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Abstracts of recently accepted papers

The H II Region/PDR Connection: Self-consistent Calculations of Physical Conditions in Star-forming Regions

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We have performed a series of calculations designed to reproduce infrared diagnostics used to determine physical conditions in star-forming regions. We self-consistently calculate the thermal and chemical structure of an H II region and photodissociation region (PDR) that are in pressure equilibrium. This differs from previous work, which used separate calculations for each gas phase. Our calculations span a wide range of stellar temperatures, gas densities, and ionization parameters. We describe improvements made to the spectral synthesis code Cloudy that made these calculations possible. These include the addition of a molecular network with ∼1000 reactions involving 68 molecular species and improved treatment of the grain physics. Data from the *Spitzer* First Look Survey, along with other archives, are used to derive important physical characteristics of the H II region and PDR. These include stellar temperatures, electron densities, ionization parameters, UV radiation flux (G_0), and PDR density. Finally, we calculate the contribution of the H II region to PDR emission line diagnostics, which allows for a more accurate determination of physical conditions in the PDR.

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The Onset of Planet Formation in Brown Dwarf Disks

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The onset of planet formation in protoplanetary disks is marked by the growth and crystallization of sub-micrometer-sized dust grains accompanied by dust settling toward the disk mid-plane. Here, we present infrared spectra of disks around brown dwarfs and brown dwarf candidates. We show that all three processes occur in such cool disks in a way similar or identical to that in disks around low- and intermediate-mass stars. These results indicate that the onset of planet formation extends to disks around brown dwarfs, suggesting that planet formation is a robust process occurring in most young circumstellar disks.

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The infrared Hourglass cluster in M8

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A detailed study of the Hourglass Nebula in the M8 star forming region is presented. The study is mainly based on recent subarcsec-resolution JHK_s images taken at Las Campanas Observatory and complemented with archival *HST* images and longslit spectroscopy retrieved from the ESO Archive Facility. Using the new numerical code CHORIZOS, we estimate the distance to the earliest stars in the region to be 1.25 kpc. Infrared photometry of all the sources detected in the field is given. From analysis of the JHK_s colour-colour diagrams, we find that an important fraction of these sources exhibit significant infrared excess. These objects are candidates to be low- and intermediate-mass pre-main sequence stars. Based on *HST* observations, the spatial distribution of gas, dust and stars in the region is analyzed. The morphological analysis of these images also reveals a rich variety of structures related to star formation (proplyds, jets, bow shocks), similar to those observed in M16 and M42, along with the detection of the first four Herbig-Haro objects in the region. Furthermore, a longslit spectrum obtained with NTT confirms the identification of one of them (HH 870) in the core of the Hourglass nebula, providing the first direct evidence of active star formation by accretion in M8.

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X-Ray Spectral Variability During an Outburst in V1118 Ori

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We present results from a multi-wavelength campaign to monitor the 2005 outburst of the low-mass young star V1118 Ori. Although our campaign covers the X-ray, optical, infrared, and radio regimes, we focus in this Letter on the properties of the X-ray emission in V1118 Ori during the first few months after the optical outburst. *Chandra* and *XMM-Newton* detected V1118 Ori at three epochs in early 2005. The X-ray flux and luminosity stayed similar within a factor of two, and at the same level as in a pre-outburst observation in 2002. The hydrogen column density showed no evidence for variation from its modest pre-outburst value of $N_{\rm H} \sim 3 \times 10^{21}$ cm^{-2}. However, a spectral change occurred from a dominant hot plasma ($\sim$ 25 MK) in 2002 and in January 2005 to a cooler plasma ($\sim$ 8 MK) in February 2005 and in March 2005. We hypothesize that the hot magnetic loops high in the corona were disrupted by the closing in of the accretion disk due to the increased accretion rate during the outburst, whereas the lower cooler loops were probably less affected and became the dominant coronal component.

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Dust distribution in protoplanetary disks - Vertical settling and radial migration

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We present the results of a three dimensional, locally isothermal, non-self-gravitating SPH code which models protoplanetary disks with two fluids: gas and dust. We ran simulations of a $1M_\odot$ star surrounded by a $0.01M_\odot$ disk comprising 99% gas and 1% dust in mass and extending from 0.5 to $\sim$ 300 AU. The grain size ranges from 10^{-6} m to 10 m for the low resolution ($\sim$ 25000 SPH particles) simulations and from 10^{-4} m to 10 cm for the high resolution ($\sim$ 160000 SPH particles) simulations. Dust grains are slowed down by the sub-Keplerian gas and lose angular momentum, forcing them to migrate towards the central star and settle to the midplane. The gas drag efficiency varies according to the grain size, with the larger bodies being weakly influenced and following marginally perturbed Keplerian orbits, while smaller grains are strongly coupled to the gas. For intermediate sized grains, the drag force decouples the dust and gas, allowing the dust to preferentially migrate radially and efficiently settle to the midplane. The resulting dust distributions for each grain size will indicate, when grain growth is added, the regions when planets are likely to form.

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Hierarchical star formation in M 51: star/cluster complexes

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We report on a study of young star cluster complexes in the spiral galaxy M 51. Recent studies have confirmed that star clusters do not form in isolation, but instead tend to form in larger groupings or complexes. We use *HST* broad and narrow band images (from both *WFPC2* and *ACS*), along with *BIMA*-CO observations to study the properties and investigate the origin of these complexes. We find that the complexes are all young (< 10 Myr), have sizes between $\sim$85 and $\sim$240 pc, and have masses between $3 - 30 \times 10^4 M_\odot$. Unlike that found for isolated young star clusters, we find a strong correlation between the complex mass and radius, namely $M \propto R^{2.33\pm0.19}$. This is similar to that found for giant molecular clouds (GMCs). By comparing the mass-radius relation of GMCs in M 51 to that of the complexes we can estimate the star formation efficiency within the complexes, although this value is heavily dependent on the assumed CO-to-H_2 conversion factor. The complexes studied here have the same surface density distribution as individual young star clusters and GMCs. If star formation within the complexes is proportional to the gas density at that point, then the shared mass-radius relation of GMCs and complexes is a natural consequence of their shared density profiles. We briefly discuss possibilities for the lack of a mass-radius relation for young star clusters. We note that many of the complexes show evidence of merging of star clusters in their centres, suggesting that larger star clusters can be produced through the build up of smaller clusters.

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Search for massive protostar candidates in the southern hemisphere: II. Dust continuum emission

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In an ongoing effort to identify and study high-mass protostellar candidates we have observed in various tracers a sample of 235 sources selected from the IRAS Point Source Catalog, mostly with $\delta < -30°$, with the SEST antenna at millimeter wavelengths. The sample contains 142 *Low* sources and 93 *High*, which are believed to be in different evolutionary stages. Both sub-samples have been studied in detail by comparing their physical properties and morphologies. Massive dust clumps have been detected in all but 8 regions, with usually more than one clump per region. The dust emission shows a variety of complex morphologies, sometimes with multiple clumps forming filaments or clusters. The mean clump has a linear size of ~ 0.5 pc, a mass of $\sim 320\ M_\odot$ for a dust temperature $T_\mathrm{d} = 30$ K, an H_2 density of 9.5×10^5 cm^{-3}, and a surface density of 0.4 g cm^{-2}. The median values are 0.4 pc, 102 $M_\odot$, 4×10^4 cm^{-3}, and 0.14 g cm^{-2}, respectively. The mean value of the luminosity-to-mass ratio, $L/M \simeq 99\ L_\odot/M_\odot$, suggests that the sources are in a young, pre-ultracompact HII phase. We have compared the millimeter continuum maps with images of the mid-IR MSX emission, and have discovered 95 massive millimeter clumps non-MSX emitters, either diffuse or point-like, that are potential prestellar or precluster cores. The physical properties of these clumps are similar to those of the others, apart from the mass that is ~ 3 times lower than for clumps with MSX counterpart. Such a difference could be due to the potential prestellar clumps having a lower dust temperature. The mass spectrum of the clumps with masses above $M \sim 100\ M_\odot$ is best fitted with a power-law $dN/dM \propto M^{-\alpha}$ with $\alpha = 2.1$, consistent with the Salpeter (1955) stellar IMF, with $\alpha = 2.35$. On the other hand, the mass function of clumps with masses $10\ M_\odot \lesssim M \lesssim 120\ M_\odot$ is better fitted with a power law of slope $\alpha = 1.5$, more consistent with the mass function of molecular clouds derived from gas observations.

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Rapid Timescales for Accretion and Melting of Differentiated Planetesimals Inferred from ^{26}Al-^{26}Mg Chronometry

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Constraining the timescales for the assembly and differentiation of planetary bodies in our young solar system is essential for a complete understanding of planet-forming processes. This is best achieved through the study of the daughter products of extinct radionuclides with short half-lives, as they provide unsurpassed time resolution as compared to long-lived chronometers. Here we report high-precision Mg isotope measurements of bulk samples of basalt, gabbro, and pyroxenite meteorites obtained by multiple-collector inductively coupled plasma mass spectrometry (MC-ICP-MS). All samples from the eucrite and mesosiderite parent bodies (EPB and MPB) with suprachondritic Al/Mg ratios have resolvable ^{26}Mg excesses compared to matrix-matched samples from the Earth, the Moon, Mars, and chondrites. Basaltic magmatism on the EPB and MPB thus occurred during the life span of the now-extinct ^{26}Al nuclide. Initial ^{26}Al/^{27}Al values range from $(1.26 \pm 0.37) \times 10^{-6}$ to $(5.12 \pm 0.81) \times 10^{-6}$ at the time of magmatism on the EPB and MPB, and are among the highest ^{26}Al abundances reported for igneous meteorites. These results indicate that widespread silicate melting and differentiation of rocky bodies occurred within 3 million years of solar system formation, when ^{26}Al and ^{60}Fe were extant enough to induce planetesimal melting. Finally, thermal modeling constrains the accretion of these differentiated asteroids to within 1 million years of solar system formation, that is, prior to the accretion of chondrite parent bodies.

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Can variability account for apparent age spreads in OB association colour-magnitude diagrams?

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We have investigated the role of photometric variability in causing the apparent age spreads observed in the colour-magnitude diagrams of OB associations. We have found that the combination of binarity, photometric uncertainty and variability on time-scales of a few years is not sufficient to explain the observed spread in either of the OB associations we have studied. Such effects can account for about half the observed spread in the σ Orionis subgroup and about 1/20 of the observed spread in Cep OB3b. This rules out variability caused by stellar rotation and rotation of structures within inner accretion discs as the source of the majority of the apparent age spreads. We also find that the variability tends to move objects parallel to isochrones in $V/V-i'$ colour-magnitude diagrams (CMDs), and thus has little influence on apparent age spreads. We conclude that the remaining unexplained spread either reflects a true spread in the ages of the pre-main-sequence (PMS) objects or arises as a result of longer term variability associated with changes in accretion flow.

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Emission lines from rotating proto-stellar jets with variable velocity profiles. I. Three-dimensional numerical simulation of the non-magnetic case.

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Using the Yguazú-a three-dimensional hydrodynamic code, we have computed a set of numerical simulations of heavy, supersonic, radiatively cooling jets including variabilities in both the ejection direction (precession) and the jet velocity (intermittence). In order to investigate the effects of jet rotation on the shape of the line profiles, we also introduce an initial toroidal rotation velocity profile, in agreement with some recent observational evidence found in jets from T Tauri stars which seems to support the presence of a rotation velocity pattern inside the jet beam, near the jet production region. Since the Yguazú-a code includes an atomic/ionic network, we are able to compute the emission coefficients for several emission lines, and we generate line profiles for the Hα, [O I]λ6300, [S II]λ6716 and [N II]λ6548 lines. Using initial parameters that are suitable for the DG Tau microjet, we show that the computed radial velocity shift for the medium-velocity component of the line profile as a function of distance from the jet axis is strikingly similar for rotating and non-rotating jet models. These findings lead us to put forward some caveats on the interpretation of the observed radial velocity distribution from a few outflows from young stellar objects, and we claim that these data should not be directly used as a doubtless confirmation of the magnetocentrifugal wind acceleration models.

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A High-Mass Protobinary System in the Hot Core W3(H_2O)

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We have observed a high-mass protobinary system in the hot core W3(H_2O) with the BIMA Array. Our continuum maps at wavelengths of 1.4 mm and 2.8 mm both achieve sub-arcsecond angular resolutions and show a double-peaked morphology. The angular separation of the two sources is 1.″19 corresponding to 2.43×10^3 AU at the source distance of 2.04 kpc. The flux densities of the two sources at 1.4 mm and 2.8 mm have a spectral index of 3, translating to an opacity law of $\kappa_\nu \propto \nu$. The small spectral indices suggest that grain growth has begun in the hot core. We have also observed 5 K components of the methyl cyanide (CH_3CN) $J = 12 \rightarrow 11$ transitions. A radial velocity difference of $2.81 \pm 0.10\,\mathrm{km\,s^{-1}}$ is found towards the two continuum peaks. Interpreting these two sources as binary components in orbit about one another, we find a minimum mass of 22 $M_\odot$ for the system. Radiative transfer models are constructed to explain both the continuum and methyl cyanide line observations of each source. Power-law distributions of both density and temperature are derived. Density distributions close to the free-fall value, $r^{-1.5}$, are found for both components, suggesting continuing accretion. The derived luminosities suggest the two sources have equivalent zero-age main sequence (ZAMS) spectral type B0.5 - B0. The nebular masses derived from the continuum observations are about 5 $M_\odot$ for source A and 4 $M_\odot$ for source C. A velocity gradient previously detected may be explained by unresolved binary rotation with a small velocity difference.

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The circumstellar disc around the Herbig AeBe star HD169142

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This is the abstract of your paper

We present 7 mm and 3.5 cm wavelength continuum observations toward the Herbig AeBe star HD169142 performed with the Very Large Array (VLA) with an angular resolution of $\simeq 1''$. We find that this object exhibits strong ($\simeq$ 4.4 mJy), unresolved ($\leq 1''$) 7 mm continuum emission, being one of the brightest isolated Herbig AeBe stars ever detected with the VLA at this wavelength. No emission is detected at 3.5 cm continuum, with a 3σ upper limit of $\simeq$ 0.08 mJy. From these values, we obtain a spectral index $\alpha \geq 2.5$ in the 3.5 cm to 7 mm wavelength range, indicating that the observed flux density at 7 mm is most likely dominated by thermal dust emission coming from a circumstellar disc. We use available photometric data from the literature to model the spectral energy distribution (SED) of this object from radio to near-ultraviolet frequencies. The observed SED can be understood in terms of an irradiated accretion disc with low mass accretion rate, $\dot{M}_{\rm acc} \simeq 10^{-8}$ $M_\odot$ yr^{-1}, surrounding a star with an age of $\simeq$ 10 Myr. We infer that the mass of the disc is $\simeq$ 0.04 $M_\odot$, and is populated by dust grains that have grown to a maximum size of 1 mm everywhere, consistent with the lack of silicate 10 μm emission. These features, as well as indications of settling in the wall at the dust destruction radius, led us to speculate the disc of HD169142 is in an advanced stage of dust evolution, particularly in its inner regions.

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The Supernova Rate-Velocity Dispersion Relation in the Interstellar Medium

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We investigate with three-dimensional numerical simulations of supernova driven turbulence in the interstellar medium (ISM) the relationship between the velocity dispersion of the gas and the supernova rate and feedback efficiency. Our simulations aim to explore the constancy of the velocity dispersion profiles in the outer parts of galactic disk at $\sim 6-8$ km s^{-1}, and the transition to the starburst regime i.e., high star formation rates associated with high velocity dispersions. With our fiducial value of the supernova feedback efficiency (i.e., $\epsilon = 0.25$ corresponding to an injected energy per supernova of 0.25×10^{51} ergs), our results show that (a) supernova driving leads to constant velocity dispersions of $\sigma \sim 6$ km s^{-1} for the total gas and $\sigma_{HI} \sim 3$ km s^{-1} for the HI gas, independent of the supernova rate, for values of the rate between 0.01 and 0.5 the Galactic value (η_G), (b) the position of the transition to the starburst regime (i.e., location of sharp increase in the velocity dispersion) at around SFR/Area $\simeq 5 \times 10^{-3} - 10^{-2}$ M$_\odot$ yr^{-1} kpc^{-2} observed in the simulations, is in good agreement with the transition to the starburst regime in the observations (e.g., NGC 628 and NGC 6949), (c) for the high SN rates, no HI gas is present in the simulations box, however, for the total gas velocity dispersion, there is good agreement between the models and the observations, (d) at the intermediate SN rates ($\eta/\eta_G \sim 0.5 - 1$), taking into account the thermal broadening of the HI line helps reach a good agreement in that regime between the models and the observations, (e) for $\eta/\eta_G < 0.5$, σ and σ_{HI} fall below the observed values by a factor of ~ 2. However, a set of simulation with different values of ϵ indicates that for larger values of the supernova feedback efficiencies, velocity dispersions of the HI gas of the order of $5-6$ km s^{-1} can be obtained, in closer agreement with the observations. The fact that for $\eta/\eta_G < 0.5$, the HI gas velocity dispersions are a factor ~ 2 smaller than the observed values could result from the fact that we might have underestimated the supernova feedback efficiency. On the other hand, it might also be an indication that other physical processes couple to the stellar feedback in order to produce the observed level of turbulence in galactic disks.

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Gas phase water in the surface layer of protoplanetary disks

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Recent observations of the ground state transition of HDO at 464 GHz towards the protoplanetary disk of DM Tau have detected the presence of water vapor in the regions just above the outer disk midplane (Ceccarelli et al 2005). In the absence of non-thermal desorption processes, water should be almost entirely frozen onto the grain mantles and HDO undetectable. In this Letter we present a chemical model that explores the possibility that the icy mantles are photo-desorbed by FUV ($6\,\mathrm{eV} \leq h\nu \leq 13.6\,\mathrm{eV}$) photons. We show that the average Interstellar FUV field is enough to create a layer of water vapor above the disk midplane over the entire disk. Assuming a photo-desorption yield of 10^{-3}, the water abundance in this layer is predicted to be $\sim 3 \times 10^{-7}$ and the average H_2O column density is $\sim 1.6 \times 10^{15}$ cm^{-2}. The predictions are very weakly dependent on the details of the model, like the incident FUV radiation field, and the gas density in the disk. Based on this model, we predict a gaseous HDO/H_2O ratio in DM Tau of $\sim 1\%$. In addition, we predict the ground state transition of water at 557 GHz to be undetectable with ODIN and/or HSO-HIFI.

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A New Exact Method for Line Radiative Transfer

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We present a new method, the Coupled Escape Probability (CEP), for exact calculation of line emission from multi-

level systems, solving only algebraic equations for the level populations. The CEP formulation of the classical two-level problem is a set of *linear equations*, and we uncover an exact analytic expression for the emission from two-level optically thick sources that holds as long as they are in the “effectively thin” regime. In comparative study of a number of standard problems, the CEP method outperformed the leading line transfer methods by substantial margins.

The algebraic equations employed by our new method are already incorporated in numerous codes based on the escape probability approximation. All that is required for an exact solution with these existing codes is to augment the expression for the escape probability with simple zone-coupling terms. As an application, we find that standard escape probability calculations generally produce the correct cooling emission by the C II 158 μm line but not by the ^{3}P lines of O I .

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Detection of Interstellar Acetone toward the Orion-KL Hot Core

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We present the first detection of interstellar acetone [$(CH_3)_2CO$] toward the high-mass star-forming region Orion-KL and the first detection of vibrationally excited $(CH_3)_2CO$ in the interstellar medium (ISM). Using the BIMA array, 28 emission features that can be assigned to 54 acetone transitions were detected. Furthermore, 37 of these transitions have not been previously observed in the ISM. The observations also show that the acetone emission is concentrated toward the hot core region of Orion-KL, contrary to the distribution of other large oxygen-bearing molecules. From our rotational temperature diagram, we find a beam-averaged $(CH_3)_2CO$ column density of $[2.0(0.3) - 8.0(1.2)] \times 10^{16}$ cm^{-2} and a rotational temperature of 176(48)-194(66) K.

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Molecular Clouds as Ensembles of Transient Cores

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We construct models of molecular clouds that are considered as ensembles of transient cores. Each core is assumed to develop in the background gas of the cloud, grow to high density and decay into the background. The chemistry in each core responds to the dynamical state of the gas and to the gas-dust interaction. Ices are deposited on the dust grains in the core's dense phase, and this material is returned to the gas as the core expands to low density. The cores of the ensemble number typically one thousand and are placed randomly in position within the cloud, and are assigned a random evolutionary phase.

The models are used to generate molecular line contour maps of a typical dark cloud. These maps are found to represent extremely well the characteristic features of observed maps of the dark cloud L673, which has been observed at both low and high resolutions. The computed maps are found to exhibit the general morphology of the observed maps, and to generate similar sizes of emitting regions, molecular column densities, and the separations between peaks of emissions of various molecular species. The models give insight into the nature of molecular clouds and the dynamical processes occurring within them, and significantly constrain dynamical and chemical processes in the interstellar medium.

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Weak-line T Tauri stars: circumstellar disks and companions - I. Spectral energy distributions and infrared excesses

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We have analysed new infrared photometric data taken by the Infrared Space Observatory, in combination with 2MASS data where available, of 12 weak-line T Tauri stars (WTTS), belonging to different molecular clouds. A control study of 6 classical T Tauri stars (CTTS) for comparison with IRAS data has also been made. WTTS traditionally are not expected to have any circumstellar material, but we have found that 11 of the WTTS studied, have a spectral energy distribution that suggests the presence of reprocessing circumstellar disks, albeit half of them with apparent inner "dust holes". The spectral energy distribution curves of all the stars in our sample show infrared excess in all cases except one. We have also searched for companions to these stars and studied their possible contributions to the infrared emission. We find that 10 of the WTTS with excess infrared emission have companions that may contribute measurably and, in some cases significantly, at infrared wavelengths. In the case of the binary systems, the amount of excess due to the companion is still unclear but it is unlikely they are the only source of all the observed excess.

We give estimations of the excesses and masses of the stars and also find their ages and radii to be in agreement with those expected for T Tauri stars. Our results suggest there is a continuum in infrared excess properties from CTTS to WTTS rather than a clear differentiation based on a somewhat arbitrary $EW(\mathrm{H}\alpha)$ criterion.

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Neptune's Migration into a Stirred-up Kuiper Belt: A Detailed Comparison of Simulations to Observations

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We use N-body simulations to examine the consequences of Neptune's outward migration into the Kuiper Belt, with the simulated end states being compared rigorously and quantitatively to the observations. These simulations confirm the 2003 findings of Chiang and coworkers, who showed that Neptune's migration into a previously stirred-up Kuiper Belt can account for the Kuiper Belt objects (KBOs) known to librate at Neptune's 5 : 2 resonance. We also find that capture is possible at many other weak, high-order mean-motion resonances, such as 11 : 6, 13 : 7, 13 : 6, 9 : 4, 7 : 3, 12 : 5, 8 : 3, 3 : 1, 7 : 2, and 4 : 1. The more distant of these resonances, such as the 9 : 4, 7 : 3, 5 : 2, and 3 : 1, can also capture particles in stable, eccentric orbits beyond 50 AU, in the region of phase space conventionally known as the "Scattered Disk." Indeed, 90% of the simulated particles that persist over the age of the solar system in the Scattered-Disk zone never had a close encounter with Neptune but instead were promoted into these eccentric orbits by Neptune's resonances during the migration epoch. This indicates that the observed Scattered Disk might not be so scattered. This model also produced only a handful of Centaurs, all of which originated at Neptune's mean-motion resonances in the Kuiper Belt. However, a noteworthy deficiency of the migration model considered here is that it does not account for the observed abundance of Main Belt KBOs having inclinations higher than 15^o. In order to rigorously compare the model end state with the observed Kuiper Belt in a manner that accounts for telescopic selection effects, Monte Carlo methods are used to assign sizes and magnitudes to the simulated particles that survive over the age of the solar system. If the model considered here is indeed representative of the outer solar system's early history, then the following conclusions are obtained: (1) The observed 3 : 2 and 2 : 1 resonant populations are both depleted by a factor of $\sim$20 relative to model expectations; this depletion is likely due to unmodeled effects, possibly perturbations by other large planetesimals. (2) The size distribution of those KBOs inhabiting the 3 : 2 resonance is significantly shallower than the Main Belt's size distribution. (3) The total number of KBOs having radii $R > 50$ km and orbiting interior to Neptune's 2 : 1 resonance is $N \sim 1.7 \times 10^5$; these bodies have a total mass of $M \sim 0.08(\rho/1$ g cm$^{-3})(p/0.04)^{-3/2} M_\oplus$, assuming they have a material density ρ and an albedo p. We also report estimates of the

abundances and masses of the Belt's various subpopulations (e.g., the resonant KBOs, the Main Belt, and the so-called Scattered Disk) and provide upper limits on the abundance of Centaurs and Neptune's Trojans, as well as upper limits on the sizes and abundances of hypothetical KBOs that might inhabit the $a > 50$ AU zone.

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Formation of Structure in Molecular Clouds: A Case Study

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Molecular clouds (MCs) are highly structured and turbulent. Colliding gas streams of atomic hydrogen have been suggested as a possible source of MCs, imprinting the filamentary structure as a consequence of dynamical and thermal instabilities. We present a two-dimensional numerical analysis of MC formation via converging H I flows. Even with modest flow speeds and completely uniform inflows, nonlinear density perturbations arise as possible precursors of MCs. Thus, we suggest that MCs are inevitably formed with substantial structure, e.g., strong density and velocity fluctuations, which provide the initial conditions for subsequent gravitational collapse and star formation in a variety of Galactic and extragalactic environments.

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Influence of Alfvén waves on the Thermal Instability in the Interstellar Medium

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he effect of Alfvén waves on the thermal instability of the Interstellar Medium (ISM) is investigated both analytically and numerically. A stability analysis of a finite amplitude circularly polarized Alfvén wave propagating parallel to an ambient magnetic field in a thermally unstable gas at thermal equilibrium is performed, leading to a dispersion relation which depends on 3 parameters, namely the square ratio of the sonic and Alfvén velocities (β), the wave amplitude and the ratio between the wave temporal period and the cooling time. Depending on the values of these 3 parameters, the Alfvén waves can stabilize the large-scale perturbations, destabilize those whose wavelength is a few times the Alfvén wavelength λ_{AW} or leave the growth rate of the short scales unchanged. In order to investigate the non-linear regime, two different numerical experiments are performed in a slab geometry. The first one deals with the development of an initial density perturbation in a thermally unstable gas in the presence of Alfvén waves. The second one addresses the influence of those waves on the thermal transition induced by a converging flow. The numerical results confirm the trends inferred from the analytic calculations, i.e. the waves prevent the instability at scales larger than λ_{AW} and trigger the growth of wavelengths close to λ_{AW}, therefore producing a very fragmented cold phase. The second numerical experiments shows that i) the magnetic pressure prevents the merging of the CNM fragments therefore maintaining the complex structure of the flow and organizing it into group of clouds ii) these groups of CNM clouds have an Alfvénic internal velocity dispersion iii) strong density fluctuations ($\simeq 10\rho_{\rm cnm}$) triggered by magnetic compression occur. We note that during this event there is no stiff variation of the longitudinal velocity field. This is at variance from the hydrodynamical case for which the clouds are uniform and do not contain significant internal motions except after cloud collisions. In this situation a strong density fluctuation occurs accompanied by a stationary velocity gradient through the cloud.

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Rotational Evolution of Solar-like Stars in Clusters from Pre-Main Sequence to Main Sequence: Empirical Results

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Rotation periods are now available for ~ 500 pre-main-sequence (PMS) and recently arrived main-sequence stars of solar-like mass ($0.4 - 1.2 M_{\odot}$) in five nearby young clusters: the Orion Nebula cluster (ONC), NGC 2264, α Per, IC 2602, and the Pleiades. In combination with estimates of stellar radii these data allow us to construct distributions of surface angular momentum per unit mass at three different epochs: nominally, 1, 2, and 50 Myr. There are sufficient data that rotational evolution can now be discussed statistically on the basis of the evolution of these distributions, not just on the evolution of means or ranges, as has been necessary in the past. Our main result is illustrated in Figure 18 and may be summarized as follows: (1) $50\% - 60\%$ of the stars on convective tracks in this mass range are released from any locking mechanism very early on and are free to conserve angular momentum throughout most of their PMS evolution, i.e., to spin up and account for the rapidly rotating young main-sequence stars; (2) the other $40\% - 50\%$ lose substantial amounts of angular momentum during the first few million years and end up as slowly rotating main-sequence stars. The duration of the rapid angular momentum loss phase is $\sim 5 - 6$ Myr, which is roughly consistent with the lifetimes of disks estimated from infrared surveys of young clusters. The rapid rotators of Orion age lose less than 10% of their (surface) specific angular momentum during the next 50 Myr, while the slow rotators lose about two-thirds of theirs. A detectable part of this loss occurs even during the ~ 1 Myr interval between the ONC and NGC 2264. The data support the view that interaction between an accretion disk and star is the primary mechanism for evolving the broad, bimodal distribution of rotation rates seen for solar-like stars in the ONC into the even broader distributions seen in the young MS clusters.

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Evolution of protoplanetary disks: constraints from DM Tauri and GM Aurigae

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We present a one-dimensional model of the formation and viscous evolution of protoplanetary disks. The formation of the early disk is modeled as the result of the gravitational collapse of an isothermal molecular cloud. The disk's viscous evolution is integrated according to two parameterizations of turbulence: the classical α representation and a β parameterization, representative of non-linear turbulence driven by the keplerian shear. We apply the model to DM Tau and GM Aur, two classical T-Tauri stars with relatively well-characterized disks, retrieving the evolution of their surface density with time. We perform a systematic Monte-Carlo exploration of the parameter space (i.e. values of the α-β parameters, and of the temperature and rotation rate in the molecular cloud) to find the values that are compatible with the observed disk surface density distribution, star and disk mass, age and present accretion rate. We find that the observations for DM Tau require $0.001 < \alpha < 0.1$ or $2 \times 10^{-5} < \beta < 5 \times 10^{-4}$. For GM Aur, we find that the turbulent viscosity is such that $4 \times 10^{-4} < \alpha < 0.01$ or $2 \times 10^{-6} < \beta < 8 \times 10^{-5}$. These relatively large values show that an efficient turbulent diffusion mechanism is present at distances larger than ~ 10 AU. This is to be compared to studies of the variations of accretion rates of T-Tauri stars versus age that mostly probe the inner disks, but also yield values of $\alpha \sim 0.01$. We show that the mechanism responsible for turbulent diffusion at large orbital distances most probably cannot be convection because of its suppression at low optical depths.

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Fundamental properties of pre-main sequence stars in young, southern star forming regions: metallicities

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Aims. The primary motivation for this project is to search for metal-rich star forming regions, in which, stars of super-solar metallicity will be created, as hopefully, will be extra-solar planets orbiting them ! The two aims of this project are: **1:** to show that our sample stars are young, lithium rich, magnetically active and non-accreting kinematic members of their respective regions. **2:** To measure the metallicity for such members.

Methods. The FEROS échelle spectrograph together with ESO's 2.2m telescope, was used to obtain high resolution (R=32000) spectra for each of our *weak-lined* T-Tauri target stars. The wavelength range of the spectra is $\simeq 4000-8000$ Å.

Results. We find (pre-main sequence) model-dependent isochronal ages of the Lupus, Chamaeleon and CrA targets to be 9.1 ± 2.1 Myr, 4.5 ± 1.6 Myr and 9.0 ± 3.9 Myr respectively. The majority of the stars have Li I 6707.8 Å equivalent widths similar to, or above those of, their similar mass Pleiades counterparts, confirming their youthfulness. Most stars are kinematic members, either single or binary, of their regions. We find a mean radial velocity for objects in the Lupus cloud to be $\overline{RV} = +2.6 \pm 1.8$ km s^{-1}, for the Chamaeleon I & II clouds, $\overline{RV} = +12.8 \pm 3.6$ km s^{-1} whereas for the CrA cloud, we find $\overline{RV} = -1.1 \pm 0.5$ km s^{-1}.

All stars are coronally and chromospherically active, exhibiting X-ray and Hα emission levels marginally less, approximately equal or superior to that of their older IC 2602/2391 and/or Pleiades counterparts. All bar three of the targets show little or no signature of accretion from a circumstellar environment, according to their positions in a J−K/H−K$'$ diagram.

For the higher quality spectra, we have performed an iron-line metallicity analysis for five (5) stars in Chamaeleon, four (4) stars in Lupus and three (3) stars in the CrA star forming regions. These results show that all three regions are slightly metal-poor, with marginally sub-solar metallicities, with $<$[Fe/H]$>= -0.11 \pm 0.14$, -0.10 ± 0.04 & -0.04 ± 0.05 respectively.

Conclusions. A sample of stars in several nearby, young star-forming regions has been established, the majority of which is young, lithium rich, magnetically active and are non-accreting kinematic members of their respective clouds. Within the errors, each region is essentially of solar metallicity. The spectroscopic data, comprising the major complement of observational products for this project, were collected at the European Southern Observatory at La Silla, Chile, proposal ID 70.C-0507(A).

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Dust Distribution in Gas Disks. II. Self-induced Ring Formation through a Clumping Instability

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Debris rings of dust are found around young luminous stars such as HR 4796A and HD 141569. Some of these entities have sharp edges and gaps, which have been interpreted as evidence for the presence of shepherding and embedded planets. Here we show that gaps and sharp edges in the debris disks of dust can also be spontaneously self-generated if they are embedded in optically thin regions of gaseous disks. This clumping instability arises in regions where an enhancement in the dust density leads to local gas temperature and pressure increases. Consequently, the relative motion between the gas and the dust is modified. The subsequent hydrodynamic drag on the dust particles leads to further enhancement of their concentration. We show that this process is linearly unstable and leads to the formation of ringlike structures within the estimated lifetime of such young objects. Once the gas is removed (e.g., by

photoevaporation), the structures are "frozen" and will persist, even when the gas might not be observable anymore.

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Orbital evolution and accretion of protoplanets tidally interacting with a gas disk: I. Effects of interaction with planetesimals and other protoplanets

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We have performed N-body simulations on the stage of protoplanet formation from planetesimals, taking into account so-called "type-I migration," and damping of orbital eccentricities and inclinations, as a result of tidal interaction with a gas disk without gap formation. One of the most serious problems in formation of terrestrial planets and jovian planet cores is that the migration time scale predicted by the linear theory is shorter than the disk lifetime ($10^6 - 10^7$ years). In this paper, we investigate retardation of type-I migration of a protoplanet due to a torque from a planetesimal disk in which a gap is opened up by the protoplanet, and torques from other protoplanets which are formed in inner and outer regions. In the first series of runs, we carried out N-body simulations of the planetesimal disk, which ranges from 0.9 to 1.1 AU, with a protoplanet seed in order to clarify how much retardation can be induced by the planetesimal disk and how long such retardation can last. We simulated six cases with different migration speeds. We found that in all of our simulations, a clear gap is not maintained for more than 10^5 years in the planetesimal disk. For very fast migration, a gap cannot be created in the planetesimal disk. For migration slower than some critical speed, a gap does form. However, because of the growth of the surrounding planetesimals, gravitational perturbation of the planetesimals eventually becomes so strong that the planetesimals diffuse into the vicinity of the protoplanets, resulting in destruction of the gap. After the gap is destroyed, close encounters with the planetesimals rather accelerate the protoplanet migration. In this way, the migration cannot be retarded by the torque from the planetesimal disk, regardless of the migration speed. In the second series of runs, we simulated accretion of planetesimals in wide range of semimajor axis, 0.5 to 2-5 AU, starting with equal mass planetesimals without a protoplanet seed. Since formation of comparable-mass multiple protoplanets ("oligarchic growth") is expected, the interactions with other protoplanets have a potential to alter the migration speed. However, inner protoplanets migrate before outer ones are formed, so that the migration and the accretion process of a runaway protoplanet are not affected by the other protoplanets placed inner and outer regions of its orbit. From the results of these two series of simulations, we conclude that the existence of planetesimals and multiple protoplanets do not affect type-I migration and therefore the migration shall proceed as the linear theory has suggested.

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Multiplicity at the Stellar/Substellar Boundary in Upper Scorpius

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We present the results of a high-resolution imaging survey of 12 brown dwarfs and very low mass stars in the closest (~ 145 pc) young (~ 5 Myr) OB association, Upper Scorpius. We obtained images with the Advanced Camera for Surveys High Resolution Channel on *HST* through the F555W (V), F775W (i'), and F850LP (z') filters. This survey discovered three new binary systems, including one marginally resolved pair with a projected separation of only 4.9 AU, resulting in an observed binary fraction of $25\% \pm 14\%$ at separations ≥ 4 AU. After correcting for detection biases assuming a uniform distribution of mass ratios for $m_s/m_p > 0.6$, the estimated binary fraction is $33\% \pm 17\%$. The binary fraction is consistent with that inferred for higher mass stars in Upper Sco, but the separation and mass ratio distributions appear to be different. All three low-mass binary systems in Upper Sco are tight (< 18 AU) and of similar mass ($m_s/m_p \geq 0.6$), consistent with expectations based on previous multiplicity studies of brown dwarfs and very low

mass stars in the field and in open clusters. The implication is that the distinct separation and mass ratio distributions of low-mass systems are set in the formation process or at very young ages, rather than by dynamical disruption of wide systems at ages ≥ 5 Myr. Finally, we combine the survey detection limits with low-mass evolutionary models to show that there are no planets or very low mass brown dwarfs with masses $> 10 M_J$ at projected separations > 20 AU or masses $> 5 M_J$ at projected separations > 40 AU orbiting any of the low-mass $(0.04 - 0.10 M_\odot)$ objects in our sample.

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Bondi-Hoyle Accretion in a Turbulent Medium

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The Bondi-Hoyle formula gives the approximate accretion rate onto a point particle accreting from a uniform medium. However, in many situations accretion onto point particles occurs from media that are turbulent rather than uniform. In this paper, we give an approximate solution to the problem of a point particle accreting from an ambient medium of supersonically turbulent gas. Accretion in such media is bimodal, at some points resembling classical Bondi-Hoyle flow, and in other cases being closer to the vorticity-dominated accretion flows recently studied by Krumholz, McKee, & Klein. Based on this observation, we develop a theoretical prediction for the accretion rate, and confirm that our predictions are highly consistent with the results of numerical simulations. The distribution of accretion rates is lognormal, and the mean accretion rate in supersonically turbulent gas can be substantially enhanced above the value that would be predicted by a naive application of the Bondi-Hoyle formula. However, it can also be suppressed by the vorticity, just as Krumholz, McKee, & Klein found for non-supersonic vorticity-dominated flows. Magnetic fields, which we have not included in these models, may further inhibit accretion. Our results have significant implications for a number astrophysical problems, ranging from star formation to the black holes in galactic centers. In particular, there are likely to be significant errors in results that assume that accretion from turbulent media occurs at the unmodified Bondi-Hoyle rate, or that are based on simulations that do not resolve the Bondi-Hoyle radius of accreting objects.

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Stars Form By Gravitational Collapse, Not Competitive Accretion

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There are now two dominant models of how stars form: gravitational collapse theory holds that star-forming molecular clumps, typically hundreds to thousands of $M_\odot$ in mass, fragment into gaseous cores that subsequently collapse to make individual stars or small multiple systems. In contrast, competitive accretion theory suggests that at birth all stars are much smaller than the typical stellar mass ($\sim 0.5\ M_\odot$), and that final stellar masses are determined by the subsequent accretion of unbound gas from the clump. Competitive accretion models explain brown dwarfs and free-floating planets as protostars ejected from star-forming clumps before accreting much mass, predicting that they should lack disks, have high velocity dispersions, and form more frequently in denser clumps. They also predict that mean stellar mass should vary within the Galaxy. Here we derive a simple estimate for the rate of competitive accretion as a function of the star-forming environment, based partly on simulations, and determine in what types

of environments competitive accretion can occur. We show that no observed star-forming region produces significant competitive accretion, and that simulations that show competitive accretion do so because their properties differ from those determined by observation. Our result shows that stars form by gravitational collapse, and explains why observations have failed to confirm predictions of the competitive accretion scenario.

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Spitzer Observations of IC 348: The Disk Population at 2-3 Million Years

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We present near and mid-infrared photometry obtained with the *Spitzer Space Telescope* of $\sim$ 300 known members of the IC 348 cluster. We merge this photometry with existing ground-based optical and near-infrared photometry in order to construct optical-infrared spectral energy distributions (SEDs) for all the cluster members and present a complete atlas of these SEDs. We employ these observations to both investigate the frequency and nature of the circumstellar disk population in the cluster. The *Spitzer* observations span a wavelength range between 3.6 and 24 μm corresponding to disk radii of $\sim 0.1 - 5$ AU from the central star. The observations are sufficiently sensitive to enable the first detailed measurement of the disk frequency for very low mass stars at the peak of the stellar IMF. Using measurements of infrared excess between 3.6 and 8 μm we find the total frequency of disk-bearing stars in the cluster to be 50 $\pm$ 6%. However, only 30 $\pm$ 4 % of the member stars are surrounded by optically thick, primordial disks, while the remaining disk-bearing stars are surrounded by what appear to be optically thin, anemic disks. Both these values are below previous estimates for this cluster. The disk fraction appears to be a function of spectral type and stellar mass. The fraction of stars with optically thick disks ranges from 11 $\pm$ 8% for stars earlier than K6, to 47 $\pm$ 12% for K6-M2 stars to 28 $\pm$ 5% for M2 - M6 stars. The disk longevity and thus conditions for planet formation appear to be most favorable for the K6-M2 stars which are objects of comparable mass to the sun for the age of this cluster. The optically thick disks around later type ($>$ M4) stars appear to be less flared than the disks around earlier type stars. This may indicate a greater degree of dust settling and a more advanced evolutionary state for the late M disk population. Finally we find that the presence of an optically thick dust disk is correlated with gaseous accretion as measured by the strength of Hα emission. A large fraction of stars classified as CTTS possess robust, optically thick disks and very few of such stars are found to be diskless. The majority (64%) of stars classified as WTTS are found to be diskless. However, a significant fraction (12%) of these stars are found to be surrounded by thick, primordial disks. These results suggest that it is more likely for dust disks to persist in the absence of active gaseous accretion than for active accretion to persist in the absence of dusty disks.

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On the interstellar extinction law for young stars

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Hydrogen column density $N_{H\,I}$ was derived from the analysis of Ly$_\alpha$ line profiles for all young stars of the Taurus-Aurigae star formation region (SFR), that were observed with HST in respective spectral band (9 stars in total). It was found that all these stars except DR Tau are situated not far from the nearest to us edge of SFR's gas cloud and more precisely inside the outer H I envelope of the cloud. This envelope has hydrogen column density $N_{H\,I} \simeq 6 \cdot 10^{20}$ cm^{-2} and surrounds molecular gas of the cloud, that consists of a diffuse component (diffuse screen) inside which

a number of compact dense clumps like TMC-1 are situated. It seems resonable to assume that the properties of dust particles within the external neutral hydrogen envelope of the cloud should not differ considerably from that of interstellar dust grains that are situated outside star formation regions. Therefore one can doubt that the extinction law curve toward the investigated young stars has a very low amplitude of local maximum at 2175 Å as Calvet et al. (2004) assumed – such kind of extinction curves are observed in the case of HD 29647 and HD 283809 background stars, the line of site to which passes through the TMC-1 clump.

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Infall and Outflow around the HH 212 protostellar system

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HH 212 is a highly collimated jet discovered in H_2 powered by a young Class 0 source, IRAS 05413-0104, in the L1630 cloud of Orion. We have mapped around it in 1.33 mm continuum, ^{12}CO ($J = 2-1$), ^{13}CO ($J = 2-1$), C^{18}O ($J = 2-1$), and SO ($J_K = 6_5 - 5_4$) emission at $\sim 2.5''$ resolution with the Submillimeter Array. A dust core is seen in the continuum around the source. A flattened envelope is seen in C^{18}O around the source in the equator perpendicular to the jet axis, with its inner part seen in ^{13}CO. The structure and kinematics of the envelope can be roughly reproduced by a simple edge-on disk model with both infall and rotation. In this model, the density of the disk is assumed to have a power-law index of $p = -1.5$ or -2, as found in other low-mass envelopes. The envelope seems dynamically infalling toward the source with slow rotation because the kinematics is found to be roughly consistent with a free fall toward the source plus a rotation of a constant specific angular momentum. A ^{12}CO outflow is seen surrounding the H_2 jet, with a narrow waist around the source. Jetlike structures are also seen in ^{12}CO near the source aligned with the H_2 jet at high velocities. The morphological relationship between the H_2 jet and the ^{12}CO outflow, and the kinematics of the ^{12}CO outflow along the jet axis are both consistent with those seen in a jet-driven bow shock model. SO emission is seen around the source and the H_2 knotty shocks in the south, tracing shocked emission around them.

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The Production of Magnetically Dominated Star-forming Regions

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We consider the dynamical evolution of an interstellar cloud that is initially in thermal equilibrium in the warm phase and is then subjected to a sudden increase in the pressure of its surroundings. We find that if the initial plasma β of the cloud is of order unity, then there is a considerable period during which the material in the cloud both has a small β and is in the thermally unstable temperature range. These conditions are not only consistent with observations of star-forming regions but also ideally suited to the production of density inhomogeneities by magnetohydrodynamic waves. The end result should be a cloud whose size and average density are typical of Giant Molecular Clouds (GMCs) and that contains denser regions whose densities are in the range inferred for the translucent clumps in GMCs.

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Determining the cosmic ray ionization rate in dynamically evolving clouds

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The ionization fraction is an important factor in determining the chemical and physical evolution of star forming regions. In the dense, dark starless cores of such objects, the ionization rate is dominated by cosmic rays; it is therefore possible to use simple analytic estimators, based on the relative abundances of different molecular tracers, to determine the cosmic ray ionization rate. This paper uses a simple model to investigate the accuracy of two well-known estimators in dynamically evolving molecular clouds. It is found that, although the analytical formulae based on the abundances of H_3^+,H_2,CO,O,H_2O and HCO^+) give a reasonably accurate measure of the cosmic ray ionization rate in static, quiescent clouds, significant discrepancies occur in rapidly evolving (collapsing) clouds. As recent evidence suggests that molecular clouds may consist of complex, dynamically evolving sub-structure, we conclude that simple abundance ratios do not provide reliable estimates of the cosmic ray ionization rate in dynamically active regions.

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Time-dependent MHD shocks and line emission: the case of the DG Tau jet

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The line emission from a growing number of Herbig-Haro jets can be observed and resolved at angular distances smaller than a few arcseconds from the central source. The interpretation of this emission is problematic, since the simplest model of a cooling jet cannot sustain it. It has been suggested that what one actually observes are shocked regions with a filling factor of $\sim 1\%$. In this framework, up to now, comparisons with observations have been based on stationary shock models. Here we introduce for the first time the self-consistent dynamics of such shocks and we show that considering their properties at different times, i.e. locations, we can reproduce observational data of the DG Tau microjet. In particular, we can interpret the spatial behavior of the [SII]6716/6731 and [NII]/[OI]6583/6300 line intensity ratios adopting a set of physical parameters that yield values of mass loss rates and magnetic fields consistent with previous estimates. We also obtain the values of the mean ionization fraction and electron density along the jet and compare these values with those derived from observations using the sulfur doublet to constrain the electron density.

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Gravitational instability in binary protoplanetary discs: new constraints on giant planet formation

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We use high-resolution three-dimensional smoothed particle hydrodynamic (SPH) simulations to study the evolution of self-gravitating binary protoplanetary discs. Heating by shocks and cooling is included. We consider different orbital separations and masses of the discs. Massive discs ($M \sim 0.1 M_\odot$) that fragment in isolation as a result of gravitational instability develop only transient overdensities in binary systems with a separation of about 60 au. This is true even when the cooling time is significantly shorter than the orbital time because efficient heating owing to strong tidally induced spiral shocks dominates. The resulting temperatures, above 200 K, would vaporize water ice in the outer disc, posing a problem even for the other model of giant planet formation, core accretion. Light discs ($M \sim 0.01 M_\odot$) do not

fragment but remain cold because their low self-gravity inhibits strong shocks. Core accretion would not be hampered in them. At separations of about 120 au, tidally induced spiral shocks weaken significantly and fragmentation occurs similarly to isolated systems. If disc instability is the main formation mechanism for giant planets, ongoing surveys targeting binary systems should find considerably fewer planets in systems with separations below 100 au.

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Spitzer/IRAC Photometry of the η Chameleontis Association

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We present IRAC 3.6, 4.5, 5.8 and 8 μm photometry for the 17 A, K and M type members of the η Chameleontis association. These data show infrared excesses toward six of the 15 K and M stars, indicating the presence of circumstellar disks around 40% of the stars with masses of 0.1–1 $M_{\odot}$. The two A-stars show no infrared excesses. The excess emission around one of the stars is comparable to the median excess for classical T Tauri stars in the Taurus association; the remaining five show comparatively weak excess emission. Taking into account published Hα spectroscopy that shows that five of the six stars are accreting, we argue that the disks with weak mid-infrared excesses are disks in which the inner disks have been largely depleted of small grains by grain growth, or, in one case, the small grains have settled to the midplane. This suggests that η Cha has a much higher fraction of disks caught in the act of transitioning into optically thin disks than that measured in younger clusters and associations.

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The Dynamical Evolution of the Short-Period Extrasolar Planet around υ Andromedae in the Pre-Main-Sequence Stage

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We study the dynamical evolution of short-period planets in the multiple planetary system during the epoch of protostellar disk depletion. Through a detailed case analysis for the triple-planet system around υ Andromedae, we identify the necessary condition for the survival of its short-period planet b. In this study, we calculate the planets' orbit evolution including effects of the post-Newtonian potential of the host star, the potential of an evolving disk, and the potential due to the flattening of the star produced by the stellar rotation and the tide from the planet. At its present-day semimajor axis of 0.059 AU, the negligible eccentricity of planet b is most likely damped by the dissipation of the tidal perturbation induced by the star on the planet. But this process also leads to the heating of the planets' interior and probably the inflation of their sizes. If planet b once had an eccentricity greater than 0.1 at its present location, the tidal dissipation process would induce it to overflow its Roche lobe, lose its mass, and undergo an orbital expansion. Using this constraint, we reconstruct the eccentricity evolution of planet b. We find that even if planet b arrives at its present location on a nearly circular orbit, its eccentricity could have been excited by the sweeping secular resonances of two outer planets, c and d, during the disk depletion. In addition to the contribution from the disk potential, the resonant condition is also modified by the precession of planet b due to the post-Newtonian correction and rotational distortion of υ And's gravitational potential. Today, the former effect offsets the secular resonance, whereas the latter effect is weak. But during the depletion of the disk, precession due to the relativistic correction is outpaced by that due to the disk potential. The passage of the sweeping secular resonance near the surface of υ And cannot be avoided unless it had a sufficiently fast spin to provide a flattened shape with a finite quadrupole moment, which dominates the precession of the planet's orbit. Finally, we show that the survival of planet b requires its eccentricity to be low at all times, which would be possible only if the spin period of υ And was shorter than 2

days during the depletion of the disk.

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Anomalous X-ray line ratios in the cTTS TW Hya

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The cTTS TW Hya has been observed with high-resolution X-ray spectrometers. Previously found high densities inferred from He-like f/i triplets strongly suggested the detected X-ray emission to be dominated by an accretion shock. Because of their radiation field dependence He-like f/i ratios do not provide unambiguous density diagnostics. Here we present additional evidence for high densities from ratios of Fe XVII lines. Key Fe XVII line ratios in TW Hya deviate from theoretical expectations at low densities as well as from the same measurements in a large sample of stellar coronae. However, a quantitative assessment of densities is difficult because of atomic physics uncertainties. In addition, estimates of low optical depth in line ratios sensitive to resonance scattering effects also support a high-density emission scenario in the X-ray emitting regions of cTTS.

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The Inability of Ambipolar Diffusion to set a Characteristic Mass Scale in Molecular Clouds

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We investigate the question of whether ambipolar diffusion (ion-neutral drift) determines the smallest length and mass scale on which structure forms in a turbulent molecular cloud. We simulate magnetized turbulence in a mostly neutral, uniformly driven, turbulent medium, using a three-dimensional, two-fluid, magnetohydrodynamics (MHD) code modified from Zeus-MP. We find that substantial structure persists below the ambipolar diffusion scale because of the propagation of compressive slow MHD waves at smaller scales. Contrary to simple scaling arguments, ambipolar diffusion thus does not suppress structure below its characteristic dissipation scale as would be expected for a classical diffusive process. We have found this to be true for the magnetic energy, velocity, and density. Correspondingly, ambipolar diffusion leaves the clump mass spectrum unchanged. Ambipolar diffusion appears unable to set a characteristic scale for gravitational collapse and star formation in turbulent molecular clouds.

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Cloud Structure and Physical Conditions in Star-forming Regions from Optical Observations. II. Analysis

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To complement the optical absorption line survey of diffuse molecular gas in Paper I, we obtained and analyzed far-ultraviolet H_2 and CO data on lines of sight toward stars in Cep OB2 and Cep OB3. Possible correlations between column densities of different species for individual velocity components, not total columns along a line of sight as in the past, were examined and were interpreted in terms of cloud structure. The analysis reveals that there are two kinds of CH in diffuse molecular gas: CN-like CH and CH^+-like CH. Evidence is provided that CO is also associated with CN in diffuse molecular clouds. Different species are distributed according to gas density in the diffuse molecular gas. Both calcium and potassium may be depleted onto grains in high-density gas, but with different dependencies on local gas density. Gas densities for components where CN was detected were inferred from a chemical model. Analysis of cloud structure indicates that our data are generally consistent with the large-scale structure suggested by maps of CO millimeter-wave emission. On small scales, the gas density is seen to vary by factors greater than 5.0 over scales of ∼10,000 AU. The relationships between column densities of CO and CH with that of H_2 along a line of sight show similar slopes for the gas toward Cep OB2 and Cep OB3, but the CO/H_2 and CH/H_2 ratios tend to differ, which we ascribe to variation in average density along the line of sight.

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On the migration-induced resonances in a system of two planets with masses in the Earth mass range

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We investigate orbital resonances expected to arise when a system of two planets, with masses in the range $1 - 4M_\oplus$, undergoes convergent migration while embedded in a section of gaseous disc where the flow is laminar. We consider surface densities corresponding to 0.5-4 times that expected for a minimum mass solar nebula at 5.2 au. For the above mass range, the planets undergo type I migration. Using hydrodynamic simulations, we find that, when the configuration is such that convergent migration occurs, the planets can become locked in a first-order commensurability for which the period ratio is $(p + 1)/p$ with p being an integer and migrate together maintaining it for many orbits. Slow convergent migration results in commensurabilities with small p such as 1 or 2. Instead, when the convergent migration is relatively rapid as tends to occur for disparate masses, higher p commensurabilities are realized such as 4:3, 5:4, 7:6 and 8:7. However, in these cases the dynamics is found to have a stochastic character with some commensurabilities showing long-term instability with the consequence that several can be visited during the course of a simulation. Furthermore, the successful attainment of commensurabilities is also a sensitive function of initial conditions. When the convergent migration is slower, such as occurs in the equal-mass case, lower p commensurabilities such as 3:2 are obtained, which show much greater stability.

Resonant capture leads to a rise in eccentricities that can be predicted using a simple analytic model that assumes the resonance is isolated, constructed in this paper. We find that, once the commensurability has been established, the system with an 8:7 commensurability is fully consistent with this prediction.

We find that very similar behaviour is found when the systems are modelled using an N-body code with simple prescriptions for the disc-planet interaction. Comparisons with the hydrodynamic simulations indicate reasonably good agreement with predictions for these prescriptions obtained using the existing semi-analytic theories of type I migration.

We have run our hydrodynamic simulations for up to $10^3 - 10^4$ orbits of the inner planet. Longer times could only be followed in the simpler N-body approach. Using that, we found that, on the one hand, an 8:7 resonance established in a hydrodynamic simulation could be maintained for more than 10^5 orbits. On the other hand, other similar cases show instability leading to another resonance and ultimately a close scattering.

There is already one known example of a system with nearly equal masses in the range of several Earth masses, namely the two pulsar planets in PSR B1257+12, which are intriguingly, in view of the results obtained here, close to a 3:2

commensurability. This will be considered in a future publication.

Future detection of other systems with masses in the Earth mass range that display orbital commensurabilities will give useful information on the role and nature of orbital migration in planet formation.

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A link between the semimajor axis of extrasolar gas giant planets and stellar metallicity

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The fact that most extrasolar planets found to date are orbiting metal-rich stars lends credence to the core accretion mechanism of gas giant planet formation over its competitor, the disc instability mechanism. However, the core accretion mechanism is not refined to the point of explaining orbital parameters such as the unexpected semimajor axes and eccentricities. We propose a model that correlates the metallicity of the host star with the original semimajor axis of its most massive planet, prior to migration, assuming that the core accretion scenario governs giant gas planet formation. The model predicts that the optimum regions for planetary formation shift inwards as stellar metallicity decreases, providing an explanation for the observed absence of long-period planets in metal-poor stars. We compare our predictions with the available data on extrasolar planets for stars with masses similar to the mass of the Sun. A fitting procedure produces an estimate of what we define as the zero-age planetary orbit (ZAPO) curve as a function of the metallicity of the star. The model hints that the lack of planets circling metal-poor stars may be partly caused by an enhanced destruction probability during the migration process, because the planets lie initially closer to their central star.

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Where Are the M Dwarf Disks Older Than 10 Million Years?

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We present 11.7 μm observations of nine late-type dwarfs obtained at the Keck I 10 m telescope in 2002 December and 2003 April. Our targets were selected for their youth or apparent IRAS 12 μm excess. For all nine sources, excess infrared emission is not detected. We find that stellar wind drag can dominate the circumstellar grain removal and plausibly explain the dearth of M dwarf systems older than 10 Myr with currently detected infrared excesses. We predict that M dwarfs possess fractional infrared excesses on the order of $L_{IR}/L_{\star} \sim 10^{-6}$ and that this may be detectable with future efforts.

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Planets in Triple Star Systems: The Case of HD 188753

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We consider the formation of the recently discovered "hot Jupiter" planet orbiting the primary component of the triple star system HD 188753. Although the current outer orbit of the triple is too tight for a Jupiter-like planet to have formed elsewhere and migrated to its current location, the binary may have been much wider in the past. We assume

here that the planetary system formed in an open star cluster, the dynamical evolution of which subsequently led to changes in the system's orbital parameters and binary configuration. We calculate cross sections for various scenarios that could have led to the multiple system currently observed and conclude that component A of HD 188753 with its planet was most likely formed in isolation, to be swapped into a triple star system by a dynamical encounter in an open star cluster. We estimate that within 500 pc of the Sun, there are about 1200 planetary systems that, like HD 188753, have orbital parameters unfavorable for forming planets but still have a planet, making it quite possible that the HD 188753 system was indeed formed by a dynamical encounter in an open star cluster.

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Turbulence Driven by Outflow-blown Cavities in the Molecular Cloud of NGC 1333

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Outflows from young stellar objects (YSOs) have been identified as a possible source of turbulence in molecular clouds. To investigate the relationship between outflows, cloud dynamics, and turbulence, we compare the kinematics of the molecular gas associated with NGC 1333, traced in ^{13}CO $(1-0)$, with the distribution of YSOs within. We find a velocity dispersion of $\sim 1 - 1.6$ km s^{-1} in ^{13}CO that does not significantly vary across the cloud and is uncorrelated with the number of nearby young stellar outflows identified from optical and submillimeter observations. However, from velocity channel maps we identify about 20 depressions in the ^{13}CO intensity of scales $\geq 0.1 - 0.2$ pc and velocity widths $1 - 3$ km s^{-1}. The depressions exhibit limb-brightened rims in both individual velocity channel maps and position-velocity diagrams, suggesting that they are slowly expanding cavities. We interpret these depressions to be remnants of past YSO outflow activity: if these cavities are presently empty, they would fill in on timescales of $\sim 10^6$ yr. This can exceed the lifetime of a YSO outflow phase or the transit time of the central star through the cavity, explaining the absence of any clear correlation between the cavities and YSO outflows. We find that the momentum and energy deposition associated with the expansion of the cavities is sufficient to power the turbulence in the cloud. In this way we conclude that the cavities are an important intermediate step between the conversion of YSO outflow energy and momentum into cloud turbulent motions.

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Low Mass Pre-Main Sequence stars in the Large Magellanic Cloud - II: HST-WFPC2 observations of two fields in the 30 Doradus region

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As a part of an ongoing effort to characterise the young stellar populations in the Large Magellanic Cloud, we present HST-WFPC2 broad and narrow band imaging of two fields with recent star formation activity in the Tarantula region. A population of objects with Hα and/or Balmer continuum excess was identified. On account of the intense Hα emission (equivalent widths up to several tens of Å), its correlation with the Balmer continuum excess and the stars' location on the HR diagram, we interpret them as low mass ($\sim 1 - 2\ M_\odot$) Pre-Main Sequence stars. In this framework, the data show that coeval high and low mass stars have significantly different spatial distributions, implying that star formation processes for different ranges of stellar masses are rather different and/or require different initial conditions. We find that the overall slope of the mass function of the young population is somewhat steeper than the classical Salpeter value and that the star formation density of this young component is $0.2 - 0.4\ M_\odot$yr^{-1}kpc^{-2}, *i.e.,* intermediate between the value for an active spiral disk and that of a starburst region. The uncertainties associated with the determination of the slope of the mass function and the star formation density are thoroughly discussed.

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Variable accretion and outflow in young brown dwarfs

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We report on the first dedicated monitoring campaign of spectroscopic variability in young brown dwarfs. High-resolution optical spectra of six targets in nearby star-forming regions were obtained over 11 nights between 2005 January-March on the Magellan 6.5m telescope. We find significant variability in Hα and a number of other emission lines related to accretion and outflow processes on a variety of timescales ranging from hours to weeks to years. The most dramatic changes are seen for 2MASS J1207334-393254 (2M1207), 2MASS J11013205-7718249 (2M1101) and ChaI-ISO217. We observe possible accretion rate changes by about an order of magnitude in two of these objects, over timescales of weeks (2M1207) or hours (2M1101). The accretion 'burst' seen in 2M1101 could be due to a 'clumpy' flow. We also see indications for changes in the outflow rate in at least three objects. In one case (ISO217), there appears to be a ~1-hour time lag between outflow and accretion variations, consistent with a scenario in which the wind originates from the inner disk edge. For some objects there is evidence for emission line variability induced by rotation. Our variability study supports a close to edge-on inclination for the brown dwarf LS-RCrA 1. The fact that all targets in our sample show variations in accretion and/or outflow indicators suggests that studies of young brown dwarf properties should be based either on large samples or time series. As an example, we demonstrate that the large scatter in the recently found accretion rate vs. mass relationship can be explained primarily with variability. The observed profile variations imply asymmetric accretion flows in brown dwarfs, which, in turn, is evidence for magnetic funneling by large-scale fields. We show that accreting sub-stellar objects may harbor magnetic fields with ~kG strength.

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Formation and Evolution of Planetary Systems: Cold Outer Disks Associated with Sun-like Stars

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We present the discovery of debris systems around three Sun-like stars based on observations performed with the *Spitzer Space Telescope* as part of a Legacy Science Program, "The Formation and Evolution of Planetary Systems" (FEPS). We also confirm the presence of debris around two other stars. All the stars exhibit infrared emission in excess of the expected photospheres in the 70 μm band but are consistent with photospheric emission at $\leq 33\mu$m. This restricts the maximum temperature of debris in equilibrium with the stellar radiation to $T < 70$ K. We find that these sources are relatively old in the FEPS sample, in the age range 0.7-3 Gyr. On the basis of models of the spectral energy distributions, we suggest that these debris systems represent materials generated by collisions of planetesimal belts. We speculate on the nature of these systems through comparisons to our own Kuiper Belt, and on the possible presence of planet(s) responsible for stirring the system and ultimately releasing dust through collisions. We further report observations of a nearby star HD 13974 ($d = 11$ pc) that are indistinguishable from a bare photosphere at both 24 and 70 μm. The observations place strong upper limits on the presence of any cold dust in this nearby system ($L_{IR}/L_\star < 10^{-5.2}$).

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Formation and Evolution of Planetary Systems (FEPS): Primordial Warm Dust Evolution from 3-30 Myr around Sun-like Stars

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We present data obtained with the Infrared Array Camera (IRAC) aboard the *Spitzer Space Telescope* (*Spitzer*) for a sample of 74 young ($t < 30$ Myr old) Sun-like (0.7 <M_{star}/M_{Sun} <1.5) stars. These are a sub-set of the observations that comprise the Spitzer Legacy science program entitled the *Formation and Evolution of Planetary Systems* (FEPS). Using IRAC we study the fraction of young stars that exhibit 3.6-8.0μm infrared emission in excess of that expected from the stellar photosphere, as a function of age from 3-30 Myr. The most straightforward interpretation of such excess emission is the presence of hot (300-1000K) dust in the inner regions (< 3 AU) of a circumstellar disk. Five out of the 74 young stars show a strong infrared excess, four of which have estimated ages of 3-10 Myr. While we detect excesses from 5 optically thick disks, and photospheric emission from the remainder of our sample, we do not detect any excess emission from *optically thin disks* at these wavelengths. We compare our results with accretion disk fractions detected in previous studies, and use the ensemble results to place additional constraints on the dissipation timescales for optically-thick, primordial disks.

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http://feps.as.arizona.edu/pub_presentations/silverstone_IRACyoung.pdf

Two-dimensional Monte Carlo simulations of H I line formation in massive young stellar object disc winds

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Massive young stellar objects (YSOs) are powerful infrared H I line emitters. It has been suggested that these lines form in an outflow from a disc surrounding the YSO. Here, new two-dimensional Monte Carlo radiative transfer calculations are described which test this hypothesis. Infrared spectra are synthesized for a YSO disc wind model based on earlier hydrodynamical calculations. The model spectra are in qualitative agreement with the observed spectra from massive YSOs, and therefore provide support for a disc wind explanation for the H I lines. However, there are some significant differences: the models tend to overpredict the Brα/Brγ ratio of equivalent widths and produce line profiles which are slightly too broad and, in contrast to typical observations, are double-peaked. The interpretation of these differences within the context of the disc wind picture and suggestions for their resolution via modifications to the assumed disc and outflow structure are discussed.

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An unbiased search for the signatures of protostars in the rho Ophiuchi Molecular Cloud II. Millimetre continuum observations

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The dense cores which conceive and cradle young stars can be explored through continuum emission from associated dust grains. We have performed a wide field survey for dust sources at 1.2 millimetres in the ρ Ophiuchi molecular cloud, covering more than 1 square degree in an unbiased fashion. We detect a number of previously unknown sources, ranging from extended cores over compact, starless cores to envelopes surrounding young stellar objects of Class 0, Class I, and Class II type. We analyse the mass distribution, spatial distribution and the potential equilibrium of the cores. For the inner regions, the survey results are consistent with the findings of previous narrower surveys. The core mass function resembles the stellar initial mass function, with the core mass function shifted by a factor of two to higher masses (for the chosen opacity and temperature). In addition, we find no statistical variation in the core mass function between the crowded inner regions and those in more isolated fields except for the absence of the most massive cores in the extended cloud. The inner region contains compacter cores. This is interpreted as due to a medium of higher mean pressure although strong pressure variations are evident in each region. The cores display a hierarchical spatial distribution with no preferred separation scale length. However, the frequency distribution of nearest neighbours displays two peaks, one of which at 5000 AU can be the result of core fragmentation. The orientations of the major axes of cores are consistent with an isotropic distribution. In contrast, the relative orientations of core pairs are preferentially in the NW-SE direction on all separation scales. These results are consistent with core production and evolution in a turbulent environment. Finally, we report the discovery of a new, low-mass Class 0 object candidate and its CO outflow.

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www.ifa.hawaii.edu/users/stanke/preprints.html

The stability of the terrestrial planets with a more massive 'Earth'

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Although the long-term numerical integrations of planetary orbits indicate that our planetary system is dynamically stable at least $\pm$4 Gyr, the dynamics of our Solar system includes both chaotic and stable motions: the large planets

exhibit remarkable stability on gigayear time-scales, while the subsystem of the terrestrial planets is weakly chaotic with a maximum Lyapunov exponent reaching the value of 1/5 Myr^{-1}. In this paper the dynamics of the Sun-Venus-Earth-Mars-Jupiter-Saturn model is studied, where the mass of Earth was magnified via a mass factor κ_E. The resulting systems dominated by a massive Earth may serve also as models for exoplanetary systems that are similar to ours. This work is a continuation of our previous study, where the same model was used and the masses of the inner planets were uniformly magnified. That model was found to be substantially stable against the mass growth. Our simulations were undertaken for more than 100 different values of κ_E for a time of 20 Myr, and in some cases for 100 Myr. A major result was the appearance of an instability window at $\kappa_E \approx 5$, where Mars escaped. This new result has important implications for theories of the planetary system formation process and mechanism. It is shown that with increasing κ_E the system splits into two, well-separated subsystems: one consists of the inner planets, and the other consists of the outer planets. According to the results, the model becomes more stable as κ_E increases and only when $\kappa_E \geq 540$ does Mars escape, on a Myr time-scale. We found an interesting protection mechanism for Venus. These results give insights also into the stability of the habitable zone of exoplanetary systems, which harbour planets with relatively small eccentricities and inclinations.

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Moving shadows on the dusty disks of young stars

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We investigate the formation of moving shadows on the circumbinary (CB) disk of young binary systems. Moving shadows can be created by a dusty disk wind of the secondary component. The densest parts of the dusty disk wind and the associated common envelope can be optically thick and may block the stellar radiation inside a certain solid angle, resulting in the appearance of a moving shadow zone. Its shape and size depends on the mass loss rate, the disk wind velocity, and optical properties of the dust. Our calculations show that the shadow zone is observable if the mass loss rate $\dot{M}_w$ is greater than $10^{-9} M_\odot$ per year. This shadow resembles a clock hand. If the orbit is an elliptical, the properties of this clock hand will change during the orbital motion of the secondary.

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A 'dry' condensation origin for circumstellar carbonates

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The signature of carbonate minerals has long been suspected in the mid-infrared spectra of various astrophysical environments such as protostars. Abiogenic carbonates are considered as indicators of aqueous mineral alteration in the presence of CO_2-rich liquid water. The recent claimed detection of calcite associated with amorphous silicates in two planetary nebulae and protostars devoid of planetary bodies questions the relevance of this indicator; but in the absence of an alternative mode of formation under circumstellar conditions, this detection remains controversial. The main dust component observed in circumstellar envelopes is amorphous silicates, which are thought to have formed by non-equilibrium condensation. Here we report experiments demonstrating that carbonates can be formed with amorphous silicates during the non-equilibrium condensation of a silicate gas in a H_2O-CO_2-rich vapour. We propose that the observed astrophysical carbonates have condensed in H_2O(g)-CO_2(g)-rich, high-temperature and high-density regions such as evolved stellar winds, or those induced by grain sputtering upon shocks in protostellar outflows.

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Very Large Array Simultaneous 1.3 cm Continuum and H_2O Maser Observations Toward IRAS 20126+4104

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We have observed simultaneously the 1.3 cm continuum and H_2O maser emission toward the high-mass protostar IRAS 20126+4104 with the Very Large Array (VLA) in its A configuration, providing an angular resolution of $\simeq$ 0.1". We have detected an unresolved continuum source [I20126N(1.3 cm)] nearly coinciding with the strongest peak of the northern double continuum source previously detected at 3.6 cm in the field and suggested to be a radio jet. In addition, we have detected 29 water maser spots, 21 of which are tightly grouped in a cluster of $\simeq$ 0.1" size displaced $\simeq$ 0.07" ($\simeq$120 AU) northwest of I20126N(1.3 cm). The relative positions of the masers with respect to I20126N(1.3 cm) have been established with 10 mas of accuracy. The overall spatial distribution and line-of-sight velocity components of the water maser spots associated with I20126N(1.3 cm) are fully consistent with those previously found by Moscadelli and collaborators through VLBI measurements and interpreted as tracing a conical outflow, with the powering source (suggested to be traced by a one-sided radio continuum jet) located at the cone vertex. Within this very reasonable scenario, our observations would indicate that the source I20126N(1.3 cm) is showing the position of the high-mass protostar. Analyzing the spatiokinematic distribution of the VLA water masers, we propose that their motions also show, in addition to proper motions on the order of 100 km s^{-1} seen in the plane of the sky, a component of rotation with velocities on the order of 20 km s^{-1}. The water masers seem then to be both rotating (as evidenced from their radial velocities) and changing their position in the plane of the sky (from the proper motions). Within this scenario, some of the water maser spots could be within a rotating circumstellar disk of $\simeq$170 AU size around a protostar of $\simeq 20M_\odot$ if it is located at the center of the water maser cluster rather than located at the position of I20126N(1.3 cm). Then, I20126N(1.3 cm) would trace one of the two peaks of a two-sided thermal jet, with the high-mass protostar located in between. We think that simultaneous high angular resolution and sensitive multifrequency (from centimeter to submillimeter wavelengths) observations are the key studies to knowing both the nature of the continuum emission (one- or two-sided jet?) and the location of the high-mass protostar, which is very relevant for modeling this important object.

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Turbulent Mixing in the Outer Solar Nebula

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The effects of turbulence on the mixing of gases and dust in the outer Solar nebula are examined using 3-D MHD calculations in the shearing-box approximation with vertical stratification. The turbulence is driven by the magneto-rotational instability. The magnetic and hydrodynamic stresses in the turbulence correspond to an accretion time at the midplane about equal to the lifetimes of T Tauri disks, while accretion in the surface layers is thirty times faster. The mixing resulting from the turbulence is also fastest in the surface layers. The mixing rate is similar to the rate of radial exchange of orbital angular momentum, so that the Schmidt number is near unity. The vertical spreading of a trace species is well-matched by solutions of a damped wave equation when the flow is horizontally-averaged. The damped wave description can be used to inexpensively treat mixing in 1-D chemical models. However, even in calculations reaching a statistical steady state, the concentration at any given time varies substantially over horizontal planes, due to fluctuations in the rate and direction of the transport. In addition to mixing species that are formed under widely varying conditions, the turbulence intermittently forces the nebula away from local chemical equilibrium. The different transport rates in the surface layers and interior may affect estimates of the grain evolution and molecular abundances during the formation of the Solar system.

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Mid-infrared imaging of a young bipolar nebula in the S287 molecular cloud

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We present diffraction-limited images in the 11.3 μm PAH band and in the continuum at 11.9 μm of the S287B star forming region obtained with the newly commissioned mid-infrared imager/spectrometer VISIR at the VLT. In both filters five point-like sources are detected, of which at least one has a spectral energy distribution reminiscent of a Lada Class I source. We also report on the discovery of a new Herbig Ae star in this region. It is particularly striking that the brightest mid-infrared source in this region has not been detected at shorter wavelengths; it is a good candidate to be the driving source of the bipolar molecular outflow and optical reflection nebulosity previously reported in S287B.

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Water in the envelopes and disks around young high-mass stars

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Single-dish spectra and interferometric maps of (sub-)millimeter lines of $H_2^{18}O$ and HDO are used to study the chemistry of water in eight regions of high-mass star formation. The spectra indicate HDO excitation temperatures of $\sim$110 K and column densities in an 11″ beam of $\sim 2\times10^{14}$ cm^{-2} for HDO and $\sim 2\times10^{17}$ cm^{-2} for H_2O, with the $N(\mathrm{HDO})/N(\mathrm{H_2O})$ ratio increasing with decreasing temperature. Simultaneous observations of CH_3OH and SO_2 indicate that 20 – 50% of the single-dish line flux arises in the molecular outflows of these objects. The outflow contribution to the $H_2^{18}O$ and HDO emission is estimated to be 10 – 20%. Radiative transfer models indicate that the water abundance is low ($\sim 10^{-6}$) outside a critical radius corresponding to a temperature in the protostellar envelope of $\approx$100 K, and 'jumps' to $H_2O/H_2 \sim 10^{-4}$ inside this radius. This value corresponds to the observed abundance of solid water and together with the derived HDO/H_2O abundance ratios of $\sim 10^{-3}$ suggests that the origin of the observed water is evaporation of grain mantles. This idea is confirmed in the case of AFGL 2591 by interferometer observations of the HDO 1_{10}–1_{11}, $H_2^{18}O$ 3_{13}–2_{20} and SO_2 $12_{0,12}$–$11_{1,11}$ lines, which reveal compact (Ø∼800 AU) emission with a systematic velocity gradient. This size is similar to that of the 1.3 mm continuum towards AFGL 2591, from which we estimate a mass of ≈0.8 $M_\odot$, or ∼5% of the mass of the central star. We speculate that we may be observing a circumstellar disk in an almost face-on orientation.

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ESO-VLT and Spitzer spectroscopy of IRAS 05328−6827: a massive young stellar object in the Large Magellanic Cloud

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We present the first thermal-infrared spectra of an extra-galactic Young Stellar Object (YSO), IRAS 05328−6827 in the H II region LHA 120-N 148 in the Large Magellanic Cloud. The observed and modelled spectral energy distribution reveals a massive YSO, $M \sim 20$ $M_\odot$, which is heavily-embedded and probably still accreting. The reduced dust content as a consequence of the lower metallicity of the LMC allows a unique view into this object, and together with a high C/O ratio may be responsible for the observed low abundance of water ice and relatively high abundances of methanol and CO_2 ices.

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Post-outburst radio observation of the region around McNeil's nebula (V1647 Ori)

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We present post-outburst (∼ 100 days after outburst) radio continuum observation of the region ($\sim 30' \times 30'$) around McNeil's nebula (V1647 Orionis). The observations were carried out using the Giant Metrewave Radio Telescope (GMRT), India, at 1272 MHz on 2004 Feb 14.5 UT. Although 8 sources have been detected within a circular diameter of 25′ centred on V1647 Ori, we did not detect any radio continuum emission from McNeil's nebula. We assign a 5σ upper limit of 0.15 mJy/beam for V1647 Ori where the beam size is $5.6'' \times 2.7''$. Even at higher frequencies of 4.9 and 8.5 GHz (VLA archival data), no radio emission has been detected from this region. Three scenarios namely emission from a homogeneous HII region, ionised stellar wind and shock-ionised gas, are explored in the light of our GMRT upper-limit. For the case of a homogeneous HII region, the radius of the emitting region is constrained to be ≤ 26 AU corresponding to a temperature $\geq 2,500$ K, which is consistent with the reported radio and Hα emission. In the ionised stellar wind picture, our upper limit of radio emission translates to $\dot{M}/v_\infty < 1.2 - 1.8 \times 10^{-10} M_\odot yr^{-1} km^{-1} s$. On the other hand, if the stellar wind shocks the dense neutral (molecular) cloud, the radio upper limit implies that

the fraction of the wind encountering the dense obstacle is $< 50\%$. Based on a recent measurement of X-ray outburst and later monitoring, the expected radio emission has been estimated. Using our radio limit, the radius (≤ 36 AU) and electron density ($\geq 7.2 \times 10^7$ cm^{-3}) of the radio emitting plasma have been constrained using a two phase medium in pressure equilibrium for a volume filling factor of 0.9.

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The paper is available as an Astro-ph preprint at
`http://arxiv.org/abs/astro-ph/0510458`

Discovery of the pre-main sequence progenitors of the magnetic Ap/Bp stars?

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We report the discovery, using FORS1 at the ESO-VLT and ESPaDOnS at the CFHT, of magnetic fields in the young A-type stars HD 101412, V380 Ori and HD 72106A. Two of these stars (HD 101412 and V380 Ori) are pre-main sequence Herbig Ae/Be (HAeBe) stars, while one (HD 72106A) is physically associated with a HAeBe star. Remarkably, evidence of surface abundance spots is detected in the spectra of HD 72106A. The magnetic fields of these objects display intensities of order 1 kG at the photospheric level, are ordered on global scales, and appear in approximately 10% of the stars studied. Based on these properties, the detected stars may well represent pre-main sequence progenitors of the magnetic Ap/Bp stars. The low masses inferred for these objects (2.6, 2.8 and 2.4 $M_\odot$) represent additional contradictions to the hypothesis of Hubrig et al. (2000, ApJ, 539, 352), who claim that magnetic fields appear in intermediate-mass stars only after 30% of their main sequence evolution is complete. Finally, we fail to confirm claims by Hubrig et al. (2004, A&A, 428, L1) of magnetic fields in the Herbig Ae star HD 139614.

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The maximum stellar mass, star-cluster formation and composite stellar populations

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We demonstrate that the mass of the most massive star in a cluster correlates non-trivially with the cluster mass. A simple algorithm according to which a cluster is filled up with stars that are chosen randomly from the standard IMF but sorted with increasing mass yields an excellent description of the observational data. Algorithms based on random sampling from the IMF without sorted adding are ruled out with a confidence larger than 0.9999. A physical explanation of this would be that a cluster forms by more-massive stars being consecutively added until the resulting feedback energy suffices to revert cloud contraction and stops further star formation. This has important implications for composite populations. For example, 10^4 clusters of mass $10^2\,M_\odot$ will not produce the same IMF as one cluster with a mass of $10^6\,M_\odot$. It also supports the notion that the integrated galaxial IMF (IGIMF) should be steeper than the stellar IMF and that it should vary with the star-formation rate of a galaxy.

Accepted by MNRAS

http://arxiv.org/abs/astro-ph/0511331 http://www.astro.uni-bonn.de/~cweidner/0511331.pdf

Bispectrum speckle interferometry of the massive protostellar outflow source IRAS 23151+5912

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We present bispectrum speckle interferometry of the massive protostellar object IRAS 23151+5912 in the near-infrared K' band. The reconstructed image shows the diffuse nebulosity north-east of two point-like sources in unprecedented detail. The comparison of our near-infrared image with mm continuum and CO molecular line maps shows that the brighter of the two point sources lies near the center of the mm peak, indicating that it is a high-mass protostar. The nebulosity coincides with the blue-shifted molecular outflow component. The most prominent feature in the nebulosity is a bow-shock-like arc. We assume that this feature is associated with a precessing jet which has created an inward-pointed cone in the swept-up material. We present numerical jet simulations that reproduce this and several other features observed in our speckle image of the nebulosity. Our data also reveal a linear structure connecting the central point source to the extended diffuse nebulosity. This feature may represent the innermost part of a jet that drives the strong molecular outflow (PA $\sim$ 80 deg) from IRAS 23151+5912. With the aid of radiative transfer calculations, we demonstrate that, in general, the observed inner structures of the circumstellar material surrounding high-mass stars are strongly influenced by the orientation and symmetry of the bipolar cavity.

Accepted by Astronomy & Astrophysics

http://www.mpifr-bonn.mpg.de/staff/tpreibis/iras23151.html

Cooling of the Earth and core formation after the giant impact

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Kelvin calculated the age of the Earth to be about 24 million years by assuming conductive cooling from being fully molten to its current state. Although simplistic, his result is interesting in the context of the dramatic cooling that took place after the putative Moon-forming giant impact, which contributed the final 10 per cent of the Earth's mass. The rate of accretion and core segregation on Earth as deduced from the U-Pb system is much slower than that obtained from Hf-W systematics, and implies substantial accretion after the Moon-forming impact, which occurred 45 ± 5 Myr after the beginning of the Solar System. Here we propose an explanation for the two timescales. We suggest that the Hf-W timescale reflects the principal phase of core-formation before the giant impact. Crystallization of silicate perovskite in the lower mantle during this phase produced Fe^{3+}, which was released during the giant impact, and this oxidation resulted in late segregation of sulphur-rich metal into which Pb dissolved readily, setting the younger U-Pb age of the Earth. Separation of the latter metal then occurred 30 ± 10 Myr after the Moon-forming impact. Over this time span, in surprising agreement with Kelvin's result, the Earth cooled by about 4,000 K in returning from a fully molten to a partially crystalline state.

Published by Nature (Vol. 437, p. 1345)

Growth of planetesimals by impacts at ∼25 m/s

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We study central collisions between millimeter-sized dust projectiles and centimeter-sized dust targets in impact experiments. Target and projectile are dust aggregates consisting of micrometer-sized SiO_2 particles. Collision velocities range up to 25 m/s. The general outcome of a collision strongly depends on the impact velocity. For collisions below 13 m/s rebound and a small degree of fragmentation occur. However, at higher collision velocities up to 25 m/s approximately 50% of the mass of the projectile rigidly sticks to the target after the collision. Thus, net growth of a body is possible in high speed collisions. This supports the idea that planetesimal formation via collisional growth is a viable mechanism at higher impact velocities. Within our set of parameters the experiments even suggest that higher impact velocities might be preferable for growth in collisions between dusty bodies. For the highest impact velocities most of the ejecta is within small dust aggregates about 500 μm in size. In detail the size distribution of ejected dust aggregates is flat for very small particles smaller than 500 μm and follows a power law for larger ejected dust aggregates with a power of -5.6 ± 0.2. There is a sharp upper cut-off at about 1 mm in size with only a few particles being slightly larger. The ejection angle is smaller than 3^o with respect to the target surface. These fast ejecta move with $40 \pm 10\%$ of the impact velocity.

Published by Icarus (Vol. 178, p. 253)

Dust in Resonant Extrasolar Kuiper Belts — Grain Size and Wavelength Dependence of Disk Structure

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This paper considers the distribution of dust which originates in the break-up of planetesimals that are trapped in resonance with a planet. The effect of radiation pressure on small dust grains causes their orbits and so their spatial distribution to be significantly different to that of the parent planetesimals which previous work has shown to be clumpy. It is shown that there are three distinct grain populations: **(I)** large grains (> a few mm) have the same clumpy resonant distribution as the planetesimals; **(II)** moderate sized grains (a few μm to a few mm) are no longer in resonance and have an axisymmetric distribution; **(III)** small grains (< a few μm) are blown out of the system by radiation pressure immediately on creation and so have a density distribution which falls off as $\tau \propto 1/r$, however the structure of these grains can be further divided into two subclasses: **(IIIa)** grains produced in the destruction of population I grains that exhibit trailing spiral structure which emanates from the resonant clumps; and **(IIIb)** grains produced from population II grains that have an axisymmetric distribution. Since observations in different wavebands are sensitive to different sized dust grains, multi-wavelength imaging of debris disks provides a valuable observational test of models which explain structure seen in sub-mm observations as due to resonant trapping of planetesimals. For example, a disk with a collisional cascade dust size distribution with no blow-out grains would appear clumpy in the sub-mm (which samples population I grains), and smooth at mid- to far-IR wavelengths (which sample population II grains). The wavelength of transition from clumpy to smooth structure is indicative of the mass of the perturbing planet. The size distribution of Vega's disk is modeled in the light of the recent Spitzer observations showing that collisions with the large quantities of population III grains seen in the mid- to far-IR may be responsible for the low levels of population II grains in this system. The origin of these population III grains must be in the destruction of the grains seen in the sub-mm images, and so at high resolution and sensitivity the far-IR and mid-IR structure of the Vega disk is predicted to include spiral structure emanating from the sub-mm clumps. Such structure could be detected with MIRI on the JWST and, if so, would confirm the presence of a planet at 65 AU in the Vega disk as well as determine the direction of its orbit.

Accepted by ApJ

http://arxiv.org/abs/astro-ph/0511219

Abstracts of recently accepted major reviews

Planet formation and migration

John C. B. Papaloizou[1,2] **and Caroline Terquem**[3,4,5]

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[3] Institut d'Astrophysique de Paris, UMR7095 CNRS, Université Pierre & Marie Curie–Paris 6, 98bis boulevard Arago, 75014 Paris, France
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[5] Institut Universitaire de France

E-mail contact: terquem@iap.fr

We review the observations of extrasolar planets, ongoing developments in theories of planet formation, orbital migration, and the evolution of multiplanet systems.

Accepted by Reports on Progress in Physics

http://arXiv.org/abs/astro-ph/0510487

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals, not reviews nor conference notes), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star formation and interstellar medium community), *New Books* (giving details of books relevant for the same community), *New Jobs* (advertising jobs specifically aimed towards persons within our specialty), and *Short Announcements* (where you can inform or request information from the community).

Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter.

The Star Formation Newsletter is available on the World Wide Web at http://www.ifa.hawaii.edu/~reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .

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Dissertation Abstracts

Photoevaporation of circumstellar discs

Richard Alexander

Thesis work conducted at: Institute of Astronomy, University of Cambridge, UK

Current address: JILA, 440 UCB, University of Colorado, Boulder, CO 80309-0440, USA

Electronic mail: rda@jilau1.colorado.edu

Ph.D dissertation directed by: Cathie Clarke

Ph.D degree awarded: October 2005

In this thesis I investigate how discs around young stars, such as T Tauri stars (TTs), evolve. I concentrate on models which combine photoevaporation by ionizing radiation with viscous evolution of the disc, as previous work suggests that such models can reproduce the rapid disc dispersal seen in observations of TTs. However these models require that TTs produce a rather large ionizing flux (of order 10^{41} ionizing photons per second), and it is not clear if TTs can produce such a large flux.

I first consider the ionizing flux resulting from the accretion of disc material on to the stellar surface. Previous models have treated the accretion shock as a hotspot on the stellar surface, and found that the ionizing flux produced has a significant effect on the evolution of the disc. However I show that absorption of ionizing radiation by neutral hydrogen in the stellar atmosphere reduces the ionizing flux significantly. I then use radiative transfer modelling to show that absorption by neutral hydrogen in the accretion column results in huge attenuation of the ionizing flux, to a level much too low to influence the disc evolution. Consequently I conclude that the ionizing flux produced by accretion does not have a significant effect on disc evolution.

My next chapter considers whether or not TT chromospheres can provide sufficiently large ionizing fluxes. I use an emission measure analysis, using data taken from the literature, to show that classical T Tauri stars can produce chromospheric ionizing fluxes in the range $\sim 10^{41}$–10^{43}s^{-1}. I suggest that the He II:C IV ultraviolet line ratio can be used as a diagnostic of the ionizing flux emitted by TTs. I analyse the behaviour of this line ratio in a much larger sample of TTs, and find no evidence for evolution of the ionizing flux as TTs evolve. Therefore I conclude that TT chromospheres can provide ionizing fluxes sufficient to drive disc photoevaporation.

I then consider the effect of X-rays on disc evolution. TTs are known to be strong X-rays sources, with X-ray luminosities comparable to the ionizing luminosities required by existing photoevaporation models. I use radiative transfer modelling, combined with a simple hydrostatic disc model, to study the effects of X-rays on the disc. The X-rays heat the disc, producing a warm ($\sim$ 5000K) layer above the cold disc midplane. However this attenuates the X-rays significantly, and I find that most of the X-rays are absorbed close to the star. Consequently the disc wind that can be driven by X-ray absorption at large radii has a rather low mass-loss rate, and will not influence disc evolution significantly.

Having thus shown that TTs produce ionizing fluxes which have a significant effect on disc evolution, I then apply this result to models of disc evolution. I first set up a simple disc model and show that a basic photoevaporation model breaks down at late times in the evolution (as the geometry of the radiative transfer problem changes). I construct hydrodynamic models of the wind produced by direct ionization of the outer part of TT discs, and show that this wind dominates the evolution at late times. I then incorporate this wind into the disc evolution model, and show that my model is consistent with current observational data. To date this is the only model which has successfully reproduced the rapid disc dispersal seen in observations of TTs, and this has important consequences for theories of disc evolution and planet formation. Finally I suggest several observational tests of the model, which will hopefully be addressed in the near future.

Spectral Energy Distributions of Embedded Protostars and Dusty Galaxies

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Ph.D dissertation directed by: Christopher F. McKee

Ph.D degree awarded: September 2005

We present analytic radiative transfer solutions for the dust continuum spectra of embedded protostars and dust-enshrouded galaxies. We develop an analytic methodology for spherically symmetric, homogeneous, centrally heated, dusty sources. We find that the dust thermal spectrum possesses scaling relations that provide a natural classification for a broad range of sources, from low-mass protostars to dusty galaxies. In particular, we find that, given our assumptions, spectral energy distributions (SEDs) can be characterized by two distance-independent parameters, the luminosity-to-mass ratio, L/M, and the surface density, Σ, for a set of two functions, namely, the density profile and the opacity curve. The functionality of our model is unique in that it provides for a self-consistent analytic solution that we have validated by comparison with a well-tested radiative transfer code (DUSTY) to find excellent agreement with numerical results over a parameter space that spans low-mass protostars to ultra-luminous infrared galaxies (ULIRGS).

We apply this methodology to infer the physical conditions of a diverse range of astrophysical sources. For protostars, we use inside-out collapse solutions for isothermal and nonisothermal equations of state to infer the accretion rates of low, intermediate, and massive protostars. We verify our approach by comparing our results for the source and evolutionary parameters for well-studied low-mass Class 0 protostars. We find that accretion rates of massive protostars inferred from the spectrum allow massive stars to form in 10^5 years within the context of the Turbulent Core Model developed by McKee & Tan (2003), thereby providing observational corroboration for their model of massive star formation. For ultra-luminous infrared galaxies (ULIRGs), we show that the millimeter to far-infrared SEDs can be well fit using the standard dust opacity index of 2 when self-consistent radiative transfer solutions are employed, indicating that the cold dust in ULIRGs can be described by a single grain model. Our approach obviates the need to use SED templates in the millimeter to far-infrared region of the spectrum; this is a common practice in the extragalactic community that relies on observed correlations established at low redshift that may not necessarily extend to high redshift.

We extend our solution to include an inhomogeneous distribution of dust. We show that the shape of the SED emitted by a clumpy envelope differs from that of a homogeneous envelope through one parameter, which is proportional to the optical depth of the clumps. We apply this generalized methodology to fit the millimeter to mid-infrared SEDs of massive protostars and well-studied ULIRGs. Our analytic solution fits the high-frequency data (up to mid-infrared wavelengths) at a level comparable to recent numerical work, suggesting that the mid-infrared emission of massive protostars and dusty galaxies could be strongly influenced by the clumpiness of the dust.

Star and Planet Formation Postdoc at NOAO

The National Optical Astronomy Observatory (NOAO) invites applications for a postdoctoral research associate to work with Joan Najita on the study of planet formation environments. Applicants with theoretical experience in astrochemistry and/or an observational background in infrared spectroscopy are particularly encouraged to apply. The specific responsibilities of the position are flexible depending on the interests and background of the postdoc. Possible responsibilities include the development of thermal-chemical models for gaseous disk atmospheres, and the reduction and analysis of ground-based (Keck, Gemini) and space-based (Spitzer/IRS) spectroscopy of young planet-forming disks.

The postdoc, while holding an appointment at NOAO, will also be a member of LAPLACE (Life And PLanets Astrobiology CEnter), a partnership between the University of Arizona and NOAO, and a node of NASA's Astrobiology Institute. The research interests of current LAPLACE members include solar-stellar astrophysics, star and planet formation, the detection and characterization of extra-solar planetary systems, and the emergence and evolution of life in the Universe. LAPLACE has created an exciting interdisciplinary atmosphere with many opportunities for interaction among Center members (see http://www.laplace.arizona.edu).

Applicants should have obtained by the starting date a Ph.D. in astronomy or a related field. The appointment is for an initial period of 2 years with the possibility of an extension to additional years. Interested applicants are asked to submit by January 6, 2006 a CV, list of publications, and a statement of current and future research interests and arrange to have three letters of reference sent. Materials may be sent electronically (preferred) or by mail to:

Human Resources Manager
National Optical Astronomy Observatory
Attn: Job #755-Postdoctoral Research Associate in Star and Planet Formation
PO Box 26732
Tucson, AZ 85726-6732
email: hrnoao@noao.edu
FAX: 520-318-8456

Questions regarding this position are welcome and may be directed to Joan Najita at 520-318-8416 or najita@noao.edu

NOAO is an equal opportunity and affirmative action employer. We value and foster a diverse research environment. Women and underrepresented minorities are particularly encouraged to apply.

Postdoctoral Fellowship with the Submillimeter Array

The University of Hawaii Institute for Astronomy (IfA) invites applications for a postdoctoral fellowship in the area of submillimeter astronomy beginning in, or before, the fall of 2006. Fellowships are for a period of two years, with the possibility of a one year extension. The successful applicant will be based at the IfA in Honolulu and will be expected to carry out research with the Submillimeter Array (SMA), an 8-element interferometer operating from 230 to 690 GHz located close to the 4,000 m summit of Mauna Kea.

The SMA fellow will enjoy all the privileges of an IfA staff member, including the opportunity to apply for time on the other telescopes on Mauna Kea and Haleakala. The salary will be approximately $52,800 with a research budget of $10,000. Funds are also provided for health benefits and relocation expenses.

Applicants must have a recent Ph.D. in astronomy or a related field by the time they begin the fellowship. Preference will be given to applicants with experience in millimeter or submillimeter wavelength astronomy and interferometry and who can contribute to the research activities and facilitate interactions with other scientists within the Institute. Current SMA programs at the IfA are in the fields of star and planet formation, and ultra-luminous galaxies.

Applications should be made through the Research Corporation of the University of Hawaii at www.rcuh.com. Click on "Employment", navigate to "Job Announcements", and enter the job reference number 25634. Please attach a resume and statement of research interests in step 3 of the application process.

Applications and 3 reference letters (sent directly to the IfA) should be received by January 13, 2006. For additional information please contact Jonathan Williams at jpw@ifa.hawaii.edu or at (808) 956-8355.

Post-doctoral Researchers in Star or Planet Formation

The University of Exeter intends to appoint one or two post-doctoral researchers in the fields of star formation or planet formation, to work with Matthew Bate in the astrophysics group. Applicants should have a strong record of publication in astrophysical hydrodynamical, magnetohydrodynamical and/or radiative transfer numerical simulations. The group's work focuses on both theoretical and observational star and planet formation. Our research was rated excellent in the last UK Research Assessment Exercise. The successful applicant(s) would be expected to make use of UK supercomputer facilities, including the UK Astrophysical Fluids Facility (UKAFF) and the supercomputer Exeter plans to purchase in 2006.

The successful applicant(s) will have an appropriate first degree and a PhD (or equivalent). Salary will be in the range scale £20,044 pa – £30,002 pa depending on qualifications and experience. The appointment(s) will be for up to 3 years in the first instance, with an expected start date in the fall of 2006.

Applicants should send an application form (http://www.ex.ac.uk/jobs reference number 4802), along with a description of their current research and future plans (3 pages), a brief curriculum vitae, and a list of refereed publications to Dr Matthew Bate, School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, United Kingdom. The closing date for receipt of applications is 15 December 2005. Please also ensure that 3 letters of reference reach Exeter by this date.

Postdoctoral Research Position in Star and Planet Formation

The Institute for Astronomy (IfA) at the University of Hawaii invites applications for a postdoctoral research position in star and planet formation located in Honolulu, Hawaii. The successful applicant will collaborate with Dr. Michael Liu (mliu@ifa.hawaii.edu) on high angular resolution studies of circumstellar disks and substellar objects based on observing programs with Hubble Space Telescope and ground-based infrared (IR) adaptive optics systems. Applicants with interests in any of these areas are encouraged to apply.

Demonstrated expertise in IR observational astronomy is essential. Previous experience with high angular resolution imaging is desirable. The successful applicant will have access to optical and IR telescopes through the IfA's guaranteed share of observing time, including natural and laser guide star adaptive optics on the telescopes of Mauna Kea and the Near-IR Coronagraphic Imager (NICI) at the Gemini-South Telescope. By the starting date, candidates should have obtained a PhD degree in astronomy, physics or equivalent area relevant to the science themes described above.

The appointment is for up to three years, subject to performance and funding. The position is available immediately, but the start date is flexible and can be anytime in 2006. The annual salary will be approximately $52,800 per year and will include support for research activities. Please submit a statement of research and three letters of reference in addition to the application requirements.

Closing date for this recruitment: is January 17, 2006.

For complete information and application requirements, please go to www.rcuh.com and click on Employment, please reference ID# 25628.

Further details may be obtained from Dr. Michael Liu (mliu@ifa.hawaii.edu). EEO/AA employer.

Permanent Lectureship/Reader in Astrophysics - University of Exeter

Applications are invited for up to two permanent posts (at Lectureship or, for suitably qualified candidates, Readership level) in a further expansion of the Astrophysics Group in the School of Physics. Our research was rated excellent in the UK's Research Assessment Exercise and we are seeking to further strengthen the Group by appointing observational or theoretical astrophysicists in an area, which would enhance its research profile. The main thrust of that programme is galactic star formation and thus the appointments will be directly in that area or in a related field such as extra-solar planets or extra-galactic star formation. The successful applicant(s) will have full competitive access to facilities available to UK astronomers, including the VLT, Gemini, and UKAFF, as well as new cluster- and super-computing resources at Exeter. An appropriate first degree and a PhD (or equivalent), with at least three years experience at postdoctoral level, are required, along with a strong record of publication in international journals, and preferably experience in obtaining research contracts and in teaching. The appointments will involve normal teaching and administrative duties within the School, staged over three years to allow the appointees to develop their research base. Salary will be in the range 25,565pa to 36,959pa (Lecturer), with accelerated incremental progression, or for appropriately quailied applicatns up to 43,850pa (Reader).

Informal enquiries may be made to Mark McCaughrean (mjm@astro.ex.ac.uk) and Matthew Bate (mbate@astro.ex.ac.uk). Application packs available from www.exeter.ac.uk/jobs or e-mail H.R.Hebbard@ex.ac.uk. Closing date for completed applications: 15 December 2005.

Star Formation Workshop 2005 – From Cloud Cores to Debris Disks

We are happy to announce the upcoming Star Formation Workshop 2005 to be held from Dec 11-14 in Taipei, Taiwan, hosted jointly by the Academia Sinica Institute of Astronomy and Astrophysics (ASIAA) and the newly funded Theoretical Institute for Advanced Research in Astrophysics (TIARA), a collaboration between the Academia Sinica and National Tsing Hua University Taiwan.

The theme this year is "From Cloud Cores to Debris Disks", which will have a broad coverage of early stages of star formation at different wavelengths from accessible instruments around the globe. Format of talks and discussions will follow the annual workshop sponsored by the Center for Star Formation Studies in the past. All past participants of previous workshops and new star formation researchers and students are welcome. Please go the following link for registration: http://www.asiaa.sinica.edu.tw/act/sf2005/workshop/. The maximum number of participants is limited to 100.

SOC:

Paul Ho (ASIAA)
David Hollenbach (NASA Ames)
Zhi-Yun Li (Virginia)
Nagayoshi Ohashi (ASIAA, Co-Chair)
Hsien Shang (ASIAA, Co-Chair)
Frank H. Shu (NTHU)
Ronald Taam (Northwestern)

LOC:

T. Hasegawa (ASIAA)
N. Hirano (ASIAA, Co-Chair)
S.-Y. Liu (ASIAA, Co-Chair)
A.-R. Lyo (ASIAA)
Y.-N. Su (ASIAA)

Workshop secretaries: Celia Chen, Cindy Chiu and Rebecca Zheng

Web: Janne Wang

Please contact loc@tiara.sinica.edu.tw for any inquiries.

69th ANNUAL MEETING OF THE METEORITICAL SOCIETY

The meeting will be held August 6 - 11, 2006, in Zurich, Switzerland.

For further information, please refer to the first announcement at:

http://www.lpi.usra.edu/meetings/metsoc2006

The Astrophysical Chemistry Group of the RSC & RAS are pleased to announce their annual meeting;

The Chemistry of Planets and Where they Come From

will be held at the Department of Physics, University of Strathclyde, Glasgow, Scotland on Thursday 5th & Friday 6th January 2006

Invited Talks include:

Laboratory Studies of Titan's Atmosphere - Prof. Odile Dutuit (Universit de Paris Sud) The Role of H3+ in Planetary Atmospheres - Prof. Steve Miller (UCL) Planets, Exo-planets and their Chemistry - t.b.c. Exo-planet Detection & Probing Earth-Like Planets - Prof. Keith Horne (St. Andrews)

Contributed Talks & Posters are also solicited from the community on associated topics - including exoplanet detections, planetary atmospheres (exoplanets, Titan, Mars, etc), planet formation theory, debris disks, protostellar disks and associated chemistry / observations, chemistry of disk materials, astrobiology etc....

Contributions are especially welcome from young scientists, including PhD's and postdocs, from chemistry, physics, biology or astronomy backgrounds!

A limited number of bursaries are available to assist young scientists attending the meeting.

Registration Closes Dec 16th 2005. For further details, registration, costs, accommodation, bursary application forms etc please visit:

http://phys.strath.ac.uk/astrochem_meet