sigma \propto r^{-p}$ with $p \approx 0.34$, significantly less steep than a steady-state accretion disk ($p = 1$) or the often adopted minimum mass solar nebula ($p = 1.5$). Even though the total mass of material is large ($M_d \approx 0.10\,\mathrm{M}_\odot$), the densities inferred in the inner disk for such a model may be too low to facilitate any mode of planet formation. However, alternative models with steeper density gradients ($p \approx 1$) can explain the observations equally well if substantial grain growth in the planet formation region ($r \leq 40$ AU) has occurred. We discuss these data in the context of such models with dust properties that vary with radius and highlight their implications for understanding disk evolution and the early stages of planet formation.

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http://arxiv.org/abs/0804.0437

High Spatial Resolution Spectroscopy of W51 IRS2E and IRS2W: Two Very Massive Young Stars in Early Formation Stages

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We present K-band spectra of the near infrared counterparts to IRS2E and IRS2W which is associated with the ultracompact HII region W51d, both of them embedded sources in the Galactic compact HII region W51 IRS2. The high spatial resolution observations were obtained with the laser guide star facility and Near infrared Integral Field Spectrograph (NIFS) mounted at the Gemini North observatory. The spectrum of the ionizing source of W51d shows

the photospheric features NIII (21155 Å) in emission and HeII (21897 Å) in absorption which lead us to classify it as an young O3 type star. We detected CO overtone in emission at 23000 Å in the spectrum of IRS2E, suggesting that it is a massive young object still surrounded by an accretion disc, probably transitioning from the hot core phase to an ultracompact HII region.

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Dissection of the protostellar envelope surrounding IRAS 05173−0555 in L1634

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Context. The youngest protostars that power energetic outflows are surrounded by infalling and rotating envelopes that contain most of the mass of the system.
Aims. We study the properties and kinematics of the protostellar envelope surrounding the embedded source IRAS 05173−0555 in L1634.
Methods. We carried out VLA ammonia observations at 1.3 cm with the VLA in the D configuration to map the gas towards the core of L1634.
Results. The NH_3 emission towards IRAS 05173−0555 is resolved and shows two components that are clearly distinguishable morphologically: a cross-like structure, roughly elongated in the direction of the HH 240/241 outflow and associated with IRAS 05173−0555, plus an arc-like stream elongated towards the north. The properties and kinematics of the gas suggest that the origin of the cross-like morphology could be the interaction between the outflow and the envelope. A more compact and flattened structure, which could be undergoing rotation about the axis of the outflow, has been detected towards the center of the cross-like envelope. The northern stream, which has properties and velocity that are different from those of the cross-like envelope, is likely part of the original cloud envelope, and could be a quiescent core that may never form stars, or instead be in a prestellar phase.

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Identifying the outflow driving sources in Orion-KL

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The enigmatic outflows of the Orion-KL region have raised discussions about their potential driving sources for several decades. Here, we present $C^{18}O(2–1)$ observations combined from the Submillimeter Array and the IRAM 30 m telescope. The molecular gas is associated on large scales with the famous northwest-southeast high-velocity outflow whereas the high-velocity gas on small spatial scales traces back to the recently identified submm source SMA1. Therefore, we infer that SMA1 may host the driving source of this outflow. Based on the previously published thermal and maser SiO data, source *I* is the prime candidate to drive the northeast-southwest low-velocity outflow. The source SMA1 is peculiar because it is only detected in several submm wavelength bands but neither in the infrared nor cm regime. We discuss that it may be a very young intermediate- to high-mass protostar. The estimated outflow masses are high whereas the dynamical time-scale of the outflow is short of the order 10^3 yrs.

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

On oligarchic growth of planets in protoplanetary disks

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In this paper we present a new semianalytical model of oligarchic growth of planets considering a distribution of planetesimal sizes, fragmentation of planetesimals in mutual collisions, sublimation of ices through the snow line, random velocities out of equilibrium and merging of planetary embryos. We show that the presence of several planetary embryos growing simultaneously at different locations in the protoplanetary disk affects the whole accretion history, specially for the innermost planets. The results presented here clearly indicate the relevance of considering a distribution of planetesimal sizes. Fragmentation occurring during planetesimalplanetesimal collisions represent only a marginal effect in shaping the surface density of solid material in the protoplanetary disc.

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Nebular gas drag and co-orbital system dynamics

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Aims. We study trajectories of planetesimals whose orbits decay due to gas drag in a primordial solar nebula and are perturbed by the gravity of the secondary body on an eccentric orbit whose mass ratio takes values from $\mu_2 = 10^{-7}$ to $\mu_2 = 10^{-3}$ increasing ten times at each step. Each planetesimal ultimately suffers one of the three possible fates: (1) trapping in a mean motion resonance with the secondary body; (2) collision with the secondary body and consequent increase of its mass; or (3) diffusion after crossing the orbit of the secondary body.

Methods. We take the Burlirsh-Stoer numerical algorithm in order to integrate the Newtonian equations of the planar, elliptical restricted three-body problem with the secondary body and the planetesimal orbiting the primary. It is assumed that there is no interaction among planetesimals, and also that the gas does not affect the orbit of the secondary body.

Results. The results show that the optimal value of the gas drag constant k for the 1:1 resonance is between 0.9 and 1.25, representing a meter size planetesimal for each AU of orbital radius. In this study, the conditions of the gas drag are such that in theory, L4 no longer exists in the circular case for a critical value of k that defines a limit size of the planetesimal, but for a secondary body with an eccentricity larger than 0.05 when $\mu_2 = 10^{-6}$, it reappears. The decrease of the cutoff collision radius increase the difusions but does not affect the distribution of trapping. The contribution to the mass accretion of the secondary body is over 40% with a collision radius $0.05 R_{\rm Hill}$ and less than 15% with $0.005 R_{\rm Hill}$ for $\mu_2 = 10^{-7}$. The trappings no longer occur when the drag constant k reachs 30. That means that the size limit of planetesimal trapping is 0.2 m per AU of orbital radius. In most cases, this accretion occurs for a weak gas drag and small secondary eccentricity. The diffusions represent most of the simulations showing that gas drag is an efficient process in scattering planetesimals and that the trapping of planetesimals in the 1:1 resonance is a less probable fate. These results depend on the specific drag force chosen.

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The star formation efficiency and its relation to variations in the initial mass function

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We investigate how the dynamical state of a turbulently supported, $1000\,M_\odot$, molecular cloud affects the properties of the cluster it forms, focusing our discussion on the star formation efficiency (SFE) and the initial mass function (IMF). A variety of initial energy states are examined in this paper, ranging from clouds with $|E_{\rm grav}| = 0.1\,E_{\rm kin}$ to clouds with $|E_{\rm grav}| = 10\,E_{\rm kin}$, and for both isothermal and piece-wise polytropic equations of state (similar to that suggested by Larson). It is found that arbitrary star formation efficiencies are possible, with strongly unbound clouds yielding very low star formation efficiencies. We suggest that the low star formation efficiency in the Maddelena cloud may be a consequence of the relatively unbound state of its internal structure. It is also found that competitive accretion results in the observed IMF when the clouds have initial energy states of $|E_{\rm grav}| \geq E_{\rm kin}$. We show that under such conditions the shape of the IMF is independent of time in the calculations. This demonstrates that the global accretion process can be terminated at any stage in the cluster's evolution, while still yielding a distribution of stellar masses that is consistent with the observed IMF. As the clouds become progressively more unbound, competitive accretion is less important and the protostellar mass function flattens. These results predict that molecular clouds should be permeated with a distributed population of stars that follow a flatter than Salpeter IMF.

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http://www.ita.uni-heidelberg.de/~pcc/papers.shtml?lang=en

Interferometric Mapping of Magnetic Fields: The Massive Star-forming Region G34.4+0.23 MM

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We report millimeter interferometric observations of polarized continuum and line emission from the massive star-forming region G34.4. Polarized thermal dust emission at 3 mm wavelength and CO line emission were observed using the Berkeley-Illinois-Maryland Association (BIMA) array. Our results show a remarkably uniform polarization pattern in both dust and in CO emission. In addition, the line emission presents a consistent uniform polarization pattern over most of the velocity channel maps. These uniform polarization patterns are aligned with the north-south main axis of the filament between the main millimeter source (MM) and the ultracompact H II region, which are the central sources in G34.4, suggesting a magnetic field orthogonal to this axis. This morphology is consistent with a magnetically supported disk seen roughly edge-on.

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Triggered massive-star formation on the borders of Galactic HII regions. IV- Star formation at the periphery of Sh2-212

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Aims: We wish to establish whether sequential star formation is taking place at the periphery of the Galactic HII region Sh2-212.

Methods: We present CO millimetre observations of this region obtained at the IRAM 30-m telescope to investigate the distribution of associated molecular material. We also use deep JHK observations obtained at the CFHT to study the stellar content of the region, and radio observations obtained at the VLA to look for the presence of an ultra-compact (UC) HII region and for maser emission.
Results: In the optical, Sh2-212 is spherically symmetric around its central exciting cluster. This HII region is located along a molecular filament. A thin, well-defined half ring of molecular material surrounds the brightest part of the HII region at the rear and is fragmented. The most massive fragment (∼200 solar masses) contains a massive young stellar object displaying a near-IR excess; its spectral energy distribution indicates a high-mass (14 solar masses), high-temperature (∼30000 K), and high-luminosity (17000 solar luminosities) source. This object ionizes a UC HII region.
Conclusions: Sh2-212 is a good example of massive-star formation triggered via the collect and collapse process. The massive YSO observed at its periphery is a good candidate for a massive star formed in isolation.

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Core Mass Function: The Role of Gravity

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We analyze the mass distribution of cores formed in an isothermal, magnetized, turbulent, and self-gravitating nearly critical molecular cloud model. Cores are identified at two density threshold levels. Our main results are that the presence of self-gravity modifies the slopes of the core mass function (CMF) at the high mass end. At low thresholds, the slope is shallower than the one predicted by pure turbulent fragmentation. The shallowness of the slope is due to the effects of core coalescence and gas accretion. Most importantly, the slope of the CMF at the high mass end steepens when cores are selected at higher density thresholds, or alternatively, if the CMF is fitted with a log-normal function, the width of the log-normal distribution decreases with increasing threshold. This is due to the fact that gravity plays a more important role in denser structures selected at higher density threshold and leads to the conclusion that the role of gravity is essential in generating a CMF that bears more resemblance with the IMF when cores are selected with an increasing density threshold in the observations.

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A large-scale optical-near infrared survey for brown dwarfs and very low-mass stars in the Orion OB1 association

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We report the initial results of a large-scale optical-near infrared survey to extend the known young population of the entire Orion star-forming region down to the substellar domain. Using deep optical I-band photometry and data from

the 2MASS survey, we selected candidates across $\sim 14.8\ deg^2$ in the ~ 8 Myr old Ori OB1a subassociation and over $\sim 6.7\ deg^2$ in the Ori OB1b subassociation (age ~ 3 Myr), with completeness down to $0.05 M_\odot$ and $0.072 M_\odot$ respectively. We obtained low resolution optical spectra for a subsample of 4 candidates in Ori OB1a and 26 in Ori OB1b; as a result we confirmed 3 new members in Ori OB1a, one of which is substellar, and 19 new members in Ori OB1b, out of which 7 are at the substellar limit and 5 are substellar. We looked into the presence of accretion signatures by measuring the strength of the Hα line in emission. Accordingly, we classified the new members as having Classical T-Tauri star (CTTS) or Weak Lined T Tauri star-like (WTTS) nature. We found that all the new members confirmed in Ori OB1a are WTTSs, while $39^{+25}_{-22}\%$ of the new members in Ori OB1b exhibit CTTS-like behavior, suggestive of ongoing accretion from a circum(sub)stellar disk. Additionally we found that none of the members confirmed in OB1a show near-IR color excess while $38^{+26}_{-21}\%$ of OB1b members show H-K color excess. These results are consistent with recent findings for low mass young stars in Orion OB1. The similarity in CTTS-like properties and near-IR excess across the substellar boundary gives support to the idea of a common formation mechanism for low mass stars and at least the most massive brown dwarfs. Finally, we remark the discovery of two new members classified as CTTSs, both exhibiting $W(H\alpha) < -140$ Å, suggesting significant ongoing accretion.

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Proplyds and Massive Disks in the Orion Nebula Cluster Imaged with CARMA and SMA

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We imaged a $2' \times 2'$ region of the Orion Nebula cluster in 1.3 mm wavelength continuum emission with the recently commissioned Combined Array for Research in Millimeter Astronomy (CARMA) and with the Submillimeter Array (SMA). Our mosaics include > 250 known near-IR cluster members, of which 36 are so-called "proplyds" that have been imaged previously with the Hubble Space Telescope. We detected 40 sources in 1 mm continuum emission (one of which is the BN Object), and several of them are spatially resolved with our observations. 33 detected sources are known near-IR cluster members, of which 11 are proplyds. The 1 mm emission from the majority of detected sources appears to trace warm circumstellar dust. However, for many of the proplyds, which are located close to the Trapezium stars, the millimeter wavelength fluxes are dominated by thermal free-free emission from hot, ionized gas. Dust masses inferred for detected sources range from 0.01 to 0.5 $M_\odot$. For the ~ 225 known near-IR cluster members not detected in our 1 mm observations, images toward the positions of near-IR sources were stacked to constrain the mean 1 mm flux of the ensemble. The average flux is detected at the $> 4\sigma$ confidence level, and implies an average disk mass of ~ 0.001 $M_\odot$, approximately an order of magnitude smaller than the minimum mass solar nebula. Most stars in the ONC thus do not appear to currently possess sufficient mass in small dust grains to form Jupiter-mass (or larger) planets. Comparison with previous results for younger and older regions indicates that massive disks evolve significantly on $\sim$Myr timescales. We also show that the percentage of stars in Orion surrounded by disks more massive than ~ 0.01 $M_\odot$ is substantially lower than in Taurus, indicating that environment has an impact on the disk mass distribution. Disks in Orion may be truncated through photoevaporation caused by the intense radiation field of the Trapezium stars, and we see marginal evidence for such a scenario in the spatial distribution of massive disks within the cluster. Our data show no statistically significant correlation between disk and stellar masses, although we see hints of a higher percentage of massive disks around lower mass stars.

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Kinematic Structure of the Orion Nebula Cluster and Its Surroundings

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We present results from 1351 high-resolution spectra of 1215 stars in the Orion Nebula Cluster (ONC) and the surrounding Orion 1c association, obtained with the Hectochelle multiobject echelle spectrograph on the 6.5 m MMT. We confirmed 1111 stars as members, based on their radial velocity and/or Hα emission. The radial velocity distribution of members shows a dispersion of $\sigma = 3.1$ km s^1. We found a substantial north-south velocity gradient and spatially coherent structure in the radial velocity distribution, similar to that seen in the molecular gas in the region. We also identified several binary and high velocity stars, a region exhibiting signs of triggered star formation, and a possible foreground population of stars somewhat older than the ONC. Stars without infrared excesses (as detected with the IRAC instrument on the Spitzer Space Telescope) exhibit a wider spread in radial velocity than the infrared excess stars; this spread is mostly due to a blueshifted population of stars that may constitute a foreground population. We also identify some accreting stars, based on Hα, that do not have detectable infrared excesses with IRAC, and thus are potential transitional disk systems (objects with inner disk holes). We propose that the substructure seen in both the stellar and gaseous components is the result of nonuniform gravitational collapse to a filamentary distribution of gas. The spatial and kinematic correlation between the stellar and gaseous components suggests that the region is very young, probably only 1 crossing time old or less, to avoid shock dissipation and gravitational interactions which would tend to destroy the correlation between stars and gas.

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Low-Mass Star Forming Cores in the GF 9 Filament

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We carried out an unbiased mapping survey of dense molecular cloud cores traced by the NH_3 (1,1) and (2,2) inversion lines in the GF 9 filament which contains an extremely young low-mass protostar GF 9-2 (Furuya et al. 2006, ApJ, 653, 1369). The survey was conducted using the Nobeyama 45 m telescope over a region of $\sim 1.5^\circ \times 1^\circ$ with an angular resolution of 73". The large-scale map revealed that the filament contains at least 7 dense cores, as well as 3 possible ones, located at regular intervals of ~ 0.9 pc. Our analysis shows that these cores have kinetic temperatures of $\lesssim 10$ K and LTE-masses of $1.8 - 8.2\ M_\odot$, making them typical sites of low-mass star formation. All the identified cores are likely to be gravitationally unstable because their LTE-masses are larger than their virial masses. Since the LTE-masses and separations of the cores are consistent with the Jeans masses and lengths, respectively, for the low-density ambient gas, we argue that the identified cores have formed via the gravitational fragmentation of the natal filamentary cloud.

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

Unveiling extremely veiled T Tauri stars

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Context. Photospheric absorption lines in classical T Tauri stars (CTTS) are weak compared to normal stars. This so-called veiling is normally identified with an excess continuous emission formed in shock-heated gas at the stellar surface below the accretion streams.

Aims. We have selected four stars (RW Aur A, RU Lup, S CrA NW and S CrA SE) with unusually strong veiling to make a detailed investigation of veiling versus stellar brightness and emission line strengths for comparisons to standard accretion models.

Methods. We have monitored the stars photometrically and spectroscopically at several epochs.

Results. In standard accretion models a variable accretion rate will lead to a variable excess emission. Consequently, the stellar brightness should vary accordingly. We find that the veiling of absorption lines in these stars is strongly variable and usually so large that it would require the release of several stellar luminosities of potential energy. At states of very large line dilution, the correspondingly large veiling factors derived correlate only weakly with brightness. Moreover, the emission line strengths violate the expected trend of veiling versus line strength. The veiling can change dramatically in one night, and is not correlated with the phase of the rotation periods found for two stars.

Conclusions. We show that in at least three of the stars, when the veiling becomes high, the photospheric lines become filled-in by line emission, which produces large veiling factors unrelated to changes in any continuous emission from shocked regions. We also consider to what extent extinction by dust and electron scattering in the accretion stream may affect veiling measures in CTTS. We conclude that the degree of veiling cannot be used as a measure of accretion rates in CTTS with rich emission line spectra.

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Near-infrared, IFU spectroscopy unravels the bow-shock HH99B

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Aims. We aim at characterising the morphology and the physical parameters governing the shock physics of the Herbig-Haro object HH99B. We obtained SINFONI-SPIFFI IFU spectroscopy (R $\sim$ 2000-4000) between 1.10 and 2.45 μm detecting more than 170 emission lines, that, to a large extent, have never observed before in a Herbig-Haro object. Most of them come from ro-vibrational transitions of molecular hydrogen ($v_{\rm up} \leq 7$, $E_{\rm up} \lesssim 38\,000$ K) and [FeII] ($E_{\rm up} \lesssim 30\,000$ K). In addition, we observed several hydrogen and helium recombination lines, along with fine-structure lines of ionic species. All the brightest lines appear resolved in velocity.

Methods. Intensity ratios of ionic lines were compared with predictions of NLTE models to derive bi-dimensional maps of extinction and electron density, along with estimates of temperature, fractional ionisation, and atomic hydrogen post-shock density. The H_2 line intensities were interpreted in the framework of Boltzmann diagrams, from which we have derived extinction and temperature maps of the molecular gas. From the intensity maps of bright lines (i.e.

H_2 2.122 μm and [FeII] 1.644 μm), the kinematical properties of the shock(s) at work in the region were delineated. Finally, from selected [FeII] lines, constraints on the spontaneous emission coefficients of the 1.257, 1.321, and 1.644 μm lines are provided.

Results. Visual extinction variations up to 4 mag emerge, showing that the usual assumption of constant extinction could be critical. The highest A_V is found at the bowhead ($A_V \sim 4$ mag) while diminishing along the flanks. The electron density increases from $\sim 3 \times 10^3$ cm^{-3} in the receding parts of the shock to $\sim 6 \times 10^3$ cm^{-3} in the apex, where we estimate a temperature of ∼16 000 K from [FeII] line ratios. Molecular gas temperature is lower in the bow flanks ($T \sim 3000$ K), then progressively increases toward the head up to $T \sim 6000$ K. In the same zone, we are able to derive the iron gas-phase abundance (∼60% of the solar value) from the [FeII]1.257/[PII]1.187 line ratio, along with the hydrogen fractional ionisation (up to 50% at the bowhead) and the atomic hydrogen post-shock gas density ($\sim 1 \times 10^4$ cm^{-3}). The kinematical properties derived for the molecular gas substantially confirm earlier ones, while new information (e.g. $v_{\rm shock} \sim 115$ km s^{-1}) is provided for the shock component responsible for the ionic emission. We also provide an indirect measure of the H_2 breakdown speed (between 70 and 90 km s^{-1}) and compute the inclination angle with respect to the line of sight. The map parameters, along with images of the observed line intensities, will be used to put stringent constraints on up-to-date shock models.

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Line Emission from Gas in Optically Thick Dust Disks around Young Stars

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We present self-consistent models of gas in optically-thick dusty disks and calculate its thermal, density and chemical structure. The models focus on an accurate treatment of the upper layers where line emission originates, and at radii $>\sim 0.7$ AU. Although our models are applicable to stars of any mass, we present here only results around $\sim 1 M_\odot$ stars where we have varied dust properties, X-ray luminosities and UV luminosities. We separately treat gas and dust thermal balance, and calculate line luminosities at infrared and sub-millimeter wavelengths from all transitions originating in the predominantly neutral gas that lies below the very tenuous and completely ionized surface of the disk. We find that the [ArII] 7μm, [NeII] 12.8μm, [FeI] 24μm, [SI] 25μm, [FeII] 26μm, [SiII] 35 μm, [OI] 63μm and pure rotational lines of H_2 and CO can be quite strong and are good indicators of the presence and distribution of gas in disks. Water is an important coolant in the disk and many water emission lines can be moderately strong. Current and future observational facilities such as the Spitzer Space Telescope, Herschel Observatory and SOFIA are capable of detecting gas emission from young disks. We apply our models to the disk around the nearby young star, TW Hya, and find good agreement between our model calculations and observations. We also predict strong emission lines from the TW Hya disk that are likely to be detected by future facilities. A comparison of CO observations with our models suggests that the gas disk around TW Hya may be truncated to ~ 120 AU, compared to its dust disk of 174 AU. We speculate that photoevaporation due to the strong stellar FUV field from TW Hya is responsible for the gas disk truncation.

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Wide-Field Infrared Imaging Polarimetry of the NGC 6334 Region: A Nest of Infrared Reflection Nebulae

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We report the detection of eighteen infrared reflection nebulae (IRNe) in the J, H, & Ks linear polarimetric observations of the NGC 6334 massive star-formation complex, of which 16 IRNe are new discoveries. Our images cover ∼180 square arcminutes, one of the widest near-infrared polarization data in star-formation regions so far. These IRNe are most likely associated with embedded young OB stars at different evolutionary phases, showing a variety of sizes, morphologies, and polarization properties, which can be divided into four categories. We argue the different nebula characteristics to be a possible evolutionary sequence of circumstellar structures around young massive stars.

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A Resolved Molecular Gas Disk around the Nearby A Star 49 Ceti

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The A star 49 Ceti, at a distance of 61 pc, is unusual in retaining a substantial quantity of molecular gas while exhibiting dust properties similar to those of a debris disk. We present resolved observations of the disk around 49 Ceti from the Submillimeter Array in the J=2-1 rotational transition of CO with a resolution of 1.0×1.2 arcsec. The observed emission reveals an extended rotating structure viewed approximately edge-on and clear of detectable CO emission out to a distance of ∼ 90 AU from the star. No 1.3 millimeter continuum emission is detected at a 3σ sensitivity of 2.1 mJy/beam. Models of disk structure and chemistry indicate that the inner disk is devoid of molecular gas, while the outer gas disk between 40 and 200 AU from the star is dominated by photochemistry from stellar and interstellar radiation. We determine parameters for a model that reproduces the basic features of the spatially resolved CO J=2-1 emission, the spectral energy distribution, and the unresolved CO J=3-2 spectrum. We investigate variations in disk chemistry and observable properties for a range of structural parameters. 49 Ceti appears to be a rare example of a system in a late stage of transition between a gas-rich protoplanetary disk and a tenuous, virtually gas-free debris disk.

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http://www.cfa.harvard.edu/∼mhughes/download/49cet_apj.ps

Sequential star formation in a cometary globule (BRC37) of IC1396

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We have carried out near-IR/optical observations to examine star formation toward a bright-rimmed cometary globule (BRC37) facing the exciting star(s) of an HII region (IC1396) containing an IRAS source, which is considered to be

an intermediate-mass protostar. With slit-less spectroscopy we detected ten Hα emission stars around the globule, six of which are near the tip of the globule and are aligned along the direction to the exciting stars. There is evidence that this alignment was originally towards an O9.5 star, but has evolved to align towards a younger O6 star when that formed. Near-IR and optical photometry suggests that four of these six stars are low-mass young stellar objects (YSOs) with masses of ~ 0.4 $M_{\odot}$. Their estimated ages of ~ 1 Myr indicate that they were formed at the tip in advance of the formation of the IRAS source. Therefore, it is likely that sequential star formation has been taking place along the direction from the exciting stars towards the IRAS source, due to the UV impact of the exciting star(s). Interestingly, one faint, Hα emission star, which is the closest to the exciting star(s), seems to be a young brown dwarf that was formed by the UV impact in advance of the formation of other YSOs at the tip.

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The Disk Around CoKu Tauri/4: Circumbinary, Not Transitional

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CoKu Tau/4 has been labeled as one of the very few known transition disk objects-disks around young stars that have their inner disks cleared of dust, arguably as a result of planetary formation. We report aperture-masking interferometry and adaptive optics imaging observations showing that CoKu Tau/4 is in fact a near-equal binary star of projected separation ∼53 mas (∼8 AU). The spectral energy distribution of the disk is then naturally explained by the inner truncation of the disk through gravitational interactions with the binary star system. We discuss the possibility that such "unseen" binary companions could cause other circumbinary disks to be labeled as transitional.

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A coagulation-fragmentation model for the turbulent growth and destruction of preplanetesimals

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To treat the problem of growing protoplanetary disc solids across the meter barrier, we consider a very simplified two-component coagulation-fragmentation model that consists of macroscopic boulders and smaller dust grains, the latter being the result of catastrophic collisions between the boulders. Boulders in turn increase their radii by sweeping up the dust fragments. An analytical solution to the dynamical equations predicts that growth by coagulation-fragmentation can be efficient and allow agglomeration of 10-meter-sized objects within the time-scale of the radial drift. These results are supported by computer simulations of the motion of boulders and fragments in 3-D time-dependent magnetorotational turbulence. Allowing however the fragments to diffuse freely out of the sedimentary layer of boulders reduces the density of both boulders and fragments in the mid-plane, and thus also the growth of the boulder radius, drastically. The reason is that the turbulent diffusion time-scale is so much shorter than the collisional time-scale that dust fragments leak out of the mid-plane layer before they can be swept up by the boulders there. Our conclusion that coagulation-fragmentation is not an efficient way to grow across the meter barrier in fully turbulent protoplanetary discs confirms recent results by Brauer, Dullemond, & Henning who solved the coagulation equation in a parameterised turbulence model with collisional fragmentation, cratering, radial drift, and a range of particle sizes. We find that a relatively small population of boulders in a sedimentary mid-plane layer can populate the entire vertical extent of the disc with small grains and that these grains are not first generation dust, but have been through several agglomeration-destruction cycles during the simulations.

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Planet formation around stars of various masses: Hot super-Earths

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We consider trends resulting from two formation mechanisms for short-period super-Earths: planet-planet scattering and migration. We model scenarios where these planets originate near the snow line in "cold finger" circumstellar disks. Low-mass planet-planet scattering excites planets to low periastron orbits only for lower mass stars. With long circularisation times, these planets reside on long-period eccentric orbits. Closer formation regions mean planets that reach short-period orbits by migration are most common around low-mass stars. Above 1 Solar mass, planets massive enough to migrate to close-in orbits before the gas disk dissipates are above the critical mass for gas giant formation. Thus, there is an upper stellar mass limit for short-period super-Earths that form by migration. If disk masses are distributed as a power law, planet frequency increases with metallicity because most disks have low masses. For disk masses distributed around a relatively high mass, planet frequency decreases with increasing metallicity. As icy planets migrate, they shepherd interior objects toward the star, which grow to 1 Earth mass. In contrast to icy migrators, surviving shepherded planets are rocky. Upon reaching short-period orbits, planets are subject to evaporation processes. The closest planets may be reduced to rocky or icy cores. Low-mass stars have lower EUV luminosities, so the level of evaporation decreases with decreasing stellar mass.

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High- and Low-Velocity Magnetized Outflows in Star Formation Process in a Gravitationally Collapsing Cloud

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The driving mechanism of outflows and jets in star formation process is studied using three-dimensional resistive MHD nested grid simulations. Starting with a Bonnor-Ebert isothermal cloud rotating in a uniform magnetic field, we calculated cloud evolution from the molecular cloud core ($n_{\rm c} = 10^4\,{\rm cm}^{-3}$, $r = 4.6 \times 10^4\,{\rm AU}$) to the stellar core ($n_{\rm c} = 10^{22}\,{\rm cm}^{-3}$, $r \sim 1 R_\odot$), where $n_{\rm c}$ and r denote the central density and radius of each object, respectively. In the collapsing cloud core, we found two distinct flows: Low-velocity flows ($\sim 5\,{\rm km\,s}^{-1}$) with a wide opening angle, driven from the adiabatic core when the central density exceeds $n_{\rm c} > 10^{12}\,{\rm cm}^{-3}$, and high-velocity flows ($\sim 30\,{\rm km\,s}^{-1}$) with good collimation, driven from the protostar when the central density exceeds $n_{\rm c} > 10^{21}\,{\rm cm}^{-3}$. High-velocity flows are enclosed by low-velocity flows after protostar formation. The difference in the degree of collimation between the two flows is caused by the strength of the magnetic field and configuration of the magnetic field lines. The magnetic field around an adiabatic core is strong and has an hourglass configuration; therefore, flows from the adiabatic core (low-velocity flow) are driven mainly by the magnetocentrifugal mechanism and guided by the hourglass-like field lines. In contrast, the magnetic field around the protostar is weak and has a straight configuration owing to Ohmic dissipation in the high-density gas region. Therefore, flows from the protostar (high-velocity flow) are driven mainly by the magnetic pressure gradient force and guided by straight field lines. Differing depth of the gravitational potential between the adiabatic core and the protostar cause the difference of the flow speed. Low-velocity flows correspond to the observed molecular outflows, while high-velocity flows correspond to the observed optical jets. We suggest that the protostellar outflow and the jet are driven by different cores, rather than that the outflow being entrained by the jet.

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Formation Scenario for Wide and Close Binary Systems

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Fragmentation and binary formation processes are studied using three-dimensional resistive MHD nested grid simulations. Starting with a Bonnor-Ebert isothermal cloud rotating in a uniform magnetic field, we calculate the cloud evolution from the molecular cloud core ($n = 10^4$ cm^{-3}) to the stellar core ($n \simeq 10^{22}$ cm^{-3}), where n denotes the central density. We calculated 147 models with different initial magnetic, rotational, and thermal energies and the amplitudes of the nonaxisymmetric perturbation. In a collapsing cloud, fragmentation is mainly controlled by the initial ratio of the rotational to the magnetic energy, regardless of the initial thermal energy and amplitude of the nonaxisymmetric perturbation. The cloud rotation promotes fragmentation, while the magnetic field delays or in some cases suppresses fragmentation through all phases of cloud evolution. The results are categorized into three types. When the clouds have larger rotational energies in relation to magnetic energies, fragmentation occurs in the low-density phase (10^{12}cm$^{-3} \lesssim$ n $\lesssim 10^{15}$cm^{-3}) with separations of 3-300 AU. Fragments that appeared in this phase are expected to evolve into wide binary systems. On the other hand, when initial clouds have larger magnetic energies in relation to the rotational energies, fragmentation occurs only in the high-density phase ($n \gtrsim 10^{17}$cm^{-3}) after the clouds experience a significant reduction of the magnetic field owing to the ohmic dissipation. Fragments appearing in this phase have mutual separations of 0.3 AU and are expected to evolve into close binary systems. No fragmentation occurs in the case of sufficiently strong magnetic field, in which single stars are expected to be born. Two types of fragmentation epoch reflect wide and close separations. We might be able to observe a bimodal distribution for the radial separation of the protostar in extremely young stellar groups.

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Conditions for the Formation of First-Star Binaries

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The fragmentation process of primordial-gas cores during prestellar collapse is studied using three-dimensional nested-grid hydrodynamics. Starting from the initial central number density of $n_c \sim 10^3$cm^{-3}, we follow the evolution of rotating spherical cores up to the stellar density . An initial condition of the cores is specified by three parameters: the ratios of the rotation and thermal energies to the gravitational energy (β_0 and α_0, respectively), and the amplitude of the bar-mode density perturbation (A_ϕ). Cores with rotation $\beta_0 > 10^{-6}$ are found to fragment during the collapse. The fragmentation condition hardly depends on either the initial thermal energy or amplitude of bar-mode perturbation A_ϕ. Since the critical rotation parameter for fragmentation is lower than that expected in first-star formation, binaries or multiples are also common for the first stars.

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Biases on Initial Mass Function Determinations. II. Real Multiple Systems and Chance Superpositions

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When calculating stellar initial mass functions (IMFs) for young clusters, one has to take into account that (1) most massive stars are born in multiple systems, (2) most IMFs are derived from data that cannot resolve such systems, and (3) multiple chance superpositions between members are expected to happen if the cluster is too distant. In this article I use numerical experiments to model the consequences of those phenomena on the observed color-magnitude diagrams and the IMFs derived from them. Real multiple systems affect the observed or apparent massive-star MF slope little but can create a significant population of apparently ultramassive stars. Chance superpositions produce only small biases when the number of superimposed stars is low but, once a certain number threshold is reached, they can affect both the observed slope and the apparent stellar upper mass limit. I apply these experiments to two well known massive young clusters in the Local Group, NGC 3603 and R136. In both cases I show that the observed population of stars with masses above 120 $M_\odot$ can be explained by the effects of unresolved objects, mostly real multiple systems for NGC 3603 and a combination of real and chance-alignment multiple systems for R136. Therefore, the case for the reality of a stellar upper mass limit at solar or near-solar metallicities is strengthened, with a possible value even lower than 150 $M_\odot$. An IMF slope somewhat flatter than Salpeter or Kroupa with γ between -1.6 and -2.0 is derived for the central region of NGC 3603, with a significant contribution to the uncertainty arising from the imprecise knowledge of the distance to the cluster. The IMF at the very center of R136 cannot be measured with the currently available data but the situation could change with new HST observations.

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A survey for low-mass spectroscopic binary stars in the young clusters around σ Orionis and λ Orionis

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We have obtained multi-epoch, high-resolution spectroscopy of 218 candidate low-mass stars and brown dwarfs (BDs) in the young clusters around σ Ori and λ Ori. We find that 196 targets are cluster members based on their radial velocity, the equivalent width of their Na I 8200 lines and the spectral type from their TiO band strength. We have identified 11 new binary stars among the cluster members based on their variable radial velocity and an additional binary from the variation in its linewidth and shape. Of these, six are double-lined spectroscopic binaries (SB2) where the components of the binary are of comparable brightness. The others are single-lined binaries (SB1) in which the companion is faint or the spectra of the stars are blended. There are three narrow-lined SB1 binaries in our sample for which the companion is more than 2.5 mag fainter than the primary. This suggests that the mass ratio distribution for the spectroscopic binaries in our sample is broad but that there may be a peak in the distribution near q = 1. The sample covers the magnitude range I_C = 14-18.9 (mass $\approx$ 0.55-0.03 $M_\odot$), but all of the binary stars are brighter than I_C = 16.6 (mass $\approx$ 0.12 $M_\odot$) and 10 are brighter than I_C = 15.5 (mass $\approx$ 0.23 $M_\odot$). There is a significant lack of spectroscopic binaries in our sample at faint magnitudes even when we account for the decrease in sensitivity with increasing magnitude. We can reject the hypothesis that the fraction of spectroscopic binaries is a uniform function of I_C magnitude with more than 99 per cent confidence. The spectroscopic binary fraction for stars more massive than about 0.1 $M_\odot$ ($I_C < 16.9$) is $f_{bright} = 0.095^{+0.012}_{0.028}$. The 90 per cent confidence upper limit to the spectroscopic binary fraction for very low-mass (VLM) stars (mass <0.1 $M_\odot$) and BDs is $f_{faint} < 7.5$ per cent. The hypothesis that f_{bright} and f_{faint} are equal can be rejected with 90 per cent confidence. The average detection probability for our survey is 50 per cent or more for binaries with separations up to 0.28 au for stars with $I_C < 16.9$ and 0.033 au for the fainter stars in our sample. We conclude that we have found strong evidence for a change in the fraction of spectroscopic binaries among young VLM stars and BDs when compared to more massive stars in the same star-forming region. This implies a difference in the total binary fraction between VLM stars and BDs compared to more massive stars or a difference in the distribution of semimajor axes, or both.

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Atomic Diagnostics of X-Ray-Irradiated Protoplanetary Disks

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We study atomic-line diagnostics of the inner regions of protoplanetary disks with our model of X-ray-irradiated disk atmospheres, which was previously used to predict observable levels of the Ne II and Ne III fine-structure transitions at 12.81 and 15.55 μm. We extend the X-ray ionization theory to sulfur and calculate the fraction of sulfur in S, S+, S2+, and sulfur molecules. For the D'Alessio generic T Tauri star disk, we find that the S I fine-structure line at 25.55 μm is below the detection level of the Spitzer Infrared Spectrometer (IRS), in large part due to X-ray ionization of atomic S at the top of the atmosphere and to its incorporation into molecules close to the midplane. We predict that observable fluxes of the S II λ6718/λ6732 forbidden transitions are produced in the upper atmosphere at somewhat shallower depths and smaller radii than the neon fine-structure lines. This and other forbidden-line transitions, such as the O I λ6300/λ6363 and C I λ9826/λ9852 lines, serve as complementary diagnostics of X-ray-irradiated disk atmospheres. We have also analyzed the potential role of the low-excitation fine-structure lines of C I, C II, and O I, which should be observable by SOFIA and Herschel.

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The influence of the environment on the propagation of protostellar outflows

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The properties of bipolar outflows depend on the structure in the environment as well as the nature of the jet. To help distinguish between the two, we investigate here the properties pertaining to the ambient medium. We execute axisymmetric hydrodynamic simulations, injecting continuous atomic jets into molecular media with density gradients (protostellar cores) and density discontinuities (thick swept-up sheets). We determine the distribution of outflowing mass with radial velocity (the mass spectrum) to quantify our approach and to compare to observationally determined values. We uncover a sequence from clump entrainment in the flanks to bow shock sweeping as the density profile steepens. We also find that the dense, highly supersonic outflows remain collimated but can become turbulent after passing through a shell. The mass spectra vary substantially in time, especially at radial speeds exceeding 15 km s^{-1}. The mass spectra also vary according to the conditions: both envelope-type density distributions and the passage through dense sheets generate considerably steeper mass spectra than a uniform medium. The simulations suggest that observed outflows penetrate highly non-uniform media.

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Observations of Disks around Brown Dwarfs in the TW Hydra Association with the Spitzer Infrared Spectrograph

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Using SpeX at the NASA Infrared Telescope Facility and the Spitzer Infrared Spectrograph, we have obtained infrared spectra from 0.7 to 40 μm for three young brown dwarfs in the TW Hydra association ($\tau \sim 10$ Myr), 2MASSW J1207334-393254, 2MASSW J1139511-315921, and SSSPM J1102-3431. The spectral energy distribution for 2MASSW J1139511-315921 is consistent with a stellar photosphere for the entire wavelength range of our data, whereas the other two objects exhibit significant excess emission at μm. We are able to reproduce the excess emission from each brown dwarf using our models of irradiated accretion disks. According to our model fits, both disks have experienced a high degree of dust settling. We also find that silicate emission at 10 and 20 μm is absent from the spectra of these disks, indicating that grains in the upper disk layers have grown to sizes larger than 5 μm. Both of these characteristics are consistent with previous observations of decreasing silicate emission with lower stellar masses and older ages. These trends suggest that either (1) the growth of dust grains, and perhaps planetesimal formation, occurs faster in disks around brown dwarfs than in disks around stars or (2) the radii of the mid-IR-emitting regions of disks are smaller for brown dwarfs than for stars, and grains grow faster at smaller disk radii. Finally, we note the possible detection of an unexplained emission feature near 14 μm in the spectra of both of the disk-bearing brown dwarfs.

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The Evolution of Circumstellar Disks in Ophiuchus Binaries

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Four Ophiuchus binaries, two Class I systems and two Class II systems, with separations of 450-1100 AU, were observed with the Owens Valley Radio Observatory (OVRO) millimeter interferometer. In each system, the 3 mm continuum maps show dust emission at the location of the primary star, but no emission at the position of the secondary. This result is different from observations of less evolved Class 0 binaries, in which dust emission is detected from both sources. The nondetection of secondary disks is, however, similar to the dust distribution seen in wide Class II Taurus binaries. The combined OVRO results from the Ophiuchus and Taurus binaries suggest that secondary disk masses are significantly lower than primary disk masses by the Class II stage, with initial evidence that massive secondary disks are reduced by the Class I stage. Although some of the secondaries retain hot inner disk material, the early dissipation of massive outer disks may negatively impact planet formation around secondary stars. Masses for the circumprimary disks are within the range of masses measured for disks around single T Tauri stars and, in some cases, larger than the minimum mass solar nebula. More massive primary disks are predicted by several formation models and are broadly consistent with the observations. Combining the 3 mm data with previous 1.3 mm observations, the dust opacity power-law index for each primary disk is estimated. The opacity index values are all less than the scaling for interstellar dust, possibly indicating grain growth within the circumprimary disks.

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Star formation in the southern dark cloud DC 296.2−3.6

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We report near and mid-infrared images of the Southern Hemisphere dark cloud DC 296.2−3.6 associated with IRAS 11431−6516. The K_s and L' images show the presence of an infrared nebulosity at the center of the dark cloud. From the analysis of the near-infrared color-color diagrams we have identified a young stellar population in the region. Five of these young stellar objects, here named A, B, C, D, and E were detected also in the mid-infrared. Sources B, D, and E are Class I-II T Tauri as suggested by the analysis of their spectral energy distributions. In addition, source E shows a long term near-infrared variability. The near-infrared color-color diagrams indicate the presence of circumstellar dust envelope in sources A, B, D and E, while the fit of SEDs of the intermediate- and low-mass objects A and B with a radiation transfer model including infalling envelope+disk+central source, suggest circumstellar disks around these two objects. The results present ed here indicate that DC 296.2−3.6, located in the far Carina arm, is associated with an embedded clusters of low-mass young stellar objects.

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Constraints on resonant-trapping for two planets embedded in a protoplanetary disc

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Context. A number of extrasolar planet systems contain pairs of Jupiter-like planets in mean motion resonances. As yet there are no known resonant systems which consist of a giant planet and a significantly lower-mass body.

Aims. We investigate the evolution of two-planet systems embedded in a protoplanetary disc, which are composed of a Jupiter-mass planet plus another body located further out in the disc. The aim is to examine how the long-term evolution of such a system depends on the mass of the outer planet.

Methods. We have performed 2D numerical simulations using a grid-based hydrodynamics code. The planets can interact with each other and with the disc in which they are embedded. We consider outermost planets with masses ranging from 10 $M_\oplus$ to 1 M_J. Combining the results of these calculations and analytical estimates, we also examine the case of outermost bodies with masses $< 10\ M_\oplus$.

Results. Differential migration of the planets due to disc torques leads to different evolution outcomes depending on the mass of the outer protoplanet. For planets with mass $\lesssim 3.5\ M_\oplus$ the type II migration rate of the giant exceeds the type I migration rate of the outer body, resulting in divergent migration. Outer bodies with masses in the range $3.5 < m_o \leq 20\ M_\oplus$ become trapped at the edge of the gap formed by the giant planet, because of corotation torques. Higher mass planets are captured into resonance with the inner planet. If $30 \leq m_o \leq 40\ M_\oplus$ or $m_o = 1\ M_J$, then the 2:1 resonance is established. If $80 \leq m_o \leq 100\ M_\oplus$, the 3:2 resonance is favoured. Simulations of gas-accreting protoplanets of mass $m_o \geq 20\ M_\oplus$, trapped initially at the edge of the gap, or in the 2:1 resonance, also result in eventual capture in the 3:2 resonance as the planet mass grows to become close to the Saturnian value.

Conclusions. Our results suggest that there is a theoretical lower limit to the mass of an outer planet that can be captured into resonance with an inner Jovian planet, which is relevant to observations of extrasolar multiplanet systems. Furthermore, capture of a Saturn-like planet into the 3:2 resonance with a Jupiter-like planet is a very robust outcome of simulations, independent of initial conditions. This result is relevant to recent scenarios of early Solar System evolution which require Saturn to have existed interior to the 2:1 resonance with Jupiter prior to the onset of the Late Heavy Bombardment.

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The effect of magnetic fields on star cluster formation

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We examine the effect of magnetic fields on star cluster formation by performing simulations following the self-gravitating collapse of a turbulent molecular cloud to form stars in ideal magnetohydrodynamics. The collapse of the cloud is computed for global mass-to-flux ratios of ∞, 20, 10, 5 and 3, i.e. using both weak and strong magnetic fields. Whilst even at very low strengths the magnetic field is able to significantly influence the star formation process, for magnetic fields with plasma $\beta < 1$ the results are substantially different to the hydrodynamic case. In these cases we find large-scale magnetically supported voids imprinted in the cloud structure; anisotropic turbulent motions and column density striations aligned with the magnetic field lines, both of which have recently been observed in the Taurus molecular cloud. We also find strongly suppressed accretion in the magnetized runs, leading to up to a 75 per cent reduction in the amount of mass converted into stars over the course of the calculations and a more quiescent mode of star formation. There is also some indication that the relative formation efficiency of brown dwarfs is lower in the strongly magnetized runs due to a reduction in the importance of protostellar ejections.

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Massive molecular outflows associated with UCHII/HII regions

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Aims: We searched for the molecular outflows from fifteen molecular clouds associated with ultra-compact and compact HII (UCHII/HII) regions and discussed possible gas heating mechanism. *Methods*: Mapping observations of CO $J = 3-2$ and $J = 2-1$ lines were carried out with the KOSMA 3m-Telescope towards the 15 HII regions/molecular cloud complexes. *Results*: Ten molecular outflows were identified out of the fifteen HII region/molecular cloud complexes. The higher outflow detection rate (67%) suggested that such outflows are as common in high mass star forming regions as those in low mass star forming regions, which is consistent with the results of other authors. The observations also showed that the outflow might occur in the HII region. The integrated CO line intensity ratios ($R_{I_{CO(3-2)}/I_{CO(2-1)}}$) were determined from the core component of the spectra as well as from both the blue and red wings. Maximum line intensity ratios from the wings and core components appeared to be related to the mid-infrared sources imaged by Midcourse Space Experiment (MSX). The relationship between the maximum line intensity ratios and MSX sources indicates that the molecular gas could be heated by the emission of dust associated with massive stars. Based on maser observations reported in the literature, we found that H_2O masers were only detected in seven regions. The H_2O masers in these regions are located near the MSX sources and within the maximum line intensity ratio regions, suggesting that H_2O masers occur in relatively warm environments.

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Debris Disks around Nearby Stars with Circumstellar Gas

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We conducted a survey for infrared excess emission from 16 nearby main-sequence shell stars using the Multiband Imaging Photometer for Spitzer (MIPS) on the Spitzer Space Telescope. Shell stars are early-type stars with narrow absorption lines in their spectra that appear to arise from circumstellar (CS) gas. Four of the 16 stars in our survey showed excess emission at 24 and 70 μm characteristic of cool CS dust and are likely to be edge-on debris disks. Including previously known disks, it appears that the fraction of protoplanetary and debris disks among the main-sequence shell stars is at least . While dust in debris disks has been extensively studied, relatively little is known

about their gas content. In the case of β Pictoris, extensive observations of gaseous species have provided insights into the dynamics of the CS material and surprises about the composition of the CS gas coming from young planetesimals. To understand the coevolution of gas and dust through the terrestrial planet formation phase, we need to study the gas in additional debris disks. The new debris disk candidates from this Spitzer survey double the number of systems in which the gas can be observed right now with sensitive line-of-sight absorption spectroscopy.

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The Collimated Jet Source in IRAS 16547-4247: Time Variation, Possible Precession, and Upper Limits to the Proper Motions Along the Jet Axis

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The triple radio source detected in association with the luminous infrared source IRAS 16547-4247 has previously been studied with high angular resolution and high sensitivity with the Very Large Array (VLA) at 3.6-cm wavelength. In this paper, we present new 3.6 cm observations taken 2.68 years after the first epoch that allow a search for variability and proper motions, as well as the detection of additional faint sources in the region. We do not detect proper motions along the axis of the outflow in the outer lobes of this source at a 4-σ upper limit of $\sim$160 km s^{-1}. This suggests that these lobes are probably working surfaces where the jet is interacting with a denser medium. However, the brightest components of the lobes show evidence of precession, at a rate of $0\overset{\circ}{.}08$ yr^{-1} clockwise in the plane of the sky. It may be possible to understand the distribution of almost all the identified sources as the result of ejecta from a precessing jet. The core of the thermal jet shows significant variations in flux density and morphology. We compare this source with other jets in low and high mass young stars and suggest that the latter can be understood as a scaled-up version of the former.

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An Ammonia Spectral Atlas of Dense Cores in Perseus

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We present ammonia observations of 193 dense cores and core candidates in the Perseus molecular cloud made using the Robert F. Byrd Green Bank Telescope. We simultaneously observed the NH_3(1,1), NH_3(2,2), C_2S ($2_1 \rightarrow 1_0$), and $C_2^{34}S(2_1 \rightarrow 1_0$) transitions near $\nu = 23$ GHz for each of the targets with a spectral resolution of $\delta v \approx 0.024$ km s^{-1}. We find ammonia emission associated with nearly all of the (sub)millimeter sources, as well as at several positions with no associated continuum emission. For each detection, we have measured physical properties by fitting a simple model to every spectral line simultaneously. Where appropriate, we have refined the model by accounting for low optical depths, multiple components along the line of sight, and imperfect coupling to the GBT beam. For the cores in Perseus, we find a typical kinetic temperature of $T_k = 11$ K, a typical column density of $N_{NH_3} \approx 10^{14.5}$ cm^{-2}, and velocity dispersions ranging from $\sigma_v = 0.07$ to 0.7 km s^1. However, many cores with show evidence for multiple velocity components along the line of sight.

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A Molecular Line Observation toward Massive Clumps Associated with Infrared Dark Clouds

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We have surveyed the N_2H^+ J=1–0, HC_3N J=5–4, CCS J_N=4_3–3_2, NH_3 (J, K) = (1, 1), (2, 2), (3, 3), and CH_3OH J=7–6 lines toward the 55 massive clumps associated with infrared dark clouds by using the Nobeyama Radio Observatory 45 m telescope and the Atacama Submillimeter Telescope Experiment 10 m telescope. The N_2H^+, HC_3N, and NH_3 lines are detected toward most of the objects. On the other hand, the CCS emission is detected toward none of the objects. The [CCS]/[N_2H^+] ratios are found to be mostly lower than unity even in the Spitzer 24 micron dark objects. This suggests that most of the massive clumps are chemically more evolved than the low-mass starless cores. The CH_3OH emission is detected toward 18 out of 55 objects. All the CH_3OH-detected objects are associated with the Spitzer 24 micron sources, suggesting that star formation has already started in all the CH_3OH-detected objects. The velocity widths of the CH_3OH J_K=7_0–6_0 A^+ and 7_{-1}–6_{-1} E lines are broader than those of N_2H^+ J=1–0. The CH_3OH J_K=7_0–6_0 A^+ and 7_{-1}–6_{-1} E lines tend to have broader linewidth in the MSX dark objects than in the others, the former being younger or less luminous than the latter. The origin of the broad emission is discussed in terms of the interaction between an outflow and an ambient cloud.

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Preliminary Orbit of the young binary Haro 1-14c

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Using the Keck Interferometer, we spatially resolved the orbit of the pre-main-sequence (PMS) binary, Haro 1-14c, for the first time. We present these interferometric observations along with additional spectroscopic radial velocity measurements of the components. We performed a simultaneous orbit fit to the interferometric visibilities and the radial velocities of Haro 1-14c. Based on a statistical analysis of the possible orbital solutions that fit the data, we determined component masses of $M_1 = 0.96^{+0.27}_{0.08}$ $M_\odot$ and $M_2 = 0.33^{+0.09}_{0.02}$ $M_\odot$ for the primary and secondary, respectively, and a distance to the system of 111^{+19}_{18} pc. The distance measurement is consistent with the close distance estimates of the Ophiuchus molecular cloud. Comparing our results with evolutionary tracks suggests an age of 3-4 Myr for Haro 1-14c. With additional interferometric measurements to improve the uncertainties in the masses and distance, we expect the low-mass secondary to provide important empirical data for calibrating the theoretical evolutionary tracks for PMS stars.

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Main-Sequence Fitting Distance to the σ Ori Cluster

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The σ Ori cluster is an unbound aggregate of a few hundred young, low–mass stars centered on the multiple system σ Ori. This cluster is of great interest because it is at an age when roughly half of the stars have lost their protoplanetary disks, and the cluster has a very large population of brown dwarfs. One of the largest sources of uncertainty in the properties of the cluster is that the distance is not well known. The directly measured Hipparcos distance to σ Ori AB is 350^{+120}_{-90} pc. On the other hand, the distance to the Orion OB1b subgroup (of which σ Ori is thought to be a member), 473±40 pc, is far better determined, but it is an indirect estimate of the cluster's distance. Also, Orion OB1b may have a depth of 40 pc along our line of sight. We use main sequence fitting to 9 main sequence cluster members to estimate a best fit distance of 420±30 pc, assuming a metallicity of −0.16±0.11 or 444 pc assuming solar metallicity. A distance as close as 350 pc is inconsistent with the observed brightnesses of the cluster members. At the best fit distance, the age of the cluster is 2–3 Myrs.

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Millimeter- and Submillimeter-Wave Observations of the OMC-2/3 Region. II. Observational Evidence for Outflow-Triggered Star Formation in the OMC-2 FIR 3/4 Region

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We have carried out millimeter interferometric observations of the Orion Molecular Cloud-2 (OMC-2) FIR 3/4 region at an angular resolution of $\sim 3''$ - $7''$ with the Nobeyama Millimeter Array (NMA) in the $H^{13}CO^+$ (J=1–0), ^{12}CO (J=1–0), SiO (v=0, J=2–1), and CS (J=2–1) lines and in the 3.3 mm continuum emission. Submillimeter single-dish observations of the same region have also been performed with Atacama Submillimeter Telescope Experiment (ASTE) in the ^{12}CO (J=3–2) and CH_3OH (J_K=7_K–6_K) lines. Our NMA observations in the $H^{13}CO^+$ emission have revealed 0.07 pc-scale dense gas associated with FIR 4. The ^{12}CO (J=3–2,1–0) emission shows high-velocity blue and redshifted components at both the north-east and south-west of FIR 3, suggesting a molecular outflow driven by FIR 3 nearly along the plane of the sky. The SiO (v=0, J=2–1) and the submillimeter CH_3OH (J_K=7_K–6_K) emission, known as shock tracers, are detected around the interface between the outflow and the dense gas. Furthermore, the ^{12}CO (J=1–0) emission shows an L-shaped structure in the P-V diagram. These results imply presence of the shock due to the interaction between the molecular outflow driven by FIR 3 and the dense gas associated with FIR 4. Moreover, our high angular-resolution ($\sim 3''$) observations of FIR 4 in the 3.3 mm continuum emission with the NMA have first found that FIR 4 consists of eleven dusty cores with a size of $\sim$ 1500 - 4000 AU and a mass of $\sim$ 0.2 - 1.4 $M_\odot$. The separation among these cores ($\sim 5 \times 10^3$ AU) is on the same order of the Jeans length ($\sim 13 \times 10^3$ AU), suggesting that the fragmentation into these cores has been caused by the gravitational instability. The time scale of the fragmentation ($\sim 3.8 \times 10^4$ yr), estimated from the separation divided by the sound speed, is similar to the time scale of the interaction between the molecular outflow and the dense gas ($\sim 1.4 \times 10^4$ yr). We suggest that the interaction between the molecular outflow from FIR 3 and the dense gas at FIR 4 triggered the fragmentation into these dusty cores, and hence the next generation of the cluster formation in FIR 4.

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Submillimeter Observations of The Isolated Massive Dense Clump IRAS 20126+4104

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We used the CSO 10.4 meter telescope to image the 350 micron and 450micron continuum and CO $J = 6 - 5$ line emission of the IRAS 20126+4104 clump. The continuum and line observations show that the clump is isolated over a 4 pc region and has a radius of about 0.5 pc. Our analysis shows that the clump has a radial density profile is proportional to $r^{-1.2}$ for r is approximately less than 0.1 pc and has is proportional to $r^{-2.3}$ for r is greater than 0.1 pc which suggests the inner region is infalling, while the infall wave has not yet reached the outer region. Assuming temperature gradient of $r^{-0.35}$, the power law indices become is proportional to $r^{-0.9}$ for r is less than 0.1 pc and is proportional to $r^{-2.0}$ for r is greater than 0.1 pc. Based on a map of the flux ratio of 350micron/450micron, we identify three distinct regions: a bipolar feature that coincides with the large scale CO bipolar outflow; a cocoon-like region that encases the bipolar feature and has a warm surface; and a cold layer outside of the cocoon region. The complex patterns of the flux ratio map indicates that the clump is no longer uniform in terms of temperature as well as dust properties. The CO emission near the systemic velocity traces the dense clump and the outer layer of the clump shows narrow line widths (roughly less than 3 km s^{-1}). The clump has a velocity gradient of about 2 km s^{-1} pc^{-1}, which we interpret as due to rotation of the clump, as the equilibrium mass (about 200 Msun) is comparable to the LTE mass obtained from the CO line. Over a scale of about 1 pc, the clump rotates in the opposite sense with respect to the 0.03 pc disk associated with the (proto)star. This is one of four objects in high-mass and low-mass star forming regions for which a discrepancy between the rotation sense of the envelope and the core has been found, suggesting that such a complex kinematics may not be unusual in star forming regions.

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The model of dynamo with small number of modes and magnetic activity of T Tauri stars

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The model that describes operation of dynamo in fully convective stars is presented. It is based on representation of stellar magnetic field as a superposition of finite number of poloidal and thoroidal free damping modes. In the frame of adopted low of stellar differential rotation we estimated minimal value of dynamo number D, starting from which generation of cyclic magnetic field in stars without radiative core is possible. We also derived expression for period of the cycle. It was found that dynamo cycles of fully convective stars and stars with thin convective envelopes differ in a qualitative way: 1) distribution of spots over latitude during the cycle is different in these stars; 2) the model predicts that spot formation in fully convective stars should be strongly suppressed at some phases of the cycle.

We have analyzed hystorical lightcurve of WTTS star V410 Tau and found that long term activity of the star is not periodic process. Rather one can speak about quasy cyclyc activity with characteristic time of ~ 4 yr and chaotic component overimposed. We concluded also that redistribution of cool spots over longitude is the reason of long term variations of V410 Tau brightness. It means that one can not compare directly results of photometric observations with predictions of our axially symmetric (for simplicity) model which allows to investigate time evolution of spot's distribution over latitude. We then discuss what kind of observations and in which way could be used to check predictions of the dynamo theory.

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Photophoretic Structuring of Circumstellar Dust Disks

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We study dust accumulation by photophoresis in optically thin gas disks. Using formulae for the photophoretic force that are applicable for the free molecular regime and for the slip-flow regime, we calculate dust accumulation distances as a function of particle size. It is found that photophoresis pushes particles (smaller than 10 cm) outward. For a Sun-like star, these particles are transported to 0.1-100 AU, depending on their size, and form an inner disk. Radiation pressure pushes small particles (~1 mm) out further to form an extended outer disk. Consequently, an inner hole opens inside ~ 0.1 AU. The radius of the inner hole is determined by the condition that the mean free path of the gas molecules equal the maximum size of the particles that photophoresis effectively works on (100 μm-10 cm, depending on the dust properties). The dust disk structure formed by photophoresis can be distinguished from the structure of model gas-free dust disks, because the particle sizes in the outer disk are larger, and the inner hole radius depends on the gas density.

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N_2H^+ and HC_3N Observations of the Orion A Cloud

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The "∫-shaped filament" of the Orion A giant molecular cloud was mapped in N_2H^+ $J = 1 \to 0$, and its northern end, the OMC-2/3 region was observed also in HC_3N $J = 5 \to 4$ and CCS $J_N = 4_3 \to 3_2$ and $7_6 \to 6_5$. The results are compared with maps of other molecular lines and the dust continuum emission. The N_2H^+ distribution is similar to the dust continuum distribution, except for the central part of the Orion Nebula. The distribution of $H^{13}CO^+$ holds resemblance to that of dust continuum, but the N_2H^+ distribution looks more similar to dust continuum distribution. The N-bearing molecules, N_2H^+ and NH_3 seem to be more intense in OMC-2, compared with the $H^{13}CO^+$ and CS distribution. This suggests that OMC-2 has higher abundance of N-bearing molecules or higher filling factor of the quiescent gas. We identified 34 cloud cores from N_2H^+ data. Their average physical parameters are $T_{ex} = 9.2 \pm 4.2$ K, $\Delta v = 0.92 \pm 0.52$ km s^{-1}, $R = 0.086 \pm 0.025$ pc, and $M = 46 \pm 32\ M_\odot$. The masses of cores identified in both N_2H^+ and $H^{13}CO^+$ in the OMC-2/3 region are rather consistent. Over the Orion Nebula region, the N_2H^+ linewidth is large (1.1−2.1 km s^{-1}). In the OMC-2/3 region, it becomes moderate (0.5−1.3 km s^{-1}), and it is smaller (0.3−1.1 km s^{-1}) in the south of the Orion Nebula. On the other hand, the gas kinetic temperature of the quiescent cores observed in N_2H^+ is rather constant (~ 20 K) over the ∫-shaped filament. The average N_2H^+ excitation temperature in Orion cores is ~ 1.6 times as high as that in Taurus cores (~ 5.7 K). The N_2H^+ excitation temperature decreases toward the south, suggesting the core gas density or N_2H^+ abundance decreases toward the south. We found one peculiar $H^{13}CO^+$ core which is not prominent in either N_2H^+, HC_3N, or dust. This core overlaps with the lobe of the intense outflow from a nearby protostar. We detected no CCS emission in the OMC-2/3 region. In general, N_2H^+ and HC_3N distribution is quite similar in the OMC-2/3 region, but we observed displacement between N_2H^+ and HC_3N over $2'$ scale in OMC-3, which has a chain of Class 0-I protostars (candidates). This displacement might be due to either chemical evolution or effect of protostellar outflows.

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Outer edges of debris discs: How sharp is sharp?

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Context. Rings or annulus-like features have been observed in most imaged debris discs. Outside the main ring, while some systems (e.g., β Pictoris and AU Mic) exhibit smooth surface brightness profiles (SB) that fall off roughly as

$\sim r^{-3.5}$, others (e.g. HR 4796A and HD 139664) display large drops in luminosity at the ring's outer edge and steeper radial luminosity profiles.

Aims. We seek to understand this diversity of outer edge profiles under the "natural" collisional evolution of the system, without invoking external agents such as planets or gas.

Methods. We use a multi-annulus statistical code to follow the evolution of a collisional population, ranging in size from dust grains to planetesimals and initially confined within a belt (the "birth ring"). The crucial effect of radiation pressure on the dynamics and spatial distribution of the smallest grains is taken into account. We explore the dependence of the resulting disc surface brightness profile on various parameters.

Results. The disc typically evolves toward a "standard" steady state, where the radial surface brightness profile smoothly decreases with radius as $r^{-3.5}$ outside the birth ring. This confirms and extends the semi-analytical study of Strubbe & Chiang (2006, ApJ, 648, 652) and provides a firm basis for interpreting observed discs. Deviations from this typical profile, in the form of a sharp outer edge and a steeper fall-off, occur for two "extreme" cases: 1) when the birth ring is so massive that it becomes radially optically thick for the smallest grains. However, the required disc mass is probably too high here to be realistic; 2) when the dynamical excitation of the dust-producing planetesimals is so low ($\langle e \rangle$ and $\langle i \rangle \leq 0.01$) that the smallest grains, which otherwise dominate the optical depth of the system, are preferentially depleted. This low-excitation case, although possibly not generic, cannot be ruled out by observations for most systems, .

Conclusions. Our "standard" profile provides a satisfactory explanation for a large group of debris discs that show smooth outer edges and $SB \propto r^{-3.5}$. Systems with sharper outer edges, barring other confining agents, could still be explained by "natural" collisional evolution if their dynamical excitation is very low. We show that such a dynamically-cold case provides a satisfactory fit to the specific HR4796A ring.

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Dynamical Shake-up of Planetary Systems. II. N-Body Simulations of Solar System Terrestrial Planet Formation Induced by Secular Resonance Sweeping

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We revisit the "dynamical shake-up" model of solar system terrestrial planet formation, wherein the whole process is driven by the sweeping of Jupiter's secular resonance as the gas disk is removed. Using a large number of 0.5 Gyr long N-body simulations, we investigate the different outcomes produced by such a scenario. We confirm that in contrast to existing models, secular resonance sweeping combined with tidal damping by the disk gas can reproduce the low eccentricities and inclinations and high radial mass concentration of the solar system terrestrial planets. At the same time, this also drives the final assemblage of the planets on a timescale of several tens of millions of years, an order of magnitude faster than inferred from previous numerical simulations which neglected these effects, but possibly in better agreement with timescales inferred from cosmochemical data. In addition, we find that significant delivery of water-rich material from the outer asteroid belt is a natural byproduct.

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'Tail-end' Bondi-Hoyle accretion in young star clusters: Implications for disks, planets, and stars

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Young stars orbiting in the gravitational potential well of forming star clusters pass through the cluster's dense molecular gas and can experience Bondi-Hoyle accretion from reservoirs outside their individual protostellar cloud cores. Accretion can occur for several million years after the stars form, but before the cluster disperses. This accretion is predominantly onto the disk and not the star. N-body simulations of stars orbiting in three young model clusters containing 30, 300, and 3000 stars are presented. The simulations include the gravitational potential of the molecular gas which smoothly disperses over time. The clusters have a star formation efficiency of 33% and a radius of 0.22 pc. We find that the disks surrounding solar-mass stars in the N=30 cluster accretes 0.01 $M_\odot$ (1 minimum-mass solar nebula, MMSN) per Myr. The accretion rate scales as M^2.1 for stars of mass M. The accretion rate is 5 times lower for N=3000 cluster, due to its higher stellar velocities and higher temperature. The Bondi-Hoyle accretion rates onto the disks are several times lower than accretion rates observed directly onto young stars (e.g., Muzerolle et al 2005): these two accretion rates follow the same M^2 behavior and may be related. The accreted disk mass is large enough that it may have a substantial and unappreciated effect on disk structure and the formation of planetary systems. We discuss a variety of implications of this process, including its effect on metallicity differences between cluster stars, compositional differences between a star and its disk, the formation of terrestrial and gas-giant planets, and isotopic anomalies observed in our Solar System.

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Dead Zone Accretion Flows in Protostellar Disks

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Planets form inside protostellar disks in a dead zone where the electrical resistivity of the gas is too high for magnetic forces to drive turbulence. We show that much of the dead zone nevertheless is active and flows toward the star while smooth, large-scale magnetic fields transfer the orbital angular momentum radially outward. Stellar X-ray and radionuclide ionization sustain a weak coupling of the dead zone gas to the magnetic fields, despite the rapid recombination of free charges on dust grains. Net radial magnetic fields are generated in the magneto-rotational turbulence in the electrically conducting top and bottom surface layers of the disk, and reach the midplane by Ohmic diffusion. A toroidal component to the fields is produced near the midplane by the orbital shear. The process is similar to the magnetization of the Solar tachocline. The result is a laminar, magnetically-driven accretion flow in the region where the planets form.

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http://arxiv.org/abs/0804.2916

The effect of ambipolar resistivity on the formation of dense cores

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We aim to understand the formation of dense cores by magnetosonic waves in regions where the thermal to magnetic pressure ratio is small. Because of the low-ionisation fraction in molecular clouds, neutral and charged particles are weakly coupled. Ambipolar diffusion then plays an important role in the formation process. A quiescent, uniform plasma is perturbed by a fast-mode wave. Using 2D numerical simulations, we follow the evolution of the fast-mode wave. The simulations are done with a multifluid, adaptive mesh refinement MHD code. Initial perturbations with wavelengths that are 2 orders of magnitude larger than the dissipation length are strongly affected by the ion-neutral drift. Only in situations where there are large variations in the magnetic field corresponding to a highly turbulent gas can fast-mode waves generate dense cores. This means that, in most cores, no substructure can be produced. However, Core D of TMC-1 is an exception to this case. Due to its atypically high ionisation fraction, waves with wavelengths up to 3 orders of magnitude greater than the dissipation length can be present. Such waves are only weakly affected by ambipolar diffusion and can produce dense substructure without large wave-amplitudes. Our results also explain the observed transition from Alfvenic turbulent motion at large scales to subsonic motions at the level of dense cores.

Accepted by Astronomy and Astrophysics

http://arXiv.org/abs/0803.4422

On the Orbital Evolution of a Jovian Planet Embedded in a Self-Gravitating Disk

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We performed a series of hydrodynamic simulations to investigate the orbital evolution of a Jovian planet embedded in a protostellar disk. In order to take into account of the effect of the disk's self-gravity, we developed and adopted an ANTARES code which is based on a 2D Godunov scheme to obtain the exact Reimann solution for isothermal or polytropic gas, with nonreflecting boundary conditions. Our simulations indicate that in the study of runaway (type III) migration it is important to carry out a fully self-consistent treatment of the gravitational interaction between the disk and the embedded planet. Through a series of convergence tests, we show that adequate numerical resolution, especially within the planet's Roche lobe, critically determines the outcome of the simulations. We consider a variety of initial conditions and show that isolated, noneccentric protoplanets do not undergo type III migration. We attribute the difference between our and previous simulations to the contribution of a self-consistent representation of the disk's self-gravity. Nevertheless, type III migration cannot be completely suppressed, and its onset requires finite-amplitude perturbations such as that induced by planet-planet interaction. We determine the radial extent of type III migration as a function of the disk's self-gravity.

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[Ne II] Observations of Gas Motions in Compact and Ultracompact H II Regions

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We present high spatial and spectral resolution observations of sixteen Galactic compact and ultracompact H II regions in the [Ne II] 12.8 microns fine structure line. The small thermal width of the neon line and the high dynamic range of the maps provide an unprecedented view of the kinematics of compact and ultracompact H II regions. These observations solidify an emerging picture of the structure of ultracompact H II regions suggested in our earlier studies of G29.96-0.02 and Mon R2 IRS1; systematic surface flows, rather than turbulence or bulk expansion, dominate the gas motions in the H II regions. The observations show that almost all of the sources have significant (5-20 km/s) velocity gradients and that most of the sources are limb-brightened. In many cases, the velocity pattern implies tangential flow along a dense shell of ionized gas. None of the observed sources clearly fits into the categories of filled expanding spheres, expanding shells, filled blister flows, or cometary H II regions formed by rapidly moving stars. Instead, the kinematics and morphologies of most of the sources lead to a picture of H II regions confined to the edges of cavities created by stellar wind ram pressure and flowing along the cavity surfaces. In sources where the radio continuum and [Ne II] morphologies agree, the majority of the ionic emission is blue-shifted relative to nearby molecular gas. This is consistent with sources lying on the near side of their natal clouds being less affected by extinction and with gas motions being predominantly outward, as is expected for pressure-driven flows.

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http://arxiv.org/abs/0804.0439

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals), *Abstracts of recently accepted major reviews* (not standard conference contributions), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star and planet formation and early solar system community), *New Jobs* (advertising jobs specifically aimed towards persons within the areas of the Newsletter), and *Short Announcements* (where you can inform or request information from the community).

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Stellar spectropolarimetry with HiVIS: Herbig Ae/Be stars, circumstellar environments and optical pumping

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Ph.D dissertation directed by: Jeff Kuhn

Ph.D degree awarded: May 2008

The near-star environment around young stars is very dynamic with winds, disks, and outflows. These processes are involved in star and planet formation, and influence the formation and habitability of planets around host stars. Even for the closest young stars, this will not be imaged by the next generation of telescopes. Other proxies must be developed to probe the circumstellar environment.

The polarization of light across individual spectral lines is such a proxy that contains information about the circumstellar material on small spatial scales. Many models have been created to relate the circumstellar environment to observable polarization changes across spectral lines. However, measuring signals at the 0.1% level requires a very careful control of systematic effects. We have recently built a high-resolution spectropolarimeter for the HiVIS spectrograph on the 3.67m AEOS telescope to address these issues.

We have obtained a large number of high precision spectropolarimetric observations of Herbig Ae/Be, Classical Be and other emission-line stars collected on 117 nights of observations. Many stars showed systematic variations in the linear polarization amplitude and direction as a function of time and wavelength in the H_α line. The detected linear polarization varies from our typical detection threshold near 0.1% up to 2%. Surprisingly, in several stars this polarization effect is *not* coincident with the H_α emission peak but is detected only in the absorptive part of the line profile and varies with the absorption. These detections are largely inconsistent with the traditional scattering models and inspired a new explanation of their polarization.

We developed a new spectropolarimetric model and argue that polarization in absorption is evidence of optical pumping. We argue that, while scattering theory fits many Be and emission-line star observations, this new theory has much more potential to explain polarization-in-absorption as seen in Herbig Ae/Be and other stellar systems.

This thesis presents a large spectropolarimetric study that combines new instrumentation, custom processing software, thorough calibrations, cross-instrument comparisons, a massive observing campaign on many targets larger than most studies to date combined, comparison of current theories on multiple objects and finally the creation of a new theory.

http://www.ifa.hawaii.edu/~dmh/D.M.Harrington-Dissertation.pdf

Massive Stars, Disks, and Clustered Star Formation

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The formation of an isolated massive star is inherently more complex than the relatively well-understood collapse of an isolated, low-mass star. The dense, clustered environment where massive stars are predominantly found further complicates the picture, and suggests that interactions with other stars may play an important role in the early life of these objects. In this thesis we present the results of numerical hydrodynamic experiments investigating interactions between a massive protostar and its lower-mass cluster siblings. We explore the impact of these interactions on the orientation of disks and outflows, which are potentially observable indications of encounters during the formation of a star. We show that these encounters efficiently form eccentric binary systems, and in clusters similar to Orion they occur frequently enough to contribute to the high multiplicity of massive stars. We suggest that the massive protostar in Cepheus A is currently undergoing a series of interactions, and present simulations tailored to that system.

We also apply the numerical techniques used in the massive star investigations to a much lower-mass regime, the formation of planetary systems around Solar-mass stars. We perform a small number of illustrative planet-planet scattering experiments, which have been used to explain the eccentricity distribution of extrasolar planets. We add the complication of a remnant gas disk, and show that this feature has the potential to stabilize the system against strong encounters between planets. We present preliminary simulations of Bondi-Hoyle accretion onto a protoplanetary disk, and consider the impact of the flow on the disk properties as well as the impact of the disk on the accretion flow.

Australis Fellowship - Joint Postdoctoral Position with Australia Telescope National Facility and Universidad de Chile

The CSIRO Australia Telescope National Facility (ATNF) and the Department of Astronomy at the Universidad de Chile (DAUCH) invite applications for a joint post-doctoral research position (Australis Fellowship) in the field of star formation. The successful applicant is expected to conduct independent research and to collaborate with Dr Kate Brooks (ATNF) and Prof. Guido Garay (DAUCH) on studies of massive star formation using centimeter, millimeter, sub-millimeter and infrared data.

The Australis Fellow is expected to spend half of the time in Santiago, Chile, at the DAUCH, and half of the time in Sydney, Australia at the ATNF Headquarters. ATNF is Australia's premier radio astronomical facility and operates the Australia Telescope Compact Array (ATCA), the Mopra 22-m telescope, the Parkes 64-m telescope, and the Long Baseline Array (LBA). For the duration of the Fellowship the appointee will have access to the 10% observing time reserved for Chilean astronomers on all astronomical facilities in Chile.

The Australis Fellowship is awarded for a two-year period, renewable for a third, and offers a competitive salary with benefits as well as additional funding for travel. Candidates must hold a Ph.D. in astronomy or related field by date of appointment. The selected candidate is expected to start their position no later than October 1st, 2008.

Applications consisting of a cover letter, curriculum vitae, publication list, and a brief (∼2 pages) description of research interests and accomplishments should arrive by June 1, 2008. Applicants should also arrange for three letters of recommendation to arrive by the same date. Email submission of all materials, including letters, to Prof. Leonardo Bronfman, Chair, Departamento de Astronomia, Universidad de Chile, Casilla 36-D, Correo Central, Santiago, Chile.

*M*eetings

Massive Star Formation: Observations Confront Theory 2007

Update: Most of the oral presentations and posters of last years massive star formation conference at Heidelberg are now available at the conference web-page: http://www.mpia-hd.mpg.de/MSF07/. Furthermore, the two panel-discussion are available for download as .avi-files as well. The proceedings are now with the printers of ASP and will likely be distributed some time this summer.

Catalogue of Protostars Bulletin (IV)

We have updated the list of confirmed and candidate Class0/1 sources and their published broad-band photometric measurements (http://astro.kent.ac.uk/protostars/), considering the literature of 2007. The full list now contains 175 objects and about 2940 datapoints taken from 275 different publications. 40 further candidate Class0/1 objects are added to the list. See below for the complete list of added objects. Special thanks to Jennifer Hatchell for provinding her complete list of photometry for the Perseus sources.

In case

1) your favourite source is missing
2) a paper containing broad-band photometric data is not in the list
3) you find a mistake
4) you have any further suggestions

please do not hesitate to contact df *at* star.kent.ac.uk.

There are some publications that certainly measure fluxes of the listed sources, but the individual fluxes are not listed in a table or provided in the text of the paper. If you are a (co-)author of such a paper, could you please provide us with the necessary data. This will greatly facilitate the usefulness of this database.

NOTE: Please remember that for security reasons we had to secure the data with a public password. The login is "proto" and the password is "star".

List of newly added objects:

IRAS 21391+5802 *Getman et al. 2007, ApJ, 654, 316*

Per6 #4 *Rebull et al. 2007, ApJS, 171, 447*

CB54 MIRa, b, c *Ciardi & Gomez Martin 2007, ApJ, 664, 377*

NGC2264D-MM1 SMA1, 2, 3, 4, 5, 6, 7 *Teixeira et al. 2007, ApJ, 667, 179*

L1251B IRS1, 2, 4, L1251B 16 *Lee et al. 2007, ApJ, 671, 1748*

Lupus3 MMS *Tachihara et al. 2007, ApJ, 659, 1382*

NGC2264C-MM5 *Peretto et al. 2007, A&A, 464, 983*

RCrA SMA2 *Groppi et al. 2007, ApJ, 670, 489*

Bolo 102, NGC1333-I4C, HH7-11 MMS6, HRF 31, 46, 47, 55, 58, 61, 62, 65, 68, 70, 71, 75, 76, 84, 86, 88
Hatchell et al. 2007, A&A, 468, 1009