THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 195 — 20 Mar 2009 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

2MASS 22344161+4041387AB: A Wide, Young, Accreting, Low-mass Binary in the LkHα233 Group

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We report the discovery of a young, 0.16″ binary, 2M2234+4041AB, found as the result of a Keck laser guide star adaptive optics imaging survey of young field ultracool dwarfs. Spatially resolved near-infrared photometry and spectroscopy indicate that the luminosity and temperature ratios of the system are near unity. From optical and near-infrared spectroscopy, we determine a composite spectral type of M6 for the system. Gravity-sensitive spectral features in the spectra of 2M2234+4041AB are best matched to those of young objects (∼1 Myr old). A comparison of the T_{eff} and age of 2M2234+4041AB to evolutionary models indicates the mass of each component is $0.10^{+0.075}_{-0.04}$ $M_\odot$. Emission lines of Hα in the composite optical spectrum of the system and Brγ in spatially resolved near-IR spectra of the two components indicate that the system is actively accreting. Both components of the system have IR excesses, indicating that they both harbor circumstellar disks. Though 2M2234+4041AB was originally identified as a young field dwarf, it lies 1.5′ from the well-studied Herbig Ae/Be star, LkHα233. The distance to LkHα233 is typically assumed to be 880 pc. It is unlikely 2M2234+4041AB could be this distant, as it would then be more luminous than any known Taurus objects of similar spectral type. We re-evaluate the distance to the LkHα233 group and find a value of 325^{+72}_{-50} pc, based on the *Hipparcos* distance to a nearby B3-type group member (HD 213976). 2M2234+4041AB is the first low-mass star to be potentially associated with the LkHα233 group. At a distance of 325 pc, its projected physical separation is 51 AU, making it one of a growing number of wide, low-mass binaries found in young star-forming regions.

Accepted by ApJ

http://xxx.lanl.gov/abs/0902.4742

Recent Science from Australian Large-Scale Millimetre Mapping Projects: Proceedings from a Swinburne University Workshop

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Since the recent upgrades to the Australia Telescope National Facility Mopra telescope backend and receiver system, it has risen from an undersubscribed facility to a sought-after instrument with heavy international competition to gain time. Furthermore, the introduction of the on-the-fly mapping capability in 2004 has made this technique one of Mopra's most popular observing modes. In addition, the recent upgrade of the NANTEN millimetre-wavelength telescope to the sub-millimetre NANTEN2 instrument, has provided a complementary, higher-frequency facility to Mopra. A two-day workshop was held at Swinburne University in June 2008 to disseminate the current state of ongoing large-scale mapping projects and associated spin-offs that the telescopes' upgrades have facilitated, and to decide upon future research directions. Here, we provide a summary of the result-oriented talks as a record of the state of Australian-access single-dish millimetre science in 2008.

Accepted by PASA

Tidal forces as a regulator of star formation in Taurus

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Only a few molecular clouds in the Solar Neighborhood exhibit the formation of only low-mass stars. Traditionally, these clouds have been assumed to be supported against more vigorous collapse by magnetic fields. The existence of strong magnetic fields in molecular clouds, however, poses serious problems for the formation of stars and of the clouds themselves. In this *Letter*, we review the three-dimensional structure and kinematics of Taurus –the archetype of a region forming only low-mass stars– as well as its orientation within the Milky way. We conclude that the particularly low star-formation efficiency in Taurus may naturally be explained by tidal forces from the Galaxy, with no need for magnetic regulation or stellar feedback.

Accepted by MNRAS

`http://arxiv.org/abs/0903.0603`

Outflows and Young Stars in Orion's Large Cometary Clouds L1622 and L1634

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New observations of protostellar outflows associated with young stars in two of Orion's outlying cometary clouds, L1622 and L1634, are presented. The Hα surface brightness of the bright rims are used to argue that both clouds are located at a distance of about 400 pc in the interior of the Orion superbubble where they are illuminated by Orion's massive stars. *Spitzer* IRAC and MIPS images reveal 28 candidate young stellar objects (YSOs). Combined with the 14 spectroscopically confirmed T Tauri stars, there are at least 34 YSOs in L1622. Narrow-band images have led to the identification of about a dozen shock complexes in L1622. At least six belong to a highly collimated externally irradiated, bipolar jet, HH 963, that is powered by a low-luminosity Class II YSO located outside the projected edge of the L1622 dark cloud. However, the sources of most shocks remain unclear. The *Spitzer*/IRAC images reveal a

compact, highly obscured, S-symmetric outflow brightest in the 4.5 μm images. A faint [S II] counter part, HH 962, is associated with the western end of this flow which appears to be powered by an obscured source in the L1622 cloud interior. The currently identified sample of YSOs implies a star formation efficiency of about 4% for L1622. The L1634 cloud contains nine YSOs and three outflows, including the well known HH 240/241 system. A new flow, HH 979, is powered by the embedded YSO IRS7 in L1634 and crosses the eastern lobe of the HH 240 outflow. *Spitzer*/IRAC images show 4.5 μm emission indicating molecular shocks from the Herbig-Haro objects closest to IRS 7. A YSO embedded in a condensation located 5' north of HH 240/241 is identified in the *Spitzer* images. This source drives an irradiated outflow, HH 980, whose lobes emerge into the ionized environment of the Orion-Eridanus superbubble interior. The star formation efficiency of L1634 is estimated to be about 3%.

Published by The Astronomical Journal (Vol. 137, p. 3843)

Increased complexity in interstellar chemistry: Detection and chemical modeling of ethyl formate and n-propyl cyanide in Sgr B2(N)

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Context. In recent years, organic molecules of increasing complexity have been found toward the prolific Galactic center source Sagittarius B2.

Aims. We wish to explore the degree of complexity that the interstellar chemistry can reach in star-forming regions.

Methods. We carried out a complete line survey of the hot cores Sgr B2(N) and (M) with the IRAM 30 m telescope in the 3 mm range, plus partial surveys at 2 and 1.3 mm. We analyzed this spectral survey in the local thermodynamical equilibrium approximation. We modeled the emission of all known molecules simultaneously, which allows us to search for less abundant, more complex molecules. We compared the derived column densities with the predictions of a coupled gas-phase and grain-surface chemical code.

Results. We report the first detection in space of ethyl formate (C_2H_5OCHO) and n-propyl cyanide (C_3H_7CN) toward Sgr B2(N). The detection of n-propyl cyanide is based on refined spectroscopic parameters derived from combined analyses of available laboratory spectroscopic data. For each molecule, we identified spectral features at the predicted frequencies having intensities compatible with a unique rotation temperature. For an assumed source size of $3''$, our modeling yields a column density of 5.4×10^{16} cm^{-2}, a temperature of 100 K, and a linewidth of 7 km s^{-1} for ethyl formate. n-Propyl cyanide is detected with two velocity components having column densities of 1.5×10^{16} cm^{-2} and 6.6×10^{15} cm^{-2}, respectively, for a source size of $3''$, a temperature of 150 K, and a linewidth of 7 km s^{-1}. The abundances of ethyl formate and n-propyl cyanide relative to H_2 are estimated to be 3.6×10^{-9} and 1.0×10^{-9}, respectively. We derived column density ratios of 0.8 / 15 / 1 for the related species t-HCOOH / CH_3OCHO / C_2H_5OCHO and 108 / 80 / 1 for CH_3CN / C_2H_5CN / C_3H_7CN. Our chemical modeling reproduces these ratios reasonably well. It suggests that the sequential, piecewise construction of ethyl and n-propyl cyanide from their constituent functional groups on the grain surfaces is their most likely formation route. Ethyl formate is primarily formed on the grains by adding CH_3 to functional-group radicals derived from methyl formate, although ethanol may also be a precursor.

Conclusions. The detection in Sgr B2(N) of the next stage of complexity in two classes of complex molecule, esters and alkyl cyanides, suggests that greater complexity in other classes of molecule may be present in the interstellar medium.

Accepted by A&A

http://de.arxiv.org/abs/0902.4694

The stellar population and complex structure of the bright-rimmed cloud IC 1396N

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Context. IC 1396N is a bright-rimmed cloud associated with an intermediate-mass star-forming region, where a number of Herbig-Haro objects, H_2 jet-like features, CO molecular outflows, and millimeter compact sources have been observed.
Aims. To study in detail the complex structure of the IC 1396N core and the molecular outflows detected in the region and to reveal the presence of additional YSOs inside this globule.
Methods. We carried out a deep survey of the IC 1396N region in the J, H, K' broadband filters and deep high-angular resolution observations in the H_2 narrowband filter with NICS at the TNG telescope. The completeness limits in the 2MASS standard are $K_s \sim 17.5$, $H \sim 18.5$ and $J \sim 19.5$.
Results. A total of 736 sources have been detected in all three bands within the area where the JHK' images overlap. There are 128 sources detected only in HK', 67 detected only in K', and 79 detected only in JH. We found only few objects exhibiting a Near-Infrared excess and no clear signs of clustering of sources towards the southern rim. In case of triggered star formation in the southern rim of the globule, this could be very recent, because it is not evidenced through Near-Infrared imaging alone. The H_2 emission is complex and knotty and shows a large number of molecular hydrogen features spread over the region, testifying a recent star-formation activity throughout the whole globule. This emission is resolved into several chains or groups of knots that sometimes show a jet-like morphology. The shocked cloudlet model scenario previously proposed to explain the V-shaped morphology of the CO molecular outflow powered by the intermediate-mass YSO BIMA 2 seems to be confirmed by the presence of H_2 emission at the position of the deflecting western clump. New possible flows have been discovered in the globule, and some of them could be very long. In particular, the YSO BIMA 3 could be powering an old and poor collimated outflow.

Accepted by A&A

http://arxiv.org/abs/0902.4543
http://www.am.ub.es/~robert/Papers.html#last

The young active star SAO 51891 (V383 Lac)

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Aims: The aim of this work is to investigate the surface inhomogeneities of a young, late-type star, SAO 51891, at different atmospheric levels, from the photosphere to the upper chromosphere, analyzing contemporaneous optical high-resolution spectra and broad-band photometry. Methods: The full spectral range of FOCES@CAHA (R 40 000) is used to perform the spectral classification and to determine the rotational and radial velocities (RVs). The lithium abundance is measured to obtain an age estimate. The BVRIJHKs photometric bands are used to construct the spectral energy distribution (SED). The variations in the observed BV fluxes and effective temperature are used to infer the presence of photospheric spots and observe their behavior over time. The chromospheric activity is studied applying the spectral subtraction technique to Halpha, CaII H&K, Hepsilon, and CaII IRT lines. Results: We find SAO51891 to be a young K0-1V star with a lithium abundance close to the Pleiades upper envelope, confirming its youth (100 Myr), which is also inferred from its kinematical membership to the Local Association. No infrared excess is detected from analysis of its SED, limiting the amount of remaining circumstellar dust. We detect a rotational modulation of the luminosity, effective temperature, CaII H&K, Hepsilon, and CaII IRT total fluxes. A simple spot model with two main active regions, about 240K cooler than the surrounding photosphere, fits very well the observed light and temperature curves. The small-amplitude radial velocity variations are also well reproduced by our spot model. The anti-correlation of light curves and chromospheric diagnostics indicates chromospheric plages spatially associated with the spots. The largest modulation amplitude is observed for the Hepsilon flux suggesting that this line is very sensitive to the presence of chromospheric plages. Conclusions: SAO 51891 is a young active star, lacking significant amounts of circumstellar dust or any evidence for low mass companions, which displays the typical phenomena produced by magnetic activity. The spots turn out to be larger and warmer than those in less active main-sequence stars. If some debris material is still present around the star, it will only be detectable by future far-infrared and sub-mm observations (e.g., Herschel or ALMA). The RV variation produced by the starspots has an amplitude comparable with those induced by Jupiter-mass planets orbiting close to the host star. SAO 51891 is another good example of an active star in which the detection of planets may be hampered by the high activity level.

Accepted by Astronomy and Astrophysics

Smoothed Particle Hydrodynamics simulations of expanding HII regions. I. Numerical method and applications

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Ionizing radiation plays a crucial role in star formation at all epochs. In contemporary star formation, ionization abruptly raises the pressure by more than three orders of magnitude; the temperature increases from $\sim 10\,\mathrm{K}$ to $\sim 10^4\,\mathrm{K}$, and the mean molecular weight decreases by a factor of more than 3. This may result in positive feedback, either by compressing pre-existing clouds and rendering them unstable, or by sweeping up gravitationally unstable shells. It may also result in negative feedback (by dispersing residual dense gas). Ionizing radiation from OB stars is also routinely invoked as a means of injecting kinetic energy into the interstellar medium and as a driver of sequential self-propagating star formation in galaxies.

We describe a new algorithm for including the dynamical effects of ionizing radiation in SPH simulations, and we present several examples of how the algorithm can be applied to problems in star formation.

We use the HEALPix software to tessellate the sky and to solve the equation of ionization equilibrium along a ray towards each of the resulting tesserae. We exploit the hierarchical nature of HEALPix to make the algorithm adaptive, so that fine angular resolution is invoked only where it is needed, and the computational cost is kept low.

Accepted by A&A

http://arxiv.org/abs/0902.2374

Interferometric Evidence for Resolved Warm Dust in the DQ Tau System

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We report on near-infrared (IR) interferometric observations of the double-lined pre-main sequence (PMS) binary system DQ Tau. We model these data with a visual orbit for DQ Tau supported by the spectroscopic orbit & analysis of Mathieu et al. (1997). Further, DQ Tau exhibits significant near-IR excess; modeling our data requires inclusion of near-IR light from an 'excess' source. Remarkably the excess source is resolved in our data, similar in scale to the binary itself (~ 0.2 AU at apastron), rather than the larger circumbinary disk (~ 0.4 AU radius). Our observations support the Mathieu et al. (1997) and Carr et al. (2001) inference of significant warm material near the DQ Tau binary.

Accepted by ApJL

http://arxiv.org/abs/0903.2521

The Two Modes of Gas Giant Planet Formation

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I argue for two modes of gas giant planet formation and discuss the conditions under which each mode operates. Gas giant planets at disk radii $r > 100$ AU are likely to form in situ by disk instability, while core accretion plus gas capture remains the dominant formation mechanism for $r < 100$ AU. During the mass accretion phase, mass loading can push disks toward fragmentation conditions at large r. Massive, extended disks can fragment into clumps of a few to tens of Jupiter masses. This is confirmed by radiation hydrodynamics simulations. The two modes of gas giant formation should lead to a bimodal distribution of gas giant semi-major axes. Because core accretion is expected to be less efficient in low-metallicity systems, the ratio of gas giants at large r to planets at small r should increase with decreasing metallicity.

Accepted by ApJL

http://arxiv.org/abs/0902.3999

Star Formation Around Supergiant Shells in the Large Magellanic Cloud

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We examine the recent star formation associated with four supergiant shells in the Large Magellanic Cloud (LMC): LMC 1, 4, 5, and 6, which have been shown to have simple expanding-shell structures. H II regions and OB associations are used to infer star formation in the last few Myr, while massive young stellar objects reveal the current ongoing star formation. Distributions of ionized H I and molecular components of the interstellar gas are compared with the sites of recent and current star formation to determine whether triggering has taken place. We find that a great majority of the current star formation has occurred in gravitationally unstable regions, and that evidence of triggered star formation is prevalent at both large and local scales.

Published by The Astronomical Journal (Vol. 137, p. 3599)

Collapse and Fragmentation of Molecular Cloud Cores. X. Magnetic Braking of Prolate and Oblate Cores.

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The collapse and fragmentation of initially prolate and oblate, magnetic molecular clouds is calculated in three dimensions with a gravitational, radiative hydrodynamics code. The code includes magnetic field effects in an approximate manner: magnetic pressure, tension, braking, and ambipolar diffusion are all modelled. The parameters varied for both the initially prolate and oblate clouds are the initial degree of central concentration of the radial density profile, the initial angular velocity, and the efficiency of magnetic braking (represented by a factor $f_{mb} = 10^{-4}$ or 10^{-3}). The oblate cores all collapse to form rings that might be susceptible to fragmentation into multiple systems. The outcome of the collapse of the prolate cores depends strongly on the initial density profile. Prolate cores with central densities 20 times higher than their boundary densities collapse and fragment into binary or quadruple systems, whereas cores with central densities 100 times higher collapse to form single protostars embedded in bars. The inclusion of magnetic braking is able to stifle protostellar fragmentation in the latter set of models, as when identical models were calculated without magnetic braking (Boss 2002), those cores fragmented into binary protostars. These models demonstrate the importance of including magnetic fields in studies of protostellar collapse and fragmentation, and suggest that even when magnetic fields are included, fragmentation into binary and multiple systems remains as a possible outcome of protostellar collapse.

Accepted by Astrophys. J.

Preprint available at http://www.dtm.ciw.edu/boss/ftp/coresx

Star Formation Activity of Cores within Infrared Dark Clouds

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Infrared Dark Clouds (IRDCs) contain compact cores which probably host the early stages of high-mass star formation. Many of these cores contain regions of extended, enhanced 4.5 μm emission, the so-called “green fuzzies,” which indicate shocked gas. Many cores also contain 24 μm emission, presumably from heated dust which indicates embedded protostars. Because ”green fuzzies” and 24 μm point sources both indicate star formation, we have developed an algorithm to identify star-forming cores within IRDCs by searching for the simultaneous presence of these two distinct indicators. We employ this algorithm on a sample of 190 cores found toward IRDCs, and classify the cores as “active” if they contain a green fuzzy coincident with an embedded 24 μm source, and as “quiescent” if they contain neither IR signature. We hypothesize that the “quiescent” cores represent the earliest “preprotostellar” (starless) core phase, before the development of a warm protostar, and that the “active” cores represent a later phase, after the development of a protostar. We test this idea by comparing the sizes, densities, and maser activity of the “active” and “quiescent” cores. We find that, on average, “active” cores have smaller sizes, higher densities, and more pronounced water and methanol maser activity than the “quiescent” cores. This is expected if the “quiescent” cores are in an earlier evolutionary state than the “active” cores. The masses of “active” cores suggest that they may be forming high-mass stars. The highest mass “quiescent” cores are excellent candidates for the elusive high-mass starless cores.

Published by The Astrophysical Journal Supplement Series (Vol. 181, p. 360)

Triggered Star Formation and Evolution of T-Tauri stars in and around Bright-Rimmed Clouds

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The aim of this paper is to quantitatively testify the "*small-scale sequential star formation*" hypothesis in and around bright-rimmed clouds (BRCs). As a continuation of the recent attempt by Ogura et al. (2007, Paper I), we have carried out BVI_c photometry of four more BRC aggregates along with deeper re-observations of 2 previously observed BRCs. Again quantitative age gradients are found in almost all the BRCs studied in the present work. Archival Spitzer/IRAC data also support this result. The global distribution of NIR excess stars in each HII region studied here clearly shows evidence that a series of radiation driven implosion (RDI) processes proceeded in the past from near the central O star(s) towards the peripheries of the HII region. We found that in general weak-line T-Tauri stars (WTTSs) are somewhat older than classical T-Tauri stars (CTTSs). Also the fraction of CTTSs among the T-Tauri stars (TTSs) associated with the BRCs is found to decrease with age. These facts are in accordance with the recent conclusion by Bertout et al. (2007) that CTTSs evolve into WTTSs. It seems that in general the EW of Hα emission in TTSs associated with the BRCs decreases with age. The mass function (MF) of the aggregates associated with the BRCs of the morphological type 'A' seems to follow that found in young open clusters, whereas 'B/C' type BRCs show significantly steeper MF.

Accepted by MNRAS

Near-Infrared Imaging of the Star-Forming Regions Sh2-157 and Sh2-152

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Near-infrared JHK' and H$-$2 ν = 1-0 S (1) imaging observations of the star-forming regions Sh2-157 and Sh2-152 are presented. The data reveal a cluster of young stars associated with H2 line emission in each region. Additionally, many IR point sources are found in the dense core of each molecular cloud. Most of these sources exhibit infrared color excesses typical of T Tauri stars, Herbig Ae/Be stars, and protostars. Several display the characteristics of massive stars. We calculate histograms of the K'-magnitude and $[H - K']$ color for all sources, as well as two-color and color-magnitude diagrams. The stellar populations inside and outside the clusters are similar, suggesting that these systems are rather evolved. Shock-driven H_2 emission knots are also detected, which may be related to evident subclusters in an earlier evolutionary stage.

Published by The Astrophysical Journal (Vol. 693, p. 430)

Star Formation History in the Small Magellanic Cloud: The Case of NGC 602

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Deep *Hubble Space Telescope*/Advanced Camera for Surveys photometry of the young cluster NGC 602, located in the remote low-density "wing" of the Small Magellanic Cloud (SMC), reveals numerous pre-main-sequence (PMS) stars as well as young stars on the main sequence. The resolved stellar content thus provides a basis for studying the star formation history (SFH) into recent times and constraining several stellar population properties, such as the present-day mass function (PDMF), the initial mass function, and the binary fraction. To better characterize the PMS population, we present a new set of model stellar evolutionary tracks for this evolutionary phase with metallicity

appropriate for the SMC (Z = 0.004). We use a stellar population synthesis code, which takes into account a full range of stellar evolution phases to derive our best estimate for the SFH in the region by comparing observed and synthetic color-magnitude diagrams. The derived PDMF for NGC 602 is consistent with that resulting from the synthetic diagrams. The star formation rate in the region has increased with time on a scale of tens of Myr, reaching (0.3-0.7) $\times$ 10^{-3} $M_\odot$ yr^{-1} in the last 2.5 Myr, comparable to what is found in Galactic OB associations. Star formation is most complete in the main cluster but continues at moderate levels in the gas-rich periphery of the nebula.

Published by The Astronomical Journal (Vol. 137, p. 3668)

Updated Pre-Main Sequence Tracks at Low Metallicities for 0.1 $\leq M/M_\odot \leq$ 1.5

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Context. Young populations at $Z < Z_\odot$ are being examined to understand the role of metallicity in the first phases of stellar evolution. For the analysis it is necessary to assign mass and age to Pre-Main Sequence (PMS) stars. While it is well known that the mass and age determination of PMS stars is strongly affected by the convection treatment, extending any calibration to metallicities different from solar is very artificial, in the absence of any calibrators for the convective parameters. For solar abundance, Mixing Length Theory models have been calibrated by using the results of 2D radiative-hydrodynamical models (MLT- α^{2D}), that are very similar to those computed with non-grey ATLAS9 atmosphere boundary conditions and a full spectrum of turbulence (FST) convection model both in the atmosphere and in the interior (NEMO-FST models).
Aims. While MLT-α^{2D} models are not available for lower metallicities, we extend to lower Z the NEMO-FST models, under the hypothesis that in such a way we are simulating the results of MLT-α^{2D} models also at smaller Z.
Methods. We use standard stellar computation techniques in which the atmospheric boundary conditions are derived making use of model atmosphere grids. This allows us to take into account the non greyness of the atmosphere, but adds a new parameter to the stellar structure uncertainty, namely the efficiency of convection in the atmospheric structure, if convection is computed in the atmospheric grid by a model different to the model adopted for the interior integration.
Results. We present PMS models for low mass stars from 0.1 to 1.5 $M_\odot$ for metallicities [Fe/H] = –0.5, –1.0 and –2.0. The calculations include the most recent interior physics and the latest generation of non-grey atmosphere models. At fixed luminosity more metal poor isochrones are hotter than solar ones by Δ log $T_{\rm eff}$ / Δ log $Z \sim$ 0.03-0.05 in the range in Z from 0.02 to 0.0002 and for ages from 10^5 to 10^7 yr.

Published by Astronomy & Astrophysics (Vol. 496, p. 223)

Protostellar Outflow Evolution in Turbulent Environments

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The link between turbulence in star-forming environments and protostellar jets remains controversial. To explore issues of turbulence and fossil cavities driven by young stellar outflows, we present a series of numerical simulations tracking the evolution of transient protostellar jets driven into a turbulent medium. Our simulations show both the effect of turbulence on outflow structures and, conversely, the effect of outflows on the ambient turbulence. We demonstrate how turbulence will lead to strong modifications in jet morphology. More importantly, we demonstrate that individual transient outflows have the capacity to re-energize decaying turbulence. Our simulations support a scenario in which the directed energy/momentum associated with cavities is randomized as the cavities are disrupted by dynamical instabilities seeded by the ambient turbulence. Consideration of the energy power spectra of the simulations reveals that the disruption of the cavities powers an energy cascade consistent with Burgers'-type turbulence and produces a driving scale length associated with the cavity propagation length. We conclude that fossil cavities interacting either with a turbulent medium or with other cavities have the capacity to sustain or create turbulent flows in star-forming

environments. In the last section, we contrast our work and its conclusions with previous studies which claim that jets cannot be the source of turbulence.

Published by The Astrophysical Journal (Vol. 692, p. 816)

On the Semimajor Axis Distribution of Extrasolar Gas Giant Planets: Why Hot Jupiters Are Rare Around High-Mass Stars

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Based on a suite of Monte Carlo simulations, I show that a stellar-mass dependent lifetime of the gas disks from which planets form can explain the lack of hot Jupiters/close-in giant planets around high-mass stars and other key features of the observed semimajor axis distribution of radial velocity-detected giant planets. Using reasonable parameters for the Type II migration rate, regions of planet formation, and timescales for gas giant core formation, I construct synthetic distributions of jovian planets. A planet formation/migration model assuming a stellar mass-dependent gas disk lifetime reproduces key features in the observed distribution by preferentially stranding planets around high-mass stars at large semimajor axes.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/abs/0902.3459

Spatially Resolved Spectroscopy of Sub-AU-Sized Regions of T Tauri and Herbig Ae/Be Disks

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We present spatially resolved near-IR spectroscopic observations of 15 young stars. Using a grism spectrometer behind the Keck interferometer, we obtained an angular resolution of a few milliarcseconds and a spectral resolution of 230, enabling probes of both gas and dust in the inner disks surrounding the target stars. We find that the angular size of the near-IR emission typically increases with wavelength, indicating hot, presumably gaseous material within the dust sublimation radius. Our data also clearly indicate Brγ emission arising from hot hydrogen gas, and suggest the presence of water vapor and carbon monoxide gas in the inner disks of several objects. This gaseous emission is more compact than the dust continuum emission in all cases. We construct simple physical models of the inner disk and fit them to our data to constrain the spatial distribution and temperature of dust and gas emission components.

Published by The Astrophysical Journal (Vol. 692, p. 309)

The *Spitzer* c2d Legacy Results: Star-Formation Rates and Efficiencies; Evolution and Lifetimes

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The c2d Spitzer Legacy project obtained images and photometry with both IRAC and MIPS instruments for five large, nearby molecular clouds. Three of the clouds were also mapped in dust continuum emission at 1.1 mm, and optical spectroscopy has been obtained for some clouds. This paper combines information drawn from studies of individual clouds into a combined and updated statistical analysis of star-formation rates and efficiencies, numbers and lifetimes for spectral energy distribution (SED) classes, and clustering properties. Current star-formation efficiencies range from 3% to 6%; if star formation continues at current rates for 10 Myr, efficiencies could reach 15-30%. Star-formation rates and rates per unit area vary from cloud to cloud; taken together, the five clouds are producing about 260 $M_\odot$ of stars per Myr. The star-formation surface density is more than an order of magnitude larger than would be predicted from the Kennicutt relation used in extragalactic studies, reflecting the fact that those relations apply to larger scales, where more diffuse matter is included in the gas surface density. Measured against the dense gas probed by the maps of dust continuum emission, the efficiencies are much higher, with stellar masses similar to masses of dense gas, and the current stock of dense cores would be exhausted in 1.8 Myr on average. Nonetheless, star formation is still slow compared to that expected in a free-fall time, even in the dense cores. The derived lifetime for the Class I phase is 0.54 Myr, considerably longer than some estimates. Similarly, the lifetime for the Class 0 SED class, 0.16 Myr, with the notable exception of the Ophiuchus cloud, is longer than early estimates. If photometry is corrected for estimated extinction before calculating class indicators, the lifetimes drop to 0.44 Myr for Class I and to 0.10 for Class 0. These lifetimes assume a continuous flow through the Class II phase and should be considered median lifetimes or half-lives. Star formation is highly concentrated to regions of high extinction, and the youngest objects are very strongly associated with dense cores. The great majority (90%) of young stars lie within loose clusters with at least 35 members and a stellar density of 1 $M_\odot$ pc^{-3}. Accretion at the sound speed from an isothermal sphere over the lifetime derived for the Class I phase could build a star of about 0.25 $M_\odot$, given an efficiency of 0.3. Building larger mass stars by using higher mass accretion rates could be problematic, as our data confirm and aggravate the "luminosity problem" for protostars. At a given $T_{\rm bol}$, the values for $L_{\rm bol}$ are mostly less than predicted by standard infall models and scatter over several orders of magnitude. These results strongly suggest that accretion is time variable, with prolonged periods of very low accretion. Based on a very simple model and this sample of sources, half the mass of a star would be accreted during only 7% of the Class I lifetime, as represented by the eight most luminous objects.

Published by The Astrophysical Journal Supplement Series (Vol. 181, p. 321)

Hot debris dust around HD 106797

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Photometry of the A0 V main-sequence star HD 106797 with AKARI and Gemini/T-ReCS is used to detect excess emission over the expected stellar photospheric emission between 10 and 20 micron, which is best attributed to hot circumstellar debris dust surrounding the star. The temperature of the debris dust is derived as Td 190 K by assuming that the excess emission is approximated by a single temperature blackbody. The derived temperature suggests that the inner radius of the debris disk is 14 AU. The fractional luminosity of the debris disk is 1000 times brighter than that of our own zodiacal cloud. The existence of such a large amount of hot dust around HD 106797 cannot be accounted for by a simple model of the steady state evolution of a debris disk due to collisions, and it is likely that transient events play a significant role. Our data also show a narrow spectral feature between 11 and 12 micron attributable to crystalline silicates, suggesting that dust heating has occurred during the formation and evolution of the debris disk of HD 106797.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/abs/0903.1333

Anthropic selection of a solar system with a high 26Al/27Al ratio; implications and a possible mechanism.

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Since our technological civilization depends on our planet's properties, anthropic selection can explain the close match between the high 26Al/27Al ratios in the earliest solar system solids, which are difficult to produce in models of star-formation, and the limiting value required to cause (the widely observed) thermal processing of planetesimals, We suggest that volatile loss on heating of planetesimals favours future development of technological civilizations in solar systems with elevated concentrations of 26Al.

Accepted by Icarus

The L723 Low-Mass Star Forming Protostellar System: Resolving a Double Core

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We present 1.35 mm Submillimeter Array (SMA) observations around the low-mass Class 0 source IRAS 19156+1906, at the center of the LDN 723 (L723) dark cloud. We detected emission from dust as well as emission from H_2CO $3_{0,3}$-$2_{0,2}$, DCN 3-2, and CN 2-1 lines, which arise from two cores, SMA 1 and SMA 2, separated by 2.9″ (880 AU in projected distance). SMA 2 is associated with the previously detected source VLA 2. Weak SiO 5-4 emission is detected, possibly tracing a region of interaction between the dense envelope and the outflow. We modeled the dust and H_2CO emission from the two cores. The results from the modeling show that the cores have similar physical properties (density and temperature distribution) but that SMA 2 has a larger p-H_2CO abundance (by a factor of 3-10) than SMA 1. The p-H_2CO abundances' findings are compatible with the value of the outer part of the circumstellar envelopes associated with Class 0 sources. SMA 2 is harboring an active multiple low-mass protostellar system and powering at least one molecular outflow. In contrast, there are no known signs of outflow activity toward SMA 1. This suggests that SMA 2 is more evolved than SMA 1. The kinematics of the two sources show marginal evidence of

infall and rotation motions. The mass detected by the SMA observation, which trace scales of $< \sim 1000$ AU, is only a small fraction of the mass contained in the large-scale molecular envelope, which suggests that L723 is still in a very early phase of star formation. Despite the apparent quiescent nature of the L723, fragmentation is occurring at the center of the cloud at different scales. Thus, at $\sim$1000 AU, the cloud has fragmented in two cores: SMA 1 and SMA 2. At the same time, at least one of these cores, SMA 2, has undergone additional fragmentation at scales of $\sim$150 AU, forming a multiple stellar system.

Published by The Astrophysical Journal (Vol. 694, p. 56)

2D numerical study of the radiation influence on shock structure relevant to laboratory astrophysics

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Radiative shocks are found in various astrophysical objects and particularly at different stages of stellar evolution. Studying radiative shocks, their topology, and thermodynamical properties is therefore a starting point to understanding their physical properties. This study has become possible with the development of large laser facilities, which has provided fresh impulse to laboratory astrophysics. We present the main characteristics of radiative shocks modeled using cylindrical simulations. We focus our discussion on the importance of multi-dimensional radiative-transfer effects on the shock topology and dynamics. We present results obtained with our code HERACLES for conditions corresponding to experiments already performed on laser installations. The multi-dimensional hydrodynamic code HERACLES is specially adapted to laboratory astrophysics experiments and to astrophysical situations where radiation and hydrodynamics are coupled. The importance of the ratio of the photon mean free path to the transverse extension of the shock is emphasized. We present how it is possible to achieve the stationary limit of these shocks in the laboratory and analyze the angular distribution of the radiative flux that may emerge from the walls of the shock tube. Implications of these studies for stellar accretion shocks are presented.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/0902.1645

Spatially Resolved 3 μm Spectroscopy of Elias 1: Origin of Diamonds in Protoplanetary Disks

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We present spatially resolved 3 μm spectra of Elias 1 obtained with an adaptive optics system. The central part of the disk is almost devoid of polycyclic aromatic hydrocarbon (PAH) emission at 3.3 μm; it shows up only at 30 AU and beyond. The PAH emission extends up to 100 AU, at least to the outer boundary of our observation. The diamond emission, in contrast, is more centrally concentrated, with the column density peaked around 30 AU from the star. There are only three Herbig Ae/Be stars known to date that show diamond emission at 3.53 μm. Two of them have low-mass companions likely responsible for the large X-ray flares observed toward the Herbig Ae/Be stars. We speculate on the origin of diamonds in circumstellar disks in terms of the graphitic material being transformed

into diamond under the irradiation of highly energetic particles.

Published by The Astrophysical Journal (Vol. 693, p. 610)

Heavy Element Enrichment of a Jupiter-mass Protoplanet as a Function of Orbital Location

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One possible mechanism for giant planet formation is disk instability in which the planet is formed as a result of gravitational instability in the protoplanetary disk surrounding the young star. The final composition and core mass of the planet will depend on the planet's mass, environment and the planetesimal accretion efficiency. We calculate heavy element enrichment in a Jupiter-mass protoplanet formed by disk instability at various radial distances from the star, considering different disk masses and surface density distributions. Although the available mass for accretion increases with radial distance (a) for disk solid surface density (σ) functions $\sigma = \sigma_0 a^{-\alpha}$ with $\alpha < 2$, the accretion timescale is significantly longer at larger radial distances. Efficient accretion is limited to the first $\sim 10^5$ years of planetary evolution, when the planet is extended and before gap opening and type II migration take place. The accreted mass is calculated for disk masses of 0.01, 0.05 and 0.1 $M_\odot$ with $\alpha = 1/2$, 1, and 3/2. We show that a Jupiter-mass protoplanet can accrete 1 to 110 $M_\oplus$ of heavy elements, depending on the disk properties. Due to the limitation on the accretion timescale, our results provide lower bounds on heavy element enrichment. Our results can explain the large variation in heavy element enrichment found in extra-solar giant planets. Since higher disk surface density is found to lead to larger heavy element enrichment, our model results are consistent with the correlation between heavy element enrichment and stellar metallicity. Our calculations also suggest that Jupiter could have formed at a larger radial distance than its current location while still accreting the mass of heavy elements predicted by interior models. We conclude that in the disk instability model the final composition of a giant planet is strongly determined by its formation environment. The heavy element abundance of a giant planet does not discriminate between its origin by either disk instability or core accretion.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0903.1997

Star-Forming Cores Embedded in a Massive Cold Clump: Fragmentation, Collapse, and Energetic Outflows

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The fate of massive cold clumps, their internal structure, and collapse need to be characterized to understand the initial conditions for the formation of high-mass stars, stellar systems, and the origin of associations and clusters. We explore the onset of star formation in the 75 $M_\odot$ SMM1 clump in the region ISOSS J18364–0221 using infrared and (sub-)millimeter observations including interferometry. This contracting clump has fragmented into two compact cores SMM1 North and South of 0.05 pc radius, having masses of 15 and 10 $M_\odot$, and luminosities of 20 $L_\odot$ and 180 $L_\odot$. SMM1 South harbors a source traced at 24 and 70 μm, drives an energetic molecular outflow, and appears supersonically turbulent at the core center. SMM1 North has no infrared counterparts and shows lower levels of turbulence, but also drives an outflow. Both outflows appear collimated, and parsec-scale near-infrared features probably trace the outflow-powering jets. We derived mass outflow rates of at least 4×10^{-5} $M_\odot$ yr^{-1} and outflow timescales of less than 10^4 yr. Our HCN(1-0) modeling for SMM1 South yielded an infall velocity of 0.14 km s^{-1} and an estimated mass infall rate of 3×10^{-5} $M_\odot$ yr^{-1}. Both cores may harbor seeds of intermediate- or high-mass stars. We compare the derived core properties with recent simulations of massive core collapse. They are consistent with the very early stages dominated by accretion luminosity.

Published by The Astrophysical Journal (Vol. 693, p. 1379)

Effects of Scattering and Dust Grain Size on the Temperature Structure of Protoplanetary Discs: a Three-Layer Approach

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The temperature in the optically thick interior of protoplanetary discs is essential for the interpretation of millimetre observations of the discs, for the vertical structure of the discs, for models of the disc evolution and the planet formation, and for the chemistry in the discs. Since large icy grains have a large albedo even in the infrared, the effect of scattering of the diffuse radiation in the discs on the interior temperature should be examined. We have performed a series of numerical radiation transfer simulations, including isotropic scattering by grains with various typical sizes for the diffuse radiation as well as for the incident stellar radiation. We also have developed an analytic model including isotropic scattering to understand the physics concealed in the numerical results. With the analytic model, we have shown that the standard two-layer approach is valid only for grey opacity (i.e. grain size $\geq$10 μm) even without scattering. A three-layer interpretation is required for grain size $\leq$10 μm. When the grain size is 0.110 μm, the numerical simulations show that the isotropic scattering reduces the temperature of the disc interior. This reduction is nicely explained by the analytic three-layer model as a result of the energy loss by scatterings of the incident stellar radiation and of the warm diffuse radiation in the disc atmosphere. For grain size $\geq$10 μm (i.e. grey scattering), the numerical simulations show that the isotropic scattering does not affect the interior temperature. This is nicely explained by the analytic two-layer model; the energy loss by scattering in the disc atmosphere is exactly offset by the 'green-house effect' due to the scattering of the cold diffuse radiation in the interior.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 393, p. 1377)

The stellar association around Gamma Velorum and its relationship with Vela OB2

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We present the results of a photometric BVI survey of 0.9 square degrees around the Wolf-Rayet binary γ^2 Vel and its early-type common proper motion companion γ^1 Vel (together referred to as the γ Vel system). Several hundred pre-main-sequence (PMS) stars are identified and the youth of a subset of these is spectroscopically confirmed by the presence of lithium in their atmospheres, Hα emission and high levels of X-ray activity. We show that the PMS stars are kinematically coherent and spatially concentrated around γ Vel. The PMS stars have similar proper motions to γ Vel, to main-sequence stars around γ Vel and to early-type stars of the wider Vela OB2 association of which γ^2 Vel is the brightest member. The ratio of main-sequence stars to low-mass (0.1–0.6 $M_\odot$) PMS stars is consistent with a Kroupa (2001) mass function. Main-sequence fitting to stars around γ Vel gives an association distance modulus of 7.76 ± 0.07 mag, which is consistent with a similarly-determined distance for Vela OB2 and also with interferometric distances to γ^2 Vel. High-mass stellar models indicate an age of 3–4 Myr for γ^2 Vel, but the low-mass PMS stars have ages of $\simeq$ 10 Myr according to low-mass evolutionary models and 5–10 Myr by empirically placing them in an age sequence with other clusters based on colour-magnitude diagrams and lithium depletion. We conclude that the low-mass PMS stars form a genuine association with γ Vel and that this is a subcluster within the larger Vela OB2 association. We speculate that γ^2 Vel formed after the bulk of the low-mass stars, expelling gas, terminating star formation and unbinding the association. The velocity dispersion of the PMS stars is too low for this star forming event to have produced all the stars in the extended Vela OB2 association. Instead, star formation must have been initiated at several sites within a molecular cloud, either sequentially or, simultaneously after some triggering event.

Accepted by MNRAS

http://uk.arxiv.org/abs/0810.5320

Zonal flows and long-lived axisymmetric pressure bumps in magnetorotational turbulence

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We study the behavior of magnetorotational turbulence in shearing box simulations with a radial and azimuthal extent up to ten scale heights. Maxwell and Reynolds stresses are found to increase by more than a factor two when increasing the box size beyond two scale heights in the radial direction. Further increase of the box size has little or no effect on the statistical properties of the turbulence. An inverse cascade excites magnetic field structures at the largest scales of the box. The corresponding 10% variation in the Maxwell stress launches a zonal flow of alternating sub- and super-Keplerian velocity. This in turn generates a banded density structure in geostrophic balance between pressure and Coriolis forces. We present a simplified model for the appearance of zonal flows, in which stochastic forcing by the magnetic tension on short time-scales creates zonal flow structures with life-times of several tens of orbits. We experiment with various improved shearing box algorithms to reduce the numerical diffusivity introduced by the supersonic shear flow. While a standard finite difference advection scheme shows signs of a suppression of turbulent activity near the edges of the box, this problem is eliminated by a new method where the Keplerian shear advection is advanced in time by interpolation in Fourier space.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0811.3937

Gas Properties and Implications for Galactic Star Formation in Numerical Models of the Turbulent, Multiphase Interstellar Medium

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Using numerical simulations of galactic disks that resolve scales from ∼1 to several hundred pc, we investigate dynamical properties of the multiphase interstellar medium (ISM) in which turbulence is driven by feedback from star formation. We focus on effects of H II regions by implementing a recipe for intense heating confined within dense, self-gravitating regions. Our models are two dimensional, representing radial-vertical slices through the disk, and include sheared background rotation of the gas, vertical stratification, heating and cooling to yield temperatures $T \sim 10 - 10^4$ K, and conduction that resolves thermal instabilities on our numerical grid. Each simulation evolves to reach a quasi-steady state, for which we analyze the time-averaged properties of the gas. In our suite of models, three parameters (the gas surface density Σ, the stellar volume density ρ_*, and the local angular rotation rate Ω) are separately controlled in order to explore environmental dependences. Among other statistical measures, we evaluate turbulent amplitudes, virial ratios, Toomre Q parameters including turbulence, and the mass fractions at different densities. We find that the dense gas ($n > 100$ cm^{-3}) has turbulence levels similar to those observed in giant molecular clouds and virial ratios ∼1-2. Our models show that the Toomre Q parameter in the dense gas evolves to values near unity; this demonstrates self-regulation via turbulent feedback. We also test how the surface star formation rate $\Sigma_{\rm SFR}$ depends on Σ, ρ_*, and Ω. Under the assumption that the star formation rate (SFR) is proportional to the amount of gas at densities above a threshold $n_{\rm th}$ divided by the free-fall time at that threshold, we find that $\Sigma_{\rm SFR} = \Sigma^{1+p}$ with $1 + p \sim 1.2$-1.4 when $n_{\rm th} = 10^2$ or 10^3 cm^{-3}, consistent with observed Kennicutt-Schmidt relations. Estimates of SFRs based on large-scale properties (the orbital time, the Jeans time, or the free-fall time at the mean density within a scale height), however, depart from rates computed using the measured amount of dense gas, indicating that resolving the ISM structure in galactic disks is necessary to obtain accurate predictions of the SFR.

Published by The Astrophysical Journal (Vol. 693, p. 1316)

Nearby Young Stars Selected by Proper Motion. I. Four New Members of the β Pictoris Moving Group From The Tycho-2 Catalog

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We describe a procedure to identify stars from nearby moving groups and associations out of catalogs of stars with large proper motions. We show that from the mean motion vector of a known or suspected moving group, one can identify additional members of the group based on proper motion data and photometry in the optical and infrared, with minimal contamination from background field stars. We demonstrate this technique by conducting a search for low-mass members of the β Pictoris moving group in the Tycho-2 catalog. All known members of the moving group are easily recovered, and a list of 51 possible candidates is generated. Moving group membership is evaluated for 33 candidates based on X-ray flux from *ROSAT*, Hα line emission, and radial velocity measurement from high-resolution infrared spectra obtained at Infrared Telescope Facility. We confirm three of the candidates to be new members of the group: TYC 1186-706-1, TYC 7443-1102-1, and TYC 2211-1309-1 which are late-K and early-M dwarfs 45-60 pc from the Sun. We also identify a common proper motion companion to the known β Pictoris Moving Group member TYC 7443-1102-1, at a 26.3$''$ separation; the new companion is associated with the X-ray source 1RXS J195602.8–320720. We argue that the present technique could be applied to other large proper motion catalogs to identify most of the elusive, low-mass members of known nearby moving groups and associations.

Published by The Astronomical Journal (Vol. 137, p. 3632)

Molecular line mapping of the giant molecular cloud associated with RCW 106 - III. Multi-molecular line mapping

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We present multi-molecular line maps obtained with the Mopra Telescope towards the southern giant molecular cloud (GMC) complex G333, associated with the HII region RCW 106. We have characterised the GMC by decomposing the 3D data cubes with GAUSSCLUMPS, and investigated spatial correlations among different molecules with principal component analysis (PCA). We find no correlation between clump size and line width, but a strong correlation between emission luminosity and line width. PCA classifies molecules into high and low density tracers, and reveals that HCO+ and N2H+ are anti-correlated.

Accepted by MNRAS

http://arxiv.org/abs/0902.2452

The Highly Eccentric Pre-Main-Sequence Spectroscopic Binary RX J0529.3+1210

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The young system RX J0529.3+1210 was initially identified as a single-lined spectroscopic binary. Using high-resolution infrared spectra, acquired with NIRSPEC on Keck II, we measured radial velocities for the secondary. The method of using the infrared regime to convert single-lined spectra into double-lined spectra, and derive the mass ratio for the binary system, has been successfully used for a number of young, low-mass binaries. For RX J0529.3+1210, a long-period (462 days) and highly eccentric (0.88) binary system, we determine the mass ratio to be 0.78 ± 0.05 using the infrared double-lined velocity data alone, and 0.73 ± 0.23 combining visible light and infrared data in a full orbital solution. The large uncertainty in the latter is the result of the sparse sampling in the infrared and the high eccentricity: the stars do not have a large velocity separation during most of their $\sim$1.3 yr orbit. A mass ratio close to unity, consistent with the high end of the 1σ uncertainty for this mass ratio value, is inconsistent with the lack of a visible light detection of the secondary component. We outline several scenarios for a color difference in the two stars, such as one heavily spotted component, higher-order multiplicity, or a unique evolutionary stage, favoring detection of only the primary star in visible light, even in a mass ratio $\sim$1 system. However, the evidence points to a lower ratio. Although RX J0529.3+1210 exhibits no excess at near-infrared wavelengths, a small 24 μm excess is detected, consistent with circumbinary dust. The properties of this binary and its membership in λ Ori versus a new nearby stellar moving group at $\sim$90 pc are discussed. We speculate on the origin of this unusual system and on the impact of such high eccentricity, the largest observed in a pre-main-sequence double-lined system to date, on the potential for planet formation.

Published by The Astronomical Journal (Vol. 137, p. 3487)

The Circumstellar Disk Mass Distribution in the Orion Trapezium Cluster

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We present the results of a submillimeter interferometric survey of circumstellar disks in the Trapezium cluster of Orion. We observed the 880 μm continuum emission from 55 disks using the Submillimeter Array, and detected 28 disks above 3σ significance with fluxes between 6 and 70 mJy and rms noise between 0.7 and 5.3 mJy. Dust masses and upper limits are derived from the submillimeter excess above free-free emission extrapolated from longer wavelength observations. Above our completeness limit of 0.0084 $M_{\odot}$, the disk mass distribution is similar to that of Class II disks in Taurus-Auriga and ρ Ophiuchus but is truncated at 0.04 $M_{\odot}$. We show that the disk mass and radius distributions are consistent with the formation of Trapezium cluster disks $\sim$1 Myr ago and subsequent photoevaporation by the ultraviolet radiation field from θ^1 Ori C. The fraction of disks that contain a minimum mass solar nebula within 60 AU radius is estimated to be 11%-13% in both Taurus and the Trapezium cluster, which suggests the potential for forming Solar Systems is not compromised in this massive star-forming region.

Published by The Astrophysical Journal Letters (Vol. 694, p. L36)

An Investigation on the Morphological Evolution of Bright-Rimmed Clouds

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A new radiative driven implosion (RDI) model based on smoothed particle hydrodynamics technique is developed and applied to investigate the morphological evolutions of molecular clouds under the effect of ionizing radiation. This model self-consistently includes the self-gravity of the cloud in the hydrodynamical evolution, the UV radiation component in the radiation transferring equations, the relevant heating and cooling mechanisms in the energy evolution, and a comprehensive chemical network. The simulation results reveal that under the effect of ionizing radiation, a molecular cloud may evolve through different evolutionary sequences. Depending on its initial gravitational state, the evolution of a molecular cloud does not necessarily follow a complete morphological evolution sequence from type A→B→C, as described by previous RDI models. When confronted with observations, the simulation results provide satisfactory physical explanations for a series of puzzles derived from bright-rimmed clouds observations. The consistency of the modeling results with observations shows that the self-gravity of a molecular cloud should not be neglected in any investigation on the dynamical evolution of molecular clouds when they are exposed to ionizing radiation.

Published by The Astrophysical Journal (Vol. 692, p. 382)

A Precise Distance to IRAS 00420+5530 via H2O Maser Parallax with the VLBA

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We have used the Very Long Baseline Array to measure the annual parallax of the H_2O masers in the star-forming region IRAS 00420+5530. This measurement yields a direct distance estimate of 2.17 ± 0.05 kpc (an error of less than 3%), which disagrees substantially with the standard kinematic distance estimate of ∼4.6 kpc (according to the rotation curve of Brand & Blitz), as well as most of the broad range of distances (1.7-7.7 kpc) used in various astrophysical analyses in the literature. The three-dimensional space velocity of IRAS 00420+5530 at this new, more accurate distance implies a substantial noncircular and anomalously slow Galactic orbit, consistent with similar observations of W3(OH) (Xu et al. and Hachisuka et al.), as well as line-of-sight velocity residuals in the rotation curve analysis of Brand & Blitz. The Perseus spiral arm of the Galaxy is thus more than a factor of 2 closer than previously presumed, and exhibits motions substantially at odds with axisymmetric models of the rotating Galaxy.

Published by The Astrophysical Journal (Vol. 694, p. 192)

Circumstellar Environment and Effective Temperature of the Young Substellar Eclipsing Binary 2MASS J05352184−0546085

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We present new *Spitzer* IRAC/PU/MIPS photometry from 3.6 to 24 μm, and new Gemini GMOS photometry at 0.48 μm, of the young brown dwarf eclipsing binary 2MASS J05352184−0546085, located in the Orion Nebula Cluster. No excess disk emission is detected: The measured fluxes at $\lambda \leq 8\mu$m are within 1σ ($\lesssim$0.1 mJy) of a bare photosphere, and the 3σ upper limit at 16 μm is a mere 0.04 mJy above the bare photospheric level. Together with the known properties of the system, this implies the absence of optically thick disks around the individual components. It also implies that if any circumbinary disk is present, it must either be optically thin and extremely tenuous (10^{-10} $M_{\odot}$) if it extends in to within ∼0.1 AU of the binary (the approximate tidal truncation radius), or it must be optically thick with a large inner hole, >0.6–10 AU in radius depending on degree of flaring. The consequence in all cases is that disk accretion is likely to be negligible or absent. This supports the recent proposal that the strong Hα emission in the primary (more

massive) brown dwarf results from chromospheric activity, and thereby bolsters the hypothesis that the surprising T_{eff} inversion observed between the components is due to strong magnetic fields on the primary. Our data also set constraints on the T_{eff} of the components independent of spectral type, and thereby on models of the aforementioned magnetic field effects. We discuss the consequences for the derived fundamental properties of young brown dwarfs and very low-mass stars in general. Specifically, if very active isolated young brown dwarfs and very low-mass stars suffer the same activity/field related effects as the eclipsing binary primary, the low-mass stellar/substellar IMF currently derived from standard evolutionary tracks may be substantially in error.

Accepted by ApJ

http://arxiv.org/abs/0903.1892

Parameters of Herbig Ae/Be and Vega-Type Stars

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Context. This work presents the characterization of 27 young early-type stars, most of them in the age range 110 Myr, and three suspected hot companions of post-T Tauri stars belonging to the Lindroos binary sample. Most of these objects show IR excesses in their spectral energy distributions, which are indicative of the presence of disks. The work is relevant in the fields of stellar physics, physics of disks and formation of planetary systems.
Aims. The aim of the work is the determination of the effective temperature, gravity, metallicity, mass, luminosity and age of these stars. An accurate modelling of their disks requires the knowledge of most of these parameters, since they will determine the energy input received by the disk and hence, its geometry and global properties.
Methods. Spectral energy distributions and mid-resolution spectra were used to estimate $T_{\rm eff}$, the effective temperature. The comparison of the profiles of the Balmer lines with synthetic profiles provides the value of the stellar gravity, g_*. High-resolution optical observations and synthetic spectra are used to estimate the metallicity, [M/H]. Once $T_{\rm eff}$, g_* and [M/H] are known for each star, evolutionary tracks and isochrones provide estimations of the mass, luminosity, age and distances (or upper limits in some cases). The method is original in the sense that it is distance-independent, i.e. the estimation of the stellar parameters does not require the knowledge of the distance to the object.
Results. Stellar parameters (effective temperature, gravity, metallicity, mass, luminosity, age and distances or upper limits) are obtained for the sample of stars mentioned above. A detailed discussion of some individual objects, in particular VV Ser, RR Tau, 49 Cet and the three suspected hot companions of post-T Tauris, is presented.
Conclusions. These results, apart from their intrinsic interest, would be extremely valuable to model the disks surrounding the stars. The paper also shows the difficulty posed by the morphology and behaviour of the system star+disk in the computation of the stellar parameters.

Published by Astronomy & Astrophysics (Vol. 495, p. 901)

How Variable is Accretion in Young Stars?

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We analyze the variability in accretion-related emission lines for 40 Classical T Tauri stars to probe the extent of accretion variations in young stellar objects. Our analysis is based on multi-epoch high-resolution spectra for young stars in Taurus-Auriga and Chamaeleon I. For all stars, we typically obtain four spectra, covering timescales from hours to months. As proxies for the accretion rate, we use the Hα 10% width and the CaII-λ8662 line flux. We find that while the two quantities are correlated, their variability amplitude is not. Converted to accretion rates, the CaII fluxes indicate typical accretion rate changes of 0.35 dex, with 32% exceeding 0.5 dex, while Hα 10% width suggests changes of 0.65 dex, with 66% exceeding 0.5 dex. We conclude that CaII fluxes are a more robust quantitative indicator of accretion than Hα 10% width, and that intrinsic accretion rate changes typically do not exceed 0.5 dex on timescales of days to months. The maximum extent of the variability is reached after a few days, suggesting that rotation is the dominant cause of variability. We see a decline of the inferred accretion rates toward later spectral types, reflecting the $\dot{M}$ versus M relationship. There is a gap between accretors and nonaccretors, pointing to a rapid shutdown of accretion. We conclude that the ~two orders of magnitude scatter in the $\dot{M}$ versus M relationship is dominated by object-to-object scatter instead of intrinsic source variability.

Published by The Astrophysical Journal Letters (Vol. 694, p. L153)

http://arxiv.org/abs/0902.4235

Disk-Braking in Young Stars: Probing Rotation in Chamaeleon I and Taurus-Auriga

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We present a comprehensive study of rotation, disk and accretion signatures for 144 T Tauri stars in the young (~2 Myr old) Chamaeleon I and Taurus-Auriga star forming regions based on multi-epoch high-resolution optical spectra from the Magellan Clay 6.5 m telescope supplemented by mid-infrared photometry from the *Spitzer Space Telescope*. In contrast to previous studies in the Orion Nebula Cluster and NGC 2264, we do not see a clear signature of disk braking in Tau-Aur and Cha I. We find that both accretors and non-accretors have similar distributions of $v \sin i$. This result could be due to different initial conditions, insufficient time for disk braking, or a significant age spread within the regions. The rotational velocities in both regions show a clear mass dependence, with F–K stars rotating on average about twice as fast as M stars, consistent with results reported for other clusters of similar age. Similarly, we find the upper envelope of the observed values of specific angular momentum j varies as $M^{0.5}$ for our sample which spans a mass range of $\sim 0.16\,M_\odot$ to $\sim 3\,M_\odot$. This power law complements previous studies in Orion which estimated $j \propto M^{0.25}$ for $\lesssim 2$ Myr stars in the same mass regime, and a sharp decline in j with decreasing mass for older stars (~ 10 Myr) with $M < 2\,M_\odot$. Furthermore, the overall specific angular momentum of this ~ 10 Myr population is five times lower than that of non-accretors in our sample, and implies a stellar braking mechanism other than disk braking could be at work. For a subsample of 67 objects with mid-infrared photometry, we examine the connection between accretion signatures and dusty disks: in the vast majority of cases (63/67), the two properties correlate well, which suggests that the timescale of gas accretion is similar to the lifetime of inner disks.

Accepted by Astrophysical Journal

http://arxiv.org/abs/0902.0001

The Shapes of Molecular Cloud Cores in Simulations and Observations

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In this study, we investigate the shapes of starless and protostellar cores using hydrodynamic, self-gravitating adaptive mesh refinement simulations of turbulent molecular clouds. We simulate observations of these cores in dust emission, including realistic noise and telescope resolution, and compare to the observed core shapes measured in Orion by Nutter & Ward-Thompson (2007). The simulations and the observations have generally high statistical similarity, with particularly good agreement between simulations and Orion B. Although protostellar cores tend to have semi-major axis to semi-minor axis ratios closer to one, the distribution of axis ratios for starless and protostellar cores is not significantly different for either the actual observations of Orion or the simulated observations. Because of the high level of agreement between the non-magnetic hydrodynamic simulations and observation, contrary to a number of previous authors, one cannot infer the presence of magnetic fields from core shape distributions.

Published by The Astrophysical Journal (Vol. 693, p. 914)

Hα Spectropolarimetry of RY Tauri and PX Vulpeculae

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Aims. To detect line effects using spectropolarimetry in order to find evidence of rotating disks and their respective symmetry axes in T Tauri stars.
Methods. We used the IAGPOL imaging polarimeter along with the Eucalyptus-IFU to obtain spectropolarimetric measurements of the T Tauri stars RY Tau (two epochs) and PX Vul (one epoch). Evidence of line effects showing a loop in the *Q-U* diagram favors a compact rather than an extended source for the line photons in a rotating disk. In addition, the polarization position angle (PA) obtained using the line effect can constrain the symmetry axis of the disk.
Results. RY Tau shows a variable Hα double peak in 2004-2005 data. A polarization line effect is evident in the *Q-U* diagram for both epochs confirming a clockwise rotating disk. A single loop is evident in 2004 changing to a linear excursion plus a loop in 2005. Interestingly, the intrinsic PA calculated using the line effect is consistent between our two epochs ($\sim$167°). An alternative intrinsic PA computed from the interstellar polarization-corrected continuum and averaged between 2001-2005 yielded a PA $\sim$137°. This last value is closer to perpendicular to the observed disk direction ($\sim$25°), as expected from single scattering in an optically thin disk. For PX Vul , we detected spectral variability in Hα along with non-variable continuum polarization when compared with previous data. The *Q-U* diagram shows a well-defined loop in Hα associated with a counter-clockwise rotating disk. The symmetry axis inferred from the line effect has a PA $\sim$91° (with an ambiguity of 90°). Our results confirm previous evidence that the emission line in T Tauri stars has its origin in a compact source scattered off a rotating accretion disk.

Published by Astronomy & Astrophysics (Col. 495, p. 195)

Stellar and Circumstellar Properties of Class I Protostars

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We present a study of the stellar and circumstellar properties of Class I sources using low-resolution (R$\sim$1000) near-infrared K- and L-band spectroscopy. We measure prominent spectral lines and features in 8 objects and use fits to standard star spectra to determine spectral types, visual extinctions, K-band excesses, and water ice optical depths. Four of the seven systems studied are close binary pairs; only one of these systems, Haro 6-10, was angularly resolvable. For certain stars some properties found in our analysis differ substantially from published values; we analyze the origin of these differences. We determine extinction to each source using three different methods and compare and discuss the resulting values. One hypothesis that we were testing, that extinction dominates over the K-band excess in obscuration

of the stellar photospheric absorption lines, appears not to be true. Accretion luminosities and mass accretion rates calculated for our targets are highly uncertain, in part the result of our inexact knowledge of extinction. For the six targets we were able to place on an H-R diagram, our age estimates, <2 Myr, are somewhat younger than those from comparable studies. Our results underscore the value of low-resolution spectroscopy in the study of protostars and their environments; however, the optimal approach to the study of Class I sources likely involves a combination of high- and low-resolution near-infrared, mid-infrared, and millimeter wavelength observations. Accurate and precise measurements of extinction in Class I protostars will be key to improving our understanding of these objects.

Published by The Astronomical Journal (Vol. 137, p. 3931)

http://arxiv.org/abs/0902.1289

Detection of Structure in Infrared-Dark Clouds with Spitzer: Characterizing Star Formation in the Molecular Ring

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We have conducted a survey of a sample of infrared-dark clouds (IRDCs) with the Spitzer Space Telescope in order to explore their mass distribution. We present a method for tracing mass using dust absorption against the bright Galactic background at 8 microns. The IRDCs in this sample are comprised of tens of clumps, ranging in sizes from 0.02 to 0.3 pc in diameter and masses from 0.5 to a few 10 Msun, the broadest dynamic range in any clump mass spectrum study to date. Structure with this range in scales confirms that IRDCs are the the precursors to stellar clusters in an early phase of fragmentation. Young stars are distributed in the vicinity of the IRDCs, but the clumps are typically not associated with stars and appear pre-stellar in nature. We find an IRDC clump mass spectrum with a slope of 1.76 +/- 0.05 for masses from 30 to 3000 Msun. This slope is consistent with numerous studies, culled from a variety of observational techniques, of massive star formation regions and is close to the mass function of Galactic stellar clusters and star clusters in other galaxies. We assert that the shape of the mass function is an intrinsic and universal feature of massive star formation regions, that are the birth sites of stellar clusters. As these clouds evolve and their constituent clumps fragment, the mass spectrum will steepen and eventually assume the form of the core mass function that is observed locally.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0903.2771

GEMINI Near-Infrared Spectroscopic Observations of Young Massive Stars Embedded in Molecular Clouds

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K-band spectra of young stellar candidates in four Southern hemisphere clusters have been obtained with the Gemini Near-Infrared Spectrograph in Gemini South. The clusters are associated with *IRAS* sources that have colours characteristic of ultracompact H II regions. Spectral types were obtained by comparison of the observed spectra with those of a near-infrared (NIR) library; the results include the spectral classification of nine massive stars and seven objects confirmed as background late-type stars. Two of the studied sources have K-band spectra compatible with those characteristic of very hot stars, as inferred from the presence of C IV, N III and N V emission lines at 2.078, 2.116 and 2.100 μm, respectively. One of them, I16177_IRS1, has a K-band spectrum similar to that of Cyg OB2 7, an O3If* supergiant star. The nebular K-band spectrum of the associated Ultra-Compact (UC) H II region shows the

s-process [Kr III] and [Se IV] high excitation emission lines, previously identified only in planetary nebula. One young stellar object was found in each cluster, associated with either the main *IRAS* source or a nearby resolved *Midecourse Space eXperiment (MSX)* component, confirming the results obtained from previous NIR photometric surveys. The distances to the stars were derived from their spectral types and previously determined JHK magnitudes; they agree well with the values obtained from the kinematic method, except in the case of IRAS 15408–5356 , for which the spectroscopic distance is about a factor of 2 smaller than the kinematic value.

Published by Monthly Notices of the Royal Astronomical Society (Vol 394, p. 467)

The Structure of Molecular Clouds: I - All Sky Near Infrared Extinction Maps

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We are studying the column density distribution of all nearby giant molecular clouds. As part of this project we generated several all sky extinction maps. They are calculated using the *median* near infrared colour excess technique applied to data from the Two Micron All-Sky Survey (2MASS). Our large scale approach allows us to fit spline functions to extinction free regions in order to accurately determine the colour excess values. Two types of maps are presented: i) Maps with a constant noise and variable spatial resolution; ii) Maps with a constant spatial resolution and variable noise. Our *standard* A_V map uses the nearest 49 stars to the centre of each pixel for the determination of the extinction. The one sigma variance is constant at 0.28 mag A_V in the entire map. The distance to the 49^{th} nearest star varies from below $1'$ near the Galactic Plane to about $10'$ at the poles, but is below $5'$ for all giant molecular clouds ($|b| < 30°$). A comparison with existing large scale maps shows that our extinction values are systematically larger by 20 % compared to Dobashi et al. and 40 % smaller compared to Schlegel et al.. This is most likely caused by the applied star counting technique in Dobashi et al. and systematic uncertainties in the dust temperature and emissivity in Schlegel et al.. Our superior resolution allows us to detect more small scale high extinction cores compared to the other two maps.

Accepted by MNRAS

http://astro.kent.ac.uk/extinction/index.html

A deep multi-band investigation of IC 2391

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We report the outcome of a deep multi-wavelength study of the IC 2391 young open cluster. We aim at uncovering new low-mass and sub-stellar members of the cluster and identifying new debris disk objects. A 30×30 square arcmin area in IC 2391 was observed using the wide-field imager at the ESO 2.2m telescope. The completeness limits of the photometry at 3σ level are V=24.7, R_C=23.7 and I_C=23.0, faint enough to reveal sub-stellar members down to $\sim$0.03 $M_\odot$. Our membership criteria are based on the use of our optical data, in combination with JHK_S magnitudes from the 2MASS catalog. We also estimate the physical parameters of the selected candidates. Debris disk candidates are identified on the basis of their infrared excess emission using near- and mid-infrared photometry from the Spitzer Space Telescope. Our optical survey, which has a limiting magnitude at 3σ level 1-2 mag fainter than previous optical surveys conducted in IC 2391, revealed 29 new low-mass member candidates of the cluster. We estimate the contamination to be at least $\sim$50%. We constrain the fraction of sub-stellar objects in the range 8-15% and discuss

possible explanations for the deficit of brown dwarfs in this cluster. We also identified 10 candidates in the cluster showing IR excess emission consistent with the presence of debris disks.

Accepted by A&A

ftp://ftp.rssd.esa.int/pub/lspezzi/preprint

The Approach to Collapse of Molecular Clouds

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The dense molecular cloud cores that form stars, like other self-gravitating objects, undergo bulk oscillations. Just at the point of gravitational instability, their fundamental oscillation mode has zero frequency. We study, using perturbation theory, the evolution of a spherical cloud that possesses such a frozen mode. We find that the cloud undergoes a prolonged epoch of subsonic, accelerating contraction. This slow contraction occurs whether the cloud is initially inflated or compressed by the oscillation. The subsonic motion described here could underlie the spectral infall signature observed in many starless dense cores

Accepted by MNRAS

Search for Remnant Clouds Associated with the TW Hya Association

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We report on a search for the parental molecular clouds of the TW Hya association (TWA), using CO emission and Na I absorption lines. TWA is the nearest young (~ 50 pc; ~ 10 Myr) stellar association, yet in spite of its youth, there are no detection of any associated natal molecular gas, as is the case for other typical young clusters. Using infrared maps as a guide, we conducted a CO cloud survey toward a region with a dust extinction of $E(B-V) > 0.2$ mag, or $A_V > 0.6$ mag. CO emission is detected toward three IR dust clouds, and we reject one cloud from the TWA, as no interstellar Na absorption was detected from the nearby Hipparcos stars, implying that it is too distant to be related. The other two clouds exhibit only faint and small-scale CO emission. Interstellar Na I absorptions of Hipparcos targets, HIP 57809, HIP 64837, and HIP 64925 (at distances of 133, 81, and 101 pc, respectively) by these couds is also detected. We conclude that only a small fraction of the interstellar matter (ISM) toward the IR dust cloud is located at distance less than 100 pc, which may be all that is left of the remnant clouds of TWA; the remaining remnant cloud having dissipated in the last ~ 1 Myr. Such a short dissipation timescale may be due to an external perturbation or kinematic segregation that has a large stellar proper motion relative to the natal cloud.

Accepted by PAJS

http://arXiv.org/abs/0903.1815

Kinematics of the Orion Nebula Cluster: Velocity Substructure and Spectroscopic Binaries

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We present a kinematic study of the Orion Nebula Cluster based upon radial velocities measured by multi-fiber echelle spectroscopy at the 6.5 meter MMT and Magellan telescopes. Velocities are reported for 1613 stars, with multi-epoch data for 727 objects as part of our continuing effort to detect and analyze spectroscopic binaries. We confirm and extend the results of Furesz et al. showing that the ONC is not relaxed, consistent with its youth, and that the stars generally follow the position-velocity structure of the moderate density gas in the region, traced by ^{13}CO. The additional radial velocities we have measured enable us to probe some discrepancies between stellar and gaseous structure which can be attributed to binary motion and the inclusion of non-members in our kinematic sample. Our multi-epoch data allow us to identify 89 spectroscopic binaries; more will be found as we continue monitoring. Our results reinforce the idea that the ONC is a cluster in formation, and thus provides a valuable testing ground for theory. In particular, our observations are not consistent with the quasi-equilibrium or slow contraction models of cluster formation, but are consistent with cold collapse models.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0903.2775

The nature of the Class I population in Ophiuchus as revealed through gas and dust mapping

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The Ophiuchus clouds, in particular L 1688, are an excellent region to study the embedded phases of star formation, due to the relatively large number of protostars. However, the standard method of finding and characterizing embedded young stellar objects (YSOs) through just their infrared spectral slope does not yield a reliable sample. This may affect the age determinations, often derived from the statistics on the total number of embedded YSOs and pre-main sequence stars within a cloud. Our aim is to characterize the structure of protostellar envelopes on an individual basis and to correctly identify the embedded YSO population of L 1688. Spectral maps of the HCO$^+$ J =4–3 and C^{18}O J =3–2 lines using the HARP-B array on the James Clerk Maxwell Telescope and SCUBA 850 μm dust maps are obtained of all sources in the L 1688 region with infrared spectral slopes consistent with, or close to, that of embedded YSOs. Selected 350 μm maps obtained with the Caltech Submillimeter Observatory are presented as well. The properties, extent and variation of dense gas, column density and dust. Using the spatial variation of the gas and dust, together with the intensity of the HCO$^+$ J =4–3 line. We are able to accurately identify the truly embedded YSOs and determine their properties. The protostellar envelopes range from 0.05 to 0.5 M$_\odot$ in mass. The concentration of HCO$^+$ emission ($\sim$ 0.5 to 0.9) is generally higher than that of the dust concentration. Combined with absolute intensities, HCO$^+$ proves to be a better tracer of protostellar envelopes than dust, which can contain disk and cloud contributions. Our total sample of 45 sources, including all previously classified Class I sources, several flat-spectrum sources and some known disks, was re-classified using the molecular emission. Of these, only 17 sources are definitely embedded YSOs. Four of these embedded YSOs have little (0.1–0.2 M$_\odot$) envelope material remaining and are likely at the interesting transitional stage from embedded YSO to T Tauri star. About half of the flat-spectrum sources are found to be embedded YSOs and about half are disks. The presented classification method is successful in separating embedded YSOs from edge-on disks and confused sources. The total embedded population of the Ophiuchus L 1688 cloud is found almost exclusively in Oph-A, Oph-B2 and the Ophiuchus ridge with only three embedded YSOs not related to these regions. The detailed characterization presented will be necessary to interpret deep interferometric ALMA and future Herschel observations.

Accepted by A&A

http://xxx.lanl.gov/abs/0902.4005

IR Dust Bubbles. II. Probing the Detailed Structure and Young Massive Stellar Populations of Galactic H II Regions

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We present an analysis of late-O/early-B-powered, parsec-sized bubbles and associated star formation using Two Micron All Sky Survey, GLIMPSE, MIPSGAL, and MAGPIS surveys. Three bubbles were selected from the Churchwell et al. catalog. We confirm that the structure identified in Watson et al. holds in less energetic bubbles, i.e., a photodissociated region, identified by 8 μm emission due to polycyclic aromatic hydrocarbons surrounding hot dust, identified by 24 μm emission and ionized gas, and identified by 20 cm continuum. We estimate the dynamical age of two bubbles by comparing bubble sizes to numerical models of Hosokawa and Inutsuka. We also identify and analyze candidate young stellar objects using spectral energy distribution (SED) fitting and identify sites of possible triggered star formation. Lastly, we identify likely ionizing sources for two sources based on SED fitting.

Published by The Astrophysical Journal (Vol. 694, p. 546)

Spitzer IRAC Detection and Analysis of Shocked Molecular Hydrogen Emission

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We use statistical equilibrium equations to investigate the IRAC color space of shocked molecular hydrogen. The location of shocked H_2 in $[3.6]-[4.5]$ vs $[4.5]-[5.8]$ color is determined by the gas temperature and density of neutral atomic hydrogen. We find that high excitation H_2 emission falls in a unique location in the color-color diagram and can unambiguously be distinguished from stellar sources. In addition to searching for outflows, we show that the IRAC data can be used to map the thermal structure of the shocked gas. We analyze archival *Spitzer* data of Herbig-Haro object HH 54 and create a temperature map, which is consistent with spectroscopically determined temperatures.

Accepted by ApJ Letters

http://www.astro.ufl.edu/∼jybarra/publications/

Spitzer Infrared Spectrograph Observations of Class I/II Objects in Taurus: Composition and Thermal History of the Circumstellar Ices

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We present observations of Taurus-Auriga Class I/II protostars obtained with the Spitzer InfraRed Spectrograph. Detailed spectral fits to the 6 and 15.2 micron ice features are made, using publicly available laboratory data, to constrain the molecular composition, abundances, and levels of thermal processing along the lines of sight. We provide an inventory of the molecular environments observed, which have an average composition dominated by water-ice with ∼12% CO_2 (abundance relative to H_2O), $> \sim$2%-9% CH_3OH, ∼14% NH_3, ∼3% CH_4, ∼2% H_2CO, ∼0.6% HCOOH, and ∼0.5% SO_2. We find CO_2/H_2O ratios nearly equivalent to those observed in cold clouds and lines of sight toward the galactic center. The unidentified 6.8 micron profiles vary from source to source, and it is shown to be likely that even combinations of the most common candidates (NH_4^+ and CH_3OH) are inadequate to explain the feature fully.

We discuss correlations among SED spectral indices, abundance ratios, and thermally processed ice fractions and their implications for CO_2 formation and evolution. Comparison of our spectral fits with cold molecular cloud sight lines indicates abundant prestellar ice environments made even richer by the radiative effects of protostars. Our results add additional constraints and a finer level of detail to current full-scale models of protostellar and protoplanetary systems.

Published by The Astrophysical Journal (Vol. 694, p. 459)

The Differential Rotation of FU Ori

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The emission of FU Orionis objects in outburst has been identified as arising in rapidly accreting protoplanetary disks, based on a number of observational properties. A fundamental test of the accretion disk scenario is that the differentially rotating disk spectrum should produce a variation of rotational velocity with the wavelength of observation, as spectra taken at longer wavelengths probe outer, more slowly rotating disk regions. Previous observations of FU Ori have shown smaller rotation at near-infrared ($\sim$2.2 μm) wavelengths than observed at optical ($\sim$0.6 μm) wavelengths consistent with the assumption of Keplerian rotation. Here we report a spectrum from the Phoenix instrument on Gemini South which shows that differential (slower) rotation continues to be observed out to $\sim$5 μm. The observed spectrum is well matched by the prediction of our accretion disk model previously constructed to match the observed spectral energy distribution and the differential rotation at wavelengths $< \sim$2.2 μm. This kinematic result allows us to confirm our previous inference of a large outer radius ($\sim$1 AU) for the rapidly accreting region of the FU Ori disk, which presents difficulties for outburst models relying purely on thermal instability. While some optical spectra have been interpreted to pose problems for the disk interpretation of FU Ori, we show that the adjustment of the maximum effective temperature of the disk model, proposed in a previous paper, greatly reduces these difficulties.

Published by The Astrophysical Journal Letters (Vol. 694, p. L64)

http://adsabs.harvard.edu/abs/2009arXiv0902.4469Z

Chemical differentiation in regions of high mass star formation II. Molecular multiline and dust continuum studies of selected objects

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The aim of this study is to investigate systematic chemical differentiation of molecules in regions of high mass star formation.We observed five prominent sites of high mass star formation in HCN, HNC, HCO^+, their isotopes, $C^{18}O$, $C^{34}S$ and some other molecular lines, for some sources both at 3 and 1.3 mm and in continuum at 1.3 mm. Taking into account earlier obtained data for N_2H^+ we derive molecular abundances and physical parameters of the sources (mass, density, ionization fraction, etc.). The kinetic temperature is estimated from CH_3C_2H observations. Then we analyze correlations between molecular abundances and physical parameters and discuss chemical models applicable to these species.The typical physical parameters for the sources in our sample are the following: kinetic temperature in the range $\sim 30-50$ K (it is systematically higher than that obtained from ammonia observations and is rather close to dust temperature), masses from tens to hundreds solar masses, gas densities $\sim 10^5$ cm^{-3}, ionization fraction $\sim 10^{-7}$. In most cases the ionization fraction slightly (a few times) increases towards the embedded YSOs. The observed clumps are close to gravitational equilibrium. There are systematic differences in distributions of various molecules. The abundances of CO, CS and HCN are more or less constant. There is no sign of CO and/or CS depletion as in

cold cores. At the same time the abundances of HCO^+, HNC and especially N_2H^+ strongly vary in these objects. They anti-correlate with the ionization fraction and as a result decrease towards the embedded YSOs. For N_2H^+ this can be explained by dissociative recombination to be the dominant destroying process. N_2H^+, HCO^+, and HNC are valuable indicators of massive protostars.

Accepted by MNRAS

arXiv:0903.1209 [astro-ph.GA]

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The APEX southern sky survey of high mass star forming regions

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Ph.D dissertation directed by: F. Wyrowski, P. Schilke and K. M. Menten

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During my dissertation work, I studied the early stages of massive star formation in the southern hemisphere, using sub-mm line and continuum data. A sample of 47 sources, chosen according to IRAS color selection criteria, was selected. The properties of this sample have been characterized both in line and continuum emission and it can serve as a suitable sample for follow-up observations with ALMA.

Pilot study:

I first conducted a pilot study on three very luminous, line rich sources out of the sample, which also served to test and refine the selection of frequency setups to be used for the large sample. The three sources were observed in line emission in a number of frequency setups between 290 GHz and 810 GHz to determine their physical and chemical properties, as well as in 870 μm dust continuum with the Large APEX BOlometer CAmera (LABOCA).

The three sources were further observed at high resolution mm continuum and line emission with the Australia Compact Telescope Array (ATCA). They are all luminous, massive objects with signs of outflow activity, are rich in sulfur-bearing species and display a high abundance of oxygen- versus nitrogen-bearing species. One of them seems to have a highly complex velocity structure. Altogether, the three sources show evidence of being hot molecular cores at a more evolved stage.

High mass star formation sample - continuum:

To characterize the sample of 47 sources, they were studied in 870 μm dust continuum with LABOCA and their morphologies and associations with mid-infrared sources were investigated. About 80% of the sources have an infrared counterpart within 0.1 pc of the dust peak, indicating luminous heating sources. Radial fits to the data resulted in an average density profile of $\sim r^{-1.6}$, which is consistent with the picture of proto-stellar density power law distribution (Shu et al. 1987, ARA&A, 25, 23). Comparison of the subsamples with (radio-loud) and without (radio-quiet) detected radio continuum shows that the radio-loud sources are on average more massive, luminous and have higher pressures. The luminosity-to-mass ratio L/M found in our sample shows no trends with mass, consistent with a constant star forming rate in the Galaxy (Shirley et al. 2008, ASPC, 387, 401). I compared the sources in the sample with a model of high mass proto-stellar evolution (Molinari et al. 2008, A&A, 481, 345). This comparison suggests that both radio-loud and radio-quiet sources have finished the accelerated accretion phase after about 2×10^5 yr.

High mass star formation sample - molecular line survey:

A subsample of the 47 sources has also been observed with APEX in a partial line survey around 338 GHz, allowing me to characterize the chemical properties of the sample. Based on their spectra, the sources could be classified as either line poor or line rich (Hatchell et al. 1998, A&AS, 133, 29). For most sources, only contribution from a cool, extended envelope was detected, while some of the line-rich sources show also a hot, compact component.

It turned out that the overall chemical make-up of the envelopes in the sources is fairly similar, despite their wide range of masses and luminosities. Analyzing infall properties of the sample, a statistical trend towards infalling motions could be found.

I found eight hot cores among the sample, all of which show a similar trend towards being oxygen-rich. Together with their 870 μm dust continuum properties and archival cm continuum data, I tentatively placed the hot cores in our sample in a transition stage between hot cores and UCHII regions. Having found various sources which have the same mass and luminosity properties as the hot cores, but do not exhibit hot core type molecular line spectra, the question is raised why only some of the sources develop hot cores.

Using the line observations as a chemical magnifying glass to zoom into the deeply embedded inner regions of the hot cores, I estimated mass accretion rate, star forming time and the pressures of the star forming core in the frame of the turbulent core model (McKee & Tan 2003, ApJ, 585, 850).

Star-Disc Encounters in Young Star Clusters: Environmental Effects on the Evolution of Protoplanetary Discs

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Ph.D dissertation directed by: Susanne Pfalzner, Andreas Eckart

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According to current knowledge, star formation occurs preferentially in clustered environments. As a byproduct of the star formation process young stars are found to be surrounded by accretion discs that are potential birth places of planets and planetary systems. Located in the hosting cluster, these protoplanetary discs are potentially subject to stellar interactions. These interactions give rise to a fundamental question of clustered star formation: How far does the cluster environment affect the evolution of protoplanetary discs and the formation of planets?

The question is addressed in the present investigation in terms of the effect of stellar encounters on stars and their disc in young clusters by combining numerical simulations of isolated star-disc encounters and stellar dynamics of young star clusters.

The investigation is composed of three key aspects. First, simulations of a dynamical model of the Orion Nebula Cluster (ONC) show that disc destruction is dominated by encounters with high-mass stars that act as gravitational foci for the lower mass stars in the cluster centre. The massive stars are thus subject to repeated encounters which can lead to a total disc destruction. This happens much more quickly and to a larger degree than for intermediate-mass stars.

Secondly, the question whether there are any observables that could trace the mechanism of encounter-induced disc-mass loss, is addressed. From numerical simulations it is found that some stars show unexpectedly high velocities as an outcome of close interactions, combined with a completely destroyed disc. Observations of the ONC confirm the presence of these high-velocity stars, which are young low-mass stars that partially lack infrared excess emission. The high-velocity stars form a characteristic pattern that is explained by the numerical simulations, finding a strong correlation between initial location in the cluster and disc destruction dynamics.

Third, the influence of the cluster properties on the encounter-induced disc-mass loss is investigated by scaling the size, density and stellar number of the basic dynamical model of the ONC. Not unexpectedly, it is found that the disc-mass loss increases with cluster density but remains rather unaffected by the size of the stellar population revealing that even in clusters four times sparser than the ONC the effect of encounters is still *non-negligible*. The density of the ONC itself marks a threshold: in less dense and less massive clusters it is the massive stars that dominate the encounter-induced disc-mass loss whereas in denser and more massive clusters the low- and intermediate-mass stars play the major role for the removal of disc mass.

http://www.astro.uni-koeln.de/sites/default/files/AeGroup/theses/2009_PhD_Olczak_Christoph.pdf

PhD position at Observatoire de Paris

Position: PhD position in numerical simulations of star formation - Laboratory Etude du rayonnement et de la matiere en astrophysique (LERMA) - Paris Observatory .

In the context of the ASTRONET project STAR FORMAT, LERMA invite applications for a PhD position to study the collapse of magnetized prestellar dense cores through numerical simulations.

Star formation remains one of the greatest unsolved challenge of modern astrophysics. If it is now well established that star formation occurs within molecular clouds through the gravitational collapse of prestellar dense cores, the conditions under which these cores collapse and fragment remain a debated issue. In particular, recent investigations have shown that the role of the magnetic field appears to be rather important, especially for the formation of a circumstellar disk, its fragmentation and the launching of outflows. For his/her PhD, the candidate will investigate the collapse of magnetized prestellar cores further, by performing numerical simulations with the RAMSES-MHD code and focussing particularly on the impact of the initial conditions on the core fragmentation and disk formation. The simulation results will also be used to feed a database.

To this end, the candidate will work under the supervision of Patrick Hennebelle and with the LERMA-ASTRONET team (Edith Falgarone, Pierre Lesaffre and Francois Levrier). Collaborations with the LUTH-ASTRONET team, (Jacques Le Bourlot, Franck Le Petit and Evelyne Roueff) and with the German team (Ralf Klessen, Robi Banerjee, Simon Glover, and Cornelis Dullemond in Heidelberg, as well as Peter Hauschildt in Hamburg), will be greatly encouraged.

Prospective applicants are encouraged to contact Patrick Hennebelle by e-mail (patrick.hennebelle *at* ens.fr) for further information. A short description of the ASTONET STAR FORMAT project is available at astro.ens.fr (Astronet Star Format).

The position is expected to start in the early fall of 2009. It is funded for three years. Some expertise on numerical analysis and software development skills is required. Applicants should send a CV and a motivation letter and arrange for two letters of reference to reach PH by June 1st, 2009. Late applications will continue to receive attention until the position is filled.

Research Associate in Young Stars and their Circumstellar Environments - Keele University

Applications are invited for a Research Associate researching the properties and environments of young, planet-forming stars. Keele has a world class stellar astrophysics group focussing on questions surrounding stellar birth and death (see http://www.astro.keele.ac.uk). The group has been strengthened by its participation in the WASP exoplanetary transit project and leadership of the WASP-South survey. The Research Associate will join a successful observational research programme investigating the properties of young, low-mass stars, their circumstellar and birth environments and how these influence the planet-forming process. Research methods will include multi-wavelength (optical, infrared, X-ray) observations of stars in young clusters using facilities such as the VLT, Spitzer and XMM-Newton.

Applicants should have a PhD in astrophysics or a related area, or an expectation of gaining a PhD within a year of appointment, as well as experience in the collection and analysis of astrophysical data or similar datasets and have a demonstrated aptitude for research in astrophysics and the publication of journal papers. Ideally applicants will have a background in researching young stars and their environments and will also have experience of the operation of astronomical telescopes and spectrographs and/or analysing X-ray and infrared datasets from satellites.

The appointment will be made for a term of up to three years with a likely starting date of October 2009 or earlier. The salary range is likely to be 29,705 – 36,533 (pounds Sterling).

To apply see http://www.keele.ac.uk/depts/uso/hr/cwisvacs.htm . Please quote post reference: RE09/05. Please copy any application to Dr Rob Jeffries at rdj *at* astro.keele.ac.uk. (http://www.astro.keele.ac.uk/∼rdj/)

ESA-CONSTELLATION workshop on brown dwarf formation

Recipes for making brownies: theory vs. observations

A joint ESA-CONSTELLATION workshop on the formation of brown dwarfs

ESA-ESTEC, Noordwijk, The Netherlands

September 9-11, 2009

http://www.rssd.esa.int/BD2009

The origin of brown dwarfs (BDs) is an important component of the theory of star formation. Recent ground based and satellite observations are revealing an increasing number of BDs; however, their origin remains somewhat mysterious as their mass is 2 orders of magnitude below the average Jeans mass in star-forming clouds. Explaining why they are so common thus requires detailed understanding of the fragmentation processes during star formation, as well as exploring other formation scenarios.

This workshop will focus on recent theoretical and observational progresses in the field of BD formation as well as explore current and future perspectives. Our purpose is to bring together the leading experts working in this field, foster new collaborations and, in particular, promote extended interactions among young PhD/post-doc researchers.

We invite interested colleagues to submit abstracts for presentations or posters. The deadline for abstract submission is April 30th 2009.

Due to space constraints at the venue, the total number of participants will be limited to about 50 including invited speakers, and, unfortunately, we cannot at this time guarantee attendance for all submitted abstracts. All persons who have submitted an abstract will receive an e-mail confirming that they are invited to attend within 10 days after abstract submission closes.

We have limited funding available to support participants, in particular PhD students and young postdocs. If you need support, please contact us at your earliest convenience by mail (Jakob Walcher, jwalcher *at* rssd.esa.int) with a short motivation and an estimate of the amount requested. Funding decisions will be made within 10 days after abstract submission closes.

If you have any further questions, please contact Loredana Spezzi (lspezzi *at* rssd.esa.int).

TOPICS:

Brown dwarf formation scenarios Observed properties of brown dwarfs Proto-brown dwarfs, circumstellar disks, and accretion processes Future observing facilities

A preliminary programme is available at the web page of the conference: http://www.rssd.esa.int/BD2009

INVITED SPEAKERS:

P. André, M. Bate, I. Bonnell, J. Bouvier, P. Clark, F. Comeron, M. Fridlund, C. Helling, P. Hennebelle, V. Joergens, R. Jayawardhana, K. Luhman, M. McCaughrean, A. Natta, P. Padoan, F. Palla, L. Testi, A. Whitworth, M.R. Zapatero Osorio

SCIENTIFIC ORGANIZING COMMITTEE:

Loredana Spezzi (chair, ESTEC)
Bruno Merin (ESAC)
Dimitris Stamatellos (Cardiff University)
Vera Konyves (Paris/Saclay)
Catarina Alves de Oliveira (LAOG, Grenoble)

Gordon Research Conference on the Origins of Solar Systems

The 2009 Gordon Conference on the Origins of Solar Systems will be held July 5-10, 2009 at Mount Holyoke College in South Hadley, MA. The goal of the meeting is to present current research on the formation of stars and planets. We will bring together astronomers, planetary scientists and meteoriticists to provide a multi-disciplinary approach to this topic, and will mix scientists from different disciplines within the sessions. There have been many exciting recent discoveries, including analyses of returned cometary material (from the NASA Stardust mission), and new information about the composition of the Sun. Direct detections of exoplanets from both ground and space will be presented, and new results from radial velocity and transit surveys such as the CoRoT mission will be discussed. An abundance of new data on planets is now inspiring the development of novel models for the formation, evolution and structure of planetary systems both in our own solar system and beyond. Students and postdocs are very much encouraged to attend the Conference and to present their work in the form of posters. The structure of this Conference allows for formal discussion sessions in the mornings and evenings and informal networking and discussion in the afternoons. The friendly atmosphere and unique range of disciplines represented encourages effective new collaborations to be made. Applications for this meeting must be submitted by June 14, 2009. Please apply early, as the meeting may become oversubscribed (full) before this deadline.

More information can be found at:

http://www.grc.org/programs.aspx?year=2009&program=origins

Moving ... ??

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Accretion Processes in Star Formation – Second Edition

Lee Hartmann

This is a revised version of the author's well-known book which appeared over 10 years ago. Much has happened in the field of low mass star formation over the past decade, so a new version of this classic book is warmly welcomed. The book provides an up-to-date, in-depth discussion of star formation at a level so it can be used as a textbook for a graduate course in low mass star formation processes. It reviews our current knowledge of the processes governing the formation of stars, from the collapse and fragmentation of cold molecular gas clouds through to the formation and evolution of disks which may ultimately form planets. Each topic is covered at two levels. A descriptive narrative integrating both observational data and theoretical models is accessible to undergraduates or non-specialists. In addition, each topic is given a rigorous theoretical development with comparison to observations, and is appropriate for first-year graduate students or those desiring a deeper understanding of the underlying physics of how stars and accretion disks form and evolve. This book is a magnificent introduction for anyone who is seriously interested in learning about low mass star formation processes.

The following lists the chapters of the revised version of the book:

1 Overview
1.1 Molecular clouds – 1.2 The IMF, clusters, and binaries – 1.3 Young stars – 1.4 Protostars – 1.5 Long-wavelength emission: dusty envelopes and disks – 1.6 Imaging of disks – 1.7 Disk accretion – 1.8 Disks and planet formation – 1.9 A picture of star and planet formation

2 Beginnings: molecular clouds
2.1 Large-scale properties of molecular clouds – 2.2 Turbulence and cloud lifetimes – 2.3 Molecular cloud formation and dispersal – 2.4 Flows, magnetic fields, and cloud formation – 2.5 Gravity and fragmentation – 2.6 Sheets and filaments – 2.7 Turbulence and cloud structure

3 Initial conditions for protostellar collapse
3.1 Molecular cloud cores – 3.2 Virial theorem and cloud stability – 3.3 Centrally-concentrated clouds – 3.4 Core lifetimes and equilibrium – 3.5 Stability of magnetized clouds – 3.6 Ambipolar diffusion of magnetic flux – 3.7 The magnetic flux "problem(s)"

4 Protostellar cloud collapse
4.1 Free-fall collapse of a uniform cloud – 4.2 Similarity solution for collapse – 4.3 Generalized models of protostellar collapse – 4.4 Rotating collapse – 4.5 Time evolution of rotating collapse – 4.6 Disk formation – 4.7 Massive protostars

5 Protostellar collapse: observations vs theory
5.1 Protostellar luminosities and accretion – 5.2 SEDs of spherical infalling envelopes – 5.3 SEDs for rotating collapse models – 5.4 A case study: L1551 IRS 5 – 5.5 The Class 0 sources – 5.6 Flat spectrum sources – 5.7 Spatial distribution of emission – 5.8 Detection of infall from line profiles – 5.9 Massive protostars

6 Binaries, clusters, and the IMF
6.1 Observations of binary and multiple systems – 6.2 Theories of multiple stellar system formation – 6.3 Evolution of multiple systems during accretion – 6.4 Young clusters – 6.5 Cluster formation – 6.6 The Initial Mass Function – 6.7 Theories of the IMF

7 Disk accretion
7.1 Energy minimization and angular momentum conservation – 7.2 The thin accretion disk – 7.3 The steady optically-thick disk – 7.4 The α disk – 7.5 Sources of viscosity: the magnetorotational instability – 7.6 The ionization problem – 7.7 Gravitational instability and angular momentum transport – 7.8 Disk boundary layers – 7.9 Disk irradiation

8 The disks of pre-main sequence stars
8.1 Disk imaging – 8.2 Disk SEDs – 8.3 Long-wavelength emission; disk masses – 8.4 Disk/magnetosphere accretion – 8.5 Accretion rates – 8.6 What drives accretion? – 8.7 The WTTS – 8.8 The Herbig Ae/Be stars – 8.9 The transitional disks

9 The FU Orionis objects
9.1 Basic observational properties – 9.2 The accretion disk model – 9.3 Disk kinematics – 9.4 Disk properties – 9.5 Time variability and circumstellar envelopes – 9.6 Outburst mechanisms – 9.7 The boundary layer problem – 9.8 Outburst statistics and evolutionary significance

10 Disk winds, jets, and magnetospheric accretion
10.1 Outflows and jets – 10.2 P Cygni profiles – 10.3 FU Ori disk winds – 10.4 T Tauri winds – 10.5 Mass loss rates – 10.6 Magnetocentrifugal acceleration and collimation – 10.7 Magnetohydrodynamic flows – 10.8 MHD disk winds – 10.9 Applications of MHD disk wind theory – 10.10 Models of magnetospheric accretion

11 Disk accretion and early stellar evolution
11.1 Pre-main sequence stellar evolutionary tracks – 11.2 Protostellar properties – 11.3 The "birthline" – 11.4 Birthlines: comparison with observations – 11.5 Age estimates – 11.6 Star formation histories

12 Disk evolution and planet formation
12.1 Clearing of optically-thick disks – 12.2 Viscous disk evolution – 12.3 Binaries – 12.4 Disk evaporation – 12.5 Dust evolution – 12.6 Core accretion and planet formation – 12.7 Gaseous gravitational instability and planet formation – 12.8 Migration – 12.9 Disk gaps and holes – 12.10 Debris disks – 12.11 Speculations

Appendix 1: Basic hydrodynamic and MHD equations
Appendix 2: Jeans masses and fragmentation
Appendix 3: Basic radiative transfer

Cambridge University Press

ISBN 978-0-521-53199-3, paperback, 332 pages, 2009
US$90.00

Available from:
hhttp://www.cambridge.org/us/catalogue/catalogue.asp?isbn=9780521531993

An Introduction to the Physics of Interstellar Dust

Endrik Krügel

This is an updated and abbreviated new version of the author's earlier book "The Physics of Interstellar Dust", which appeared in 2003 (see Star Formation Newsletter #125). Whereas the earlier volume because of its sheer size and detail was directed mostly to researchers, the present slimmer and cheaper book will appeal also to many students interested in dust as it relates to star formation and the interstellar medium. The book discusses in depth the nature of interstellar and circumstellar dust grains. The composition, morphology and size distribution of dust grains, their growth and destruction mechanisms, dynamical behaviour, optical properties, spectral features and basic surface reactions are all dealt with. Also discussed are the roles dust plays in star formation and the spectral appearance of protostars and dusty galactic nuclei. The relevant physics towards understanding this vast material is presented throughout the chapters as well as in two appendices, including the necessary thermodynamics, radiative transport, optical properties, solid state physics, and statistical and quantum mechanics.

The book contains the following chapters:

Taylor & Francis

ISBN 978-1-58488-707-2, hardbound, 387 pages, 2008
US$83.95

Available from:
http://www.taylorandfrancis.com

Physics and Chemistry of the Interstellar Medium

Sun Kwok

This is a textbook on the interstellar medium aimed at graduate or advanced undergraduate students who are already familiar with basic physics and chemistry. The book provides a comprehensive discussion of the many processes governing the interstellar medium, and by adhering to fundamental principles and avoiding phenomenological descriptions, the book should stay relevant for a long time. Throughout the book theory is compared to observations, and numerous figures, especially of spectra, are shown, all drawn from the research literature. Each chapter comes with a set of exercises, some of which are given solutions in an appendix.

The book contains the following chapters:

population distribution – 9.8 Molecular abundance by absorption spectroscopy – 9.9 Ortho/para ratios – 9.10 Isotopic abundance – 9.11 Isomers – 9.12 Conformers

10 Interstellar Grains
10.1 Interstellar extinction – 10.2 Dust absorption and scattering – 10.3 Dust emission – 10.4 Thermal coupling between the dust and gas – 10.5 Reflection and scattering – 10.6 Dust absorption in the X-ray region – 10.7 Stochastic heating – 10.8 Interstellar polarization – 10.9 Photoelectric effect – 10.10 Grain processing

11 The Chemical Composition of Interstellar and Circumstellar Grains
11.1 Optical properties of solids – 11.2 Inorganic compunds – 11.3 Organic compounds

12 Carbonaceous Grains
12.1 The aromatic infrared bands – 12.2 The 2175-A absorption feature – 12.3 The diffuse interstellar bands – 12.4 Extended red emission – 12.5 The 21-μm feature – 12.6 The 30-μm feature – 12.7 Plateau features – 12.8 Photochemistry

13 The Origin of Interstellar Dust
13.1 The formation of dust in the atmospheres of AGB stars – 13.2 Models of carbonaceous dust – 13.3 Laboratory simulations of cosmic dust – 13.4 UV processing of ices – 13.5 Interstellar dust and the solar system – 13.6 Possible enrichment of the solar system by interstellar grains

14 Chemical Reactions in the ISM
14.1 An example: CO chemistry – 14.2 Photodissociation – 14.3 Attenuation of the radiation field – 14.4 Cosmic ray ionization – 14.5 Gas-phase reactions – 14.6 A rate equation – 14.7 Photon-dominated regions – 14.8 Grain-surface chemistry

15 Gas Dynamics, Gravitational Collapse, and Stellar Winds
15.1 Hydrodynamical equations – 15.2 Self-gravitating hydrostatic spheres – 15.3 The virial theorem – 15.4 Pressureless gravitational collapse – 15.5 Gravitational instability – 15.6 Stellar winds from hot stars – 15.7 Winds from AGB stars – 15.8 Systematic motions in star forming regions

16 Interaction between Stars and the Interstellar Medium
16.1 Supersonic dynamics – 16.2 Supernova remnants – 16.3 Interstellar bubbles – 16.4 Interacting stellar winds – 16.5 The momentum paradox

17 Beyond the Galaxy
17.1 Overall structure of the ISM – 17.2 Radiative interactions between different states of matter – 17.3 Application to extragalactic astronomy

Appendix 1: Vector Formulae in Different Coordinate Systems
Appendix 2: Ionization Potentials for Atoms and Molecules
Appendix 3: List of Interstellar Molecules
Appendix 4: Solutions to Selected Exercises

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ISBN 978-1-891389-46-7, hardbound, 569 pages, 2007
US$ 86.00

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