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Abstracts of recently accepted papers

Circumstellar material in the Vega inner system revealed by CHARA/FLUOR

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Context. Only a handful of debris disks have been imaged up to now. Due to the need for high dynamic range and high angular resolution, very little is known about the inner planetary region, where small amounts of warm dust are expected to be found.
Aims. We investigate the close neighbourhood of Vega with the help of infrared stellar interferometry and estimate the integrated K-band flux originating from the central 8 AU of the debris disk.
Methods. We performed precise visibility measurements at both short (∼30 m) and long (∼150 m) baselines with the FLUOR beam-combiner installed at the CHARA Array (Mt Wilson, California) in order to separately resolve the emissions from the extended debris disk (short baselines) and from the stellar photosphere (long baselines).
Results. After revising Vega's K-band angular diameter ($\theta_{\rm UD} = 3.202 \pm 0.005$ mas), we show that a significant deficit in squared visibility ($\Delta V^2 = 1.88 \pm 0.34\%$) is detected at short baselines with respect to the best-fit uniform disk stellar model. This deficit can be either attributed to the presence of a low-mass stellar companion around Vega, or as the signature of the thermal and scattered emissions from the debris disk. We show that the presence of a close companion is highly unlikely, as well as other possible perturbations (stellar morphology, calibration), and deduce that we have most probably detected the presence of dust in the close neighbourhood of Vega. The resulting flux ratio between the stellar photosphere and the debris disk amounts to $1.29 \pm 0.19\%$ within the FLUOR field-of-view (∼7.8 AU). Finally, we complement our K-band study with archival photometric and interferometric data in order to evaluate the main physical properties of the inner dust disk. The inferred properties suggest that the Vega system could be currently undergoing major dynamical perturbations.

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The H II Region of the First Star

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Simulations predict that the first stars in a ΛCDM universe formed at redshifts $z > 20$ in minihalos with masses of about $10^6 M_\odot$. We have studied their radiative feedback by simulating the propagation of ionization fronts (I-fronts) created by these first Population III stars ($M_\star = 15 - 500 M_\odot$) at $z = 20$, within the density field of a cosmological simulation of primordial star formation, outward through the host minihalo and into the surrounding gas. A three-dimensional ray-tracing calculation tracks the I-front once the H II region evolves a "champagne flow" inside the minihalo, after the early D-type I-front detaches from the shock and runs ahead, becoming R type. We take account of the hydrodynamic back-reaction by an approximate model of the central wind. We find that the escape fraction of ionizing radiation from the host halo increases with stellar mass, with $0.7 \leq f_{esc} \leq 0.9$ for $80 \leq M_\star/M_\odot \leq 500$. To quantify the ionizing efficiency of these stars as they begin cosmic reionization, we find that for $M_\star \geq 80 M_\odot$, the ratio of gas mass ionized to stellar mass is $\sim 60,000$, roughly half the number of ionizing photons released per stellar baryon. Nearby minihalos are shown to trap the I-front, so their centers remain neutral. This is contrary to the recent suggestion that these stars would trigger formation of a second generation by fully ionizing neighboring minihalos, stimulating H_2 formation in their cores. Finally, we discuss how the evacuation of gas from the host halo reduces the growth and luminosity of "miniquasars" that may form from black hole remnants of the first stars.

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A New Galactic 6 cm Formaldehyde Maser

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We report the detection of a new H_2CO maser in the massive star forming region G23.71−0.20 (IRAS 18324−0820), i.e., the fifth region in the Galaxy where H_2CO maser emission has been found. The new H_2CO maser is located toward a compact H II region, and is coincident in velocity and position with 6.7 GHz methanol masers and with an IR source as revealed by Spitzer/IRAC GLIMPSE data. The coincidence with an IR source and 6.7 GHz methanol masers suggests that the maser is in close proximity to an embedded massive protostar. Thus, the detection of H_2CO maser emission toward G23.71−0.20 supports the trend that H_2CO 6 cm masers trace molecular material very near young massive stellar objects.

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NGC 2401: a template of the young population of the Norma-Cygnus arm in the Third Galactic Quadrant

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Based on a deep optical CCD $[UBV(RI)_C]$ photometric survey and on the Two-Micron All Sky Survey (2MASS) data, we derived the main parameters of the open cluster NGC 2401. We found that this cluster is placed at 6.3 ± 0.5 kpc ($V_O - M_V = 14.0 \pm 0.2$) from the Sun and is 25 Myr old, which allows us to identify NGC 2401 as a member of the young population belonging to the innermost side of the extension of the Norma-Cygnus spiral arm in the Third Galactic Quadrant. A spectroscopic study of the emission star LSS 440 that lies in the cluster area revealed that it is a B0Ve star; however, we could not confirm that it is a cluster member. We also constructed the cluster luminosity function (LF) down to $V \sim 22$ and the cluster initial mass function (IMF) for all stars with masses above $M \sim 1-2M_{\odot}$. It was found that the slope of the cluster IMF is $x \approx 1.8 \pm 0.2$. The presence of a probable pre-main-sequence (PMS) star population associated with the cluster is weakly revealed.

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Strongly induced collapse in the Class 0 protostar NGC 1333 IRAS 4A

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Context: The onset of gravitational collapse in cluster-forming clouds is still poorly known.
Aims: Our goal is to use the Class 0 protostar IRAS 4A, which is undergoing collapse in the active molecular cloud NGC 1333, to set constraints on this process. In particular we want to measure the mass infall rate and investigate whether the collapse could have been triggered by a strong external perturbation.
Methods: We analyze existing continuum observations to derive the density structure of the envelope, and use our new molecular line observations with the IRAM 30m telescope to probe its velocity structure. We perform a detailed comparison of this set of data with a numerical model of collapse triggered by a fast external compression.
Results: Both the density and velocity structures of the envelope can be well fitted by this model of collapse induced by a fast external compression for a time of 1-2 $\times$ 10^4 yr after the formation of the central protostar. We deduce a high mass infall rate of 0.7-2 $\times 10^{-4}$ $M_{\odot}$ yr^{-1}. The momentum required for the perturbation to produce this high mass infall rate is on the same order as the momenta measured for the NGC 1333 numerous outflows. Our analysis also shows that the turbulence is highly non uniform in the envelope, dropping from supersonic to subsonic values toward the center. The inner subsonic turbulence is most likely a relic of the conditions prevailing in the dense core before the onset of collapse.
Conclusion: The vigorous collapse undergone by IRAS 4A was triggered by a fast external compression, probably related to the expansion of a nearby cavity, which could have simultaneously triggered the collapse of the nearby Class 0 protostar IRAS 4B. This cavity could have been generated by an outflow but we have not found a good protostellar candidate yet.

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The high-mass star-forming region IRAS 18182−1433

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Aims: We present mm line and continuum observations at high spatial resolution characterizing the physical and chemical properties of the young massive star-forming region IRAS 18182−1433.
Methods: The region was observed with the Submillimeter Array in the 1.3 mm band. The data are complemented with short-spacing information from single-dish CO(2–1) observations. SiO(1–0) data from the VLA are added to the analysis.
Results: Multiple massive outflows emanate from the mm continuum peak. The CO(2–1) data reveal a quadrupolar outflow system consisting of two outflows inclined by $\sim 90°$. One outflow exhibits a cone-like red-shifted morphology with a jet-like blue-shifted counterpart where a blue counter-cone can only be tentatively identified. The SiO(1–0) data suggest the presence of a third outflow. Analyzing the $^{12}CO/^{13}CO$ line ratios indicates decreasing CO line opacities with increasing velocities. Although we observe a multiple outflow system, the mm continuum peak remains single-

peaked at the given spatial resolution (∼13500 AU). The other seven detected molecular species – also high-density tracers like CH_3CN, CH_3OH, $HCOOCH_3$ – are all ∼1-2″ offset from the mm continuum peak, but spatially associated with a strong molecular outflow peak and a cm emission feature indicative of a thermal jet. This spatial displacement between the molecular lines and the mm continuum emission could be either due to an unresolved sub-source at the position of the cm feature, or the outflow/jet itself alters the chemistry of the core enhancing the molecular abundances toward that region. A temperature estimate based on the $CH_3CN(12_k - 11_k)$ lines suggests temperatures of the order 150 K. A velocity analysis of the high-density tracing molecules reveals that at the given spatial resolution none of them shows any coherent velocity structure which would be consistent with a rotating disk. We discuss this lack of rotation signatures and attribute it to intrinsic difficulties to observationally isolate massive accretion disks from the surrounding dense gas envelopes and the molecular outflows.

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

The Jeans mass and the origin of the knee in the IMF

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We use numerical simulations of the fragmentation of a 1000 $M_\odot$ molecular cloud and the formation of a stellar cluster to study how the initial conditions for star formation affect the resulting initial mass function (IMF). In particular, we are interested in the relation between the thermal Jeans mass in a cloud and the *knee* of the initial mass function, i.e. the mass separating the region with a flat IMF slope from that typified by a steeper, Salpeter-like, slope. In three isothermal simulations with $M_{\rm Jeans} = 1 M_\odot$, $M_{\rm Jeans} = 2 M_\odot$ and $M_{\rm Jeans} = 5 M_\odot$, the number of stars formed, at comparable dynamical times, scales roughly with the number of initial Jeans masses in the cloud. The mean stellar mass also increases (though less than linearly) with the initial Jeans mass in the cloud. It is found that the IMF in each case displays a prominent knee, located roughly at the mass scale of the initial Jeans mass. Thus clouds with higher initial Jeans masses produce IMFs which are shallow to higher masses. This implies that a universal IMF requires a physical mechanism that sets the Jeans mass to be near 1 $M_\odot$. Simulations including a barotropic equation of state as suggested by Larson, with cooling at low densities followed by gentle heating at higher densities, are able to produce realistic IMFs with the knee located at $\approx 1 M_\odot$, even with an initial $M_{\rm Jeans} = 5 M_\odot$. We therefore suggest that the observed universality of the IMF in the local Universe does not require any fine tuning of the initial conditions in star forming clouds but is instead imprinted by details of the cooling physics of the collapsing gas.

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Iron meteorites as remnants of planetesimals formed in the terrestrial planet region

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Iron meteorites are core fragments from differentiated and subsequently disrupted planetesimals. The parent bodies are usually assumed to have formed in the main asteroid belt, which is the source of most meteorites. Observational evidence, however, does not indicate that differentiated bodies or their fragments were ever common there. This view is also difficult to reconcile with the fact that the parent bodies of iron meteorites were as small as 20 km in diameter and that they formed 1-2 Myr earlier than the parent bodies of the ordinary chondrites. Here we show that the iron-meteorite parent bodies most probably formed in the terrestrial planet region. Fast accretion times there allowed small planetesimals to melt early in Solar System history by the decay of short-lived radionuclides (such as ^{26}Al,

^{60}Fe). The protoplanets emerging from this population not only induced collisional evolution among the remaining planetesimals but also scattered some of the survivors into the main belt, where they stayed for billions of years before escaping via a combination of collisions, Yarkovsky thermal forces, and resonances. We predict that some asteroids are main-belt interlopers (such as (4) Vesta). A select few may even be remnants of the long-lost precursor material that formed the Earth.

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Satellites of the Largest Kuiper Belt Objects

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We have searched the four brightest objects in the Kuiper Belt for the presence of satellites using the newly commissioned Keck Observatory Laser Guide Star Adaptive Optics system. Satellites are seen around three of the four objects: Pluto (whose satellite Charon is well-known and whose recently discovered smaller satellites are too faint to be detected), 2003 EL61 (where a second satellite is seen in addition to the previously known satellite), and 2003 UB313 (where a satellite is seen for the first time). The object 2005 FY9, the brightest Kuiper Belt object (KBO) after Pluto, does not have a satellite detectable within 0.4" with a brightness of more than 1% of the primary. The presence of satellites around three of the four brightest KBOs is inconsistent with the fraction of satellites in the Kuiper Belt at large at the 99.2% confidence level, suggesting a different formation mechanism for these largest KBO satellites. The two satellites of 2003 EL61, and the one satellite of 2003 UB313, with fractional brightnesses of 5% and 1.5%, and 2%, of their primaries, respectively, are significantly fainter relative to their primaries than other known KBO satellites, again pointing to possible differences in their origin.

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Resolving the kinematic distance ambiguity of southern massive young stellar object candidates

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We investigate the use of H I data to resolve the near/far ambiguity in kinematic distances of massive young stellar object (MYSO) candidates. Kinematic distances were obtained from ^{13}CO $1-0$ (and N_2H^+) spectral-line observations with the Mopra Telescope towards 94 candidates selected from the Red MSX Source (RMS) survey in the fourth Galactic quadrant ($282° < l < 350°$). H I data from the Southern Galactic Plane Survey (SGPS) were used in conjunction with the H I self-absorption (SA) technique to determine the near or far distance. We resolved the kinematic distance ambiguity to 70 per cent of the sources. We can also simultaneously solve for any multiple line-of-sight component sources. We discuss the advantages and disadvantages of this technique in comparison with other methods, and also perform confidence checks on the reliability of using the H I SA technique.

We examined the projected location of these sources in both the Galactic plane and longitude$-$velocity ($l-v$) diagrams to ascertain any recognizable spiral arm pattern. Although no obvious spiral pattern was found when compared to that proposed by Cordes and Lazio, far distance sources tended to lie on or near spiral arm loci. Near distance sources,

however, had peculiar velocity uncertainties consistent with the separation between the spiral arms themselves. The $l - v$ plot shows a more consistent picture, with tangent points of the spiral arm loci easily seen.

We conclude that using the H I SA technique to determine kinematic distance ambiguities is a quick and reliable method in most cases, with an 80 per cent success rate in determining the correct designation of whether an object is at the near or far distance.

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Tidal stripping and disk kinematics in the RW Aurigae system

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We present interferometric maps of the RW Aur system obtained with the IRAM Plateau de Bure Interferometer in CO(J=2–1), CO(J=1–0), and nearby continuum. The sub-arcsecond angular resolution ($0.89'' \times 0.58''$) and high-sensitivity reached at 1.3mm enable us to resolve three molecular structures: (1) an optically thick disk around RW Aur A in rotation about the optical jet axis, (2) a disturbed asymmetric peak around RW Aur B, (3) a 600 AU-long "arm" of material trailing from the RW Aur A disk. Comparison with Keplerian models indicate that the RW Aur A disk is the smallest detected so far around a T Tauri star (radius 40-57 AU) and that the CO emitting layer at the outer edge is warmer than the dust ($T_{\rm out} \simeq 60 - 100$ K) and relatively thick ($N_{\rm warm} \simeq 0.1 - 10 \times 10^{22}$ cm-2).

The morphology and kinematics of the detected features strongly suggest that we are witnessing tidal stripping of the primary disk by the recent fly-by of RW Aur B. We speculate that tidal dissipation might explain the warmer gas temperatures in the RW Aur A disk compared with typical T Tauri stars, and perhaps play a role in its elevated accretion rate. We also find that the rotation sense of the RW Aur A disk is opposite to transverse velocity shifts in the optical jet reported by Woitas et al. (2005). We argue that these transverse shifts are likely to represent only upper limits to the true jet rotation speed. The limits remain consistent with current models of MHD launching from the disk.

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http://aramis.obspm.fr/∼cabrit/rwaur.ps

A Comparative Study on Lithium Abundances in Solar-Type Stars With and Without Planets

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We have investigated the abundance anomalies of lithium for stars with planets in the temperature range of $5600-5900$ K reported by Israelian and coworkers, as compared to 20 normal stars in the same temperature and metallicity ranges. Our result indicates a higher probability of lithium depletion for stars with planets in the main-sequence stage. It seems that stellar photospheric abundances of lithium in stars with planets may be somewhat affected by the presence of planets. Two possible mechanisms are considered to account for the lower Li abundances of stars with planets. One is related to the rotation-induced mixing due to the conservation of angular momentum by the protoplanetary disk, and the other is a shear instability triggered by planet migration. These results provide new information on stellar evolution and the lithium evolution of the Galaxy.

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Clumpy shocks and the clump mass function

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In this paper, we examine whether clumpy, colliding, flows could be responsible for the clump mass functions that have been observed in several regions of embedded star formation, which have been shown to be described by a Salpeter type slope. The flows presented here, which comprise a population of initially identical clumps and the calculations are performed with and without the inclusion of self-gravity. When the shock region is at its densest, we find that the clump mass spectrum is always well modelled by a Salpeter type slope. This is true regardless of whether the self-gravity is included in the simulations or not. In the non-self-gravitating simulations, this slope is retained at lower Mach numbers (Mach 5 and 10) as the simulations progress past the densest phase. In the simulations which include self-gravity, we find that low Mach number runs yield a flatter mass function after the densest phase. This is simply a result of increased coagulation due to gravitational collapse of the flows. In the high Mach number runs (Mach 20) the Salpeter slope is always lost. The self gravitating calculations also show that the sub-group of gravitationally bound clumps in which star formation occurs, always contain the most massive clumps in the population. The mass function of these bound star forming clumps is not at all similar to the Salpeter type mass function observed for stars in the field. We conclude that the clump mass function may not only have nothing to do with gravity, but also nothing to do with the star formation process and the resulting mass distribution of stars. This raises doubt over the claims that the clump mass function is the origin of the stellar IMF, for regions such as rho Oph, Serpens and the Orion B cloud.

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The $\dot{M} - M$ relationship in pre-main sequence stars

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We examine the recent data and analysis of Natta et al. concerning the accretion rate on to young stars as a function of stellar mass, and conclude that the apparently steep dependence of accretion rate on mass is strongly driven by selection/detection thresholds. We argue that a convincing demonstration of a physical relationship between accretion and stellar mass requires further studies which, as is the case for Natta et al., include information on upper limits, and which quantify the possible incompleteness of the sample, at both low and high accretion rates. We point out that the distribution of detections in the $(M, \dot{M})$-plane is consistent with conventional accretion disc models, and that higher sensitivity observations might be able to test the hypothesis of accelerated disc clearing at late times.

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Hydroxyl maser disc and outflow in the Orion-BN/KL region

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Multi Element Radio Linked Interferometer Network (MERLIN) measurements of 1.6-GHz hydroxyl (OH) masers associated with Orion-Becklin–Neugebauer/Kleinmann–Low (Orion-BN/KL) are presented, and the data are compared with data on other masers, molecular lines, compact radio continuum sources and infrared sources in the region. OH masers are detected over an area of 30 arcsec in diameter, with the majority lying along an approximately E–W structure that extends for $\sim$ 18 arcsec, encompassing the infrared sources IRc2, IRc6 and IRc7. Radial velocities range from -13 to +42 km s^{-1}. The system of OH masers shows a velocity gradient together with non-circular

motions. The kinematics are modelled in terms of an expanding and rotating disc or torus. The rotation axis is found to be in the same direction as the molecular outflow. There is an inner cavity of radius ~ 1300 au with no OH masers. The inner cavity, like the H_2O 'shell' masers and SiO masers, is centred on radio source I. Some of the OH masers occur in velocity-coherent strings or arcs that are longer than 5 arcsec (2250 au). One such feature, Stream A, is a linear structure at position angle $\sim 45°$, lying between IRc2 and BN. We suggest that these masers trace shock fronts, and have appeared, like a vapour trail, 200 yr after the passage of the runaway star BN. The radio proper motions of BN, source I and source n project back to a region near the base of Stream A that is largely devoid of OH masers. The 1612-MHz masers are kinematically distinct from the other OH masers. They are also more widely distributed and appear to be associated with the outflow as traced by H2O masers and by the 2.12-μm emission from shocked H_2. The magnetic field traced by the OH masers ranges from 1.8 to 16.3 mG, with a possible reversal. No OH masers were found associated with even the most prominent proplyds within 10 arcsec of θ^1 Ori C.

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On the evolution of multiple protoplanets embedded in a protostellar disc

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Context. Theory predicts that low mass protoplanets in a laminar protostellar disc will migrate into the central star prior to disc dispersal. It is known that protoplanets on orbits with eccentricity $e \geq H/r$, where H is the disc scale height and r is the radius, can halt or reverse their migration.
Aims. We examine whether a system of interacting protoplanetary cores can excite and sustain significant eccentricity of the population, allowing some planetary cores to survive in the disc over its lifetime.
Methods. We employ two distinct numerical schemes: an N-body code, adapted to include migration and eccentricity damping due to the gas disc via analytic prescriptions, and a hydrodynamics code that explicitly evolves a 2D protoplanetary disc model with embedded protoplanets. The former allows us to study the long term evolution, the latter to model the systems with greater fidelity but for shorter times.
Results. After a brief period of chaotic interaction between the protoplanets that involves scattering, orbital exchange, collisions and the formation of co-orbital planets, we find that the system settles into a quiescent state of inward migration. Differential migration causes the protoplanets to form a series of mean motion resonances, such that a planet is often in resonance with both its interior and exterior neighbours. This helps prevent close encounters and leads to the protoplanetary swarm, or subgroups within it, migrating inward at a uniform rate. In about 2% of runs a single planet is scattered onto a distant orbit with significant eccentricity, allowing it to survive in the disc for $\sim 10^6$ years. Over 20% of runs produce co-orbital planets that survive for the duration of the simulation, occupying mutual horseshoe or tadpole orbits.
Conclusions. Disc-induced damping overwhelms eccentricity growth through planet-planet interactions, such that a protoplanetary swarm migrates inward. We suggest co-orbital planets may be observed in future exoplanet searches.

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On the width and shape of gaps in protoplanetary disks

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Although it is well known that a massive planet opens a gap in a protoplanetary gaseous disk, there is no analytic description of the surface density profile in and near the gap. The simplest approach, which is based upon the balance between the torques due to the viscosity and the gravity of the planet and assumes local damping, leads to gaps with overestimated width, especially at low viscosity. Here, we take into account the fraction of the gravity torque that is evacuated by pressure supported waves. With a novel approach, which consists of following the fluid elements

along their trajectories, we show that the flux of angular momentum carried by the waves corresponds to a pressure torque. The equilibrium profile of the disk is then set by the balance between gravity, viscous and pressure torques. We check that this balance is satisfied in numerical simulations, with a planet on a fixed circular orbit. We then use a reference numerical simulation to get an ansatz for the pressure torque, that yields gap profiles for any value of the disk viscosity, pressure scale height and planet to primary mass ratio. Those are in good agreement with profiles obtained in numerical simulations over a wide range of parameters. Finally, we provide a gap opening criterion that simultaneously involves the planet mass, the disk viscosity and the aspect ratio.

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The Remarkable Mid-Infrared Jet of Massive Young Stellar Object G35.20-0.74

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The young massive stellar object G35.20-0.74 was observed in the mid-infrared using T-ReCS on Gemini South. Previous observations have shown that the near infrared emission has a fan-like morphology that is consistent with emission from the northern lobe of a bipolar radio jet known to be associated with this source. Mid-infrared observations presented in this paper show a monopolar jet-like morphology as well, and it is argued that the mid-infrared emission observed is dominated by thermal continuum emission from dust. The mid-infrared emission nearest the central stellar source is believed to be directly heated dust on the walls of the outflow cavity. The hydroxyl, water, and methanol masers associated with G35.20-0.74 are spatially located along these mid-infrared cavity walls. Narrow jet or outflow cavities such as this may also be the locations of the linear distribution of methanol masers that are found associated with massive young stellar objects. The fact that G35.20-0.74 has mid-infrared emission that is dominated by the outflow, rather than disk emission, is a caution to those that consider mid-infrared emission from young stellar objects as only coming from circumstellar disks.

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MHD simulations of radiative jets from young stellar objects – Hα emission

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We study the Hα emission from jets using two-dimensional axisymmetrical simulations. We compare the emission obtained from hydrodynamic (HD) simulations with that obtained from magnetohydrodynamics (MHD) simulations. The magnetic field is supposed to be present in the jet only, and with a toroidal configuration. The simulations have time-dependent ejection velocities and different intensities for the initial magnetic field. The results show an increase in the Hα emission along the jet for the magnetized cases with respect to the HD case. The increase in the emission is due to a better collimation of the jet in the MHD case, and to a small increase in the shock velocity. These results could have important implications for the interpretation of the observations of jets from young stellar objects.

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Probing T Tauri Accretion and Outflow with 1 Micron Spectroscopy

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In a high dispersion 1 μ survey of 39 classical T Tauri stars veiling is detected in 80%, and He I λ10830 and Pγ line emission in 97% of the stars. On average, the 1 μ veiling exceeds the level expected from previously identified sources of excess emission, suggesting the presence of an additional contributor to accretion luminosity in the star-disk interface region. Strengths of both lines correlate with veiling, and at Pγ there is a systematic progression in profile morphology with veiling. He I λ10830 has an unprecedented sensitivity to inner winds, showing blueshifted absorption below the continuum in 71% of the CTTS compared to 0% at Pγ. This line is also sensitive to magnetospheric accretion flows, with redshifted absorption below the continuum found in 47% of the CTTS compared to 24% at Pγ.

The blueshifted absorption at He I λ10830 shows considerable diversity in its breadth and penetration depth into the continuum, indicating that a range of inner wind conditions exist in accreting stars. We interpret the broadest and deepest blue absorptions as formed from scattering of the 1 μ continuum by outflowing gas whose full acceleration region envelopes the star, suggesting radial outflow from the star. In contrast, narrow blue absorption with a range of radial velocities more likely arises via scattering of the 1 μ continuum by a wind emerging from the inner disk. Both stellar and disk winds are accretion powered since neither is seen in non-accreting WTTS and among the CTTS helium strength correlates with veiling.

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A gas-poor planetesimal capture model for the formation of giant planet satellite systems

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Assuming that an unknown mechanism (e.g., gas turbulence) removes most of the subnebula gas disk in a timescale shorter than that for satellite formation, we develop a model for the formation of regular (and possibly at least some of the irregular) satellites around giant planets in a gas-poor environment. In this model, which follows along the lines of the work of Safronov et al. [1986. Satellites. Univ. of Arizona Press, Tucson, pp. 89-116], heliocentric planetesimals collide within the planet's Hill sphere and generate a circumplanetary disk of prograde and retrograde satellitesimals extending as far out as $\sim R_H/2$. At first, the net angular momentum of this proto-satellite swarm is small, and collisions among satellitesimals leads to loss of mass from the outer disk, and delivers mass to the inner disk (where regular satellites form) in a timescale $\leq 10^5$ years. This mass loss may be offset by continued collisional capture of sufficiently small < 1 km interlopers resulting from the disruption of planetesimals in the feeding zone of the giant planet. As the planet's feeding zone is cleared in a timescale $\leq 10^5$ years, enough angular momentum may be delivered to the proto-satellite swarm to account for the angular momentum of the regular satellites of Jupiter and Saturn. This feeding timescale is also roughly consistent with the independent constraint that the Galilean satellites formed in a timescale of $10^5 - 10^6$ years, which may be long enough to accommodate Callisto's partially differentiated state [Anderson et al., 1998. Science 280, 1573; Anderson et al., 2001. Icarus 153, 157-161]. In turn, this formation timescale can be used to provide plausible constraints on the surface density of solids in the satellitesimal disk (excluding satellite embryos ~ 1 g cm^{-2} for satellitesimals of size ~ 1 km), which yields a total disk mass smaller than the mass of the regular satellites, and means that the satellites must form in several ~ 10 collisional cycles. However, much more work will need to be conducted concerning the collisional evolution both of the circumplanetary satellitesimals and of the heliocentric planetesimals following giant planet formation before one can assess the significance of this agreement. Furthermore, for enough mass to be delivered to form the regular satellites in the required timescale one may need to rely on (unproven) mechanisms to replenish the feeding zone of the giant planet. We compare this model to the solids-enhanced minimum mass (SEMM) model of Mosqueira and Estrada [2003a. Icarus 163, 198-231; 2003b. Icarus 163, 232-255], and discuss its main consequences for Cassini observations of the saturnian satellite system.

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Investigation of Diffuse Hard X-Ray Emission from the Massive Star-forming Region NGC 6334

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textitChandra ACIS-I data of the molecular cloud and H II region complex NGC 6334 were analyzed. The hard X-ray clumps detected with ASCA (Sekimoto and coworkers) were resolved into 792 point sources. After removing the point sources, an extended X-ray emission component was detected over a 5×9 pc^2 region, with the 0.5-8 keV absorption-corrected luminosity of 2×10^{33} ergs s^{-1}. The contribution from faint point sources to this extended emission was estimated as at most $\sim 20\%$, suggesting that most of the emission is diffuse in nature. The X-ray spectrum of the diffuse emission was observed to vary from place to place. In tenuous molecular cloud regions with hydrogen column density of $(0.5-1) \times 10^{22}$ cm^{-2}, the spectrum can be represented by a thermal plasma model with temperatures of several keV. The spectrum in dense cloud cores exhibits harder continuum, together with higher absorption of more than $\sim 3 \times 10^{22}$ cm^{-2}. In some of such highly obscured regions, the spectra show extremely hard continua equivalent to a photon index of ~ 1, and favor a nonthermal interpretation. These results are discussed in the context of thermal and nonthermal emission, both powered by fast stellar winds from embedded young early-type stars through shock transitions.

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The discovery of an expanding X-ray source in the HH 154 protostellar jet

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Context. Protostellar jets are a new class of X-ray sources which has been discovered with both XMM-*Newton* and *Chandra*. The mechanism responsible for the X-ray emission is still not clear. Self-shocking in jets, shocks where the jet hits the surrounding medium, reflected or scattered stellar X-ray emission have all been invoked as possible explanations.
Aims. One key diagnostic discriminating among physical emission mechanisms is the motion of the X-ray source: hydrodynamical numerical models of continuous protostellar jets plowing through a uniform medium show an X-ray emitting shock front moving at several hundreds km s^{-1}. In the nearest X-ray emitting protostellar jet, HH 154, this is detectable, with the spatial resolution of the *Chandra* X-ray observatory, over a few years baseline, allowing a robust discrimination among different mechanisms. *Methods.* We have performed, in October 2005, a deep *Chandra* X-ray observation of HH 154. Comparison with the previous (2001) *Chandra* observation allows to detect proper motion down to the level predicted by models of X-ray emitting shocks in the jet.
Results. The 2005 *Chandra* observation of HH 154 shows unexpected morphological changes of the X-ray emission in comparison with the 2001 data. Two components are present: a stronger, point-like component with no detectable motion and a weaker component which has expanded in size by approximately 300 AU over the 4 years time base of the two observations. This expansion corresponds to approximately 500 km s^{-1}, very close to the velocity of the X-ray emitting shock in the simple theoretical models.
Conclusions. The 2005 data show a more complex system than initially thought (and modeled), with multiple components with different properties. The observed morphology is possibly indicating a pulsed jet propagating through a non-homogeneous medium, likely with medium density decreasing with distance from the driving source. Detailed theoretical modeling and deeper X-ray observations will be needed to understand the physics of this fascinating class of sources.

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Which jet launching mechanism(s) in T Tauri stars?

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Aims We examine whether ejection phenomena from accreting T Tauri stars can be described by only one type of self-collimated jet model.
Methods We present analytical kinematic predictions valid soon after the Alfvén surface for all types of steady magnetically self-confined jets.
Results We show that extended disc winds, X-winds, and stellar winds occupy distinct regions in the poloidal speed vs. specific angular momentum plane. Comparisons with current observations of T Tauri jets yield quantitative constraints on the range of launching radii, magnetic lever arms, and specific energy input in disc and stellar winds. Implications on the origin of jet asymmetries and disc magnetic fields are outlined. *Conclusions* We argue that ejection phenomena from accreting T Tauri stars most likely include three dynamical components: (1) an outer self-collimated steady disc wind carrying most of the mass-flux in the optical jet (when present), confining (2) a pressure-driven coronal stellar wind and (3) a hot inner flow made of blobs sporadically ejected from the magnetopause. If the stellar magnetic moment is parallel to the disc magnetic field, then the highly variable inner flow resembles a "Reconnection X-wind", that has been proven to efficiently brake down an accreting and contracting young star. If the magnetic moment is anti-parallel, then larger versions of the solar coronal mass ejections are likely to occur. The relative importance of these three components in the observed outflows and the range of radii involved in the disc wind are expected to vary with time, from the stage of embedded source to the optically revealed T Tauri star phase.

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ACIS-I observations of NGC 2264. Membership and X-ray properties of PMS stars

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Aims. Improving the member census of the NGC 2264 star forming region and studying the origin of X-ray activity in young PMS stars.
Methods. We analyze a deep, 100 ksec long, Chandra ACIS observation covering a 17'x17' field in NGC 2264. The preferential detection in X-rays of low mass PMS stars gives strong indications of their membership. We study X-ray activity as a function of stellar and circumstellar characteristics by correlating the X-ray luminosities, temperatures and absorptions with optical and near-infrared data from the literature.
Results. We detect 420 X-ray point sources. Optical and NIR counterparts are found in the literature for 85% of the sources. We argue that more than 90% of these counterparts are NGC 2264 members, thus significantly increasing the known low mass cluster population by about 100 objects. Among the sources without counterpart about 50% are likely associated with members, several of which we expect to be previously unknown protostellar objects. With regard to activity we confirm several previous findings: X-ray luminosity is related to stellar mass, although with a large scatter; L_X/L_{bol} is close to but almost invariably below the saturation level, 10^{-3}, especially when considering the *quiescent* X-ray emission. A comparison between CTTS and WTTS shows several differences: CTTS have, at any given mass, activity levels that are both lower and more scattered; emission from CTTS may also be more time variable and is on average slightly harder than that of WTTS. However, we find evidence in some CTTS of extremely cool, $\sim 0.1 - 0.2$keV, plasma which we speculate is heated by accretion shocks.
Conclusions. Activity in low mass PMS stars, while generally similar to that of saturated MS stars, may be significantly affected by mass accretion in several ways: accretion is likely responsible for very soft X-ray emission directly produced in the accretion shock; it may reduce the average energy output of solar-like coronae, at the same time making them hotter and more dynamic. We briefly speculate on a physical scenario that can explain these observations.

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http://www.astropa.unipa.it/∼ettoref

Extinction techniques and impact on dust property determination

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The near infrared extinction powerlaw index (β) and its uncertainty is derived from three different techniques based on star counts, colour excess and a combination of them. We have applied these methods to 2MASS data to determine maps of β and near infrared extinction of the small cloud IC 1396 W. The combination of star counts and colour excess results in the most reliable method to determine β. It is found that the use of the correct β-map to transform colour excess values into extinction is fundamental for column density profile analysis of clouds. We describe how artificial photometric data, based on the model of stellar population synthesis of the Galaxy (Robin et al. 2003), can be used to estimate uncertainties and derive systematic effects of the extinction methods presented here. We find that all colour excess based extinction determination methods are subject to small but systematic offsets, which do not affect the star counting technique. These offsets occur since stars seen through a cloud do not represent the same population as stars in an extinction free control field.

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The Irradiation Origin of Beryllium Radioisotopes and Other Short-lived Radionuclides

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Two explanations exist for the short-lived radionuclides ($T_{1/2} \leq 5$ Myr) present in the solar system when the calcium-aluminum-rich inclusions (CAIs) first formed. They originated either from the ejecta of a supernova or by the in situ irradiation of nebular dust by energetic particles. With a half-life of only 53 days, ^{7}Be is then the key discriminant, since it can be made only by irradiation. Using the same irradiation model developed earlier by our group, we calculate the yield of ^{7}Be. Within model uncertainties associated mainly with nuclear cross sections, we obtain agreement with the experimental value. Moreover, if ^{7}Be and ^{10}Be have the same origin, the irradiation time must be short (a few to tens of years), and the proton flux must be of order $F \sim 2 \times 10^{10}$ cm^{-2} s^{-1}. The X-wind model provides a natural astrophysical setting that gives the requisite conditions. In the same irradiation environment, ^{26}Al, ^{36}Cl, and ^{53}Mn are also generated at the measured levels within model uncertainties, provided that irradiation occurs under conditions reminiscent of solar impulsive events (steep energy spectra and high ^{3}He abundance). The decoupling of the ^{26}Al and ^{10}Be observed in some rare CAIs receives a quantitative explanation when rare gradual events (shallow energy spectra and low ^{3}He abundance) are considered. The yields of ^{41}Ca are compatible with an initial solar system value inferred from the measured initial ^{41}Ca/^{40}Ca ratio and an estimate of the thermal metamorphism time (from Young et al.), alleviating the need for two-layer proto-CAIs. Finally, we show that the presence of supernova-produced ^{60}Fe in the solar accretion disk does not necessarily mean that other short-lived radionuclides have a stellar origin.

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How Dry is the Brown Dwarf Desert? Quantifying the Relative Number of Planets, Brown Dwarfs, and Stellar Companions around Nearby Sun-like Stars

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Sun-like stars have stellar, brown dwarf, and planetary companions. To help constrain their formation and migration scenarios, we analyze the close companions (orbital period < 5 yr) of nearby Sun-like stars. By using the same sample to extract the relative numbers of stellar, brown dwarf, and planetary companions, we verify the existence of a very dry brown dwarf desert and describe it quantitatively. With decreasing mass, the companion mass function drops by almost 2 orders of magnitude from 1 $M_\odot$ stellar companions to the brown dwarf desert and then rises by more than an order of magnitude from brown dwarfs to Jupiter-mass planets. The slopes of the planetary and stellar companion mass functions are of opposite sign and are incompatible at the 3σ level, thus yielding a brown dwarf desert. The minimum number of companions per unit interval in log mass (the driest part of the desert) is at $M = 31^{+25}_{-18} M_J$. Approximately 16% of Sun-like stars have close ($P < 5$ yr) companions more massive than Jupiter: 11% $\pm$ 3% are stellar, < 1% are brown dwarf, and $5\% \pm 2\%$ are giant planets. The steep decline in the number of companions in the brown dwarf regime, compared to the initial mass function of individual stars and free-floating brown dwarfs, suggests either a different spectrum of gravitational fragmentation in the formation environment or post-formation migratory processes disinclined to leave brown dwarfs in close orbits.

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Can Warm Neutral Medium Survive Inside Molecular Clouds?

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Recent high resolution numerical simulations have suggested that the interstellar atomic hydrogen clouds have a complex two-phase structure. Since molecular clouds form through the contraction of HI gas, the question arises as to whether this structure is maintained in the molecular phase or not. Here we investigate whether the warm neutral atomic hydrogen (WNM) can exist in molecular clouds. We calculate how far a piece of WNM which is not heated by the UV photons could penetrate into the cloud, and find that in the absence of any heating it is unlikely that large fraction of WNM survives inside high pressure molecular clouds. We then consider two possible heating mechanisms, namely dissipation of turbulent energy and dissipation of MHD waves propagating in the WNM inside the cloud. We find that the second one is sufficient to allow the existence of WNM inside a molecular cloud of size $\simeq 1$ pc having pressure equal to $\simeq 10 \times P_{\rm ISM}$. This result suggests the possibility that channels of magnetised WMN may provide efficient energy injection for sustaining internal turbulence which otherwise decays in a crossing time.

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The Formation and Evolution of Planetary Systems (FEPS): Discovery of an Unusual Debris System Associated with HD 12039

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We report the discovery of a debris system associated with the $\sim$ 30 Myr old G3/5V star HD 12039 using *Spitzer Space Telescope* observations from $3.6 - 160\mu$m. An observed infrared excess ($L_{IR}/L_\star = 1 \times 10^{-4}$) above the expected photosphere for $\lambda \geq 14\mu$m is fit by thermally emitting material with a color temperature of $T \sim 110$ K, warmer than the majority of debris disks identified to date around Sun-like stars. The object is not detected at 70 μm with a 3σ upper limit 6 times the expected photospheric flux. The spectrum of the infrared excess can be explained by warm, optically thin material comprised of blackbody-like grains of size $\geq 7\mu$m that reside in a belt orbiting the star at 4-6 AU. An alternate model dominated by smaller grains, near the blowout size $a \sim 0.5\mu$m, located at 30-40 AU is also possible but requires the dust to have been produced recently, since such small grains will be expelled from the system by radiation pressure in approximately a few times 10^2 yr.

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Molecular Line Observations of a Carbon-Chain-Rich Core L492

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We report on molecular abundances and distributions in a starless dense core L492. We have found that the abundances of carbon-chain molecules such as CCS, C_3S, HC_3N, HC_5N, and HC_7N are comparable to those in chemically young dark cloud cores called "carbon-chain–producing regions", such as L1495B, L1521B, L1521E, and TMC-1. This is the first dark cloud core with extremely rich in carbon-chain-molecules that is found outside the Taurus region. In addition, the deuterium fractionation ratios of DNC/HNC and DCO^+/HCO^+ are also comparable to those in carbon-chain–producing regions, being significantly lower than those in the evolved prestellar cores such as L1498 and L1544. On the other hand, the abundances of NH_3 and N_2H^+ are systematically higher than those in carbon-chain–producing regions. Our mapping observations reveal that the central hole of molecular distributions, which were reported for CCS and $C^{34}S$ in evolved prestellar cores is not significant in L492, indicating that the depletion factor of molecules is not very high. Furthermore, L492 is dynamically more evolved than carbon-chain–producing regions, and the protostellar collapse has started like L1498 and L1544. Therefore, it is likely that the chemical and dynamical evolutionary stage of L492 is intermediate between carbon-chain–producing regions (L1495B, L1521B, L1521E, and TMC-1) and evolved prestellar cores (L1498 and L1544).

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Dynamical Expansion of Ionization and Dissociation Front around a Massive Star. II. On the Generality of Triggered Star Formation

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We analyze the dynamical expansion of the H II region, photodissociation region, and the swept-up shell, solving the UV- and FUV-radiative transfer, the thermal and chemical processes in the time-dependent hydrodynamics code. Following our previous paper, we investigate the time evolutions with various ambient number densities and central stars. Our calculations show that basic evolution is qualitatively similar among our models with different parameters. The molecular gas is finally accumulated in the shell, and the gravitational fragmentation of the shell is generally expected. The quantitative differences among models are well understood with analytic scaling relations. The detailed physical and chemical structure of the shell is mainly determined by the incident FUV flux and the column density of the shell, which also follow the scaling relations. The time of shell-fragmentation, and the mass of the gathered molecular gas are sensitive to the ambient number density. In the case of a low density, the shell-fragmentation occurs over a longer timescale, and the accumulated molecular gas is more massive than in the case of a high density. The variations with different central stars are more moderate. The time of the shell-fragmentation differs by a factor of several with the various stars of $M_* = 12 - 101\ M_\odot$. According to our numerical results, we conclude that the expanding H II region should be an efficient trigger for star formation in molecular clouds if the mass of the ambient molecular material is large enough.

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A Late Episode of Irradiation in the Early Solar System: Evidence from Extinct ^{36}Cl and ^{26}Al in Meteorites

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Late-formed halogen-rich phases in a refractory inclusion and a chondrule from the Allende meteorite exhibit large ^{36}S excesses that linearly correlate with the chlorine concentration, providing strong evidence in support of the existence of the short-lived nuclide ^{36}Cl (mean life of 0.43 Myr) in the early solar system. The inferred ^{36}Cl/^{35}Cl ratios at the time when these phases formed are very high ($\sim 4 \times 10^{-6}$) and essentially the same for the inclusion and the chondrule and confirm the earlier report of ^{36}S excess in another meteorite. In addition, the ^{36}Cl is decoupled from ^{26}Al. The observed and any possible higher levels of ^{36}Cl cannot be the result of a supernova or AGB stellar source but require a late episode of energetic particle bombardment by the early Sun, in support of the arguments based on the previous discovery of ^{10}Be. It is now clear that a blend of several sources is required to explain the short-lived nuclei when the solar system formed.

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An *XMM-Newton* observation of the young open cluster NGC 2547: coronal activity at 30 Myr

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We report on *XMM-Newton* observations of the young open cluster NGC 2547 which allow us to characterize coronal activity in solar-type stars, and stars of lower mass, at an age of 30 Myr. X-ray emission is seen from stars at all spectral types, peaking among G stars at luminosities (0.3 – 3 keV) of $L_x \simeq 10^{30.5}$ erg s^{-1} and declining to $L_x \leq 10^{29.0}$ erg s^{-1} among M stars with masses ≥ 0.2 M. Coronal spectra show evidence for multi-temperature differential emission measures and low coronal metal abundances of $Z \simeq 0.3$. The G- and K-type stars of NGC 2547 follow the same relationship between X-ray activity and Rossby number established in older clusters and field stars, although most of the solar-type stars in NGC 2547 exhibit saturated or even supersaturated X-ray activity levels. The median levels of L_x and L_x/L_{bol} in the solar-type stars of NGC 2547 are very similar to those in T-Tauri stars of the Orion Nebula cluster (ONC), but an order of magnitude higher than in the older Pleiades. The spread in X-ray activity levels among solar-type stars in NGC 2547 is much smaller than in older or younger clusters.

Coronal temperatures increase with L_x, L_x/L_{bol} and surface X-ray flux. The most active solar-type stars in NGC 2547 have coronal temperatures intermediate between those in the ONC and the most active older zero-age main-sequence (ZAMS) stars. We show that simple scaling arguments predict higher coronal temperature in coronally saturated stars with lower gravities. A number of candidate flares were identified among the low-mass members and a flaring rate [for total flare energies $(0.3 - 3$ keV$) > 10^{34}$ erg] of one every 350^{+350}_{-120} ks was found for solar-type stars, which is similar to rates found in the ONC and Pleiades. Comparison with ROSAT High Resolution Imager (HRI) data taken 7 yr earlier reveals that only $10 - 15$ per cent of solar-type stars or stars with $L_x > 3 \times 10^{29}$ erg s^{-1} exhibit X-ray variability by more than a factor of 2. This is comparable with clusters of similar age but less than in both older and younger clusters. The similar median levels of X-ray activity and rate of occurrence for large flares in NGC 2547 and the ONC demonstrate that the X-ray radiation environment around young solar-type stars remains relatively constant over their first 30 Myr.

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Large Area Mapping at 850 μm. IV. Analysis of the Clump Distribution in the Orion B South Molecular Cloud

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We present results from a survey of a 1300 arcmin^2 region of the Orion B South molecular cloud, including NGC 2024, NGC 2023, and the Horsehead Nebula (B33), obtained using the Submillimetre Common-User Bolometer Array (SCUBA) on the James Clerk Maxwell Telescope (JCMT). Submillimeter continuum observations at 450 and 850 μm are discussed. Using an automated algorithm, 57 discrete emission features ("clumps") are identified in the 850 μm map. The physical conditions within these clumps are investigated under the assumption that the objects are in quasi-hydrostatic equilibrium. The best-fit dust temperature for the clumps is found to be $T_d = 18 \pm 4$ K, with the exception of those associated with the few known far-infrared sources residing in NGC 2024. The latter internally heated sources are found to be much warmer. In the region surrounding NGC 2023, the clump dust temperatures agree with clump gas temperatures determined from molecular line excitation measurements of the CO molecule. The bounding pressure on the clumps lies in the range $log(k^{-1}P\mathrm{cm}^3\mathrm{K}^{-1}) = 6.1 \pm 0.3$. The cumulative mass distribution is steep at the high-mass end, as is the stellar initial mass function. The distribution flattens significantly at lower masses, with a turnover around $3 - 10M_\odot$.

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The Spitzer c2d Survey of Large, Nearby, Interstellar Clouds. III. Perseus Observed with IRAC

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We present observations of 3.86 degree^2 of the Perseus molecular cloud complex at 3.6, 4.5, 5.8 and 8.0 μm with the Spitzer Space Telescope Infrared Array Camera (IRAC). The maps show strong extended emission arising from shocked H_2 in outflows in the region and from polycyclic aromatic hydrocarbon (PAH) features, in particular in the prominent Perseus ring. More than 120,000 sources are extracted toward the cloud. Based on their IRAC colors and comparison to off-cloud and extragalactic fields, we identify 400 candidate young stellar objects. About two thirds of these are associated with the young clusters IC 348 and NGC 1333, which account for 14% of the surveyed cloud area, while the remaining third is distributed over the remaining cloud, including a number of smaller groups around B1, L1448 and L1455. We classify the young stellar objects according to the traditional scheme based on the slope of their spectral energy distributions from near-infrared 2MASS K_s through mid-infrared IRAC and MIPS 24 μm wavelengths. Significant differences are found for the numbers of embedded Class I objects relative to more evolved Class II objects in IC 348, NGC 1333 and the remaining cloud with the embedded Class I and "flat spectrum" YSOs constituting 14%, 36% and 47% of the total number of YSOs identified in each of these regions. These numbers suggest a difference in evolution over the cloud: NGC 1333 previously has been suggested to be younger than IC 348 based on near-infrared studies of the YSO populations and the larger number of Class I objects in NGC 1333 supports this. The high number of Class I objects in the extended cloud (61% of the Class I objects in the entire cloud) suggests that a significant fraction of the current star formation is occuring outside these two clusters. Finally we discuss a number of outflows and identify their driving sources, including the known deeply embedded Class 0 sources outside the two major clusters. The Class 0 objects are found to be detected by Spitzer and have very red [3.6] − [4.5] colors but do not show similarly red [5.8] − [8.0] colors. The Class 0 objects are easily identifiable in color-color diagrams plotting these two colors but are, in some cases, problematic to extract with automatic source extraction routines due to the extended emission from shocked gas or scattered light in cavities related to the associated outflows.

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http://peggysue.as.utexas.edu/SIRTF/PAPERS/pap50.pub.pdf

c2d *Spitzer* IRS Spectra of Disks around T Tauri Stars. I. Silicate Emission and Grain Growth

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Infrared $\sim 5-35\mu$m spectra for 40 solar mass T Tauri stars and 7 intermediate-mass Herbig Ae stars with circumstellar disks were obtained using the *Spitzer Space Telescope* as part of the c2d IRS survey. This work complements prior spectroscopic studies of silicate infrared emission from disks, which were focused on intermediate-mass stars, with observations of solar mass stars limited primarily to the 10 μm region. The observed 10 and 20 μm silicate feature strengths/shapes are consistent with source-to-source variations in grain size. A large fraction of the features are weak

and flat, consistent with micron-sized grains indicating fast grain growth (from 0.1 to 1.0 μm in radius). In addition, approximately half of the T Tauri star spectra show crystalline silicate features near 28 and 33 μm, indicating significant processing when compared to interstellar grains. A few sources show large 10-to-20 μm ratios and require even larger grains emitting at 20 μm than at 10 μm. This size difference may arise from the difference in the depth into the disk probed by the two silicate emission bands in disks where dust settling has occurred. The 10 μm feature strength versus shape trend is not correlated with age or Hα equivalent width, suggesting that some amount of turbulent mixing and regeneration of small grains is occurring. The strength versus shape trend is related to spectral type, however, with M stars showing significantly flatter 10 μm features (larger grain sizes) than A/B stars. The connection between spectral type and grain size is interpreted in terms of the variation in the silicate emission radius as a function of stellar luminosity, but could also be indicative of other spectral-type-dependent factors (e.g., X-rays, UV radiation, and stellar/disk winds).

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Occurrence Frequency of CO Outflows in Massive Protostellar Candidates

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We mapped 12 massive protostellar candidates in the CO J=2−1 line, which in combination with Zhang et al. (2005) completes an unbiased survey of outflows for all 48 sources with l>50° in a sample of 101 massive protostellar candidates. We detected outflows in 10 sources, implying 88% occurrence frequency of outflows for the 48 sources. This supports the conclusion of previous studies that bipolar outflows are an integral component in the formation process of massive stars. The vast majority of the observed outflows are much more massive (>10 $M_\odot$) and energetic (>100 $M_\odot$ km s^{-1}) than outflows from low-mass protostars. They also have large mass outflow rates (>2×10^{-4} $M_\odot$ yr^{-1}), suggesting large (∼1×10^{-4} $M_\odot$ yr^{-1}) accretion rates sufficient to overcome radiation pressure of the central massive protostars. We compared the frequency distribution of collimation factors of 40 massive outflows including those of this study with that of 36 low-mass outflows from the literature, and found *no* significant difference between the two. All these results are consistent with the suggestion that massive stars form through accretion as do low-mass stars but with much higher accretion rates.

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Discovery of a Very Young Field L Dwarf, 2MASS J01415823-4633574

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While following up L dwarf candidates selected photometrically from the Two Micron All Sky Survey, we uncovered an unusual object designated 2MASS J01415823-4633574. Its optical spectrum exhibits very strong bands of vanadium oxide but abnormally weak absorptions by titanium oxide, potassium, and sodium. Morphologically, such spectroscopic characteristics fall intermediate between old field early-L dwarfs [log(g) ≈ 5] and very late M giants [log(g) ≈ 0], leading us to favor low gravity as the explanation for the unique spectral signatures of this L dwarf. Such a low gravity can

be explained only if this L dwarf is much lower in mass than a typical old field L dwarf of similar temperature and is still contracting to its final radius. These conditions imply a very young age. Further evidence of youth is found in the near-infrared spectrum, including a triangular-shaped H-band continuum, reminiscent of young brown dwarf candidates discovered in the Orion Nebula Cluster. Using the above information along with comparisons to brown dwarf atmospheric and interior models, our current best estimate is that this L dwarf has an age of $1 - 50$ Myr and a mass of $6 - 25 M_J$. Although the lack of a lithium detection (pseudo-equivalent width < 1 Å) might appear to contradict other evidence of youth, we suggest that lithium becomes weaker at lower gravity like all other alkali lines and thus needs to be carefully considered before being used as a diagnostic of age or mass for objects in this regime. The location of 2MASS 0141-4633 on the sky coupled with a distance estimate of ~ 35 pc and the above age estimate suggests that this object may be a brown dwarf member of either the 30 Myr old Tucana/Horologium association or the ~ 12 Myr old β Pic moving group. Distance as determined through trigonometric parallax (underway) and a measure of the total space motion are needed to test this hypothesis.

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On the Location of the Snow Line in a Protoplanetary Disk

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In a protoplanetary disk, the inner edge of the region where the temperature falls below the condensation temperature of water is referred to as the snow line. Outside the snow line, water ice increases the surface density of solids by a factor of 4. The mass of the fastest growing planetesimal (the isolation mass) scales as the surface density to the 3/2 power. It is thought that ice-enhanced surface densities are required to make the cores of the gas giants (Jupiter and Saturn) before the disk gas dissipates. Observations of our solar system's asteroid belt suggest that the snow line occurred near 2.7 AU. In this paper we revisit the theoretical determination of the snow line. In a minimum-mass disk characterized by conventional opacities and a mass accretion rate of $10^{-8} M_\odot$ yr^{-1}, the snow line lies at 1.6-1.8 AU, just past the orbit of Mars. The minimum-mass disk, with a mass of 0.02 $M_\odot$, has a lifetime of 2 million years with the assumed accretion rate. Moving the snow line past 2.7 AU requires that we increase the disk opacity, accretion rate, and/or disk mass by factors ranging up to an order of magnitude above our assumed baseline values.

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Low Mass Stars and Brown Dwarfs in NGC 2024: Constraints on the Substellar Mass Function

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We present results from a near-infrared spectroscopic study of candidate brown dwarfs and low mass stars in the young cluster NGC 2024. Using FLAMINGOS on the KPNO 2.1m and 4m telescopes, we have obtained spectra of ~70 new members of the cluster and classified them via the prominent J and H band water absorption features. Derived spectral types range from ~M1 to later than M8 with typical classification errors of 0.5-1 subclasses. By combining these spectral types with JHK photometry, we place these objects on the H-R diagram and use pre-main sequence evolutionary models to infer masses and ages. The mean age for this low mass population of NGC 2024 is 0.5 Myr and derived masses range from ~0.7-0.02 $M_\odot$ with 23 objects falling below the hydrogen-burning limit. The logarithmic mass function rises to a peak at ~0.2 $M_\odot$ before turning over and declining into the substellar regime. There is a possible secondary peak at ~0.035 $M_\odot$ however the errors are also consistent with a flat IMF in this region. The ratio of brown dwarfs to stars is similar to that found in the Trapezium but roughly twice the ratio found in IC 348, leading us to conclude that the substellar IMF in young clusters may be dependent on the local star forming environment.

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Cluster Formation in Protostellar Outflow-driven Turbulence

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Most, perhaps all, stars go through a phase of vigorous outflow during formation. We examine, through three-dimensional MHD simulation, the effects of protostellar outflows on cluster formation. We find that the initial turbulence in the cluster-forming region is quickly replaced by motions generated by outflows. The protostellar outflow-driven turbulence ("protostellar turbulence" for short) can keep the region close to a virial equilibrium long after the initial turbulence has decayed away. We argue that there exist two types of turbulence in star-forming clouds: a primordial (or "interstellar") turbulence and a protostellar turbulence, with the former transformed into the latter mostly in embedded clusters such as NGC 1333. Since the majority of stars are thought to form in clusters, an implication is that the stellar initial mass function is determined to a large extent by the stars themselves, through outflows that individually limit the mass accretion onto forming stars and collectively shape the environments (density structure and velocity field) in which most cluster members form. We speculate that massive cluster-forming clumps supported by protostellar turbulence gradually evolve toward a highly centrally condensed "pivotal" state, culminating in rapid formation of massive stars in the densest part through accretion.

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Possible Molecular Spiral Arms in the Protoplanetary Disk of AB Aur

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The circumstellar dust disk of the Herbig Ae star AB Aur has been found to exhibit complex spiral-like structures in the near-IR image obtained with the Subaru Telescope. We present maps of the disk in both ^{12}CO (3-2) and dust continuum at 345 GHz with the SMA at an angular resolution of $1''.0 \times 0.7''$(144AU $\times$ 100AU). The continuum emission traces a dust disk with a central depression and a maximum overall dimension of 450AU (FWHM). This dust disk exhibits several distinct peaks that appear to coincide with bright features in the near-IR image, in particular the brightest inner spiral arm. The CO emission traces a rotating gas disk of size 530AU $\times$ 330AU with a deprojected maximum velocity of 2.8 km s^{-1} at 450 AU. In contrast to the dust disk, the gas disk exhibits an intensity peak at the stellar position. Furthermore, the CO emission in several velocity channels traces the innermost spiral arm seen in the near-IR. We compare the observed spatial-kinematic structure of the CO emission to a simple model of a disk in Keplerian rotation, and find that only the emission tracing the main spiral arm clearly lies outside the confines of our model. This emission has a net outward radial motion compared with the radial velocity predicted by the model at the location of the main spiral arms. The disk of AB Aur is therefore quite different from the Keplerian disks seen around many Herbig Ae stars. The spiral-like structures of the disk with non-Keplerian motions we revealed in ^{12}CO(3-2), together with the central depression of the dust disk, may be explained to be driven by the possible existence of a giant planet forming in the disk.

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Evidence for T Tauri-like emission in the EXor V1118 Ori from near-IR and X-ray data

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We present a near-IR study of the EXor variable V1118 Ori, performed by following a slightly declining phase after a recent outburst. In particular, the near-IR (0.8 - 2.3 μm) spectrum, obtained for the first time, shows a large variety of emission features of the HI (Paschen and Brackett series), He I recombination and CO overtone. By comparing the observed spectrum with a wind model, a mass loss rate of 4 10^{-8} $M_\odot$ yr^{-1} can be derived along with other parameters whose values are typical of an accreting T Tauri star. In addition, we have used X-ray data from the XMM archive, taken in two different epochs during the declining phase monitored in IR. X-ray emission (in the range 0.5 - 10 keV) permits to derive several parameters (as plasma temperatures and L_X luminosity) which confirm the T Tauri nature of the source. In the near-IR the object maintains a low extinction (A_V $\sim$ 2) during all the activity phases, confirming that variable extinction does not contribute to brightness variations. The lack of both a significant amount of circumstellar material and any evidence of IR cooling from collimated jet/outflow driven by the source, indicates that, at least this member of the EXor class, is in a late stage of the Pre-Main Sequence evolution. Going from inactive to active phases the luminosity increases considerably (from 1.4 $L_\odot$ to more than 25 $L_\odot$) and the observed spectral energy distribution (SED) assumes different shapes, all typical of a T Tauri star. In the X-ray regime, an evident fading is present, detected in the post-outburst phase, that cannot be reconciled with the presence of any absorbing material. This circumstance, combined with the persistence (in the pre- and post-outburst phases) of a temperature component at about 10 MK, suggests that accretion has some influence in regulating the coronal activity.

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Testing Theoretical Evolutionary Models with AB Doradus C and the Initial Mass Function

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We assess the constraints on the evolutionary models of young low-mass objects that are provided by the measurements of the companion AB Dor C by Close and coworkers and by a new comparison of model-derived IMFs of star-forming regions to the well-calibrated IMF of the solar neighborhood. After performing an independent analysis of all of the imaging and spectroscopic data for AB Dor C that were obtained by Close, we find that AB Dor C (which has no methane) is not detected at a significant level (S/N $\sim$ 1.2) in the SDI data when one narrowband image is subtracted from another but that it does appear in the individual SDI frames, as well as the images at J, H, and K_s. Although our broadband photometry for AB Dor C is consistent with that of Close, the uncertainties that we measure are larger. Using the age of $\tau = 75 - 150$ Myr recently estimated for AB Dor by Luhman and coworkers, the luminosity predicted by the models of Chabrier and Baraffe is consistent with the value that we estimate from the photometry for AB Dor C. We measure a spectral type of M6 $\pm$ 1 from the K-band spectrum of AB Dor C, which is earlier than the value of M8 $\pm$ 1 reported by Close and is consistent with the model predictions when a dwarf temperature scale is adopted. In a test of these evolutionary models at much younger ages, we show that the low-mass IMFs that they produce for star-forming regions are similar to the IMF of the solar neighborhood. If the masses of the low-mass stars and brown dwarfs in these IMFs of star-forming regions were underestimated by a factor of 2 as suggested by Close, then the IMF characterizing the current generation of Galactic star formation would have to be radically different from the IMF of the solar neighborhood.

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Evolution of Rotating Molecular Cloud Core with Oblique Magnetic Field

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We studied the collapse of rotating molecular cloud cores with inclined magnetic fields, based on three-dimensional numerical simulations. The numerical simulations start from a rotating Bonnor–Ebert isothermal cloud in a uniform magnetic field. The magnetic field is initially taken to be inclined from the rotation axis. As the cloud collapses, the magnetic field and rotation axis change their directions. When the rotation is slow and the magnetic field is relatively strong, the direction of the rotation axis changes to align with the magnetic field, as shown earlier by Matsumoto & Tomisaka. When the magnetic field is weak and the rotation is relatively fast, the magnetic field inclines to become perpendicular to the rotation axis. In other words, the evolution of the magnetic field and rotation axis depends on the relative strength of the rotation and magnetic field. Magnetic braking acts to align the rotation axis and magnetic field, while the rotation causes the magnetic field to incline through dynamo action. The latter effect dominates the former when the ratio of the angular velocity to the magnetic field is larger than a critical value $\Omega_0/B_0 > 0.39\, G^{1/2}\, c_s^{-1}$, where B_0, Ω_0, G, and c_s denote the initial magnetic field, initial angular velocity, gravitational constant, and sound speed, respectively. When the rotation is relatively strong, the collapsing cloud forms a disk perpendicular to the rotation axis and the magnetic field becomes nearly parallel to the disk surface in the high density region. A spiral structure appears due to the rotation and the wound-up magnetic field in the disk.

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L-band (3.5 μm) IR-excess in massive star formation – II. RCW 57/NGC 3576

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Context. We present a JHK_sL survey of the massive star forming region RCW 57 (NGC 3576) based on L-band data at 3.5 μm taken with SPIREX (South Pole Infrared Explorer), and 2MASS JHK_s data at 1.25-2.2 μm. This is the second of two papers, the first one concerning a similar JHK_sL survey of 30 Doradus.
Aims. Colour-colour and colour-magnitude diagrams are used to detect sources with infrared excess. This excess emission is interpreted as coming from circumstellar disks, and hence gives the cluster disk fraction (CDF). Based on the CDF and the age of RCW 57, it is possible to draw conclusions on the formation and early evolution of massive stars.
Methods. The infrared excess is detected by comparing the locations of sources in JHK_sL colour-colour and L vs. $(K_s - L)$ colour-magnitude diagrams to the reddening band due to interstellar extinction.
Results. A total of 251 sources were detected. More than 50% of the 209 sources included in the diagrams have an infrared excess.
Conclusions. Comparison with other JHK_sL surveys, including the results on 30 Doradus from the first paper, support a very high initial disk fraction (> 80%) even for massive stars, although there is an indication of a possible faster evolution of circumstellar disks around high mass stars. 33 sources only found in the L-band indicate the presence of heavily embedded, massive Class I protostars. We also report the detection of diffuse PAHs emission throughout the RCW 57 region.

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Fragmentation and Evolution of Molecular Clouds. I. Algorithm and First Results

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We present a series of simulations of the fragmentation of a molecular cloud, leading to the formation of a cluster of protostellar cores. We use Gaussian initial conditions with a power spectrum $P(k) \propto k^{-2}$, assume an isothermal equation of state, and neglect turbulence and magnetic fields. The purpose of these simulations is to address a specific numerical problem called artificial fragmentation, which plagues simulations of cloud fragmentation. We argue that this is a serious problem, and that the only reasonable and practical way to address it within the smoothed particle hydrodynamics (SPH) algorithm is to use a technique called particle splitting. We performed three simulations, with $N_{gen} = 0$, 1, and 2 levels of particle splitting. All simulations start up with 64^3 SPH particles, but their effective resolutions correspond to 64^3, 128^3, and 256^3 particles, respectively. The third simulation properly resolves the Jeans mass throughout the entire system, at all times, thus preventing artificial fragmentation. The high resolution of our simulations results in the formation of a large number of protostellar cores, nearly 3000 for the largest simulation. The final mass distribution of cores is lognormal, and the distribution shifts down in mass as the resolution improves. The width of the distribution is about 1.5 (e.g., a factor of 30 in the mass), and the low-mass edge of the distribution corresponds to the lowest core mass that the code can resolve. This result differs from previous claims of a relationship between the mean of the distribution and the initial Jeans mass.

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SUBARU Near Infrared Coronagraphic Images of T Tauri

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High angular resolution near-infrared (JHK) adaptive optics images of T Tau were obtained with the infrared camera CIAO mounted on the Subaru 8.2m Telescope in 2002 and 2004. The images resolve a complex circumstellar structure around the multiple system. We resolved T Tau Sa and Sb as well as T Tau N and S. The estimated orbit of T Tau Sb indicates that it is probably bound to T Tau Sa. The K band flux of T Tau S decreased by $\sim$1.7 Jy in November 2002 compared with that in 2001 mainly because T Tau Sa became fainter. The arc-like ridge detected in our near-infrared images is consistent what is seen at visible wavelengths, supporting the interpretation in previous studies that the arc is part of the cavity wall seen relatively pole-on. Halo emission is detected out to $\sim 2''$ from T Tau N. This may be the light scattered off the common envelope surrounding the T Tauri multiple system.

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http://www.naoj.org/staff/mayamast/SubaruImagesOfTTauri.pdf

The Southern Flanking Fields of the 25 Orionis Group

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The stellar group surrounding the Be (B1Vpe) star 25 Orionis was discovered to be a pre-main-sequence population by the Centro de Investigaciones de Astronomia (CIDA) Orion Variability Survey and subsequent spectroscopy. We analyze Sloan Digital Sky Survey multi-epoch photometry to map the southern extent of the 25 Ori group and to characterize its pre-main-sequence population. We compare this group to the neighboring Orion OB1a and OB1b subassociations and to active star formation sites (NGC 2068/NGC 2071) within the Lynds 1630 dark cloud. We find that the 25 Ori group has a radius of 1.4°, corresponding to 8-11 pc at the distances of Orion OB1a and OB1b. Given that the characteristic sizes of young open clusters are a few pc or less this suggests that 25 Ori is an unbound association rather than an open cluster. Due to its PMS population having a low Classical T Tauri fraction (∼10%) we conclude that the 25 Ori group is of comparable age to the 11 Myr Orion OB1a subassociation.

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ISM gas removal from starburst galaxies and the premature death of star clusters

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Recent observational studies of the age distribution of star clusters in nearby merging galaxies and starburst (SB) galaxies indicate a premature death of the young clusters. The fate of an evolving star cluster crucially depends of its gas content. This behaves like a glue that helps to keep the star system gravitationally bound. In SB systems where the rate of supernovae (SNe) explosions is elevated one should expect an efficient heating of the gas and its complete removal which could then favor the rapid dissociation of the evolving star clusters. Based on a contemporaneous study of the dynamical evolution of the interstellar gas in SB environments (Melioli & de Gouveia Dal Pino 2004, A&A, 424, 817) where it has been considered also the presence of dense clouds that may inhibit the heating efficiency of the interstellar gas by the SNe, we have here computed the timescales for gas removal from young clusters embedded in these systems and found that they are consistent with the very short timescales for cluster dissolution which are inferred from the observational studies above. Our results indicate that typical SB proto-clusters should start to disperse after less than 5 Myr. For a given total gas mass content, this result is nearly insensitive to the initial star formation efficiency.

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A Two-Fluid Analysis of the Kelvin-Helmholtz Instability in the Dusty Layer of a Protoplanetary Disk: A Possible Path toward Planetesimal Formation through Gravitational Instability

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We analyze the stability of the dust layer in protoplanetary disks to understand the effect of relative motion between gas and dust. Previous analyses not including the effect of the relative motion between gas and dust show that shear-induced turbulence may prevent the dust grains from settling sufficiently to be gravitationally unstable. We determine the growth rate of the Kelvin-Helmholtz instability in a wide range of parameter space and propose a possible path toward planetesimal formation through gravitational instability. We expect the density of the dust layer to become $\rho_d/\rho_g \sim 100$ if the dust grains can grow up to 10 m.

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Keck Interferometer Observations of FU Orionis Objects

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We present new K-band long-baseline interferometer observations of three young stellar objects of the FU Orionis class, namely, V1057 Cyg, V1515 Cyg, and Z CMa-SE, obtained at the Keck Interferometer during its commissioning science period. The interferometer clearly resolves the source of near-infrared emission in all three objects. Using simple geometric models, we derive size scales ($0.5 - 4.5$ AU) for this emission. All three objects appear significantly more resolved than expected from simple models of accretion disks tuned to fit the broadband optical and infrared spectrophotometry. We explore variations in the key parameters that are able to lower the predicted visibility amplitudes to the measured levels and conclude that accretion disks alone do not reproduce the spectral energy distributions and K-band visibilities simultaneously. We conclude that either disk models are inadequate to describe the near-infrared emission or additional source components are needed. We hypothesize that large-scale emission (tens of AU) in the interferometer field of view is responsible for the surprisingly low visibilities. This emission may arise in scattering by large envelopes believed to surround these objects.

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Nearby debris disk systems with high fractional luminosity reconsidered

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By searching the IRAS and ISO databases we compiled a list of 60 debris disks which exhibit the highest fractional luminosity values ($f_d > 10^{-4}$) in the vicinity of the Sun ($d < 120$ pc). Eleven out of these 60 systems are new discoveries. Special care was taken to exclude bogus disks from the sample. We computed the fractional luminosity values using available IRAS, ISO, and Spitzer data, and analysed the galactic space velocities of the objects. The results revealed that stars with disks of high fractional luminosity often belong to young stellar kinematic groups, providing an opportunity to obtain improved age estimates for these systems. We found that practically all disks with $f_d > 5{\times}10^{-4}$ are younger than 100 Myr. The distribution of the disks in the fractional luminosity versus age

diagram indicates that (1) the number of old systems with high f_d is lower than was claimed before; (2) there exist many relatively young disks of moderate fractional luminosity; and (3) comparing the observations with a current theoretical model of debris disk evolution a general good agreement could be found.

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Modeling the Jovian subnebula – II. Composition of regular satellite ices

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We use an evolutionary turbulent model of Jupiter's subnebula to constrain the composition of ices incorporated in its regular icy satellites. We consider CO_2, CO, CH_4, N_2, NH_3, H_2S, Ar, Kr and Xe as the major volatile species existing in the gas-phase of the solar nebula. All these volatile species, except CO_2 which crystallized as a pure condensate, are assumed to be trapped by H_2O to form hydrates or clathrate hydrates in the solar nebula. Once condensed, these ices were incorporated into the growing planetesimals produced in the feeding zone of proto-Jupiter. Some of these solids then flowed from the solar nebula to the subnebula, and may have been accreted by the forming Jovian regular satellites. We show that ices embedded in solids entering at early epochs into the Jovian subdisk were all vaporized. This leads us to consider two different scenarios of regular icy satellite formation in order to estimate the composition of the ices they contain. In the first scenario, icy satellites were accreted from planetesimals that have been produced in Jupiter's feeding zone without further vaporization, whereas, in the second scenario, icy satellites were accreted from planetesimals produced in the Jovian subnebula. In this latter case, we study the evolution of carbon and nitrogen gas-phase chemistries in the Jovian subnebula and we show that the conversions of N_2 to NH_3, of CO to CO_2, and of CO to CH_4 were all inhibited in the major part of the subdisk. Finally, we assess the mass abundances of the major volatile species with respect to H_2O in the interiors of the Jovian regular icy satellites. Our results are then compatible with the detection of CO_2 on the surfaces of Callisto and Ganymede and with the presence of NH_3 envisaged in subsurface oceans within Ganymede and Callisto.

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Saturn's internal structure and carbon enrichment

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We use the clathrate hydrate trapping theory to calculate the enrichments in O, N, S, Xe, Ar and Kr compared to solar in Saturn's atmosphere. For this, we calibrate our calculations using two different carbon abundance determinations that cover the domain of measurements published in recent decades: one derived from the NASA *Kuiper* Airborne Observatory measurements and the other obtained from the *Cassini* spacecraft observations. We show that these two carbon abundances imply a different minimum heavy element content for Saturn. Using the *Kuiper* Airborne Observatory measurement for calibration, the amount of ices accreted by Saturn is found to be consistent with current interior models of this planet. On the other hand, using the *Cassini* measurement for calibration leads to an ice content in the planet's envelope that is higher than the one derived from the interior models. In this case, reconciling the interior models with the amount of C measured by the *Cassini* spacecraft requires that significant differential sedimentation of water and volatile species has taken place in Saturn's interior during its lifetime.

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24 μm Detections of Disks around Very Low-mass Stars and Brown Dwarfs in IC 348: Grain Growth/Settling and Inner Holes?

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We present observations of six late-type members of the young cluster IC 348 detected at 24 μm with the Multiband Imaging Photometer for *Spitzer* (MIPS). At least four of the objects are probably substellar. Combining these data with ground-based optical and near-infrared photometry and complementary observations with the Infrared Array Camera (IRAC), we have modeled the spectral energy distributions using detailed models of irradiated accretion disks. We are able to fit the observations with models using a range of maximum grain sizes from ISM-type dust to grains as large as 1 millimeter. Two objects show a lack of excess emission at wavelengths shortward of 5.8-8 μm but significant excess at longer wavelengths, indicative of large optically thin or evacuated inner holes. Our models indicate an inner hole of radius $\sim 0.5 - 0.9$ AU for the brown dwarf L316; this is the first brown dwarf with evidence for an AU-scale inner disk hole. We examine several possible mechanisms for the inner disk clearing in this case, including photoevaporation and planet formation.

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Weighing the young stellar discs around Sgr A*

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It is believed that young massive stars orbiting Sgr A* in two stellar discs on scales of $\sim 0.1 - 0.2$ parsec were formed either farther out in the Galaxy and then quickly migrated inwards or *in situ* in a massive self-gravitating disc. Comparing N-body evolution of stellar orbits with observational constraints, we set upper limits on the masses of the two stellar systems. These masses turn out to be a few times lower than the expected total stellar mass estimated from the observed young high-mass stellar population and the standard galactic initial mass function (IMF). If these stars were formed *in situ*, in a massive self-gravitating disc, our results suggest that the formation of low-mass stars was suppressed by a factor of at least a few, requiring a top-heavy IMF for stars formed near Sgr A*.

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Discovery of a Population of Pre-Main-Sequence Stars in NGC 346 from Deep *Hubble Space Telescope* ACS Images

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We report the discovery of a rich population of low-mass stars in the young, massive NGC 346 star-forming region in the Small Magellanic Cloud from deep V, I, and Hα images taken with the *Hubble Space Telescope* Advanced Camera for Surveys. These stars have likely formed together with the NGC 346 cluster, $\simeq 3-5$ Myr ago. Their magnitudes and colors are those of pre-main-sequence stars in the mass range $0.6-3M_{\odot}$, mostly concentrated in the main cluster, but with secondary subclusters spread over a region across ~ 45 pc. These subclusters appear to be spatially coincident with previously known knots of molecular gas identified in ground-based and *Infrared Space Observatory* observations. We show that NGC 346 is a complex region, being shaped by its massive stars, and the observations presented here represent a key step toward the understanding of how star formation occurred and has progressed in this low-metallicity environment.

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A SCUBA survey of L1689 - the dog that didn't bark

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We present submillimetre data for the L1689 cloud in the ρ Ophiuchi molecular cloud complex. We detect a number of starless and prestellar cores and protostellar envelopes. We also detect a number of filaments for the first time in the submillimetre continuum that are parallel both to each other, and to filaments observed in the neighbouring L1688 cloud. These filaments are also seen in the 13CO observations of L1689. The filaments contain all of the star-formation activity in the cloud. L1689 lies next to the well studied L1688 cloud that contains the rho Oph-A core. L1688 has a much more active star-formation history than L1689 despite their apparent similarity in 13CO data. Hence we label L1689 as the dog that didn't bark. We endeavour to explain this apparent anomaly by comparing the total mass of each cloud that is currently in the form of dense material such as prestellar cores. We note firstly that L1688 is more massive than L1689, but we also find that when normalised to the total mass of each cloud, the L1689 cloud has a much lower percentage of mass in dense cores than L1688. We attribute this to the hypothesis of Loren, that the star formation in the rho Ophiuchi complex is being affected and probably dominated by the external influence of the nearby Upper Scorpius OB association and predominantly by sigma Sco. L1689 is further from sigma Sco and is therefore less active. The influence of sigma Sco appears nonetheless to have created the filaments that we observe in L1689.

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Very Low Luminosity Young Cluster and the Luminosity and Mass Functions in S106

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We present the results of deep near-infrared observations searching for very low mass young stellar objects (YSOs) in the massive star-forming region of S106 taken with the Subaru Telescope. The survey, whose limiting magnitude exceeds 20 mag in the JHK' bands, is sensitive enough to provide unprecedented details in the two nebular lobes. In addition, it reveals a census of the stellar population down to objects below the deuterium-burning limit, a fiducial boundary between brown dwarfs and planetary-mass objects. Based on color-color diagrams, nearly 600 embedded YSO candidates with near-infrared excesses have been identified in an area of $\sim 5' \times 5'$ that are not uniformly distributed but centrally concentrated. Combining the reddening-corrected luminosity of the YSO candidates with the theoretical evolutionary models, we suggest that there exists a substantial substellar population. If we divide the cluster into three subgroups based on stellar and cloud properties, both their luminosity functions and mass functions across the stellar-substellar boundary demonstrate local variation on a subparsec scale. Nevertheless, all the mass functions have distinct characteristics in common: they do not have any turnover and do not decline down to the completeness limits. Furthermore, the mass function for S106 appears to be more abundant in young substellar objects compared to those obtained for other young clusters, such as Trapezium and IC 348. This implies that the substellar mass function for young clusters may have a variation.

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Weak-line T Tauri Star Disks I. Initial *Spitzer* Results from the Cores to Disks Legacy Project

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Using the *Spitzer Space Telescope*, we have observed 90 weak-line and classical T Tauri stars in the vicinity of the Ophiuchus, Lupus, Chamaeleon, and Taurus star-forming regions as part of the Cores to Disks (c2d) *Spitzer* Legacy project. In addition to the *Spitzer* data, we have obtained contemporaneous optical photometry to assist in constructing spectral energy distributions. These objects were specifically chosen as solar-type young stars with low levels of Hα emission, strong X-ray emission, and lithium absorption i.e. weak-line T Tauri stars, most of which were undetected in the mid-to-far IR by the IRAS survey. Weak-line T Tauri stars are potentially extremely important objects in determining the timescale over which disk evolution may take place. Our objective is to determine whether these young stars are diskless or have remnant disks which are below the detection threshold of previous infrared missions. We find that only 5/83 weak-line T Tauri stars have detectable excess emission between 3.6 and 70 micron which would indicate the presence of dust from the inner few tenths of an AU out to the planet-forming regions a few tens of AU from the star. Of these sources, two have small excesses at 24 microns consistent with optically thin disks; the others have optically thick disks already detected by previous IR surveys. All of the seven classical T Tauri stars show excess emission at 24 and 70 micron, although their properties vary at the shorter wavelengths. Our initial results show that disks are rare among young stars selected for their weak Hα emission.

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Testing grain surface chemistry : a survey of deuterated formaldehyde and methanol in low-mass Class 0 protostars

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Context: Despite the low cosmic abundance of deuterium (D/H $\sim 10^{-5}$), high degrees of deuterium fractionation in molecules are observed in star-forming regions with enhancements that can reach 13 orders of magnitude, a level that current models have difficulty accounting for.
Aims: Multi-isotopologue observations are a very powerful constraint for chemical models. The aim of our observations is to understand the processes that form the observed high abundances of methanol and formaldehyde in low-mass protostellar envelopes (gas-phase processes ? chemistry on the grain surfaces ?), as well as to better constrain the chemical models.
Methods: With the IRAM 30m single-dish telescope, we observed deuterated formaldehyde (HDCO and D_2CO) and methanol (CH_2DOH, CH_3OD, and CHD_2OH) towards a sample of seven low-mass class 0 protostars. Using population diagrams, we then derived the fractionation ratios of these species (abundance ratio between the deuterated molecule and its main isotopologue) and compared them to the predictions of grain chemistry models.
Results: These protostars show a similar level of deuteration as in IRAS16293−2422, where doubly-deuterated methanol – and even triply-deuterated methanol – were first detected. Our observations point to the formation of methanol on the grain surfaces, while formaldehyde formation cannot be fully pinned down. While none of the scenarii can be excluded (gas-phase or grain chemistry formation), they both seem to require abstraction reactions to reproduce the observed fractionations.

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Modeling the ortho-to-para abundance ratio of cyclic C_3H_2 in cold dense cores

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Aims. We report a detailed attempt to model the ortho-to-para abundance ratio of $c{-}C_3H_2$ so as to reproduce observed values in the cores of the well-known source TMC-1. According to observations, the ortho-to-para ratios vary, within large uncertainties, from a low of near unity to a high of approximately three depending on the core.
Methods. We used the osu.2003 network of gas-phase chemical reactions augmented by reactions that specifically consider the formation, depletion, and interconversion of the ortho and para forms of $c{-}C_3H_2$ and its precursor ion $c{-}C_3H_3^+$. We investigated the sensitivity of the calculated ortho-to-para ratio for $c{-}C_3H_2$ to a large number of factors.
Results. For the less evolved cores C, CP, and D, we had no difficulty reproducing the observed ortho-to-para ratios of 1-2. In order to reproduce observed ortho-to-para ratios of near three, observed for the evolved cores A and B, it was necessary to include rapid ion-catalyzed interconversion processes.

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CB17: Inferring the dynamical history of a prestellar core with chemo-dynamical models

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We present a detailed theoretical study of the isolated Bok globule CB17 (L1389) based on spectral maps of CS,

HCO^+, $C^{18}O$, $C^{34}S$, and $H^{13}CO^+$ lines. A phenomenological model of prestellar core evolution, a time-dependent chemical model, and a radiative transfer simulation for molecular lines are combined to reconstruct the chemical and kinematical structure of this core. In addition we investigate the influence of various physical factors on molecular line profiles. It is shown that the intensity of the external UV field, the probability for molecules to stick onto dust grains, the core age, and the rotation velocity all significantly affect the molecular line spectra. Due to this influence, the asymmetry of optically thick lines allows to remove the ambiguity between the sticking probability and the core age. We demonstrate that these parameters are well constrained, when results of the modeling are compared to observations in multiple lines of sight through the core. We developed a general criterion that allows to quantify the difference between observed and simulated spectral maps. By minimizing this difference, we find that very high and very low values of the effective sticking probability S are not appropriate for the studied prestellar core. The most probable S value for CB17 is 0.3–0.5. The spatial distribution of the intensities and self-absorption features of optically thick lines is indicative of UV irradiation of the core. By fitting simultaneously optically thin transitions of $C^{18}O$, $H^{13}CO^+$, and $C^{34}S$ as well as optically thick transitions of HCO^+ and CS, we isolate the model that reproduces all the available spectral maps to a reasonable accuracy and, thus, represents a good approximation to the core chemical and kinematical structure. The line asymmetry pattern in CB17 is reproduced by a combination of infall, rotation, and turbulent motions with velocities ~ 0.05 km s^{-1}, ~ 0.1 km s^{-1}, and ~ 0.1 km s^{-1}, respectively. These parameters corresponds to energy ratios $E_{\rm rot}/E_{\rm grav} \approx 0.03$, $E_{\rm therm}/E_{\rm grav} \approx 0.8$, and $E_{\rm turb}/E_{\rm grav} \approx 0.05$ (the rotation parameters are determined for $i = 90°$). The chemical age of the core is about 2 Myrs. In particular, this is indicated by the central depletion of CO, CS, and HCO^+. On the other hand, the depletion is not strong enough to show up in intensity maps as a ring-like pattern. Based on the angular momentum value, we argue that the core is going to fragment, i.e., to form a binary (multiple) star.

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The Fate of Discs around Massive Stars in Young Clusters

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AIM: The aim of this work is to understand whether there is a difference in the dispersion of discs around stars in high-density young stellar clusters like the Orion Nebula Cluster (ONC) according to the mass of the star.
METHOD:Two types of simulations were combined — N-body simulations of the dynamics of the stars in the ONC and mass loss results from simulations of star-disc encounters, where the disc mass loss of all stars is determined as a function of time.
RESULTS: We find that in the Trapezium, the discs around high-mass stars are dispersed much more quickly and to a larger degree by their gravitational interaction than for intermediate-mass stars. This is consistent with the very recent observations of IC 348, where a higher disc frequency was found around solar mass stars than for more massive stars, suggesting that this might be a general trend in large young stellar clusters.

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Ammonia in infrared dark clouds

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Context. While low mass clouds have been relatively well studied, our picture of high-mass star formation remains unclear. Infrared Dark Clouds appear to be the long sought population of cold and dense aggregations with the potential of harbouring the earliest stages of massive star formation. Up to now there has been no systematic study

on the temperature distribution, velocity fields, chemical and physical state toward this new cloud population.
Aims. Knowing these properties is crucial for understanding the presence, absence and the very potential of star formation. The present paper aims at addressing these questions. We analyse temperature structures and velocity fields and gain information on their chemical evolution.
Methods. We mapped the $(J, K) = (1, 1)$ and $(2, 2)$ inversion transitions of ammonia in 9 infrared dark clouds. Our observations allow the most reliable determination of gas temperatures in IRDCs to date.
Results. The gas emission is remarkably coextensive with the extinction seen at infrared wavelengths and with the submillimeter dust emission. Our results show that IRDCs are on average cold ($T < 20$ K) and have variations among the different cores. IRDC cores are in virial equilibrium, are massive ($M > 100 M_{\odot}$), highly turbulent ($1 - 3$ km s^{-1}) and exhibit significant velocity structure (variations around $1 - 2$ km s^{-1} over the cloud).
Conclusions. We find an increasing trend in temperature from IRDCs with high ammonia column density to high mass protostellar objects and Ultracompact HII regions, stages of early warm high-mass star formation. The linewidths of IRDCs are smaller than those observed in high mass protostellar objects and hot core/Ultracompact HII regions. On basis of this sample, and by comparison of the ammonia gas properties within a cloud and between different clouds, we infer that while active star formation is not yet pervasive in most IRDCs, local condensations might collapse in the future or have already begun forming stars.

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Line profiles of water for the photon dominated region and embedded sources in the S140 region

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A radiative transfer method for the treatment of molecular lines is presented. We apply this method to previous SWAS and ISO observations of water vapor in the source S140 in order to make models to plan for, and to interpret, HIFI data. Level populations are calculated with the use of a three-dimensional (multi-zone) escape probability method and with a long characteristic code that uses Monte Carlo techniques with fixed directions. Homogeneous and inhomogeneous models are used to compute the differences between water line profiles across the S140 region. We find that when an outflow or infall velocity field with a gradient of a few kms^{-1} is adopted, line profiles with a FWHM of 6 kms^{-1} are found, in agreement with observations. Inhomogeneous models are favoured to produce a single-peaked line profile. When zooming in on smaller regions within the PDR, the shapes of the line profiles start to differ due to the different temperature and density distributions there. The embedded sources are traced by high excitation lines of, e.g., 3_{21}-2_{21}, 3_{03}-2_{12}, 2_{12}-1_{01} and 2_{20}-1_{11}. The computed intensities are roughly consistent with existing ISO observations. Water emission in a PDR source like S140 requires a combination of a pure PDR and an embedded source in order to match the observations. Because of its good angular resolution, HIFI will be able to distinguish between a dense star forming region or a more diffuse gas component. It is therefore important for future observing programs to consider both in their predictions of the emission characteristics of water in these environments.

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The Herbig B0e star HD 53367: circumstellar activity and evidence of binarity

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Aims. We investigate the spectroscopic behaviour of the young B0e star HD 53367 within a cooperative observing programme conducted from 1994 to 2005.
Methods. The data include more than 100 high-resolution spectra collected at the Crimean Astronomical Observatory (CrAO) near Hα, Hβ, He I λ 5876, 6678 Å, DNa I, and O II λ 6641 Å lines. Two spectra obtained at the Observatório do Pico dos Dias (LNA), in the spectral bands λλ 4575–4725 Å and λλ 5625–5775 Å, were used for spectral classification of HD 53367. The temporal behaviour of the circumstellar lines Hα and Hβ as well as the photospheric lines O II λ 6641 Å and He I λ 6678 Å were investigated during different stages of the photometric activity of this object.
Results. We confirm that the long-term photometric variability of HD 53367 is related to the alternation of two states of this object when the gaseous circumstellar envelope disappears and rises again. Both these processes start near the star and spread to the outlying parts of the envelope. We find that the radial velocities of He I and O II photospheric lines demonstrate a cyclic variability with a period of P=183.7 days and semi-amplitude K=19 km s^{-1}. The radial velocity change is interpreted in the framework of a model in which the star is a component of an eccentric binary system. An orbital solution is derived and the system's parameters estimated. We find that the orbital eccentricity is e=0.28, and the mean companion separation is 1.7 AU.
Conclusions. Based on the estimated parameters, we conclude that the system consists of a massive ($\sim 20\,M_\odot$) main sequence primary B0e star, and a secondary which is most likely a 5 solar mass pre-main sequence object. We found evidence that the main part of the circumstellar gas in this system is concentrated near the secondary companion. Although the young age of HD 53367, its evolved primary B0e star seems to have already became a classical Be star exhibiting a specific alternation of the B–Be stages.

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http://www.edpsciences.org/articles/aa/pdf/forthpdf/aa3704-05_forth.pdf

Outflows, Disks, and Stellar Content in a Region of High-Mass Star Formation: G5.89-0.39 with Adaptive Optics

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We present adaptive optics (AO)-assisted near-infrared Fabry-Perot observations of both the H_2 $\nu = 1 - 0S(1)$ line in the area surrounding the shell-like ultracompact H II region (UCH II) G5.89-0.39 and the Brγ emission in the region of ionized gas. This work aims at investigating the near-IR counterpart to the widely debated massive outflow detected toward this source. We also study the connection of the outflow(s) with the possible driving source(s) to better constrain the stellar content within this UCH II region. Our data show evidence of a total of three outflows in this region, with distinct orientations and different driving sources. Two prominent bow-shock structures are identified in our H_2 data in a north–south orientation. The molecular jet, likely associated with these features, is not compatible with the orientation of the outflow previously detected at high spatial resolution in SiO emission. Moreover, we propose the driving source of this jetlike structure as the O5 V star recently detected by Feldt and coworkers. However, we report the detection of a bipolar structure, separated by a dark lane, at the location of the 1.3 mm continuum source (i.e., the candidate source to power the SiO outflow). Finally, a third bipolar outflow is traced through the Brγ emission. The confirmation through CO interferometric observations of this outflow activity would therefore favor an accretion scenario for high-mass star formation.

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Infrared Dark Clouds: Precursors to Star Clusters

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Infrared dark clouds (IRDCs) are dense molecular clouds seen as extinction features against the bright mid-infrared Galactic background. Millimeter continuum maps toward 38 IRDCs reveal extended cold dust emission to be associated with each of the IRDCs. IRDCs range in morphology from filamentary to compact and have masses of 120 to 16,000 $M_\odot$, with a median mass of $\sim 940 M_\odot$. Each IRDC contains at least one compact ($\leq$0.5 pc) dust core and most show multiple cores. We find 140 cold millimeter cores unassociated with MSX 8 μm emission. The core masses range from 10 to 2100 $M_\odot$, with a median mass of 120 $M_\odot$. The slope of the IRDC core mass spectrum ($\alpha \sim 2.1 \pm 0.4$) is similar to that of the stellar IMF. Assuming that each core will form a single star, the majority of the cores will form OB stars. IRDC cores have similar sizes, masses, and densities as hot cores associated with individual, young high-mass stars, but they are much colder. We therefore suggest that IRDC represent an earlier evolutionary phase in high-mass star formation. In addition, because IRDCs contain many compact cores and have the same sizes and masses as molecular clumps associated with young clusters, we suggest that IRDCs are the cold precursors to star clusters. Indeed, an estimate of the star formation rate within molecular clumps with similar properties to IRDCs ($\sim 2 M_\odot$ yr^{-1}) is comparable to the global star formation rate in the Galaxy, supporting the idea that all stars may form in such clumps.

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Predicting Planets in Known Extra-Solar Planetary Systems III: Forming Terrestrial Planets

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Recent results have shown that many of the known extrasolar planetary systems contain regions which are stable for both Earth-mass and Saturn-mass planets. Here we simulate the formation of terrestrial planets in four planetary systems – 55 Cancri, HD 38529, HD 37124, and HD 74156 – under the assumption that these systems of giant planets are complete and that their orbits are well-determined. Assuming the giant planets formed and migrated quickly, then terrestrial planets may form from a second generation of planetesimals. In each case, Moon- to Mars-sized planetary embryos are placed in between the giant planets and evolved for 100 Myr. We find that planets form relatively easily in 55 Cnc, with masses up to 0.6 Earth masses and in some cases substantial water contents and orbits in the habitable zone. HD 38529 is likely to support an asteroid belt but no terrestrial planets of significant mass. No terrestrial planets form in HD 37124 and HD 74156, although in some cases 1-2 lone embryos survive for 100 Myr. If migration occurred later, depleting the planetesimal disk, then massive terrestrial planets are unlikely to form in any of these systems.

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http://lasp.colorado.edu/~raymond/predict3.pdf

High-resolution simulations of the final assembly of Earth-like planets 1: terrestrial accretion and dynamics

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The final stage in the formation of terrestrial planets consists of the accumulation of $\sim$ 1000-km "planetary embryos" and a swarm of billions of 1-10 km "planetesimals." During this process, water-rich material is accreted by the terrestrial planets via impacts of water-rich bodies from beyond roughly 2.5 AU. We present results from five high-

resolution dynamical simulations. These start from 1000-2000 embryos and planetesimals, roughly 5-10 times more particles than in previous simulations. Each simulation formed 2-4 terrestrial planets with masses between 0.4 and 2.6 Earth masses. The eccentricities of most planets were ~ 0.05, lower than in previous simulations, but still higher than for Venus, Earth and Mars. Each planet accreted at least the Earth's current water budget.

We demonstrate several new aspects of the accretion process: 1) The feeding zones of terrestrial planets change in time, widening and moving outward. Even in the presence of Jupiter, water-rich material from beyond 2.5 AU is not accreted for several millions of years. 2) Even in the absence of secular resonances, the asteroid belt is cleared of >99% of its original mass by self-scattering of bodies into resonances with Jupiter. 3) If planetary embryos form relatively slowly, then the formation of embryos in the asteroid belt may have been stunted by the presence of Jupiter. 4) Self-interacting planetesimals feel dynamical friction from other small bodies, which has important effects on the eccentricity evolution and outcome of a simulation.

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http://lasp.colorado.edu/∼raymond/highres1.pdf

Oscillations in the stable starless core Barnard 68

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New molecular line observations of the Bok globule Barnard 68 in HCO^+ irrefutably confirm the complex pattern of red and blue asymmetric line profiles seen across the face of the cloud in previous observations of CS. The new observations thus strengthen the previous interpretation that Barnard 68 is undergoing peculiar oscillations. Furthermore, the physical chemistry of B68 indicates that the object is much older than the sound crossing time and is therefore long-lived. A model is presented for the globule in which a modest external pressure perturbation is shown to lead to oscillations about a stable equilibrium configuration. Such oscillations may be present in other stable starless cores as manifested by a similar signature of inward and outward motions.

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IRAS 16293-2422: Evidence for Infall onto a Counterrotating Protostellar Accretion Disk

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We report high spatial resolution VLA observations of the low-mass star-forming region IRAS 16293-2422 using four molecular probes: ethyl cyanide (CH_3CH_2CN), methyl formate (CH_3OCHO), formic acid (HCOOH), and the ground vibrational state of silicon monoxide (SiO). Ethyl cyanide emission has a spatial scale of $\sim$ 20" and encompasses binary cores A and B as determined by continuum emission peaks. Surrounded by formic acid emission, methyl formate emission has a spatial scale of $\sim$ 6" and is confined to core B. SiO emission shows two velocity components with spatial scales less than 2" that map $\sim$ 2" northeast of the A and B symmetry axis. The redshifted SiO is $\sim$ 2" northwest of blueshifted SiO along a position angle of $\sim 135°$ which is approximately parallel to the A and B symmetry axis. We interpret the spatial position offset in red- and blueshifted SiO emission as due to rotation of a protostellar accretion disk, and we derive $\sim 1.4 M_\odot$ interior to the SiO emission. In the same vicinity, Mundy et al. also concluded rotation of a nearly edge-on disk from OVRO observations of much stronger and ubiquitous ^{13}CO emission, but the direction of rotation is opposite to the SiO emission findings. Taken together, SiO and ^{13}CO data suggest evidence for a counterrotating disk. Moreover, archival BIMA array ^{12}CO data show an inverse P Cygni profile with the strongest absorption in close proximity to the SiO emission, indicating unambiguous material infall toward the counterrotating

protostellar disk at a new source location within the IRAS 16293-2422 complex. The details of these observations and our interpretations are discussed.

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Dust Stratification in Young Circumstellar Disks

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We present high-resolution infrared spectra of four YSOs (T Tau N, T Tau S, RNO 91, and HL Tau). The spectra exhibit narrow absorption lines of 12CO, 13CO, and C18O as well as broad emission lines of gas phase12CO. The narrow absorption lines of CO are shown to originate from the colder circumstellar gas. We find that the line of sight gas column densities resulting from the CO absorption lines are much higher than expected for the measured extinction for each source and suggest the gas to dust ratio is measuring the dust settling and/or grain coagulation in these extended disks. We provide a model of turbulence, dust settling and grain growth to explain the results.

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Spectacular Spitzer Images of the Trifid Nebula: Protostars in a Young, Massive-star-forming Region

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IRAC and MIPS images of the Trifid Nebula (M20) reveal its spectacular appearance in infrared light, highlighting the nebula's special evolutionary stage. The images feature recently-formed massive protostars and numerous young stellar objects, and a single O star that illuminates the surrounding molecular cloud from which it formed, and unveil large-scale, filamentary dark clouds. The hot dust grains show contrasting infrared colors in shells, arcs, bow-shocks and dark cores. Multiple protostars are detected in the infrared, within the cold dust cores of TC3 and TC4, which were previously defined as Class 0. The cold dust continuum cores of TC1 and TC2 contain only one protostar each; the newly discovered infrared source in TC2 is the driving source of the HH399 jet. The *Spitzer* color-color diagram allowed us to identify ∼160 young stellar objects (YSOs) and classify them into different evolutionary stages. The diagram also revealed a unique group of YSOs which are bright at 24μm but have the spectral energy distribution peaking at 5-8μm. Despite expectation that Class 0 sources would be "starless" cores, the *Spitzer* images, with unprecedented sensitivity, uncover mid-infrared emission from these Class 0 protostars. The mid-infrared detections of Class 0 protostars show that the emission escapes the dense, cold envelope of young protostars. The mid-infrared emission of the protostars can be fit by two temperatures of 150 and 400 K; the hot core region is probably optically thin in the mid-infrared regime, and the size of hot core is much smaller than that of the cold envelope. The presence of multiple protostars within the cold cores of Class 0 objects implies that clustering occurs at this early stage of star formation. The TC3 cluster shows that the most massive star is located at the center of the cluster and at the bottom of the gravitational-potential well.

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Spitzer Observations of Two TW Hydrae Association Brown Dwarfs

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We present *Spitzer Space Telescope* observations of two TW Hydrae association brown dwarfs, 2MASSW J1207334-393254 and 2MASSW J1139511-315921, in the IRAC and MIPS 24 μm bands. On the basis of their IRAC colors, we have classified them as classical and weak-line T Tauri stars, respectively. For 2MASSW J1207334-393254, we have found that a flat-disk model fits the data very well. This brown dwarf shows the presence of warm ($T \geq 100$ K) circumstellar dust close ($R \leq 0.2$ AU) to it and does not display any signs of cleansing of dust within several AU of the star. In comparison with other TWA members that show excess in IR, we suggest that there exists a different disk evolution/dust processing mechanism for stellar and substellar objects. The star 2MASSW J1139511-315921 does not show any significant excess in any of the IRAC bands but a small one at 24 μm, which is not significant enough to suggest the presence of warm dust around this star. It shows signs of dust cleansing in the inner several AU, similar to most of the other TWA members.

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Analysis of the dust evolution in the circumstellar disks of T Tauri stars

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We present a compositional analysis of $8 - 13\,\mu$m spectra of 32 young stellar objects (YSOs). Our sample consists of 5 intermediate-mass stars and 27 low-mass stars. While the spectra and first scientific results have already been published by Przygodda et al. (2003) and Kessler-Silacci et al. (2004) we perform a more detailed analysis of the $\sim 10\,\mu$m silicate feature. In our analysis we assume that this emission feature can be represented by a linear superposition of the wavelength-dependent opacity $\kappa_{\rm abs}(\lambda)$ describing the optical properties of silicate grains with different chemical composition, structure, and grain size. The determination of an adequate fitting equation is another goal of this study. Using a restricted number of fitting parameters we investigate which silicate species are necessary for the compositional fitting. Particles with radii of $0.1\,\mu$m- and $1.5\,\mu$m consisting of amorphous olivine and pyroxene, forsterite, enstatite, and quartz have been considered. Only compact, homogeneous dust grains have been used in the presented fitting procedures. In this context we show that acceptable fitting results can also be achieved if emission properties of porous silicate grains are considered instead. Although some previous studies give reasons for the similarity between the dust in circumstellar disks of T Tauri stars and Herbig Ae/Be stars, a quantitative comparison has been missing, so far. Therefore, we conclude with a discussion of the results of a $10\,\mu$m spectroscopic survey of van Boekel et al. (2005) who focus on Herbig Ae/Be stars, the higher mass counterparts of T Tauri stars and draw comparisons to this and other studies. We find that the results of our study of T Tauri systems partly agree with previous studies of Herbig Ae/Be stars.

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Exploring brown dwarf disks: A 1.3 mm survey in Taurus

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We have carried out sensitive 1.3 mm observations of 20 young brown dwarfs in the Taurus star-forming region, representing the largest sample of young substellar objects targeted in a deep millimeter continuum survey to date. Under standard assumptions, the masses of brown dwarf disks range from <=0.4 to several Jupiter masses. Their *relative* disk masses are comparable to those derived for coeval low-mass stars: most of them are in the <=1% – 5% range, and there is no clear change of relative disk mass with object mass from 0.015 to 3 solar masses. Specifically, we do not find evidence for disk truncation, as would be expected in the ejection scenario for brown dwarf origin, although the signature of ejection may be hidden in our non-detections. We use the derived mm fluxes, complemented by mid-infrared data from the Spitzer Space Telescope and ground-based near-infrared images, to construct spectral energy distributions (SEDs) for six of our sources, and model those SEDs with a Monte Carlo radiative transfer code. While the model fits are by no means unique, they allow us to investigate disk properties such as the degree of flaring and minimum radii. In several cases, we find that the SEDs in the mid-infrared exhibit lower flux levels than predicted by hydrostatic models, implying dust settling to the disk midplane. What's more, at least 25% of our targets are likely to have disks with radii >10 AU; models with smaller disks cannot reproduce the mm fluxes even if they are very massive. This finding is in contrast to the results of some simulations of the ejection scenario for brown dwarf formation that suggest only ~5% of ejected objects would harbor disks larger than 10 AU. Our findings imply that ejection is probably not the dominant formation process, but may still be relevant for some brown dwarfs.

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Photopolarimetric activity and circumstellar environment of the young binary system DF Tau

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We present the results of multi-year photometric and polarimetric observations of the young binary system DF Tau in the $UBVRI$ bands, as well as bispectrum speckle interferometric observations in the H and K bands obtained between 2001 and 2003. The photometric and polarimetric observations suggest that the linear polarization of DF Tau does not depend on its brightness, and the polarization variation has a stochastic character. This result confirms earlier suggestions about the dominant role of hot accretion spots in the photometric activity of this star. We argue that the hot spots are at high latitudes and/or the star rotation axis is inclined to the line-of-sight. The influence of circumstellar (CS) dust on the variability is probably small since the inclination of the primary's CS disk to the line-of-sight is large.

Using the total mass of the binary system DF Tau from Hartigan & Kenyon (2003, ApJ, 583, 334), we calculated new orbital parameters of the system. The new value of the orbital period ($P = 74.1$ yr) disagrees with the photometric cycle of about 40 yr revealed by Lamzin et al. (2001b, A&A, 372, 922) from analysis of the historical light curve of this star. This suggests that this cycle is not caused by the orbital motions of the binary components, but probably reflects the cyclical variability of the global magnetic field on the main component.

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Far-ultraviolet scattering by dust in Orion

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We have modelled diffuse far-ultraviolet (FUV) spectrum observed by the *Far Ultraviolet Spectroscopic Explorer* (*FUSE*) near M42 as the scattering of the starlight from the Trapezium stars by dust in front of the nebula. The dust grains are known to be anomalous in Orion with $R_V = 5.5$ and these are the first measurements of the FUV optical properties of the grains outside of 'normal' Milky Way dust. We find an albedo varying from 0.3 ± 0.1 at 912 Å to 0.5 ± 0.2 at 1020 Å which is consistent with theoretical predictions.

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Polarization of radiation scattered in magnetized turbulent envelopes

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We consider the single scattering of the non-polarized radiation of a central star on the electrons of a plasma circumstellar envelope. We assume that such an envelope is magnetized and consists of a turbulent plasma. Two types of envelopes are considered: a spherical envelope with the dipole magnetic field and a cone-like jet with the radial magnetic field. It is shown that the existence of turbulent motions in the envelopes drastically changes the polarization degree spectrum $p(\lambda)$ and the positional angle spectrum $\chi(\lambda)$ of scattered radiation compared to the non-turbulent case. The difference in spectra can be used to estimate the ratio for the energy of magnetic fluctuations to the energy of a regular magnetic field.

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The Unusual X-ray Spectrum of FU Orionis

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FU Orionis objects (FUors) have undergone strong optical outbursts and are thought to be young low-mass stars accreting at high rates of up to $\dot{M}_{acc} \sim 10^{-4}$ M$_\odot$ yr^{-1}. FUors have been extensively studied at optical and infrared wavelengths, but little is known about their X-ray properties. We have thus initiated a program aimed at searching for and characterizing their X-ray emission. First results are presented here for the prototype star FU Orionis based on observations obtained with *XMM-Newton.* Its CCD X-ray spectrum is unusual compared to those of accreting classical T Tauri stars (cTTS). The cool and hot plasma components typically detected in cTTS are present but are seen through different absorption column densities. The absorption of the cool component is consistent with $A_V \approx 2.4$ mag anticipated from optical studies but the absorption of the hot component is at least ten times larger. The origin of the excess absorption is uncertain but cold accreting gas or a strong near-neutral wind are likely candidates. The hot plasma component accounts for most of the observed X-ray flux and thermal models give very high temperatures kT $\geq$ 5 keV. The most prominent feature in the X-ray spectrum is an exceptionally strong Fe K emission line at 6.67 keV and weak emission from fluorescent Fe I at $\approx$6.4 keV may also be present. The high plasma temperature clearly demonstrates that the emission is dominated by magnetic processes. We discuss possible origins of the unusual X-ray spectrum in the context of a complex physical environment that likely includes disk accretion, a strong wind, magnetic activity, and close binarity.

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Discovery of two young brown dwarfs in an eclipsing binary system

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Brown dwarfs are considered to be 'failed stars' in the sense that they are born with masses between the least massive stars (0.072 $M_\odot$) and the most massive planets (0.013 $M_\odot$); they therefore serve as a critical link in our understanding of the formation of both stars and planets. Even the most fundamental physical properties of brown dwarfs remain, however, largely unconstrained by direct measurement. Here we report the discovery of a brown-dwarf eclipsing binary system, in the Orion Nebula star-forming region, from which we obtain direct measurements of mass and radius for these newly formed brown dwarfs. Our mass measurements establish both objects as brown dwarfs, with masses of 0.054 ± 0.005 $M_\odot$ and 0.034 ± 0.003 $M_\odot$. At the same time, with radii of 0.669 ± 0.034 $R_\odot$ and 0.511 ± 0.026 $R_\odot$, these brown dwarfs are more akin to low-mass stars in size. Such large radii are generally consistent with theoretical predictions for young brown dwarfs in the earliest stages of gravitational contraction. Surprisingly, however, we find that the less-massive brown dwarf is the hotter of the pair; this result is contrary to the predictions of all current theoretical models of coeval brown dwarfs.

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http://people.vanderbilt.edu/~keivan.stassun/pubs.htm

Ray-tracing for complex astrophysical high-opacity structures

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We present a ray-tracing technique for radiative transfer modeling of complex three-dimensional (3D) structures which include dense regions of high optical depth like in dense molecular clouds, circumstellar disks, envelopes of evolved stars, and dust tori around active galactic nuclei. The corresponding continuum radiative transfer problem is described and the numerical requirements for inverse 3D density and temperature modeling are defined. We introduce a relative intensity and transform the radiative transfer equation along the rays to solve machine precision problems and to relax strong gradients in the source term. For the optically thick regions where common ray-tracers are forced to perform small trace steps, we give two criteria for making use of a simple approximative solver crossing the optically thick region quickly. Using an example of a density structure with optical depth changes of 6 orders of magnitude and sharp temperature variations, we demonstrate the accuracy of the proposed scheme using a common 5th-order Runge-Kutta ray-tracer with adaptive step size control. In our test case, the gain in computational speed is about a factor of 870. The method is applied to calculate the temperature distribution within a massive molecular cloud core for different boundary conditions for the radiation field.

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The secrets of the nearest starburst cluster: II. The present-day mass function in NGC 3603

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Based on deep VLT/ISAAC JHK photometry, we have derived the present-day mass function of the central starburst cluster NGC 3603 YC (Young Cluster) in the giant HII region NGC 3603. The effects of field contamination, individual reddening, and a possible binary contribution are investigated. The MF slopes resulting from the different methods are compared, and lead to a surprisingly consistent cluster MF with a slope of $\Gamma = -0.9 \pm 0.15$. Analyzing different radial annuli around the cluster core, no significant change in the slope of the MF is observed. However, mass segregation in the cluster is evidenced by the increasing depletion of the high-mass tail of the stellar mass distribution with increasing radius. We discuss the indications of mass segregation with respect to the changes observed in the binned and cumulative stellar mass functions, and argue that the cumulative function as well as the fraction of high- to low-mass stars provide better indicators for mass segregation than the MF slope alone. Finally, the observed mass function and starburst morphology of NGC 3603 YC is discussed in the context of massive local star-forming regions such as the Galactic Center Arches cluster, R 136/30 Dor in the LMC, and the Orion Trapezium cluster, all providing resolved templates for extragalactic star formation. Despite the similarity in the observed MF slopes, dynamical considerations suggest that the starburst clusters do not form gravitationally bound systems over a Hubble time. Both the environment (gravitational potential of the Milky Way) and the concentration of stars in the cluster core determine the dynamical stability of a dense star cluster, such that the long-term evolution of a starburst is not exclusively determined by the stellar evolution of its members, as frequently assumed for globular cluster systems.

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http://www.mpia.de/homes/brandner/pubs/ngc3603_imf.pdf

^{60}Fe in Chondrites: Debris from a Nearby Supernova in the Early Solar System?

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^{60}Fe decays to ^{60}Ni with a half-life of 1.49×10^6 yr, so all of the original ^{60}Fe atoms incorporated into the solar system have decayed. Because ^{60}Fe is produced only in stars, its initial abundance in the solar system provides a constraint on the stellar contribution of radionuclides to the early solar system and on the nature of the stellar source. Because of its short half-life, ^{60}Fe is also a potential high-resolution chronometer of early-solar-system events. The presence of ^{60}Fe in primitive meteorites has been confirmed in sulfides, but the initial abundance of ^{60}Fe in the solar system has been only loosely constrained because it is uncertain when the sulfides formed. We show that ^{60}Fe was present with abundance ratios of ^{60}Fe/^{56}Fe $= (2.2 - 3.7) \times 10^{-7}$ when ferromagnesian chondrules formed. By applying the time difference of 1.5-2.0 million years between formation of ferromagnesian chondrules and Ca-Al-rich inclusions (CAIs), the oldest known solar system solids, a solar system initial ^{60}Fe/^{56}Fe ratio [(^{60}Fe/^{56}Fe)$_0$] of $(5-10) \times 10^{-7}$ is estimated. This new solidly based (^{60}Fe/^{56}Fe)$_0$ ratio is consistent with predictions for nucleosynthesis in a supernova or in an intermediate-mass asymptotic giant branch (AGB) star just before the solar system formation, but is too high for the source to have been a low-mass AGB star. Considering the rarity of encounters between a molecular cloud and an AGB star, our results can be considered strong evidence of a contribution of material from a nearby supernova and of a role for a supernova in the origin of the solar system.

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Kinematics of SiO J=8-7 Emission towards the HH 212 Jet

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We present SiO J=8-7 (347.3 GHz) observations towards HH 212 using the ASTE telescope. Our observations with a 22"-diameter beam show that the SiO emission is highly concentrated within 1' of the driving source. We carefully compare the SiO observations with archival H_2 1-0 S(1) images and published H_2 echelle spectra. We find that, although the SiO velocities closely match the radial velocities seen in H_2, the distribution of H_2 and SiO emission differ markedly. We attribute the latter to the different excitation conditions required for H_2 and SiO emission, particularly the higher critical density ($n_{H_2} \sim 10^8$ cm^{-3}) of the SiO J=8-7 emission. The kinematic similarities imply that the H_2 and SiO are associated with the same internal working surfaces. We conclude that the SiO J=8-7 emission has a potential to probe the jet/wind launching region through interferometric observations in the future, particularly for the youngest, most deeply embedded protostars where IR observations are not possible.

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First Two-Micron Imaging Polarimetry of β Pictoris

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High-resolution K-band imaging polarimetry of the β Pic dust disk has been conducted with adaptive optics and a coronagraph using the Subaru 8.2 m telescope. Polarization of $\sim$ 10% is detected out to $r \sim$ 120 AU with a centrosymmetric vector pattern around the central star, confirming that the disk is seen as an infrared reflection nebula. We have modeled our near-infrared and previous optical polarization results in terms of dust scattering in the disk and have found that both the degrees of polarization and the radial intensity profiles are well reproduced. We argue that the observed characteristics of the disk dust are consistent with the presence of ice-filled fluffy aggregates consisting of submicron grains in the β Pic system. There is a gap around 100 AU in both the intensity and polarization profiles, which suggests a paucity of planetesimals in this region. The radial intensity profile also shows ripple-like structures, which are indicative of the presence of multiple planetesimal belts, as in the case of the M-type Vega-like star AU Mic.

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VLT-ISAAC 3-5 μm spectroscopy of embedded young low-mass stars – III. Intermediate-mass sources in Vela

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Aims. We study in this paper the ice composition in the envelope around intermediate-mass class I Young Stellar Objects (YSOs).
Methods. We performed a spectroscopic survey toward five intermediate-mass class I YSOs located in the Southern Vela molecular cloud in the $L(2.85 - 4.0\mu\text{m})$ and $M(4.55 - 4.8\mu\text{m})$ bands at resolving powers $\lambda/\Delta\lambda = 600 - 800$ up to 10 000, using the Infrared Spectrometer and Array Camera mounted on the *Very Large Telescope-ANTU*. Lower mass companion objects were observed simultaneously in both bands.
Results. Solid H_2O at 3 μm is detected in all sources, including the companion objects. CO ice at 4.67 μm is detected in a few main targets and one companion object. One object (LLN 19) shows little CO ice but strong gas-phase CO ro-vibrational lines in absorption. The CO ice profiles are different from source to source. The amount of water ice and CO ice trapped in a water-rich mantle may correlate with the flux ratio at 12 and 25 μm. The abundance of H_2O-rich CO likely correlates with that of water ice. A weak feature at 3.54 μm attributed to solid CH_3OH and a broad feature near 4.62 μm are observed toward, but not toward the other sources. The derived abundances of solid CH_3OH and OCN^- are $\sim 10 \pm 2\%$ and $\sim 1 \pm 0.2\%$ of the H_2O ice abundance respectively. The H_2O optical depths do not show an increase with envelope mass, nor do they show lower values for the companion objects compared with the main protostar. The line-of-sight CO ice abundance does not correlate with the source bolometric luminosity.
Conclusions. Comparison of the solid CO profile toward LLN 17, which shows an extremely broad CO ice feature, and that of its lower mass companion at a few thousand AU, which exhibits a narrow profile, together with the detection of OCN^- toward LLN 17 provide direct evidences for local thermal processing of the ice.

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Imaging and integral-field spectroscopy of shocked H_2 around G25.65+1.05

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Near-infrared imaging of the emission from molecular hydrogen is a powerful method for discovering outflows in star-forming regions. We present new near-infrared images, and long-slit and integral-field spectroscopy of the ultracompact H II region G25.65+1.05. These new observations reveal shocked H_2 emission associated with a bipolar outflow from a young high-mass star at the centre of the source. The physical parameters of the outflow are discussed and compared with those of outflows from lower mass stars.

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The C_4H Zeeman Effect in TMC-1: Understanding Low-Mass Star Formation

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We have searched for the C_4H Zeeman effect toward the cold dense TMC-1 cyanopolyyne peak (CP) core and obtained an upper limit of $14.5 \pm 14\mu$G for a magnetic field $B = |B| \cos\theta$, where θ is the angle between the field and the plane of the sky. C_4H is particularly suited to the detection of small dense cores that result from the evolution of magnetized clumps undergoing ambipolar diffusion (AD) to smaller denser cores that directly form stars. These are the so-called quasi-static models. We discuss three distinct types of model for such systems, those of the Mouschovias, Shu, and Myers groups, respectively. We see no indications of line-broadening or high densities in the core, such as those predicted to follow the ambipolar diffusion and free-fall contractions, but the dearth of observational data for B fields in low-mass protostars makes it difficult to form definite conclusions from our results. We also discuss several models emphasizing recent formulations of large-scale (100 pc) flows of supersonic turbulence that appear to surmount earlier difficulties such as too large a star formation (SF) rate and the need for a magnetically subcritical initial cloud. Possible reasons for the null result on the C_4H Zeeman effect are that (1) in the case of the quasi-static models, TMC-1 CP has not evolved yet to the onset of dynamic collapse, which follows the much longer AD phase, and (2) there is a

weak $|B|$ field throughout the Taurus complex and it is directed close to the plane of the sky, whereas the Zeeman effect is sensitive only to line-of-sight (circular) polarization. In the supersonic turbulence models, the subsonic nature observed for the C_4H emission lines argues that the energetic turbulence that formed TMC-1 CP has passed by TMC-1 CP at least a Myr ago (the crossing time for the energetic turbulence to traverse the clump).

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Planets Rapidly Create Holes in Young Circumstellar Disks

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Recent spectral observations by the *Spitzer Space Telescope* reveal that some disks around young ($\sim$a few times 10^6 yr old) stars have remarkably sharp transitions to a low-density inner region in which much of the material has been cleared away. It has been recognized that the most plausible mechanism for the sharp transition at a specific radius is the gravitational influence of a massive planet. This raises the question of whether the planet can also account for the hole extending all the way to the star. Using high-resolution numerical simulations, we show that Jupiter-mass planets drive spiral waves that create holes on timescales ~ 10 times shorter than viscous or planet migration times. We find that the theory of spiral wave-driven accretion in viscous flows by Takeuchi et al. can be used to provide a consistent interpretation of the simulations. In addition, although the hole surface densities are low, they are finite, allowing mass accretion toward the star. Our results therefore imply that massive planets can form extended, sharply bounded spectral holes that can still accommodate substantial mass accretion rates. The results also imply that holes are more likely than gaps for Jupiter-mass planets around solar-mass stars.

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The distribution of ortho-H2D+ (1,1,0-1,1,1) in L1544: tracing the deuteration factory in prestellar cores.

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Prestellar cores are unique laboratories for studies of the chemical and physical conditions preceding star formation. We observed the prestellar core L1544 in the fundamental transition of ortho-H2D+ (1,1,0-1,1,1) at different positions over 100", and found a strong correlation between its abundance and the CO depletion factor. We also present a tentative detection of the fundamental transition of para-D2H+ (1,1,0-1,0,1) at the dust emission peak. Maps in N2H+, N2D+, HCO+ and DCO+ are used, and interpreted with the aid of a spherically symmetric chemical model that predicts the column densities and abundances of these species as a function of radius. The correlation between the observed deuterium fractionation of H3+, N2H+ and HCO+ and the observed integrated CO depletion factor across the core can be reproduced by this chemical model. In addition a simpler model is used to study the H2D+ ortho-to-para ratio. We conclude that, in order to reproduce the observed ortho-H2D+ observations, the grain radius should be larger than 0.3 microns.

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Predictions for the correlation between giant and terrestrial extrasolar planets in dynamically evolved systems

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The large eccentricities of many giant extrasolar planets may represent the endpoint of gravitational scattering in initially more crowded systems. If so, the early evolution of the giant planets is likely to be more restrictive of terrestrial planet formation than would be inferred from the current, dynamically quiescent, configurations. Here, we study statistically the extent of the anti-correlation between giant planets and terrestrial planets expected in a scattering model. We use marginally stable systems of three giant planets, with a realistic range of planetary masses, as a simple model for the initial conditions prior to scattering, and show that after scattering the surviving planets reproduce well the known extrasolar planet eccentricities beyond $a > 0.5$ AU. By tracking the minimum periastron values of all planets during the evolution, we derive the distribution of orbital radii across which strong perturbations (from crossing orbits) are likely to affect low mass planet formation. We find that scattering affects inner planet formation at orbital separations less than 50% of the final periastron distance, q_{fm}, of the innermost massive planet in approximately 30% of the realizations, and can occasionally influence planet formation at orbital separations less than 20% of q_{fm}. The domain of influence of the scattering massive planets increases as the mass differential between the massive planets decreases. Observational study of the correlation between massive and terrestrial extrasolar planets in the same system has the potential to constrain the origin of planetary eccentricity.

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http://lanl.arxiv.org/abs/astro-ph/0604077

An observational survey of molecular emission ahead of Herbig-Haro objects

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Context. A molecular survey recently performed ahead of HH 2 supports the idea that the observed molecular enhancement is due to UV radiation from the HH object.
Aims. The aim of the present work is to determine whether all HH objects with enhanced HCO^+ emission ahead of them also exhibit the same enhanced chemistry as HH 2. We thus observed several molecular lines at several positions ahead of five Herbig-Haro objects where enhanced HCO^+ emission was previously observed. *Methods.* We mapped the five Herbig-Haro objects using the IRAM-30 m. For each position we searched for more than one molecular species, and where possible for more than one transition per species. We then estimated the averaged beam column densities for all species observed and also performed LVG analyses to constrain the physical properties of the gas.
Results. The chemically richest quiescent gas is found ahead of the HH 7-11 complex, in particular at the HH 7-11 A position. In some regions we also detected a high velocity gas component. We find that the gas densities are always higher than those typical of a molecular cloud while the derived temperatures are always quite low, ranging from 10 to 25 K. The emission of most species seems to be enhanced with respect to that of a typical dense clump, probably due to the exposure to a high UV radiation from the HH objects. Chemical differentiation among the positions is also observed. We attempt a very simple chemical analysis to explain such differentiation.

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The magnetic field in the star-forming region Cepheus A from H_2O maser polarization observations

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We present linear and circular polarization observations of the H_2O masers in 4 distinct regions spread over 1×2 arcsec around the HW2 high-mass young stellar object in the Cepheus A star-forming region. We find magnetic fields between 100-600 mG in the central maser region, which has been argued to trace a circumstellar disk. The masers further from HW2 have field strengths between 30-100 mG. In all cases the magnetic field pressure is found to be similar to the dynamic pressure, indicating that the magnetic field is capable of controlling the outflow dynamics around HW2. In addition to several H_2O maser complexes observed before, we also detect a new maser filament, $\simeq$ 1"($\simeq$ 690 AU) East of HW2, which we interpret as a shocked region between the HW2 outflow and the surrounding medium. We detect a linear polarization gradient along the filament as well as a reversal of the magnetic field direction. This is thought to mark the transition between the magnetic field associated with the outflow and that found in the surrounding molecular cloud. In addition to the magnetic field we determine several other physical properties of the maser region, including density and temperatures as well as the maser beaming angles.

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High-Resolution Simulations of a Moon-forming Impact and Postimpact Evolution

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In order to examine the "giant impact hypothesis" for the formation of the Moon, we run the first grid-based, high-resolution hydrodynamic simulations of an impact between proto-Earth and a protoplanet. The spatial resolution for the impact-generated disk is greatly improved from previous particle-based simulations. This allows us to explore the fine structures of a circumterrestrial debris disk and its long-term evolution. We find that in order to form a debris disk from which a lunar-sized satellite can be accumulated, the impact must result in a disk of mostly liquid or solid debris, where pressure is not effective, well before the accumulation process starts. If the debris is dominated by vapor gas, strong spiral shocks are generated, and therefore the circumterrestrial disk cannot survive more than several days. This suggests that there could be an appropriate mass range for terrestrial planets to harbor a large moon as a result of giant impacts, since vaporization during an impact depends on the impact energy.

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Multiple Outflows and Protostars Near IC348 and the Flying Ghost Nebula

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Using optical (Hα, [S II], & i$'$), near-IR (H_2, J, H, & K_S), mid-IR (Spitzer IRAC 4.5μm), and submillimeter (850 μm & 450 μm) data, we have examined the region surrounding the IC 348 cluster and the neighboring "Flying Ghost Nebula" and found a multitude of shocks from protostellar outflows including HH 211 which had previously not been detected in visible wavelength images. We have identified 13 protostars in the region which drive protostellar outflows. The region surrounding the FGN is rich in ongoing star formation with a number of outflows similar to those found in

other sites of moderate star formation in Perseus (e.g. L1448, L1455, & Barnard 1). We have also found a candidate bent jet in this region. The axis defined by the bending angle suggests that this source may have been ejected from a multiple star system near the IC 348 IR source.

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SCUBA observations of the Horsehead Nebula – what did the horse swallow?

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We present observations taken with the Submillimetre Common-User Bolometer Array (SCUBA) on the James Clerk Maxwell Telescope (JCMT) of the Horsehead Nebula in Orion (B33), at wavelengths of 450 and 850 μm. We see bright emission from that part of the cloud associated with the photon-dominated region (PDR) at the 'top' of the horse's head, which we label B33-SMM1. We characterise the physical parameters of the extended dust responsible for this emission, and find that B33-SMM1 contains a more dense core than was previously suspected, with a mass of $\sim$2 $M_\odot$ in a region of 0.31 $\times$ 0.13 pc, and a peak volume density of $\sim$6 $\times$ 10^5 cm^{-3}. We compare the SCUBA data with data from the Infrared Space Observatory (ISO) and find that the emission at 6.75-μm is offset towards the west, indicating that the mid-infrared emission is tracing the PDR while the submillimetre emission comes from the molecular cloud core behind the PDR. We calculate the virial balance of this core and find that it is not gravitationally bound but is being confined by the external pressure from the HII region IC434, and that it will either be destroyed by the ionising radiation, or else may undergo triggered star formation.

Furthermore we find evidence for a lozenge-shaped clump in the 'throat' of the horse, which is not seen in emission at shorter wavelengths. We label this source B33-SMM2 and find that it is brighter at submillimetre wavelengths than B33-SMM1. We calculate the physical parameters of SMM2 and find it has a mass of $\sim$4 $M_\odot$ in a region 0.15 $\times$ 0.07 pc, with a peak volume density of $\sim$2 $\times$ 10^6 cm^{-3} and peak column density of $\sim$9 $\times$ 10^{22} cm^{-2}. SMM2 is seen in absorption in the 6.75-μm ISO data, from which we obtain an independent estimate of the column density in excellent agreement with that calculated from the submillimetre emission. We calculate the stability of this core against collapse and find that it is in approximate gravitational virial equilibrium. This is consistent with it being a pre-existing core in B33, possibly pre-stellar in nature, but that it may also eventually undergo collapse under the effects of the HII region.

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Models of particle layers in the midplane of the solar nebula

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In the absence of global turbulence, solid particles in the solar nebula tend to settle into a thin layer in the central plane. Shear between this layer and pressure-supported gas produces localized turbulence in the midplane; the thickness of the particle layer is determined by balance between settling and turbulent diffusion. A numerical model is described, which allows computation of the vertical structure of a layer of particles of arbitrary size, with self-consistent distributions of particle density, turbulent velocity, and radial fluxes of particles and gas. Effects of varying particle size and the abundances of solids and gas are evaluated. If the surface density of solids is increased by an order of magnitude over nominal solar abundance, the peak density within a layer of small particles can approach the critical value needed for gravitational instability. However, depletion of the nebular gas is much less effective for raising the density of such a layer to the critical value, due to decreased coupling of particles to the gas as the density of the gas decreases. The variation of radial particle flux with surface density of the particle layer is not consistent with secular instability of the layer driven by gas drag.

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Astrophysical studies of extrasolar planetary systems using infrared interferometric techniques

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Ph.D dissertation directed by: Jean Surdej

Ph.D degree awarded: March 2006

The study of extrasolar planetary systems has thrived during the last two decades, stimulated by the discovery of circumstellar dust and extrasolar planets around main sequence stars. However, direct imaging of planetary systems has been possible in only very particular cases so far, due to the huge contrast and to the small angular separation between stars and their circumstellar environment. Even in these favourable cases, the inner regions where terrestrial planets are expected to be forming, and where life could develop, have not been investigated yet. Infrared interferometry is a very promising technique in this context, as it provides the required angular resolution to separate the emissions from the star and its immediate neighbourhood.

The present work aims at developing the high dynamic capabilities of interferometric techniques for the characterisation of planetary systems. As a first step, we demonstrate that current interferometric facilities have the potential of detecting dust in the first few astronomical units of massive debris disks around nearby stars. Our observations of Vega with the FLUOR near-infrared beam combiner at the CHARA Array reveal the presence of warm dust responsible for a K-band flux about 78 times fainted than the stellar photospheric emission. In order to extend the imaging of planetary systems to fainter disks and to giant extrasolar planets, we investigate in a second step the performance of future ground-based nulling interferometers, taking into account atmospheric effects in a realistic way. Our simulations show that a nulling instrument installed at ESO's Very Large Telescope Interferometer would detect circumstellar features as faint as a few 10^{-4} of the stellar flux. Finally, the third part of this work is dedicated to the implementation of nulling interferometry on future space-borne missions, with the goal to characterise extrasolar planets down to Earth-like bodies.

http://vela.astro.ulg.ac.be/themes/telins/harigs/oa/Absil_thesis.pdf

Protostellar jets in the NIR: interaction with the ISM and correlation with the exciting source evolutionary phase

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Ph.D degree awarded: March 2006

I present an in-depth near-IR (NIR) analysis of a sample of H_2 jets from young embedded sources to compare the physical, kinematical properties and cooling mechanisms of the different flows. The sample comprises 23 outflows driven by Class 0 and I sources having low-intermediate solar luminosity (1-600 $L_\odot$). For such an analysis, I have utilized narrow band images centered on the H_2 (2.12 μm) and [FeII] (1.64 μm) spectral lines, low resolution spectra ($\mathcal{R} \sim 600$) in the range 1-2.5 μm and high resolution spectra ($\mathcal{R} \sim 10\,000$) centered on H_2 (2.12 μm) and [FeII] (1.64 μm) lines. At NIR wavelengths these two tracers (H_2, [FeII]) are the main coolants of the gas, that is excited by strong radiative shocks. Narrow band images have been used to detect such shocked regions in both ionic and molecular components. [FeII] have been observed in ~74% of the outflows which in some cases indicate the presence of embedded Herbig Haro (HH) like objects. H_2 line ratios have been used to estimate the visual extinction and the average temperature of the molecular gas. A_v values range from ~2 to ~15 mag, while average temperatures range between ~2000 and ~4000 K. In several knots, however, a stratification of temperatures is found with maximum values up to 5000 K. Such a stratification is more commonly observed in those knots which also show [FeII] emission, while a thermalized gas at a single temperature is generally found in knots emitting only in molecular lines. Combining narrow band imaging with the parameters derived from the spectroscopic analysis, it was possible to measure the total luminosity of the H_2 and [FeII] shocked regions (L_{H_2} and $L_{[FeII]}$) in each flow. H_2 is the major NIR coolant with an average $L_{H_2}/L_{[FeII]}$ ratio of ~10^2. About 83% of the sources have a L_{H_2}/L_{bol} ratio ~0.04, irrespective of the Class of the driving source, while a smaller group of sources (mostly Class I) have L_{H_2}/L_{bol} an order of magnitude smaller. Such a separation reveals the non-homogeneous behaviour of Class I, where sources with very different outflow activity can be found. These less luminous jets are originated by older sources, where $L_{\rm bol}$ is not dominated anymore by the accretion luminosity. This is confirmed by a further analysis conducted on jets from six intermediate and high mass sources, four of them not included in the original sample. They have a faster evolution with respect to the low mass ones and thus only a fraction of their $L_{\rm bol}$ is due to the accretion luminosity. For these objects I find a defined separation between the two Classes in the L_{H_2}-$L_{\rm bol}$ plot. Viceversa, there is a straight correlation between L_{H_2} and $L_{\rm acc}$ for all these sources. Finally, I compare the derived jet physical parameters to theoretical shock models. The observed H_2 emission in the HH objects can be mostly reproduced by models of J-type shocks with magnetic precursors.

ftp://ftp.tls-tautenburg.de/pub/caratti/caratti.pdf

New Jobs

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Postdoctoral Fellowship on Young Stellar Objects, their Surroundings and Jets

INAF - Osservatorio Astronomico di Palermo (OAPa) Giuseppe S. Vaiana will appoint one fellow in the area of Astrophysics under the European Commission's Marie Curie Actions Host Fellowship - Transfer of Knowledge programme "Young Stellar Objects, their Surroundings and Jets: Advanced Observational and MHD Studies" (PHOENIX). The selected fellow will work in one of the following areas:

1. Physics of YSOs and protostellar jets, with specific expertise on data analysis and emission processes in the optical and/or infrared and/or radio bands;
2. MHD of the astrophysical plasmas aimed at modeling the ambient medium surrounding YSOs and its interaction with the central star and with the protostellar jets.

The fellowship is expected to start before the end of September 2006 and to last 24 months.

Candidates should have a PhD or at least four years of full-time research experience at postgraduate level in a relevant field. In either case the candidate cannot have more than ten years of research experience.

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Female candidates are explicitly encouraged to apply.

For eligibility and application details please check the PHOENIX website
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For further information, pls contact Salvatore Orlando (orlando@astropa.unipa.it)

All documents should arrive by 30 May 2006 at:
INAF - Osservatorio Astronomico di Palermo
Marie Curie Fellowship Selection
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First Announcement and Call for Applications

The International Max-Planck Research School (IMPRS) for Astronomy and Cosmic Physics at the University of Heidelberg

announces the

Heidelberg Summer School 2006

on the

Interstellar Medium

September 25 - 29, 2006

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The IMPRS Summer School 2006 aims: (1) to present an overview of this progress; (2) to bring together students of various research areas; (3) to encourage young researchers and advanced students to continue research in these fields; (4) to strengthen future interdisciplinary research of the interstellar medium.

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A limited number of grants is available to partially cover travel expenses.

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Please find more information, our poster, and the application forms under:

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From Stars to Planets - Connecting our Understanding of Star and Planet Formation

1st Announcement

University of Florida, Gainesville

Wed. 11th - Sat. 14th April 2007

Recent observational advances in the fields of extra-solar planets and protoplanetary disks have been dramatic. However, theories to explain the properties of the discovered planets remain in their infancy. At the same time, the more mature field of star formation has seen significant progress, particularly in the realization of the importance of the clustered mode of star formation and observations of the lifetimes of circumstellar disks in such clustered regions.

This conference aims to bring together researchers from the star and planet formation communities to help them better understand the recent observational advances in each of these fields and make connections between the physical mechanisms responsible for star and planet formation. We expect the discussions to help motivate future observational tests of theoretical ideas.

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

The number of participants will be limited to 120. For more information and to show your interest in attending by pre-registration please visit http://conference.astro.ufl.edu/STARSTOPLANETS/

Organizers:

Jonathan Tan, Stan Dermott, Eric B. Ford, Jian Ge, Elizabeth Lada, and Charles Telesco

Contact: starstoplanets@astro.ufl.edu

http://conference.astro.ufl.edu/STARSTOPLANETS/

Pale Blue Dot III - Searching for Life on Distant Worlds

Adler Planetarium and Astronomy Museum Chicago, Illinois, USA September 18-20, 2006

The Adler Planetarium and Astronomy Museum and the NASA Astrobiology Institute (http://nai.arc.nasa.gov/) are co-convening the third Pale Blue Dot workshop, which is made possible by the Brinson Foundation. Pale Blue Dot III will provide a venue to forge links between terrestrial and astronomical biosignatures, and to develop ideas and methods that may be used for the detection of life beyond Earth. Pale Blue Dot III will also establish a two way dialogue between scientists and media that will facilitate lasting relationships, better media coverage of science, and enhanced public awareness and understanding of science.

Scientific themes addressed by the workshop include: 1) Earth as a Pale Blue Dot: Planetary Scale Biosignatures; 2) Environmental Evolution of Venus, Earth, Mars and Titan; 3) Remote-Sensing Techniques for Biosignature Detection; 4) Recognizing Habitable Environments in our Cosmic Neighborhood; 5) Future Observations of Distant Habitable Worlds; 6) Contemplating the Distribution of Life in the Universe

To receive further news and updates on the workshop, please register your expression of interest at

http://www.adlerplanetarium.org/pale_blue_dot

The Pale Blue Dot III Program Organizing Committee

Contact: Grace Wolf-Chase

Electronic mail: gwolfchase@adlerplanetarium.org

Short Announcements

An online catalog of spatially resolved circumstellar disks is now available at circumstellardisks.org. Designed as a database and research tool for the community, the catalog currently contains 87 resolved disks around both pre-main sequence and main sequence stars, with accompanying reference links to 1450 published articles.

The catalog contains entries for systems where a published, refereed article provides evidence for a spatially resolved disk and where the disk outer radius can be determined. Systems resolved in scattered light, thermal continuum, line emission, or through the presence of a dark lane, are included. The catalog is graphically displayed through a sortable table which provides the star name, spectral type, stellar category (e.g., T Tauri star, main sequence debris disk), and distance to the object as well as basic disk parameters such as diameter and disk inclination. Each item in the main catalog table is linked to a page with more detailed information on that particular object, including a list of references that either spatially resolve the disk or provide unresolved photometric measurements at wavelengths longer than 1 micron, where disk emission will, for most systems, dominate. Images of the disk in question are also displayed when the image is in the public domain, or when an author has given permission to include them.

The catalog will be updated as new disks and references become available in ADS. Researchers wishing to expedite the inclusion of a new disk candidate should send an email to mccabe@jpl.nasa.gov with the citation to their new journal article. To expand the range of disk images available in the database, the community is strongly encouraged to submit image files from their copyrighted journal articles, along with a short statement giving permission for them to be displayed.

The database can be accessed at the following address: http://circumstellardisks.org

Best regards,

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

Latex macros for submitting abstracts and dissertation abstracts (by e-mail to reipurth@ifa.hawaii.edu) are appended to each issue of the newsletter. You can also submit via the Newsletter web interface at http://www2.ifa.hawaii.edu/star-formation/index.cfm
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The Star Formation Newsletter is available on the World Wide Web at http://www.ifa.hawaii.edu/users/reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .