THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 202 — 28 Oct 2009 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

Discovery of Large-Scale Gravitational Infall in a Massive Protostellar Cluster

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We report Mopra (ATNF), Anglo-Australian Telescope, and Atacama Submillimeter Telescope Experiment observations of a molecular clump in Carina, BYF73 = G286.21+0.17, which give evidence of large-scale gravitational infall in the dense gas. From the millimetre and far-infrared data, the clump has mass $\sim 2{\times}10^4\,M_\odot$, luminosity ~ 2–$3{\times}10^4\,L_\odot$, and diameter $\sim$0.9 pc. From radiative transfer modelling, we derive a mass infall rate $\sim 3.4{\times}10^{-2}\,M_\odot yr^{-1}$. If confirmed, this rate for gravitational infall in a molecular core or clump may be the highest yet seen. The near-infrared K-band imaging shows an adjacent compact HII region and IR cluster surrounded by a shell-like photodissociation region showing H_2 emission. At the molecular infall peak, the K imaging also reveals a deeply embedded group of stars with associated H_2 emission. The combination of these features is very unusual and we suggest they indicate the ongoing formation of a massive star cluster. We discuss the implications of these data for competing theories of massive star formation.

Accepted by MNRAS

www.astro.ufl.edu/~peterb/papers/BYF73mnFinal.pdf
arxiv.org/abs/0812.1789

Chaotic star formation and the alignment of stellar rotation with disc and planetary orbital axes

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We investigate the evolution of the relative angle between the stellar rotation axis and the circumstellar disc axis of a star that forms in a stellar cluster from the collapse of a turbulent molecular cloud. This is an inherently chaotic environment with variable accretion, both in terms of rate and the angular momentum of the material, and dynamical interactions between stars. We find that the final stellar rotation axis and disc spin axis can be strongly misaligned, but this occurs primarily when the disc is truncated by a dynamical encounter so that the final disc rotation axis depends simply on what fell in last. This may lead to planetary systems with orbits that are misaligned with the stellar rotation axis, but only if the final disc contains enough mass to form planets. We also investigate the time variability of the inner disc spin axis, which is likely to determine the direction of a protostellar jet. We find that the jet direction varies more strongly for lighter discs, such as those that have been truncated by dynamical interactions or have suffered a period of rapid accretion. Finally, we note that variability of the angular momentum of the material accreting by a star implies that the internal velocity field of such stars may be more complicated than that of aligned differential rotation.

Accepted by MNRAS

http://arxiv.org/abs/0909.4255

Odin observations of water in molecular outflows and shocks

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Aims. We investigate the *ortho*-water abundance in outflows and shocks in order to improve our knowledge of shock chemistry and of the physics behind molecular outflows.
Methods. We used the Odin space observatory to observe the $H_2O(1_{10} - 1_{01})$ line. We obtain strip maps and single pointings of 13 outflows and two supernova remnants where we report detections for eight sources. We used `RADEX` to compute the beam averaged abundances of o-H_2O relative to H_2. In the case of non-detection, we derive upper limits on the abundance.
Results. Observations of CO emisson from the literature show that the volume density of H_2 can vary to a large extent, a parameter that puts severe uncertainties on the derived abundances. Our analysis shows a wide range of abundances reflecting the degree to which shock chemistry affects the formation and destruction of water. We also compare our results with recent results from the SWAS team.
Conclusions. Elevated abundances of *ortho*-water are found in several sources. The abundance reaches values as high as what would be expected from a theoretical C-type shock where all oxygen, not in the form of CO, is converted to water. However, the high abundances we derive could also be due to the low densities (derived from CO observations) that we assume. The water emission may in reality stem from high density regions much smaller than the Odin beam. We do not find any relationship between the abundance and the mass loss rate. On the other hand, there is a relation between the derived water abundance and the observed maximum outflow velocity.

Accepted by Astronomy and Astrophysics

S 235 B explained: an accreting Herbig Be star surrounded by reflection nebulosity

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The intent of this study is to determine the nature of the star and associated nebulosity S 235 B, which are located in a region of active star formation still heavily obscured by the parent molecular cloud. Low-resolution ($R = 400$)

long-slit spectra of the star and nebulosity, and medium- ($R = 1800$) and high-resolution ($R = 60\,000$) spectra of the central star are presented along with the results of Fabry-Perot interferometric imaging of the entire region. Based on the long-slit and Fabry-Perot observations, the nebulosity appears to be entirely reflective in nature, with the stellar component S 235 B$\star$ providing most of the illuminating flux. The stellar source itself is classified here as a B1V star, with emission line profiles indicative of an accretion disk. S 235 B$\star$ thus belongs to the relatively rare class of early-type Hebrig Be stars. Based on the intensity of the reflected component, it is concluded that the accretion disk must be viewed nearly edge-on. Estimates of the accretion rate of S 235 B$\star$ from the width of the Hα profile at 10% of maximum intensity, a method which has been used lately for T Tauri stars and Brown Dwarfs, appear to be inconsistent with the mass outflow rate and accretion rate implied from previous infrared observations by Felli et al. (2006), suggesting this empirical law does not extend to higher masses.

Accepted by Monthly Notices of the Royal Astronomical Society

Digging into NGC 6334I(N): Multiwavelength Imaging of a Massive Protostellar Cluster

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We present a high-resolution, multi-wavelength study of the massive protostellar cluster NGC 6334 I(N) that combines new spectral line data from the Submillimeter Array (SMA) and VLA with a reanalysis of archival VLA continuum data, 2MASS and *Spitzer* images. As shown previously, the brightest 1.3 mm source SMA1 contains substructure at subarcsecond resolution, and we report the first detection of SMA1b at 3.6 cm along with a new spatial component at 7 mm (SMA1d). We find SMA1 (aggregate of sources a, b, c, and d) and SMA4 to be comprised of free-free and dust components, while SMA6 shows only dust emission. Our 1.5″ resolution 1.3 mm molecular line images reveal substantial hot-core line emission toward SMA1 and to a lesser degree SMA2. We find CH_3OH rotation temperatures of 165 ± 9 K and 145 ± 12 K for SMA1 and SMA2, respectively. We estimate a diameter of 1400 AU for the SMA1 hot core emission, encompassing both SMA1b and SMA1d, and speculate that these sources comprise a $\gtrsim$800 AU separation binary that may explain the previously-suggested precession of the outflow emanating from the SMA1 region. Compact line emission from SMA4 is weak, and none is seen toward SMA6. The LSR velocities of SMA1, SMA2, and SMA4 all differ by 1-2 km s^{-1}. Outflow activity from SMA1, SMA2, SMA4, and SMA6 is observed in several molecules including SiO(5–4) and IRAC 4.5 μm emission; 24 μm emission from SMA4 is also detected. Eleven water maser groups are detected, eight of which coincide with SMA1, SMA2, SMA4, and SMA6, while two others are associated with the Sandell source SM2. We also detect a total of 83 Class I CH_3OH 44 GHz maser spots which likely result from the combined activity of many outflows. Our observations paint the portrait of multiple young hot cores in a protocluster prior to the stage where its members become visible in the near-infrared.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0909.5256, or http://www.cv.nrao.edu/∼cbrogan/ms.long.pdf

Debris Disks in the Upper Scorpius OB Association

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We present MIPS 24μm and 70μm photometry for 205 members of the Upper Scorpius OB Association. These data are combined with published MIPS photometry for 15 additional association members to assess the frequency of circumstellar disks around 5 Myr old stars with spectral types between B0 and M5. Twelve stars have a detectable 70μm excess, each of which also has a detectable 24μm excess. A total of 54 stars are identified with a 24μm excess more than 32% above the stellar photosphere. The MIPS observations reveal 19 excess sources – 8 A/F/G stars and 11 K/M stars – that were not previously identified with an 8μm or 16μm excess. The lack of short-wavelength emission and the weak 24μm excess suggests that these sources are debris systems or the remnants of optically thick primordial disks with inner holes. Despite the wide range of luminosities of the stars hosting apparent debris systems, the excess characteristics are consistent with all stars having dust at similar orbital radii after factoring in variations in the radiation blowout particle size with spectral type. The results for Upper Sco are compared to similar photometric surveys from the literature to re-evaluate the evolution of debris emission. After considering the completeness limits of published surveys and the effects of stellar evolution on the debris luminosity, we find that the magnitude of the 24μm excess around F-type stars increases between ages of 5 and 17 Myr as found by previous studies, but at $< 2.6\sigma$ confidence. For B7-A9 and G0-K5 stars, any variations in the observed 24μm excess emission over this age range are significant at less than 2σ confidence.

Accepted by ApJ

http://arxiv.org/abs/0909.4124

The structure of hot molecular cores over 1000 AU

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Context Hot molecular cores (HMCs) are believed to be the cradles of stars with mass above $\sim$6 $M_\odot$. It is hence important to resolve their structure and kinematics and thus study phenomena directly related to the star formation process, such as outflow, infall, and rotation. Establishing the presence of embedded early-type (proto)stars is also crucial for our understanding of the nature of HMCs.
Aims With the aim to attain the best available angular resolution to date, we have performed observations of the molecular gas in two well known HMCs (G10.47+0.03 and G31.41+0.31) with an angular resolution of $\sim$0\farcs1. Also continuum observations were made at different wavelengths to reveal HII regions associated with early-type stars embedded in the cores.
Methods We used the Very Large Array in the most extended configuration to image the NH_3(4,4) inversion transition. Continuum measurements were made at 7 mm, 1.3 cm, and 3.6 cm using the A-array configuration.
Results We have detected two new continuum sources in G31.41+0.31, possibly thermal jets, and confirmed the presence of one ultracompact and two hypercompact HII regions in G10.47+0.03. Evidence that the gas is infalling towards the embedded (proto)stars is provided for both G10.47+0.03 and G31.41+0.31, while in G10.47+0.03 part of the ammonia gas appears to be also expanding in two collimated bipolar outflows. From the temperature profile in the cores, we establish an approximate bolometric luminosity for both sources in the range 1×10^5–7×10^5 $L_\odot$. Finally, a clear velocity gradient across the core is detected in G31.41+0.31. The nature of such a gradient is discussed and two alternative explanations are proposed: outflow and rotation.
Conclusions We propose a scenario where G10.47+0.03 is in a more advanced evolutionary stage than G31.41+0.31. In this scenario, thermal jets develop until the accretion rate is sufficiently high to trap or even quench any HII region. When the jets have pierced the core and the stellar mass has grown enough, hypercompact HII regions appear and the destruction of the HMC begins.

Accepted by Astron. Astrophys.

http://www.arcetri.astro.it/∼starform/preprints/cesa_20.ps.gz

The properties of SCUBA cores in the Perseus molecular cloud: the bias of clump-finding algorithms

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We present a new analysis of the properties of star-forming cores in the Perseus molecular cloud, identified in SCUBA $850\,\mu$m data originally presented by Hatchell et al. (2005). Our goal is to determine which core properties can be robustly identified and which depend on the extraction technique. Four regions in the cloud are examined: NGC 1333, IC348/HH211, L1448 and L1455. We identify clumps of dust emission using two popular automated algorithms, CLFIND and GAUSSCLUMPS, finding 85 and 122 clumps in total respectively. Using the catalogues of Hatchell et al. (2007), we separate these clumps into starless, Class 0 and Class I cores. Some trends are true for both populations: clumps become increasingly elongated over time; clumps are consistent with constant surface brightness objects (i.e. $M \propto R^2$), with an average brightness $\approx$ 4–10 times larger than the surrounding molecular cloud; the clump mass distribution (CMD) resembles the stellar intial mass function, with a slope $\alpha = -2.0 \pm 0.1$ for CLFIND and $\alpha = -3.15 \pm 0.08$ for GAUSSCLUMPS, which straddle the Salpeter value ($\alpha = -2.35$). The mass at which the slope shallows (similar for both algorithms at $M \approx 6\,\mathrm{M}_\odot$) implies a star-forming efficiency of between 10 and 20 per cent. Other trends reported elsewhere depend critically on the clump-finding technique: we find protostellar clumps are both smaller (for GAUSSCLUMPS) and larger (for CLFIND) than their starless counterparts; the functional form, best-fitting to the CMD, is different for the two algorithms. The GAUSSCLUMPS CMD is best-fitted with a log-normal distribution, whereas a broken power law is best for CLFIND; the reported lack of massive starless cores in previous studies can be seen in the CLFIND but not the GAUSSCLUMPS data. Our approach, exploiting two extraction techniques, highlights similarities and differences between the clump populations, illustrating the caution that must be exercised when comparing results from different studies and interpreting the properties of samples of continuum cores.

Accepted by MNRAS

http://arxiv.org/abs/0910.4070

Outflows and Massive Stars in the protocluster IRAS 05358+3543

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We present new near-IR H_2, CO J=2-1, and CO J = 3-2 observations to study outflows in the massive star forming region IRAS 05358+3543. The Canada-France-Hawaii Telescope H_2 images and James Clerk Maxwell Telescope CO data cubes of the IRAS 05358 region reveal several new outflows, most of which emerge from the dense cluster of sub-mm cores associated with the Sh 2-233IR NE cluster to the northeast of IRAS 05358. We used Apache Point Observatory (APO) JHK spectra to determine line of sight velocities of the outflowing material. Analysis of archival VLA cm continuum data and previously published VLBI observations reveal a massive star binary as a probable source of one or two of the outflows. We have identified probable sources for 6 outflows and candidate counterflows for 7 out of a total of 11 seen to be originating from the IRAS 05358 clusters. We classify the clumps within Sh 2-233IR NE as an early protocluster and Sh 2-233IR SW as a young cluster, and conclude that the outflow energy injection rate approximately matches the turbulent decay rate in Sh 2-233IR NE.

Accepted by the Astrophysical Journal

Preprints and additional figures available at http://casa.colorado.edu/g̃insbura/iras05358.htm

Detection of Low-Amplitude Brightness Oscillations in the Unique Eclipsing System V718 Per (HMW 15, H 187)

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We present new results of our visual (VRI) and near-infrared (JHK) photometry for the unusual young star V718 Per. They show that, in addition to prolonged eclipses following one another with a period of 4.7 yr, the star also exhibits low-amplitude brightness oscillations with a period that is approximately a factor of 8 shorter than the main one. In contrast to the large-scale eclipses accompanied by the star's reddening, the low-amplitude oscillations are neutral in character and are produced by large particles. Bimodal oscillations of this type can arise in a circumstellar disk divided by a large matter-free gap into two zones - an inner, dense region and an outer, less dense disk. Such configurations emerge in the presence of a fairly massive perturbing body in the disk. In this case, density waves rotating with different angular velocities can be formed in each of these zones. Therefore,when such systems are observed nearly edge-on, two oscillation modes with different periods can be present in the extinction variations.We suggest that such a situation takes place in the case of V718 Per. Since this star exhibits no signatures of spectroscopic binarity, the perturbing body can be either a giant planet or a brown dwarf.

Published by the Astronomy Letters, (35, 829, 2009)

Modelling CO formation in the turbulent interstellar medium

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We present results from high-resolution three-dimensional simulations of turbulent interstellar gas that self-consistently follow its coupled thermal, chemical and dynamical evolution, with a particular focus on the formation and destruction of H_2 and CO. We quantify the formation timescales for H_2 and CO in physical conditions corresponding to those found in nearby giant molecular clouds, and show that both species form rapidly, with chemical timescales that are comparable to the dynamical timescale of the gas.

We also investigate the spatial distributions of H_2 and CO, and how they relate to the underlying gas distribution. We show that H_2 is a good tracer of the gas distribution, but that the relationship between CO abundance and gas density is more complex. The CO abundance is not well-correlated with either the gas number density n or the visual extinction $A_{\rm V}$: both have a large influence on the CO abundance, but the inhomogeneous nature of the density field produced by the turbulence means that n and $A_{\rm V}$ are only poorly correlated. There is a large scatter in $A_{\rm V}$, and hence CO abundance, for gas with any particular density, and similarly a large scatter in density and CO abundance for gas with any particular visual extinction. This will have important consequences for the interpretation of the CO emission observed from real molecular clouds.

Finally, we also examine the temperature structure of the simulated gas. We show that the molecular gas is not isothermal. Most of it has a temperature in the range of 10–20 K, but there is also a significant fraction of warmer gas, located in low-extinction regions where photoelectric heating remains effective.

Accepted by MNRAS

http://arxiv.org/abs/0907.4081

Near infrared imaging of the cometary globule CG 12

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Context. Cometary globule 12 is a relatively little investigated medium- and low mass star forming region 210 pc above the Galactic plane.
Aims. This study sets out to discover the possibly embedded members of the CG 12 stellar cluster, to refine the NIR photometry of the known member stars and to study the star formation activity in CG 12 and its relation to the distribution of molecular gas, dust and mid- to far-infrared emission in the cloud.
Methods. NIR J, H, and Ks imaging and stellar photometry is used to analyse the stellar content and the structure of CG 12.
Results. Several new members and member candidates of the CG 12 stellar cluster were found. The new members include in particular a highly embedded source with a circumstellar disk or shell and a variable star with a circumstellar disk which forms a binary with a previously known A spectral type cluster member. The central source of the known collimated molecular outflow in CG 12 and an associated "hourglass"-shaped object due to reflected light from the source were also detected. The maximum visual extinction in the cloud, based on observations of background stars, is ∼20m , but this is only a lower limit for the extinction through the two dense cloud cores. HIRES-enhanced IRAS images are used together with SOFI JHKs imaging to study the two associated IRAS point sources, 13546-3941 and 13547-3944. Two new 12 μm sources coinciding with NIR excess stars were detected in the direction of IRAS 13546-3941. The IRAS 13547-3944 emission at 12 and 25 μm originates in the Herbig AeBe star h4636n and the 60 and 100 μm emission from an adjacent cold source.

Accepted by Astronomy & Astrophysics

arXiv:0910.4864

Laboratory Experiments, Numerical Simulations, and Astronomical Observations of Deflected Supersonic Jets: Application to HH 110

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Collimated supersonic flows in laboratory experiments behave in a similar manner to astrophysical jets provided that radiation, viscosity, and thermal conductivity are unimportant in the laboratory jets, and that the experimental and astrophysical jets share similar dimensionless parameters such as the Mach number and the ratio of the density between the jet and the ambient medium. When these conditions apply, laboratory jets provide a means to study their astrophysical counterparts for a variety of initial conditions, arbitrary viewing angles, and different times, attributes especially helpful for interpreting astronomical images where the viewing angle and initial conditions are fixed and the time domain is limited. Experiments are also a powerful way to test numerical fluid codes in a parameter range where the codes must perform well. In this paper we combine images from a series of laboratory experiments of deflected supersonic jets with numerical simulations and new spectral observations of an astrophysical example, the young stellar jet HH 110. The experiments provide key insights into how deflected jets evolve in 3-D, particularly within working surfaces where multiple subsonic shells and filaments form, and along the interface where shocked jet material penetrates into and destroys the obstacle along its path. The experiments also underscore the importance of the viewing angle in determining what an observer will see. The simulations match the experiments so well that we can use the simulated velocity maps to compare the dynamics in the experiment with those implied by the astronomical

spectra. The experiments support a model where the observed shock structures in HH 110 form as a result of a pulsed driving source rather than from weak shocks that may arise in the supersonic shear layer between the Mach disk and bow shock of the jet's working surface.

Accepted by ApJ

http://sparky.rice.edu/ hartigan/pub.html
http://arxiv.org/pdf/0910.0318

Adaptive Optics Echelle Spectroscopy of [Fe II] 1.644 μm in the RW Aur Jet: A Narrow Slice Down the Axis of the Flow

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We present new adaptive optics echelle spectra of the near-infrared [Fe II] lines in the redshifted and blueshifted jets from the T Tauri star RW Aur. The spectra have an unprecedented combination of high spatial and spectral resolution that makes it possible to trace the dynamics of the flow to a projected distance of only 10 AU from the source. As noted by previous studies, the redshifted flow is much slower than its fainter blueshifted counterpart. Our observations clearly show that both the radial velocities and the emission line widths are larger closer to the source on both sides of the jet. The line widths are $20\% - 30\%$ of the jet velocity on both sides of the flow, significantly larger than would be produced by a divergent constant velocity flow. The observed line widths could arise from a layered velocity structure in the jet or from magnetic waves. A bright knot in the redshifted jet has no concomitant increase in line width, implying that it is not heated by a bow shock. Alternate heating mechanisms include planar shocks, ambipolar diffusion and magnetic reconnection.

Accepted by ApJ

http://sparky.rice.edu/~hartigan/pub.html
http://arxiv.org/pdf/0909.1524

Gravitational Collapse and Filament Formation: Comparison with the Pipe Nebula

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Recent models of molecular cloud formation and evolution suggest that such clouds are dynamic and generally exhibit gravitational collapse. We present a simple analytic model of global collapse onto a filament and compare this with our numerical simulations of the flow-driven formation of an isolated molecular cloud to illustrate the supersonic motions and infall ram pressures expected in models of gravity-driven cloud evolution. We compare our results with observations of the Pipe Nebula, an especially suitable object for our purposes as its low star formation activity implies insignifcant perturbations from stellar feedback. We show that our collapsing cloud model can explain the magnitude of the velocity dispersions seen in the ^{13}CO filamentary structure by Onishi et al. and the ram pressures required by Lada et al. to confine the lower-mass cores in the Pipe nebula. We further conjecture that higher-resolution simulations will show small velocity dispersions in the densest core gas, as observed, but which are infall motions and not supporting turbulence. Our results point out the inevitability of ram pressures as boundary conditions for molecular cloud filaments, and the possibility that especially lower-mass cores still can be accreting mass at significant rates, as suggested by observations.

Accepted by ApJ

http://arxiv.org/abs/0909.2018

Spitzer Observations of the Lambda Orionis cluster I: the frequency of young debris disks at 5 Myr

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We present IRAC/MIPS *Spitzer* observations of intermediate-mass stars in the 5 Myr old λ Orionis cluster. In a representative sample of stars earlier than F5 (29 stars), we find a population of 9 stars with a varying degree of moderate 24μm excess comparable to those produced by debris disks in older stellar groups. As expected in debris disks systems, those stars do not exhibit emission lines in their optical spectra. We also include in our study the star HD 245185, a known Herbig Ae object which displays excesses in all *Spitzer* bands and shows emission lines in its spectrum. We compare the disk population in the λ Orionis cluster with the disk census in other stellar groups studied using similar methods to detect and characterize their disks and spanning a range of ages from 3 Myr to 10 Myr. We find that for stellar groups of 5 Myr or older the observed disk frequency in intermediate mass stars (with spectral types from late B to early F) is higher than in low mass stars (with spectral types K and M). This is in contradiction with the observed trend for primordial disks evolution, in which stars with higher stellar masses dissipate their primordial disks faster. At 3 Myr the observed disk frequency in intermediate mass stars is still lower than for low mass stars indicating that second generation dusty disks start to dominate the disk population at 5 Myr for intermediate mass stars. This result agrees with recent models of evolution of solids in the region of the disk where icy objects form (> 30 AU), which suggest that at 5-10 Myr collisions start to produce large amount of dust during the transition from runaway to oligarchic growth (reaching sizes of ∼500 km) and then dust production peaks at 10-30 Myr, when objects reach their maximum sizes (≥1000 km)

Accepted by The Astrophysical Journal

Low-Metallicity Protostars and the Maximum Stellar Mass Resulting from Radiative Feedback: Spherically Symmetric Calculations

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The final mass of a newborn star is set at the epoch when the mass accretion onto the star is terminated. We study the evolution of accreting protostars and the limits of accretion in low metallicity environments under spherical symmetry. Accretion rates onto protostars are estimated via the temperature evolution of prestellar cores with different metallicities. The derived rates increase with decreasing metallicity, from $\dot{M} \simeq 10^{-6}\ M_\odot$/yr at $Z = Z_\odot$ to $10^{-3}\ M_\odot$/yr at $Z = 0$. With the derived accretion rates, the protostellar evolution is numerically calculated. We find that, at lower metallicity, the protostar has a larger radius and reaches the zero-age main-sequence (ZAMS) at higher stellar mass. Using this protostellar evolution, we evaluate the upper stellar mass limit where the mass accretion is hindered by radiative feedback. We consider the effects of radiation pressure exerted on the accreting envelope, and expansion of the H II region. The mass accretion is finally terminated by radiation pressure on dust grains in the envelope for $Z > 10^{-3}\ Z_\odot$ and by the expanding H II region for lower metallicty. The mass limit from these effects increases with decreasing metallicity from $M_* \simeq 10\ M_\odot$ at $Z = Z_\odot$ to $\simeq 300\ M_\odot$ at $Z = 10^{-6}\ Z_\odot$. The termination of accretion occurs after the central star arrives at the ZAMS at all metallicities, which allows us to neglect protostellar evolution effects in discussing the upper mass limit by stellar feedback. The fragmentation induced by line cooling in low-metallicity clouds yields prestellar cores with masses large enough that the final stellar mass is set by the

feedback effects. Although relaxing the assumption of spherical symmetry will alter feedback effects, our results will be a benchmark for more realistic evolution to be explored in future studies.

Published in ApJ 703, 1810, 2009

http://www.iop.org/EJ/abstract/0004-637X/703/2/1810/

Dispersion of Magnetic Fields in Molecular Clouds. II

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We expand our study on the dispersion of polarization angles in molecular clouds. We show how the effect of signal integration through the thickness of the cloud as well as across the area subtended by the telescope beam inherent to dust continuum measurements can be incorporated in our analysis to correctly account for its effect on the measured angular dispersion and inferred turbulent to large-scale magnetic field strength ratio. We further show how to evaluate the turbulent magnetic field correlation scale from polarization data of sufficient spatial resolution and high enough spatial sampling rate. We apply our results to the molecular cloud OMC-1, where we find a turbulent correlation length of $\delta \approx 16$ mpc, a turbulent to large-scale magnetic field strength ratio of approximately 0.5, and a plane-of-the-sky large-scale magnetic field strength of approximately 760 μG.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0909.5227

A $C^{18}O$ study of the origin of the power-law nature in the IMF

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We have performed $C^{18}O$ (J=1–0) mapping observations of a $20' \times 20'$ area of the OMC-1 region in the Orion A cloud. We identified 65 $C^{18}O$ cores, which have mean radius, velocity width in FWHM, and LTE mass of 0.18±0.03 pc, 0.40±0.15 km s^{-1}, and 7.2±4.5 $M_\odot$, respectively. All the cores are most likely to be gravitationally bound by considering the uncertainty in the $C^{18}O$ abundance. We derived a $C^{18}O$ core mass function, which shows a power-law-like behavior above 5 $M_\odot$. The best-fit power-law index of -2.3 ± 0.3 is consistent with those of the dense core mass functions and the stellar initial mass function (IMF) previously derived in the OMC-1 region. This agreement strongly suggests that the power-law form of the IMF has been already determined at the density of $\sim 10^3$ cm^{-3}, traced by the $C^{18}O$ (J=1–0) line. Consequently, we propose that the origin of the IMF should be searched in tenuous cloud structures with densities of less than 10^3 cm^{-3}.

Accepted by The Astrophysical Journal Letters

http://hibari.isas.jaxa.jp/nikeda/preprints/nikeda_20091006_oria_c18o.pdf

Ionized Gas Toward Molecular Clumps: Physical Properties of Massive Star-Forming Regions

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We have conducted a search for ionized gas at 3.6 cm, using the Very Large Array, toward 31 Galactic intermediate- and high-mass clumps detected in previous millimeter continuum observations. In the 10 observed fields, 35 HII regions are identified, of which 20 are newly discovered. Many of the HII regions are multiply peaked indicating the presence of a cluster of massive stars. We find that the ionized gas tends to be associated toward the millimeter clumps; of the 31 millimeter clumps observed, 9 of these appear to be physically related to ionized gas, and a further 6 have ionized gas emission within 1'. For clumps with associated ionized gas, the combined mass of the ionizing massive stars is compared to the clump masses to provide an estimate of the instantaneous star formation efficiency. These values range from a few percent to 25%, and have an average of 7% ± 8%. We also find a correlation between the clump mass and the mass of the ionizing massive stars within it, which is consistent with a power law. This result is comparable to the prediction of star formation by competitive accretion that a power-law relationship exists between the mass of the most massive star in a cluster and the total mass of the remaining stars.

Accepted by Astrophysical Journal

http://arxiv.org/abs/0910.0251

PROSAC: A Submillimeter Array survey of low-mass protostars. II. The mass evolution of envelopes, disks, and stars from the Class 0 through I stages

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Context. The key question about early protostellar evolution is how matter is accreted from the large-scale molecular cloud, through the circumstellar disk onto the central star.
Aims. We constrain the masses of the envelopes, disks, and central stars of a sample of low-mass protostars and compare the results to theoretical models for the evolution of young stellar objects through the early protostellar stages.
Methods. A sample of 20 Class 0 and I protostars has been observed in continuum at (sub)millimeter wavelengths at high angular resolution (typically 2″) with the Submillimeter Array. Using detailed dust radiative transfer models of the interferometric data, as well as single-dish continuum observations, we have developed a framework for disentangling the continuum emission from the envelopes and disks, and from that estimated their masses. For the Class I sources in the sample HCO^+ 3–2 line emission has furthermore been observed with the Submillimeter Array. Four of these sources show signs of Keplerian rotation, making it possible to determine the masses of the central stars. In the other sources the disks are masked by optically thick envelope and outflow emission.
Results. Both Class 0 and I protostars are surrounded by disks with typical masses of about 0.05 $M_\odot$, although significant scatter is seen in the derived disk masses for objects within both evolutionary stages. No evidence is found for a correlation between the disk mass and evolutionary stage of the young stellar objects. This contrasts the envelope mass, which decreases sharply from $\sim 1\ M_\odot$ in the Class 0 stage to $\lesssim 0.1\ M_\odot$ in the Class I stage. Typically, the disks have masses that are 1–10% of the corresponding envelope masses in the Class 0 stage and 20–60% in the Class I stage. For the Class I sources for which Keplerian rotation is seen, the central stars contain 70–98% of the total mass in the star-disk-envelope system, confirming that these objects are late in their evolution through the embedded protostellar stages, with most of the material from the ambient envelope accreted onto the central star. Theoretical models tend to overestimate the disk masses relative to the stellar masses in the late Class I stage.

Conclusions. The results argue in favor of a picture in which circumstellar disks are formed early during the protostellar evolution (although these disks are not necessarily rotationally supported) and rapidly process material accreted from the larger scale envelope onto the central star.

Accepted by A&A

http://arxiv.org/abs/0909.3386

Herbig-Haro Objects around CG 30

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In this work we study Herbig-Haro objects located in the region around the head of the cometary globule CG 30. Two sets of optical images are presented. The first set was obtained with the 3.5 m New Technology Telescope in 1995 in three emission lines: Hα, [S II]$\lambda\lambda$6731,6716 Åand [OII]λ3729 Å. The second set is an Hα image of the CG 30/31/38 complex obtained in 2006 with the 8 m Subaru telescope. A proper motion study of the HH objects in the region was performed using the Hα images from both epochs. Due to the high resolution of our images we were able to, for the first time, resolve the HH 120 object into ten knots and measure proper motions for some of them. We discover several new HH objects and a large bipolar jet, HH 950, emerging from the head of CG 30. We suggest that two previously known submillimeter sources are the driving sources for the HH 120 and HH 950 flows.

Accepted by Rev. Mexicana Astron. Astrofis.

Can gas in young debris disks be constrained by their radial brightness profiles?

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Disks around young stars are known to evolve from optically thick, gas-dominated protoplanetary disks to optically thin, almost gas-free debris disks. It is thought that the primordial gas is largely removed at ages of $\sim$ 10 Myr and indeed, only little amounts of gas have been deduced from observations for debris disks at ages of $\gtrsim$10 Myr. However, gas detections are difficult and often indirect, not allowing one to discern the true gas densities. This suggests using dynamical arguments: it has been argued that gas, if present with higher densities, would lead to flatter radial profiles of the dust density and brightness than those actually observed. In this paper, we systematically study the influence of gas on the radial profiles of brightness. We assume that dust is replenished by planetesimals orbiting in a "birth ring" and model the dust distribution and scattered-light brightness profile in the outer part of the disk exterior to the birth ring, under different assumptions about the gas component. Our numerical simulations, supported with an analytic model, show that the radial profile of dust density and the surface brightness are surprisingly insensitive to variation of the parameters of a central star, location of the dust-producing planetesimal belt, dustiness of the disk and — most importantly — the parameters of the ambient gas. The radial brightness slopes in the outer disks are all typically in the range $-3...-4$. This result holds for a a wide range of gas densities (three orders of magnitude), for different radial profiles of the gas temperature, both for gas of solar composition and gas of strongly non-solar composition. The slopes of $-3...-4$ we find are the same that were theoretically found for gas-free debris disks, and they are the same as actually retrieved from observations of many debris disks. Our specific results for three young (10–30 Myr old), spatially resolved, edge-on debris disks (β Pic, HD 32297, and AU Mic) show that the observed radial profiles of the surface brightness do not pose any stringent constraints on the gas component of the disk. We cannot exclude that outer parts of the systems may have retained substantial amounts of primordial gas which is not evident in the gas observations (e.g. as much as 50 Earth masses for β Pic). However, the possibility that gas, most

likely secondary, is only present in little to moderate amounts, as deduced from gas detections (e.g. ~ 0.05 Earth masses in the β Pic disk or even less), remains open, too.

Accepted by Astronomy and Astrophysics (15 September 2009)

URL for preprints: http://arxiv.org/abs/0909.4225

Pre-main sequence stars in the Cepheus flare region

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We present results of optical spectroscopic and $BVR_{\rm C}I_{\rm C}$ photometric observations of 77 pre-main sequence (PMS) stars in the Cepheus flare region. A total of 64 of these are newly confirmed PMS stars, originally selected from various published candidate lists. We estimate effective temperatures and luminosities for the PMS stars, and comparing the results with pre-main sequence evolutionary models we estimate stellar masses of 0.2–2.4 $M_{\odot}$ and stellar ages of 0.1–15 Myr. Among the PMS stars, we identify 15 visual binaries with separations of 2–10 arcsec. From archival IRAS, 2MASS, and Spitzer data, we construct their spectral energy distributions and classify 5% of the stars as Class I, 10% as Flat SED, 60% as Class II, and 3% as Class III young stellar objects (YSOs). We identify 12 CTTS and 2 WTTS as members of NGC 7023, with mean age of 1.6 Myr. The 13 PMS stars associated with L 1228 belong to three small aggregates: RNO 129, L 1228 A, and L 1228 S. The age distribution of the 17 PMS stars associated with L 1251 suggests that star formation has propagated with the expansion of the Cepheus flare shell. We detect sparse aggregates of $\sim$6–7 Myr-old PMS stars around the dark clouds L 1177 and L 1219, at a distance of ~ 400 pc. Three T Tauri stars appear to be associated with the Herbig Ae star SV Cep at a distance of 600 pc. Our results confirm that the molecular complex in the Cepheus flare region contains clouds of various distances and star forming histories.

Accepted by ApJS

http://arxiv.org/abs/0910.1894

Anchoring Magnetic Field in Turbulent Molecular Clouds

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One of the key problems in star formation research is to determine the role of magnetic fields. Starting from the atomic inter-cloud medium (ICM) which has density nH 1 per cubic cm, gas must accumulate from a volume several hundred pc across in order to form a typical molecular cloud. Star formation usually occurs in cloud cores, which have linear sizes below 1 pc and densities nH2 ¿ 1e5 per cubic cm. With current technologies, it is hard to probe magnetic fields at scales lying between the accumulation length and the size of cloud cores, a range corresponds to many levels of turbulent eddy cascade, and many orders of magnitude of density amplification. For field directions detected from the two extremes, however, we show here that a significant correlation is found. Comparing this result with molecular cloud simulations, only the sub-Alfvenic cases result in field orientations consistent with our observations.

Accepted by ApJ

http://arxiv.org/abs/0908.1549

2MASS wide field extinction maps: III. The Taurus, Perseus, and California cloud complexes

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We present a near-infrared extinction map of a large region in the sky ($\sim 3\,500$ deg^2) in the general directions of Taurus, Perseus, and Aries. The map has been obtained using robust and optimal methods to map dust column density at near-infrared wavelengths (Nicer, described in Lombardi et al. 2001, and Nicest, described in Lombardi 2009) toward $\sim$ 23 million stars from the Two Micron All Sky Survey (2MASS) point source catalog. We measure extinction as low as $A_K = 0.04$ mag with a 1-σ significance, and a resolution of 2.5 arcmin in our map. A 250 deg^2 section of our map encompasses the Taurus, Perseus, and California molecular cloud complexes. We determine the distances of the clouds by comparing the observed density of foreground stars with the prediction of galactic models, and we obtain results that are in excellent agreement with recent VLBI parallax measurements. We characterize the large-scale structure of the map and find a $\sim 25° \times 15°$ region close to the galactic plane ($l \sim 135°$, $b \sim -14°$) with small extinction ($A_K < 0.04$ mag); we name this region the Perseus-Andromeda hole. We find that over the region that encompasses the Taurus, Perseus, and California clouds the column density measurements below $A_K < 0.2$ mag are perfectly described by a log-normal distribution, and that a significant deviation is observed at larger extinction values. If turbulence models are invoked to justify the log-normal distribution, the observed departure could be interpreted as the results of the effect of gravity that acts on the cores of the clouds. Finally, we investigate the cloud structure function, and show that significant deviations from the results predicted by turbulent models are observed in at least one cloud.

Accepted by Astronomy & Astrophysics

Oxygen isotopic compositions of solar corundum grains

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Oxygen is one of the major rock-forming elements in the Solar System and the third most abundant element of the Sun. Oxygen isotopic composition of the Sun, however, is not known due to a poor resolution of astronomical spectroscopic measurements. Several $\Delta^{17}O$ values have been proposed for the composition of the Sun based on (1) the oxygen isotopic measurements of the solar wind implanted into metallic particles in lunar soil (¡ -20 permil, Hashizume & Chaussidon 2005; +35 permil, Ireland et al. 2006), (2) the solar wind returned by the Genesis spacecraft (-27±6 permil, McKeegan et al. 2009), and (3) the mineralogically pristine calcium-aluminum-rich inclusions (CAIs) (-23±2 permil, Makide et al. 2009; -35 permil, Gounelle et al. 2009). CAIs are the oldest Solar System solids, and are believed to have formed by evaporation, condensation, and melting processes in hot nebular region(s) when the Sun was infalling (class 0) or evolved (class I) protostar. Corundum (Al_2O_3) is thermodynamically the first condensate from a cooling gas of solar composition. Corundum-bearing CAIs, however, are exceptionally rare, suggesting either continuous reaction of the corundum condensates with a cooling nebular gas and their replacement by hibonite ($CaAl_{12}O_{19}$) or their destruction by melting together with less refractory condensates during formation of igneous CAIs. In contrast to the corundum-bearing CAIs, isolated micrometer-sized corundum grains are common in the acid-resistant residues from unmetamorphosed chondrites. These grains could have avoided multistage reprocessing during CAI formation, and, therefore, can potentially provide constraints on the initial oxygen isotopic composition of the solar nebula, and, hence, of the Sun. Here we report oxygen isotopic compositions of ~60 micrometer-sized corundum grains in the acid-resistant residues from unequilibrated ordinary chondrites (Semarkona (LL3.0), Bishunpur (LL3.1), Roosevelt County 075 (H3.2)) and unmetamorphosed carbonaceous chondrites (Orgueil (CI1), Murray (CM2), and Alan Hills A77307 (CO3.0)) measured with a Cameca ims-1280 ion microprobe. All corundum grains, except two, are ^{16}O-rich (Δ^{17}O = -22.7±8.5 permil, 2σ), and compositionally similar to the mineralogically pristine CAIs from the CR carbonaceous chondrites (-23.3±1.9 permil, 2σ), and solar wind returned by the Genesis spacecraft (-27±6 permil, 2σ). One corundum grain is highly ^{17}O-enriched (δ^{17}O $\sim$ +60 permil, δ^{18}O $\sim$ -40 permil) and is probably of presolar origin; the origin of another ^{17}O-rich grain (δ^{17}O $\sim$ -15 permil, δ^{18}O -35 permil) is unclear. We conclude that the ^{16}O-rich corundum grains in the acid-resistant residues from unequilibrated ordinary and unmetamorphosed carbonaceous chondrites recorded initial oxygen isotopic composition of the solar nebula, and, hence, of the Sun. Our inferred oxygen isotopic composition of the Sun is inconsistent with the more extreme ^{16}O-rich value (Δ^{17}O $\sim$ -35 permil) proposed by Gounelle et al. (2009) on the basis of two extremely ^{16}O-rich CAIs from the CH/CB-like chondrite Isheyevo and with the ^{16}O-poor value observed as a component of the solar wind implanted into the metallic particles in lunar soil (Ireland et al. 2006).

Accepted by The Astrophysical journal

HST/STIS observations of the RW Aurigae bipolar jet: mapping the physical parameters close to the source

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Context. We present the results of new spectral diagnostic investigations applied to high-resolution long-slit spectra obtained with the Hubble Space Telescope Imaging Spectrograph (HST/STIS) of the jet from the T Tauri star RW Aur.
Aims. Our primary goal is to determine basic physical parameters (electron density $n_{\rm e}$ and electron temperature $T_{\rm e}$, hydrogen ionisation fraction $x_{\rm e}$, total hydrogen density $n_{\rm H}$, radial velocity $v_{\rm r}$ and the mass outflow rate $\dot{M}_{\rm j}$) along both the red- and blueshifted lobes of the RW Aur jet.
Methods. The input dataset consists of seven long-slit spectra, of $0\farcs1$ spatial resolution, taken with the STIS slit parallel to the jet, and stepped across it. We use the Bacciotti & Eislöffel (1999) method to analyse the forbidden doublets [O I] $\lambda\lambda$6300,6363, [S II] $\lambda\lambda$ 6716,6731, and [N II] $\lambda\lambda$ 6548,6583 Å to extract $n_{\rm e}$, $T_{\rm e}$, $x_{\rm e}$, and $n_{\rm H}$.
Results. We were able to extract the parameters as far as 3.9 arcsec in the red- and 2.1 arcsec in the blueshifted beam. The electron density at the base of both lobes is close to the critical density for [S II] emission but then it decreases gradually with distance from the source. The range of electron temperatures derived for this jet ($T_{\rm e} = 10^4 - 2 \times 10^4$ K) is similar to those generally found in other outflows from young stars. The ionisation fraction $x_{\rm e}$ varies between 0.04 and 0.4, increasing within the first few arcseconds and then decreasing in both lobes. The total hydrogen density, derived as $n_{\rm H} = n_{\rm e}/x_{\rm e}$, is on average 3.2×10^4cm^{-3} and shows a gradual decrease along the beam. Variations of the above quantities along the jet lobes appear to be correlated with the position of knots. Combining the derived parameters with $v_{\rm r}$ measured from the HST spectra and other characteristics available for this jet, we estimate $\dot{M}_{\rm j}$ following two different procedures. The mass-outflow rate $\dot{M}_{\rm j}$ is moderate and similar in the two lobes, despite the fact that the well-known asymmetry in the radial velocity persists close to the source. Using the results of the BE diagnostics we find averages along the first 2.1 arcsec of both flows (a region presumably not yet affected by interaction with the jet environment) of $2.6 \times 10^{-9}\ M_\odot\ {\rm yr}^{-1}$ for the red lobe and $2.0 \times 10^{-9}\ M_\odot\ {\rm yr}^{-1}$ for the blueshifted flow, with an uncertainty of $\pm \log M_\odot$=1.6.
Conclusions. The fact that the derived mass outflow rate is similar in the two lobes appears to indicate that the central engine is constrained on the two sides of the system and that the observed asymmetries are due to environmental conditions. Possible suggestions for the origin of the differences are discussed. The RW Aur jet appears to be the second densest outflow from a T Tauri star studied so far, but its other properties are quite similar to those found in other jets from young stars, suggesting that a common acceleration mechanism operates in these sources.

Accepted by Astronomy & Astrophysics

Available at http:arXiv.org/abs/0910.0379

Pre-Discovery 2007 Image of the HR 8799 Planetary System

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We present a pre-discovery H-band image of the HR 8799 planetary system that reveals all three planets in August 2007. The data were obtained with the Keck adaptive optics system, using angular differential imaging and a coronagraph. We confirm the physical association of all three planets, including HR 8799d, which had only been detected in 2008 images taken two months apart, and whose association with HR 8799 was least secure until now. We confirm that the planets are 2–3 mag fainter than field brown dwarfs of comparable near-infrared colors. We note that similar under-luminosity is characteristic of young substellar objects at the L/T spectral type transition, and is likely due to enhanced dust content and non-equilibrium CO/CH_4 chemistry in their atmospheres. Finally, we place an upper limit of $\gtrsim$18 mag per square arc second on the >120 AU H-band dust-scattered light from the HR 8799 debris disk. The integrated scattered light flux is $<10^{-4}$ times fainter than the stellar photosphere, or >24 times fainter than for the debris ring around HR 4796A.

Accepted by Astrophysical Journal Letters

http://arxiv.org/abs/0910.0915

Bondi-Hoyle-Lyttleton Accretion onto a Protoplanetary Disk

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Young stellar systems orbiting in the potential of their birth cluster can accrete from the dense molecular interstellar medium during the period between the star's birth and the dispersal of the cluster's gas. Over this time, which may span several Myr, the amount of material accreted can rival the amount in the initial protoplanetary disk; the potential importance of this 'tail-end' accretion for planet formation was recently highlighted by Throop & Bally (2008). While accretion onto a point mass is successfully modeled by the classical Bondi-Hoyle-Lyttleton solutions, the more complicated case of accretion onto a star-disk system defies analytic solution. In this paper we investigate via direct hydrodynamic simulations the accretion of dense interstellar material onto a star with an associated gaseous protoplanetary disk. We discuss the changes to the structure of the accretion flow caused by the disk, and vice versa. We find that immersion in a dense accretion flow can redistribute disk material such that outer disk migrates inwards, increasing the inner disk surface density and reducing the outer radius. The accretion flow also triggers the development of spiral density features, and changes to the disk inclination. The mean accretion rate onto the star remains roughly the same with and without the presence of a disk. We discuss the potential impact of this process on planet formation, including the possibility of triggered gravitational instability; inclination differences between the disk and the star; and the appearance of spiral structure in a gravitationally stable system.

Accepted by ApJ

http://arxiv.org/abs/0910.3539

Star formation in the Cometary Globule Ori I-2

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We investigate the young stellar population in and near the cometary globule Ori I-2. The analysis is based on deep Nordic Optical Telescope R-band and Hα images, JCMT SCUBA 450 and 850 μm images combined with near-infrared 2MASS photometry and mid-infrared archival *Spitzer* images obtained with the IRAC (3.6, 4.5, 5.8 and 8 μm), and MIPS (24 and 70 μm) instruments. We identify a total of 125 sources within the $5' \times 5'$ region imaged by IRAC. Of these sources 87 are detected in the R-band image and 51 are detected in the 2MASS survey. The detailed physical properties of the sources are explored using a combination of near/mid-infrared color-color diagrams, greybody fitting of SEDs and an online SED fitting tool that uses a library of 2D radiation transfer based accretion models of young stellar objects with disks. Ori I-2 shows clear evidence of triggered star formation with four young low luminosity pre-main sequence stars embedded in the globule. At least two, possibly as many as four, additional low-mass PMS objects, were discovered in the field which are probably part of the young σ Orionis cluster. Among the PMS stars which have formed in the globule, MIR-54 is a young, deeply embedded Class 0/I object, MIR-51 and 52 are young Class II sources, while MIR-89 is a more evolved, heavily extincted Class II object with its apparent colors mimicking a Class 0/I object. The Class 0/I object MIR-54 coincides with a previously known IRAS source and is a strong sub-millimeter source. It is most likely the source for the molecular outflow and the large parsec scale Herbig-Haro flow. However the nearby Class II source, MIR-52, which is strong a Hα emission line star, also appears to drive an outflow approximately aligned with the outflow from MIR-54, and because of the proximity of the two outflows, either star could contribute. MIR-89 appears to excite a low excitation HH object, HH 992, discovered for the first time in this study.

Accepted by Astrophysical Journal

http://arxiv.org/abs/0910.1898

Evidence for Dynamical Changes in a Transitional Protoplanetary Disk with Mid-infrared Variability

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We present multi-epoch Spitzer Space Telescope observations of the transitional disk LRLL 31 in the 2-3 Myr-old star forming region IC 348. Our measurements show remarkable mid-infrared variability on timescales as short as one week. The infrared continuum emission exhibits systematic wavelength-dependent changes that suggest corresponding dynamical changes in the inner disk structure and variable shadowing of outer disk material. We propose several possible sources for the structural changes, including a variable accretion rate or a stellar or planetary companion embedded in the disk. Our results indicate that variability studies in the infrared can provide important new constraints on protoplanetary disk behavior.

Accepted by ApJ Letters

http://arxiv.org/abs/0909.5201

On the distribution of protostar masses

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The distribution of protostar masses is studied for core-environment systems whose duration of infall follows a waiting-time distribution. Each core-environment system has a continuous density profile with no barrier to mass flow. The core is an isothermal sphere and the environment is a filament, a layer, or a uniform medium. The infall is terminated by gas dispersal due to outflows and turbulence. The distribution of infall durations is a declining exponential, the simplest waiting-time distribution. The resulting distribution of protostar masses closely resembles the initial mass function, provided the environment density is sufficiently high, and the distribution of initial core masses is sufficiently narrow. The high-mass tail of the mass function increases strongly with environment density and weakly with environment dimension. "Isolated" regions of low environment density form protostars of low mass from within the parent core. In contrast, "clustered" regions of high environment density form protostars of low mass from core gas, and protostars of high mass from core and environment gas.

Accepted by Astrophysical Journal

http://arxiv.org/abs/0910.3120

Direct detection of a flared disk around a young massive star HD200775 and its 10 to 1000AU scale properties

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We made mid-infrared observations of the $10\,M_\odot$ Herbig Be star HD200775 with the Cooled Mid-Infrared Camera and Spectrometer (COMICS) on the 8.2 m Subaru Telescope. We discovered diffuse emission of an elliptical shape extended in the north-south direction in ∼1000 AU radius around unresolved excess emission. The diffuse emission is perpendicular to the cavity wall formed by the past outflow activity and is parallel to the projected major axis of the central close binary orbit. The centers of the ellipse contours of the diffuse emission are shifted from the stellar position and the amount of the shift increases as t he contour brightness level decreases. The diffuse emission is well explained in all of geometry, size, and configuration by an inclined flared disk where only its surface emits the mid-infrared photons. Our results give the first well-resolved infrared disk images around a massive star and strongly support that HD200775 is formed through the disk accretion. The disk survives the main accretion phase and shows a structure similar to that around lower-mass stars with 'disk atmosphere'. At the same time, the disk also shows properties characteristic to massive stars such as photoevaporation traced by the 3.4 mm free-free emission and unusual silicate emission with a peak at $9.2\,\mu$m, which is shorter than that of many astronomical objects. It provides a good place to compare the disk properties between massive and lower-mass stars.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0910.4328

A torque formula for non-isothermal Type I planetary migration - I. Unsaturated horseshoe drag

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We study the torque on low-mass planets embedded in protoplanetary discs in the two-dimensional approximation, incorporating non-isothermal effects. We couple linear estimates of the Lindblad (or wave) torque to a simple, but non-linear, model of adiabatic corotation torques (or horseshoe drag), resulting in a simple formula that governs Type I migration in non-isothermal discs. This formula should apply in optically thick regions of the disc, where viscous and thermal diffusion act to keep the horseshoe drag unsaturated. We check this formula against numerical hydrodynamical simulations, using three independent numerical methods, and find good agreement.

Accepted by MNRAS

http://arxiv.org/abs/0909.4552

The Arecibo Methanol Maser Galactic Plane Survey - III: Distances and Luminosities

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We derive kinematic distances to the 86 6.7 GHz methanol masers discovered in the Arecibo Methanol Maser Galactic Plane Survey. The systemic velocities of the sources were derived from ^{13}CO ($J = 2-1$), CS ($J = 5-4$), and NH_3 observations made with the ARO Submillimeter Telescope, the APEX telescope, and the Effelsberg 100 m telescope, respectively. Kinematic distance ambiguities were resolved using HI self-absorption with HI data from the VLA Galactic Plane Survey. We observe roughly three times as many sources at the far distance compared to the near distance. The vertical distribution of the sources has a scale height of ~ 30 pc, and is much lower than that of the Galactic thin disk. We use the distances derived in this work to determine the luminosity function of 6.7 GHz maser emission. The luminosity function has a peak at approximately $10^{-6}\ L_\odot$. Assuming that this luminosity function applies, the methanol maser population in the Large Magellanic Cloud and M33 is at least 4 and 14 times smaller, respectively, than in our Galaxy.

Accepted by ApJ

http://arxiv.org/abs/0910.3763

Deuterium chemistry in the Orion Bar PDR: "warm" chemistry starring CH_2D^+

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Context: High levels of deuterium fractionation in gas-phase molecules are usually associated with cold regions, such as prestellar cores. Significant fractionation ratios are also observed in hot environments such as hot cores or hot corinos, where they are believed to be produced by the evaporation of the icy mantles surrounding dust grains, and are thus remnants of a previous cold (either gas-phase or grain surface) chemistry. The recent detection of DCN towards the Orion Bar, in a clump at a characteristic temperature of 70 K, has shown that high deuterium fractionation can also be detected in PDRs. The Orion Bar clumps thus appear to be a good environment for the observational study of

deuterium fractionation in luke warm gas, allowing us to validate chemistry models for a different temperature range, where dominating fractionation processes are predicted to differ from those in cold gas (< 20 K).
Aims: We aimed to study observationally in detail the chemistry at work in the Orion Bar PDR, to understand whether DCN is either produced by ice mantle evaporation or is the result of warm gas-phase chemistry, involving the CH_2D^+ precursor ion (which survives higher temperatures than the usual H_2D^+ precursor).
Methods: Using the APEX and the IRAM 30 m telescopes, we targeted selected deuterated species towards two clumps in the Orion Bar.
Results: We confirmed the detection of DCN and detected two new deuterated molecules (DCO^+ and HDCO) towards one clump in the Orion Bar PDR. Significant deuterium fractionations are found for HCN and H_2CO, but we measured a low fractionation in HCO^+. We also provide upper limits to other molecules relevant to deuterium chemistry.
Conclusions: We argue that grain evaporation in the clumps is unlikely to be a dominant process, and we find that the observed deuterium fractionation ratios are consistent with predictions of pure gas-phase chemistry models at warm temperatures (T $\sim$ 50 K). We show evidence that warm deuterium chemistry driven by CH_2D^+ is at work in the clumps.

Accepted by A&A

http://arxiv.org/abs/0909.4683

The Fundamental Gas Depletion and Stellar-mass Buildup Times of Star Forming Galaxies

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Stars do not form continuously distributed over star-forming galaxies. They form in star clusters of different masses. This nature of clustered star formation is taken into account in the theory of the integrated galactic stellar initial mass function (IGIMF) in which the galaxy-wide IMF (the IGIMF) is calculated by adding all IMFs of young star clusters. For massive stars, the IGIMF is steeper than the universal IMF in star clusters and steepens with decreasing SFR which is called the IGIMF effect. The current SFR and the total Hα luminosity of galaxies therefore scale non-linearly in the IGIMF theory compared to the classical case in which the galaxy-wide IMF is assumed to be constant and identical to the IMF in star clusters. We here apply for the first time the revised SFR–$L_{\mathrm{H}\alpha}$ relation on a sample of local volume star forming galaxies with measured Hα luminosities. The fundamental results are: i) the SFRs of galaxies scale linearly with the total galaxy neutral gas mass, ii) the gas depletion time scales of dwarf irregular and large disk galaxies are about 3 Gyr implying that dwarf galaxies do not have lower star formation efficiencies than large disk galaxies, and iii) the stellar mass buildup times of dwarf and large galaxies are only in agreement with downsizing in the IGIMF context, but contradict downsizing within the traditional framework that assumes a constant galaxy-wide IMF.

Accepted by ApJ

http://arxiv.org/abs/0910.1089

A Wide-Field Survey of the Orion Nebula Cluster in the Near-Infrared

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We present J, H and K_S photometry of the Orion Nebula Cluster obtained at the CTIO/Blanco 4 m telescope in Cerro Tololo with the ISPI imager. From the observations we have assembled a catalog of about $\sim$ 7800 sources distributed over an area of approximately $30' \times 40'$, the largest of any survey deeper than 2MASS in this region. The catalog

provides absolute coordinates accurate to about 0.15 arcseconds and 3σ photometry in the 2MASS system down to $J \simeq 19.5$ mag, $H \simeq 18.0$ mag, $K_S \simeq 18.5$ mag, enough to detect planetary size objects 1 Myr old under $A_V \simeq 10$ mag of extinction at the distance of the Orion Nebula. We present a preliminary analysis of the catalog, done comparing the (J-H,H-K_S) color-color diagram, the (H,J-H) and (K_S,H-K_S) color-magnitude diagrams and the JHK_S luminosity functions of three regions at increasing projected distance from the Trapezium. Sources in the inner region typically show IR colors compatible with reddened T Tauri stars, whereas the outer fields are dominated by field stars seen through an amount of extinction which decreases with the distance from the center. The color-magnitude diagrams make it possible to clearly distinguish between the main ONC population, spread across the full field, and background sources.

Accepted by Astronomical Journal

http://arxiv.org/abs/0910.4194

Trigonometric Parallaxes of 6.7 GHz Methanol Masers

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Emission from the 6.7 GHz methanol maser transition is very strong, relatively stable, has small internal motions and is observed toward numerous massive star forming regions in the Galaxy. Our goal is to perform high precision astrometry using this maser transition to obtain accurate distances to their host regions. Eight strong masers were observed during five epochs of VLBI observations with the European VLBI Network between 2006, June, and 2008, March. We report trigonometric parallaxes for five star forming regions, with accuracies as good as ~ 22 μas. Distances to these sources are $2.57^{+0.34}_{-0.27}$ kpc for ON 1, $0.776^{+0.104}_{-0.083}$ kpc for L 1206, $0.929^{+0.034}_{-0.033}$ kpc for L 1287, $2.38^{+0.13}_{-0.12}$ kpc for NGC 281-W and $1.59^{+0.07}_{-0.06}$ kpc for S 255. The distances and proper motions yield the full space motions of the star forming regions hosting the masers, and we find that these regions lag circular rotation on average by $\sim$17 km s^{-1}, a value comparable to that found recently by similar studies.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/0910.0150

Effects of X-ray irradiation and disk flaring on the [Ne II] 12.8μm emission from young stellar objects

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The [Ne II] fine-structure emission line at 12.8μm has been detected in several young stellar objects (YSO) spectra. This line is thought to be produced by X-ray irradiation of the warm protoplanetary disk atmospheres, however the observational correlation between [Ne II] luminosities and measured X-ray luminosities shows a large scatter. Such spread limits the utility of this line as a probe of the gaseous phase of disks, as several authors have suggested pollution by outflows as a probable cause of the observed scatter. In this work we explore the possibility that the large variations in the observed [Ne II] luminosity may be caused instead by different star-disk parameters. In particular we study the effects that the hardness of the irradiating source and the structure (flaring) of the disk have on the luminosity and spectral profile of the [Ne II] 12.8 μm line. We find that varying these parameter can indeed cause up to an order of magnitude variation in the emission luminosities which may explain the scatter observed, although our models predict somewhat smaller luminosities than those recently reported by other authors who observed the line with the *Spitzer* Space Telescope. Our models also show that the hardness of the spectrum has only a limited (undetectable) effect on the line profiles, while changes in the flaring power of the disk significantly affect the size of the [Ne II] emission region and, as a consequence, its line profile. In particular we suggest that broad line profiles centred on the stellar radial velocity may be indicative of flat disks seen at large inclination angles.

Accepted by Monthly Notices of the Royal Astronomical Society

http://arxiv.org/abs/0910.0058

Warm Extended Dense Gas Lurking At The Heart Of A Cold Collapsing Dense Core

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In order to investigate when and how the birth of a protostellar core occurs, we made survey observations of four well-studied dense cores in the Taurus molecular cloud using CO transitions in submillimeter bands. We report here the detection of unexpectedly warm (30 − 70 K), extended (radius of 2400 AU), dense (a few times 10^5 cm^{-3}) gas at the heart of one of the dense cores, L1521F (MC27), within the cold dynamically collapsing components. We argue that the detected warm, extended, dense gas may originate from shock regions caused by collisions between the dynamically collapsing components and outflowing/rotating components within the dense core. We propose a new stage of star formation, "warm-in-cold core stage (WICCS)", i.e., the cold collapsing envelope encases the warm extended dense gas at the center due to the formation of a protostellar core. WICCS would constitutes a missing link in evolution between a cold quiescent starless core and a young protostar in class 0 stage that has a large-scale bipolar outflow.

Accepted by the Astrophysical Journal Letters.

http://arxiv.org/abs/0910.0463

Two Massive, Low-Luminosity Cores Toward Infrared Dark Clouds

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This article presents high-resolution interferometric mosaics in the 850 μm waveband of two massive, quiescent infrared dark clouds. The two clouds were chosen based on their likelihood to represent environments preceding the formation of massive stars. The brightest compact sources detected in each cloud have masses $\approx 110\,M_\odot$ and $\approx 60\,M_\odot$ with radii < 0.1 pc, implying mean densities of $\langle n \rangle \approx 10^6\,\mathrm{cm}^{-3}$ and $\langle N \rangle \approx 1\,\mathrm{g\,cm}^{-2}$. Supplementary data show these cores to be cold and inactive. Low upper limits to their bolometric luminosities and temperatures place them at a very early stage of evolution while current models of massive star formation suggest they have the potential to form massive stars.

Accepted by The Astrophysical Journal

Time-dependent MHD shocks and line intensity ratios in the HH 30 jet: A focus on cooling function and numerical resolution

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Context. The coupling between time-dependent, multidimensional MHD numerical codes and radiative line emission is of utmost importance in the studies of the interplay between dynamical and radiative processes in many astrophysical environments, with particular interest for problems involving radiative shocks. There is a widespread consensus that line emitting knots observed in Herbig-Haro jets can be interpreted as radiative shocks. Velocity perturbations at the jet base steepen into shocks to emit the observed spectra. To derive the observable characteristics of the emitted spectra, such as line intensity ratios, one has to study physical processes that involve the solution of the MHD equations coupled with radiative cooling in non-equilibrium conditions.
Aims. In this paper we address two different aspects relevant to the time-dependent calculations of the line intensity ratios of forbidden transitions, resulting from the excitation by planar, time-dependent radiative shocks traveling in a stratified medium. The first one concerns the impact of the radiation and ionization processes included in the cooling model, and the second one the effects of the numerical grid resolution.
Methods. Dealing with both dynamical and radiative processes in the same numerical schememeans to treat phenomena characterized by different time and length scales. This may be especially arduous and computationally expensive when discontinuities are involved, such as in the case of shocks. Adaptive Mesh Refinement (AMR) methods have been introduced in order to alleviate these difficulties. In this paper we apply the AMR methodology to the treatment of radiating shocks and show how this method is able to vastly reduce the integration time.
Results. The technique is applied to the knots of the HH 30 jet to obtain the observed line intensity ratios and derive the physical parameters, such as density, temperature and ionization fraction. We consider the impact of two different cooling functions and different grid resolutions on the results.
Conclusions. We conclude that the use of different cooling routines has effects on results whose weight depends upon the line ratio considered. Moreover, we find the minimum numerical resolution of the simulation grid behind the shock to achieve convergence in the results. This is crucial for the forthcoming 2D calculations of radiative shocks.

Accepted by Astronomy and Astrophysics

Large-Scale CO Maps of the Lupus Molecular Cloud Complex

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Fully sampled degree-scale maps of the ^{13}CO 2–1 and CO 4–3 transitions toward three members of the Lupus Molecular Cloud Complex — Lupus I, III, and IV — trace the column density and temperature of the molecular gas. Comparison with IR extinction maps from the c2d project requires most of the gas to have a temperature of 8–10 K. Estimates of the cloud mass from ^{13}CO emission are roughly consistent with most previous estimates, while the line widths are higher, around 2 km s^{-1}. CO 4–3 emission is found throughout Lupus I, indicating widespread dense gas, and toward Lupus III and IV. Enhanced line widths at the NW end and along the edge of the B 228 ridge in Lupus I, and a coherent velocity gradient across the ridge, are consistent with interaction between the molecular cloud and an expanding HI shell from the Upper-Scorpius subgroup of the Sco-Cen OB Association. Lupus III is dominated by the effects of two HAe/Be stars, and shows no sign of external influence. Slightly warmer gas around the core of Lupus IV and a low line width suggest heating by the Upper-Centaurus-Lupus subgroup of Sco-Cen, without the effects of an HI shell.

Accepted by ApJS

http://www.astro.ex.ac.uk/people/nfht/publications.html

Radio Jets and Disks in the Intermediate-mass Star-forming Region NGC2071IR

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We report the results of simultaneous radio continuum and water maser observations toward the NGC 2071IR star-forming region, carried out with the VLA in its A configuration. We detect continuum emission toward the infrared sources IRS 1 and IRS 3 at 1.3 and 3.6 cm. In addition, a new continuum source, VLA 1, is also detected at both wavelengths, which is located between IRS 1 and IRS 3. IRS 1 breaks up into three continuum peaks (IRS 1E, 1C, and 1W), aligned in the east-west direction (P.A. = 100°). IRS 1 is the central source, while the sources E and W seem to be condensations ejected by IRS 1. In the same way, IRS 3 is also forming a triple system (IRS 3N, 3C and 3S), which is elongated in the northeast-southwest direction and the condensations, IRS 3N and IRS 3S, are symmetrically located along the major axis. Based on the morphology and the continuum emission, we suggest that both, IRS 1 and IRS 3, are radio jets, which have ejected condensations into the interstellar medium. Moreover, IRS 1 and IRS 3 seem to be the driving sources of the large-scale outflows observed in H_2 and CO, respectively. In addition, we also detected water emission toward the systems IRS 1, IRS 3, and the new source VLA 1. Based on the spatial-kinematic distribution of the water masers, we find evidence that the water masers are tracing part of circumstellar disks around IRS 1C and IRS 3C. Moreover, we estimate that the sources IRS 1C and IRS 3C have central masses of $\sim$ 5 and $\sim$ 1 $M_\odot$, respectively. We conclude that the radio continuum and water maser emission are tracing disk-YSO-outflow systems toward IRS 1 and IRS 3, which are low- and intermediate-mass YSOs, respectively.

Accepted by ApJ

A *Spitzer Space Telescope* far-infrared spectral atlas of compact sources in the Magellanic Clouds. I. The Large Magellanic Cloud

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We present far-infrared spectra, λ=52–93 μm, obtained with the *Spitzer Space Telescope* in the Spectral Energy Distribution mode of its MIPS instrument, of a representative sample of the most luminous compact far-infrared sources in the Large Magellanic Cloud. These include carbon stars, OH/IR Asymptotic Giant Branch (AGB) stars, post-AGB objects and Planetary Nebulae, the R CrB-type star HV 2671, the OH/IR red supergiants WOH G064 and IRAS 05280−6910, the three B[e] stars IRAS 04530−6916, R 66 and R 126, the Wolf-Rayet star Brey 3a, the Luminous Blue Variable (LBV) R 71, the supernova remnant N 49, a large number of young stellar objects (YSOs), compact H II regions and molecular cores, and a background galaxy at a redshift $z \simeq 0.175$. We use the spectra to constrain the presence and temperature of cold dust and the excitation conditions and shocks within the neutral and ionized gas, in the circumstellar environments and interfaces with the surrounding interstellar medium (ISM). First, we introduce a spectral classification scheme. Then, we measure line strengths, dust temperatures, and IR luminosities. Objects associated with star formation are readily distinguished from evolved stars by their cold dust and/or fine-structure lines. Evolved stars, including the LBV R 71, lack cold dust except in some cases where we argue that this is swept-up

ISM. This leads to an estimate of the duration of the prolific dust-producing phase ("superwind") of several thousand years for both RSGs and massive AGB stars, with a similar fractional mass loss experienced despite the different masses. We tentatively detect line emission from neutral oxygen in the extreme RSG WOH G064, which suggests a large dust-free cavity with implications for the wind driving. In N 49, the shock between the supernova ejecta and ISM is revealed in spectacular fashion by its strong [O I] λ63-μm emission and possibly water vapour; we estimate that 0.2 $M_\odot$ of ISM dust was swept up. On the other hand, some of the compact H II regions display pronounced [O III] λ88-μm emission. The efficiency of photo-electric heating in the interfaces of ionized gas and molecular clouds is estimated at 0.1–0.3%. We confirm earlier indications of a low nitrogen content in the LMC. Evidence for solid state emission features is found in both young and evolved objects, but the carriers of these features remain elusive; some of the YSOs are found to contain crystalline water ice. The spectra constitute a valuable resource for the planning and interpretation of observations with the *Herschel Space Observatory* and the *Stratospheric Observatory For Infrared Astronomy* (SOFIA).

Accepted by The Astronomical Journal

http://arxiv.org/abs/0910.3339

183 GHz H_2O maser emission around low-mass protostar Serpens SMM1

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We report the first interferometric detection of 183GHz water emission in the lowmass protostar Serpens SMM1 using the Submillimeter Array with a resolution of 3" and rms of ~7 Jy in a 3 km s^{-1} bin. Due to the small size and high brightness of more than 240 Jy/beam, it appears to be maser emission. In total three maser spots were detected out to ~700 AU from the central protostar, lying along the red-shifted outflow axis, outside the circumstellar disk but within the envelope region as evidenced by the continuum measurements. Two of the maser spots appear to be blue-shifted by about 1 to 2 km s^{-1}. No extended or compact thermal emission froma passively heated protostellar envelopewas detected with a limit of 7 Jy (16 K), in agreement with recent modelling efforts. We propose that the maser spots originate within the cavity walls due to the interaction of the outflow jet with the surrounding protostellar envelope. Hydrodynamical models predict that such regions can be dense and warm enough to invert the 183 GHz water transition.

Accepted by ApJ Letters

http://arxiv.org/abs/0910.0831

Dense and warm molecular gas in the envelopes and outflows of southern low-mass protostars

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Context. Observations of dense molecular gas lie at the basis of our understanding of the density and temperature structure of protostellar envelopes and molecular outflows. The Atacama Pathfinder EXperiment (APEX) opens up the study of southern (Dec < -35°) protostars.
Aims. We aim to characterize the properties of the protostellar envelope, molecular outflow and surrounding cloud, through observations of high excitation molecular lines within a sample of 16 southern sources presumed to be embedded YSOs, including the most luminous Class I objects in Corona Australis and Chamaeleon.
Methods. Observations of submillimeter lines of CO, HCO+ and their isotopologues, both single spectra and small maps (up to 80" × 80"), were taken with the FLASH and APEX-2a instruments mounted on APEX to trace the gas around the sources. The HARP-B instrument on the JCMT was used to map IRAS 15398-3359 in these lines.

HCO+ mapping probes the presence of dense centrally condensed gas, a characteristic of protostellar envelopes. The rare isotopologues C18O and H13CO+ are also included to determine the optical depth, column density, and source velocity. The combination of multiple CO transitions, such as 3-2, 4-3 and 7-6, allows to constrain outflow properties, in particular the temperature. Archival submillimeter continuum data are used to determine envelope masses.
Results. Eleven of the sixteen sources have associated warm and/or dense ($> 10^6$ cm^{-3}) quiescent gas characteristic of protostellar envelopes, or an associated outflow. Using the strength and degree of concentration of the HCO+ 4-3 and CO 4-3 lines as a diagnostic, five sources classified as Class I based on their spectral energy distributions are found not to be embedded YSOs. The $C^{18}O$ 3-2 lines show that for none of the sources, foreground cloud layers are present. Strong molecular outflows are found around six sources, with outflow forces an order of magnitude higher than for previously studied Class I sources of similar luminosity.
Conclusions. This study provides a starting point for future ALMA and Herschel surveys by identifying truly embedded southern YSOs and determining their larger scale envelope and outflow characteristics.

Accepted by A&A

http://arxiv.org/abs/0910.1034

The relation between the most-massive star and its parental star cluster mass

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We present a thorough literature study of the most-massive star, $m_{\rm max}$, in several young star clusters in order to assess whether or not star clusters are populated from the stellar initial mass function (IMF) by random sampling over the mass range $0.01 \leq m \leq 150\ M_\odot$ without being constrained by the cluster mass, $M_{\rm ecl}$. The data reveal a partition of the sample into lowest mass objects ($M_{\rm ecl} \leq 10^2 M_\odot$), moderate mass clusters ($10^2 M_\odot < M_{\rm ecl} \leq 10^3 M_\odot$) and rich clusters above $10^3 M_\odot$. Additionally, there is a plateau of a constant maximal star mass ($m_{\rm max} \approx 25\ M_\odot$) for clusters with masses between $10^3 M_\odot$ and $4 \cdot 10^3 M_\odot$. Statistical tests of this data set reveal that the hypothesis of random sampling from the IMF between 0.01 and 150 $M_\odot$ is highly unlikely for star clusters more massive than $10^2 M_\odot$ with a probability of $p \approx 2 \cdot 10^{-7}$ for the objects with $M_{\rm ecl}$ between $10^2 M_\odot$ and $10^3 M_\odot$ and $p \approx 3 \cdot 10^{-9}$ for the more massive star clusters. Also, the spread of $m_{\rm max}$ values at a given $M_{\rm ecl}$ is smaller than expected from random sampling. We suggest that the basic physical process able to explain this dependence of stellar inventory of a star cluster on its mass may be the interplay between stellar feedback and the binding energy of the cluster-forming molecular cloud core. Given these results, it would follow that an integrated galactic initial mass function (IGIMF) sampled from such clusters would automatically be steeper in comparison to the IMF within individual star clusters.

Accepted by MNRAS

http://arxiv.org/abs/0909.1555

Outflows in ρ Ophiuchi as Seen with the Spitzer Infrared Array Camera

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Using the IRAC images from the *Spitzer c2d* program, we have made a survey of mid-infrared outflows in the ρ Ophiuchi molecular cloud. Extended objects that have prominent emission in IRAC channel 2 (4.5 μm) compared to IRAC channel 1 (3.6 μm) and stand out as green objects in the three-color images (3.6 μm in blue, 4.5 μm in green, 8.0 μm in red) are identified as mid-infrared outflows. As a result, we detected 13 new outflows in the ρ Ophiuchi molecular cloud that have not been previously observed in optical or near-infrared. In addition, at the positions of previously observed HH objects or near-infrared emission, we detected 31 mid-infrared outflows, among which seven

correspond to previously observed HH objects and 30 to near-infrared emission. Most of the mid-infrared outflows detected in the ρ Ophiuchi cloud are concentrated in the L1688 dense core region. In combination with the survey results for Young Stellar Objects (YSOs) and millimeter and sub-millimeter sources, the distribution of mid-infrared outflows in the ρ Ophiuchi molecular complex hints a propagation of star formation in the cloud in the direction from the northwest to the southeast as suggested by previous studies of the region.

Accepted by AJ

http://arxiv.org/abs/0910.0540

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).

Latex macros for submitting abstracts and dissertation abstracts (by e-mail to reipurth@ifa.hawaii.edu) are appended to each issue of the newsletter. You can also submit via the Newsletter web interface at http://www2.ifa.hawaii.edu/star-formation/index.cfm
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Dissertation Abstracts

Chemical Evolution from Cores to Disks

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Ph.D dissertation directed by: Ewine van Dishoeck
Ph.D degree awarded: October 2009

Stars like our Sun are formed in large, tenuous clouds of gas and dust. As the star is formed at the centre, the remaining material collapses into a thick disk around it. The chemical composition of such a cloud changes dramatically during this process. Spherical models have always been used to model this chemical evolution, but they cannot properly describe the disk. This thesis presents the first model that follows the entire chemical evolution from a pre-stellar core to a circumstellar disk in two spatial dimensions. It follows material as it falls in from the cloud to the star and disk. The density, temperature and UV flux along these trajectories serve as input for a gas-phase chemical network – including freeze-out onto and evaporation from cold dust grains. The model offers new insights into the chemical history of disks, in particular of the region where planets and comets are formed. Applications of the model include the gas/ice ratios of carbon monoxide and water (Chapter 2), the abundances of key gas-phase molecules (Chapter 3), the crystallinity of the dust (Chapter 4), the isotope-specific photodissociation of carbon monoxide (Chapter 5) and the charge balance of polycyclic aromatic hydrocarbons (PAHs; Chapter 6). The main conclusions are as follows:

- Our 2D collapse model produces realistic density and velocity profiles, allowing us to track the chemistry all the way from pre-stellar cores to circumstellar disks. Combined with full radiative transfer to get temperatures and UV fluxes, this makes it an excellent tool to study the chemical evolution during low-mass star formation.
- It is important to take the vertical structure of a disk into account when computing the infall trajectories. The outer parts of a disk can intercept material and keep it from accreting onto the disk at much smaller radii, as it would if the disk is treated as completely flat.
- Both CO and H_2O freeze out before the onset of collapse. H_2O remains frozen throughout the collapse phase, except when it gets into the inner 5–10 AU of a disk. From there, it may move outwards again to colder regions as the disk expands to conserve angular momentum. CO rapidly evaporates once the collapse starts, although some of it is likely to be trapped in the H_2O ice. In the coldest parts of a disk, all CO freezes out again.
- The material from which solar-system comets are formed must be of mixed origins. Our collapse model predicts a large degree of chemical processing towards the comet-forming zone in the disk. The observed fractions of crystalline silicates in comets are also indicative of strong processing. However, strong processing cannot explain why the chemical composition of cometary ices so closely resembles that of interstellar ices. The detections of amorphous silicates in comets also point at the presence of unprocessed material. Hence, it would seem that comets were formed partially from processed material and partially from pristine material.
- The chemical diversity between individual comets is likely a result of them having formed at different locations in the solar nebula. The physical conditions in a disk change in time, so if two comets were formed several 10^4 or 10^5 yr aparhe observed emission originates mostly from PAHs with a size of at least 100 carbon atoms.

Postdoctoral Position in Star Formation and Molecular Cloud Physics at Yale University

The Yale University Astronomy Department invites applications for a post-doctoral research position in observational star formation and molecular cloud physics. The successful applicant will collaborate with Prof. Hector Arce on studies of star-forming regions using millimeter, sub-millimeter and infrared data as well as radiative transfer codes. The successful applicant is expected to help with observations in observatories throughout the world (including Chile, Spain and the United States) and to participate in the analysis and interpretation of the acquired data. The postdoctoral associate will also have time to perform his or her own research. The initial appointment is for two years, renewable for a third, and offers competitive salary and benefits, and travel and research funds. Candidates must hold a Ph.D. in astronomy or related field by date of appointment. The applicant should have experience in observations of star-forming regions at centimeter, millimeter, sub-millimeter, and/or infrared wavelengths.

Conveniently located between New York City and Boston, Yale University offers a world-class intellectual environment and access to front-line astronomical facilities, including the Keck, WIYN, and SMARTS telescopes, astronomical facilities in Chile (through collaboration with the Universidad de Chile), as well High-Performance Computing facilities. Yale is also part of the SDSS-III collaboration.

Applications consisting of a cover letter, curriculum vitae, publication list, and a brief (2-3 page) description of research interests and plans should arrive by December 4, 2009. Applicants should also arrange for three letters of recommendation to arrive by the same date. Email all materials, including letters, to susan.delong *at* yale.edu. Yale University is an Affirmative Action/Equal Opportunity Employer, and we particularly encourage applications from women and members of minority groups.

Postdoctoral Fellow(s) - Exo-Planets, Brown Dwarfs and Young Stars - University of Toronto

Applications are invited for one or more postdoctoral research position(s) at the University of Toronto to start in 2010. The successful candidate(s) will work with Prof. Ray Jayawardhana and his collaborators on observational and analytical studies of extra-solar planets, brown dwarfs and young stars, and will be encouraged to pursue independent research on related topics. On-going projects include high-contrast imaging searches for sub-stellar companions around young stars, photometric and spectroscopic studies of extra-solar planets, investigations of brown dwarf variability and multiplicity, and the SONYC (Substellar Objects in Nearby Young Clusters) ultra-deep survey, using data from VLT, Subaru, Gemini, Keck, Spitzer, CFHT, Las Campanas and other major observatories. The position is for two years, with extension to a third year possible, and comes with a competitive salary and funds for research expenses. Applicants should send a curriculum vitae, a description of research interests and plans and a list of publications, and should arrange for three letters of recommendation to be sent directly to the above address. E-mail submission preferred. Applications received before 2009 December 1 will receive full consideration. Early expressions of interest and inquiries are welcome.

PhD Positions in Star and Planet Formation - ETH Zurich

The Institute of Astronomy of the Swiss Federal Institute of Technology (ETH Zurich) has established a new research group in star and planet formation led by Professor Michael Meyer. The focus of the research group will be in the areas of: (i) star clusters and the origin of the initial mass function; (ii) formation and evolution of planetary systems; and (iii) ground- and space-based optical/infrared instrumentation.

Applications are invited for new PhD positions in related to A) star formation and kinematics of star clusters, and B) direct imaging of extra-solar planets and circumstellar disks around stars young and old. Salaries for PhD students start at CHF 49,500 (USD 47,800). Students will have the opportunity to study observational and theoretical aspects of astronomy through formal coursework, conduct research with a range of experts in star and planet formation within the group, and take advantage of observational facilities and interact with colleagues internationally.

Switzerland is a member of ESO and ESA, and successful applicants will have full access to their facilities, as well as data from ongoing programs utilizing the Hubble Space Telescope, and the Spitzer Space Telescope. The Institute of Astronomy maintains a network of workstations and a large fast-connection Beowulf cluster and has competitive access to the Cray XT5, IBM and other supercomputers of the Swiss National Supercomputing Center (CSCS). Members of the Institute also play a leading role in the interdisciplinary PLANET-Z initiative linking research groups at the ETH Zurich in astronomy, earth science, and computational astrophysics at the University of Zurich. Interested applicants will have an opportunity to participate in setting up a new infrared instrumentation laboratory.

Applications are invited from all nationalities and should consist of a CV, description of relevant research experience, academic transcripts, scores from relevant standardized tests when available (e.g. TOEFL, Physics GRE) a personal statement of interests and goals, and the names of three references that can be contacted if necessary. Materials should be sent electronically in a single pdf file to eth-astro-star-planet *at* phys.ethz.ch. Review of applications will begin December 1, 2009. More information about the Institute for Astronomy, ETH Zurich can be found at: http://www.astro.phys.ethz.ch/

The ETH Zurich will provide benefits for maternity leave, retirement, accident insurance, and relocation costs: http://www.pa.ethz.ch/

IAU Symposium 270: Computational Star Formation

May 31, 2010 – June 4, 2010
Barcelona, Spain

Computational Astronomy is a relatively new branch of research that spans a wide range of skills, including the theory of gaseous and stellar dynamics, computational and algorithmic science, and visualization. It is also usually accompanied by serious comparisons with observations. Simulations of star formation and young cluster evolution have now reached a level of sophistication where they can reproduce the initial stellar mass function, the binary distribution as a function of stellar mass and period, the spatial distribution of stars in young clusters, the evolution of clusters, and the structure and evolution of galaxies. At the same time, there are large differences in techniques, algorithms, and computer hardware, and equally large differences in the assumptions about initial and boundary conditions and what physical processes to include.

The IAU Symposium 270 will be the forum to discuss simulations and observations of star formation in 2010. The result of this Symposium will be a better understanding of the similarities and differences between computational techniques, and a recognition of the successes and shortcomings in matching the simulation results to detailed observations of star formation.

SOC: T. Abel, J. Alves (co-chair), J. Ballesteros-Paredes, I. Bonnell, F. Bournaud, A. Burkert, C. Dobbs, B. Elmegreen (co-chair), J. Girart, G. Hensler, W. Kim, R. Klessen, M. Krumholz, J. Makino, F. Nakamura, Å. Nordlund, R. Pudritz, V. Trimble (co-chair), A. Tutukov

LOC: J. Alves, F. Alves, A. Bertolin, R. Estalella, P. Frau, J. Girart, J. Isern

Invited speakers so far include: T. Abel, J. Alves, P. André, J. Ascenso, J. Bally, S. Basu, M. Bate, I. Bonnell, F. Bournaud, L. Deharveng, C. Dobbs, N. Evans, S. Glover, A. Goodman, S. Goodwin, E. Grebel, P. Hennebelle, G. Hensler, R. Klessen, P. Kroupa, M. Krumholz, C. Lada, R. Larson, M. Mac Low, M. Machida, J. Makino, F. Nakamura, M. Norman, E. Ostriker, P. Padoan, D. Price, R. Pudritz, A. Raga, E. Tasker, R. Teyssier, E. Vázquez-Semanedi, K. Wada

http://www.iaus270.org/

2nd Announcement: From Stars to Galaxies

From Stars to Galaxies: connecting our understanding of star and galaxy formation

2nd Announcement University of Florida, Gainesville Wed. 7th - Sat. 10th April 2010

Science topics: Massive Star Formation Star Cluster Formation, Giant Molecular Clouds, Star Formation in the Milky Way, Star Formation in Nearby Galaxies, The Extremes of Star Formation.

Gas and star formation are being resolved in large samples of nearby galaxies, and this trend will accelerate with the advent of the next generation of telescopes. Many large surveys of the Galactic interstellar medium and young stellar population are complete, in progress or being planned. At the same time, many open questions remain: What are the physical drivers of star formation, including what sets its rate and efficiency? What sets the initial mass function of stars and clusters? What are the time-scales for giant molecular cloud (GMC) formation and evolution? How does the star formation process depend on environment? How do massive stars form and how do they influence their natal protocluster, GMC and galaxy?

This conference aims to bring together researchers studying star formation on local and extragalactic scales to help them better understand the recent observational and theoretical advances in each of these fields and make connections between the physical mechanisms responsible for star formation from the scales of individual stars to entire galaxies. We expect the discussions to help motivate future observational tests of theoretical ideas.

The conference will be held at the University of Florida in Gainesville, located within 2 hours drive from Orlando, Tampa, Jacksonville, St. Augustine, and the Atlantic and Gulf Coasts. The weather in April is generally dry, sunny and warm.

Confirmed speakers include: Joao Alves, John Bally, Shantanu Basu, Matthew Bate, Henrik Beuther, Leo Blitz, Alberto Bolatto, Daniela Calzetti, Paola Caselli, Richard Crutcher, Bruce Elmegreen, Neal Evans, Lee Hartmann, Fabian Heitsch, Melvin Hoare, Simon Glover, James Jackson, Kelsey Johnson, Rob Kennicutt, Richard Klein, Andrey Kravtsov, Charles Lada, Elizabeth Lada, Soren Larsen, Adam Leroy, Zhi-Yun Li, Jessica Lu, Mark Krumholz, Mordecai Mac Low, Sergio Molinari, Eve Ostriker, Paolo Padoan, Francesco Palla, Nick Scoville, Evan Skillman, Linda Tacconi.

If you are interested in attending the conference please visit the website

http://conference.astro.ufl.edu/STARSTOGALAXIES/home.html

consider if your proposed contribution fits into the scientific themes of the meeting and then submit your title and abstract by November 15th 2009. These will be reviewed by the SOC as the basis for selection of participants, whose total number is limited to 250.

Best regards,

Jonathan Tan

on behalf of the SOC

39th Liège International Astrophysical Colloquium

The Multi-Wavelength View of Hot, Massive Stars

Liège, July 5-9, 2010

With the advent of new, high-performance, ground-based and space-borne facilities, the multi-wavelength investigation of massive stars has definitely been transformed over the last decade. It is indeed nowadays possible to study these objects in all wavelength regions, all the way from radio to gamma-rays. The aim of this four and a half day meeting, which will be organized in the well-known series of the Liège astrophysical colloquia, is to bring together astrophysicists from different backgrounds to discuss how this multi-wavelength approach is revolutionizing our view of massive stars and their surroundings in our Galaxy and beyond.

The colloquium will include five thematic sessions:
massive star formation, confronting theory and observation
evolution and interaction of massive stars with their environment
stellar winds, diagnostics across the electromagnetic spectrum
massive binaries: interaction and evolution
future instrumentation and its application to massive star research

Invited reviews will be presented on the following topics:
Long-wavelength (mid-IR to mm) studies of massive star formation (Henrik Beuther, Heidelberg)
The multi-wavelength view of massive star formation in massive clusters (Hans Zinnecker, Potsdam, TBC)
Feedback from massive YSOs and massive main-sequence stars (You Hua Chu, Urbana-Champaign)
Circumstellar Matter around evolved massive stars (Nathan Smith, Berkeley, TBC)
Evolution of single massive stars with special emphasis on the LBV and RSG phase (André Maeder, Genève)
Theory of stellar winds (Stan Owocki, Delaware, TBC)
Radio observations of massive stars (Ronny Blomme, Brussels)
X-rays, clumping and wind structures (Lida Oskinova, Potsdam)
UV, optical and near-IR diagnostics of massive stars (Fabrice Martins, Montpellier)
Theoretical models of interacting winds in massive binaries (Julian Pittard, Leeds)
Results of the 2009 multi-wavelength campaign on eta Carinae (Mike Corcoran, GSFC)
Results of the 2009 multi-wavelength campaign on WR140 (Peredur Williams, Edinburgh)
Signatures of binary evolution processes in massive stars (Dany Vanbeveren, Brussels)
Massive Star Research within the ELT era (Chris Evans, Edinburgh)

http://www.ago.ulg.ac.be/PeM/Coll/Liac39/

Short Announcements

Online Query Tool for Extinction Values

We have started an online query tool for extinction values at http://astro.kent.ac.uk/extinction/. The search currently includes the published extinction maps from Schlegel et al, 1998, Dobashi et al. 2003, Rowles and Froebrich 2009, and several large scale maps based on the NICE(R) method. If you would like your maps to be included into the search, please email df *at* star.kent.ac.uk with the details.

Regards,
Dirk Froebrich
University of Kent