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Abstracts of recently accepted papers

The first brown dwarf with a disk in Chamaeleon II

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In this letter we characterize the candidates for young stars and brown dwarfs detected in a survey with ISOCAM in the Chamaeleon II dark cloud. Photometric data coming from a wide-field optical imaging survey, combined with IR measurements from the 2MASS catalogue and from the *Spitzer* satellite, allow us to study the nature of the candidates. Using intermediate-band filters we can provide a first estimate of the temperatures for objects cooler than about 3800 K. On the basis of spectroscopic and photometric data, we confirm that ISO-CHA II 13 is a young substellar object with a mass of about $0.05 M_{\odot}$. It is thus the first object in Cha II whose substellar nature has been spectroscopically confirmed. By having a temperature of about 2880 K and displaying a substantial infrared excess, it joins the list of young brown dwarfs observed to have a surrounding disk.

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http://peggysue.as.utexas.edu/SIRTF/PAPERS/pap93.pub.pdf

On the AU Mic Debris Disk: Density Profiles, Grain Properties and Dust Dynamics

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Context: AU Mic is a young M-type star surrounded by an edge-on optically thin debris disk that shares many common observational properties with the disk around β Pictoris. In particular, the scattered light surface brightness profile falls off as $\sim r^{-5}$ outside 120 AU for β Pictoris and 35 AU for AU Mic. In both cases, the disk color raises with increasing distance beyond these reference radii.
Aims: We present the first comprehensive analysis of the AU Mic disk properties since the system was discovered by Kalas et al. (2004). We explore whether the dynamical model, successful to reproduce the β Pic brightness profile (e.g. Augereau et al. 2001), could apply to AU Mic.
Methods: We calculate the surface density profile of the AU Mic disk by performing the inversion of the near-IR and visible scattered light brightness profiles measured by Liu (2004a) and Krist et al. (2005), respectively. We discuss the grain properties by analysing the blue color of the disk in the visible (Krist et al. 2005) and by fitting the disk spectral energy distribution. We finally evaluate the radiation and wind forces on the grains. The impact of the recurrent X-ray and UV-flares on the dust dynamics is also discussed.
Results: We show that irrespective of the mean scattering asymmetry factor of the grains, most of the emission arises from an asymmetric, collisionally-dominated region that peaks close to the surface brightness break around 35 AU.

The elementary scatterers at visible wavelengths are found to be sub-micronic, but the inferred size distribution underestimates the amount of large grains, resulting in too low sub-millimeter emissions compared to the observations. From our inversion procedure, we find that the V- to H-band scattering cross sections ratio increases outside 40 AU, in line with the observed color gradient of the disk. This behaviour is expected if the grains have not been produced locally but placed in orbits of high eccentricity by a size-dependent pressure force, resulting in a paucity of large grains beyond the outer edge of the parent bodies disk. Because of the low luminosity of AU Mic, radiation pressure is inefficient to diffuse the smallest grains in the outer disk, even when the flares are taken into account. Conversely, we show that a standard, solar-like stellar wind generates a pressure force onto the dust particles that behaves much like a radiation pressure force. With an assumed $\dot{M} \simeq 3 \times 10^2 \dot{M}_\odot$, the wind pressure overcomes the radiation pressure and this effect is enhanced by the stellar flares. This greatly contributes to populating the extended AU Mic debris disk and explains the similarity between the β Pictoris and AU Mic brightness profiles. In both cases, the color gradient beyond 120 AU for β Pictoris and 35 AU for AU Mic, is believed to be a direct consequence of the dust dynamics.

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http://arxiv.org/pdf/astro-ph/0604313

Who Is Eating the Outflow?: High-Angular Resolution Study of an Intermediate-Mass Protostar in L1206

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Context. Up to now only a few intermediate-mass molecular outflows have been studied with enough high-angular resolution.
Aims. The aim of this work is to study in detail the intermediate-mass YSO IRAS 22272+6358A, which is embedded in L1206, and its molecular outflow, in order to investigate the interaction of the outflow with the dense protostellar material, and to compare their properties with those of lower mass counterparts.
Methods. We carried out OVRO observations of the 2.7 mm continuum emission, CO (J=1→0), $C^{18}O$(J=1→0), and HC_3N (J=12→11) in order to map with high-angular resolution the core of L1206, and to derive the properties of the dust emission, the molecular outflow and the dense protostellar envelope.
Results. The 2.7 mm continuum emission has been resolved into four sources, labeled OVRO 1, 2, 3, and 4. The intermediate-mass Class 0/I object OVRO 2, with a mass traced by the dust emission of 14.2 $M_\odot$, is the source associated with IRAS 22272+6358A. The CO (J=1→0) observations have revealed a very collimated outflow driven by OVRO 2, at a PA $\simeq$ 140°, that has a very weak southeastern red lobe and a much stronger northwestern blue lobe. Photodissociation toward the red lobe produced by the ionization front coming from the bright-rimmed diffuse HII region could be responsible of the morphology of the outflow. The spatial correlation between the outflow and the elongated dense protostellar material traced by HC_3N (J=12→11) suggests an interaction between the molecular outflow and the protostellar envelope. Shocks produced by the molecular outflow, and possibly by the shock front preceding the ionization front could account for the southern enhancement of HC_3N. The properties of the intermediate-mass protostar OVRO 2 and the molecular outflow are consistent with those of lower mass counterparts. The $C^{18}O$ abundance relative to molecular hydrogen estimated toward OVRO 2 is 3×10^{-8}, a value ∼6 to 13 times lower than typical abundances estimated toward molecular clouds. The most plausible explanation for such a difference is CO depletion toward OVRO 2.

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http://www.am.ub.es/∼robert/Papers.html#last or http://arxiv.org/abs/astro-ph/0604028

A detailed modelling of the chemically rich clumps along the CB3 outflow

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In order to investigate the origin and the structure of the low velocity, chemically rich clumps observed along the lobes of low- and intermediate-mass outflows, we construct a detailed model of the S1 clump along the CB3 outflow. We use a time-dependent chemical model coupled with a radiative transfer model to reproduce the observed line profile for a direct comparison with previous observations of this clump. We find that the simultaneous fitting of multiple species and transitions is a powerful tool in constraining the physical parameters of the gas. Different scenarios for the clump formation have been investigated. The models that better reproduce all the observed lines are those where the clump is formed, at least partially, before the advent of the outflow; with the advent of the outflow the clump undergoes a short period of non-dissociative shock and the consequent release of the icy mantle together with the high temperature chemistry leads to the observed chemical enrichment. Our results also suggest the presence of substructure within the clump: a more extended component traced by CS, SO and the lower energy transitions (3_K-2_K and 2_K-1_K) of CH_3OH, and a more compact component traced by H_2CO, SO_2 and the higher energy transitions (5_K-4_K) of CH_3OH.

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http://herschel.ifsi-roma.inaf.it/pubblicazioni.htm

Molecular Outflows from G35.2-0.74N

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We present interferometric observations of the massive star-forming region associated with G35.2-0.74N using the Berkeley Illinois Maryland Association Array. With the aim of better understanding the outflow in this region we observed ^{12}CO $J = 1 \rightarrow 0$, C^{17}O $J = 1 \rightarrow 0$ and the 2.7mm continuum. The C^{17}O and continuum emission peak close to the sources G35.2-0.74N (G35.2N) and G35MM2 and indicate a mass of $\sim$40$M_\odot$-140$M_\odot$ of circumstellar material associated with these sources. The ^{12}CO traces a weak filament of emission coincident with the radio and infrared jet from G35.2N but the emission is dominated by an extended outflow with a NE-SW axis which has a total mass of $\sim$13$M_\odot$. Each lobe of this extended outflow has a hollow shell structure and the location of these shells makes the source G35MM2 a more likely candidate for the source driving the outflow than G35.2N. The mass-velocity distribution is calculated for several parts of the outflow. Fitting these distributions with power laws some of the same break-points are seen as previously identified in the ^{12}CO $J = 3 \rightarrow 2$ emission from the outflow. We conclude this indicates the temperature dependence of emissivity is not responsible for all the break-points seen and molecular dissociation is a more plausible explanation for their origin. We model the molecular outflow using the ZEUS-2D hydrodynamic code which we have augmented so that it can also track the composition of the gas. We find that a general hydromagnetic wind, without an enchanced, on axis, jet-like component , can reproduce the shape of the observed outflow. Models looking at the time evolution of the stellar wind indicate that the structure of the outflow is dominated by the initial wind conditions, rather than its later evolution. The models also show that scaling the density of the wind profile effects the apparent collimation of the resulting outflow. This may help explain some of the apparent differences between outflows from high mass and low mass young stars.

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http://www.josephbirks.com/astro/G35.2N_paper_04052006.pdf

Star formation through gravitational collapse *and* competitive accretion

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Competitive accretion, a process to explain the origin of the IMF, occurs when stars in a common gravitational potential accrete from a distributed gaseous component. Stars located near the centre of the potential benefit from the gravitational attraction of the full potential and accrete at much higher rates than do isolated stars. We show that concerns recently raised on the efficiency of competitive accretion are incorrect as they use globally averaged properties which are inappropriate for the detailed physics of a forming stellar cluster. A full treatment requires a realistic treatment of the cluster potential, the distribution of turbulent velocities and gas densities. Accreting gas does not travel at the global virial velocity of the system due to the velocity-sizescale relation inherent in turbulent gas and due to the lower velocity dispersion of small-N clusters in which much of the accretion occurs. Accretion occurs due to the effect of the local potential in funneling gas down to the centre. Stars located in the gas-rich centres of such systems initially accrete from low relative velocity gas attaining larger masses before needing to accrete the higher velocity gas. Stars not in the centres of such potentials, or that enter the cluster later when the velocity dispersion is higher, do not accrete significantly and thus retain their low-masses. In competitive accretion, most stars do not continue to accrete significantly such that their masses are set from the fragmentation process. It is the few stars which continue to accrete that become higher-mass stars. Competitive accretion is therefore likely to be responsible for the formation of higher-mass stars and can explain the mass distribution, mass segregation and binary frequency of these stars. Global kinematics of competitive accretion models include large-scale mass infall, with mean inflow velocities of order ≈ 0.5 km/s at scales of 0.5 pc, but infall signatures are likely to be confused by the large tangential velocities and the velocity dispersion present. Finally, we discuss potential limitations of competitive accretion and conclude that competitive accretion is currently the most likely model for the origin of the high-mass end of the IMF.

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Rapid Formation of Super-Earths around M Dwarf Stars

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While the recent microlensing discoveries of super-Earths orbiting two M dwarf stars have been taken as support for the core accretion mechanism of giant planet formation, we show here that these planets could also have been formed by the competing mechanism of disk instability, coupled with photoevaporative loss of their gaseous envelopes by a strong external source of UV radiation, i.e., an O star. M dwarfs that form in regions of future high-mass star formation would then be expected to have super-Earths orbiting at distances of several AU and beyond, while those that form in regions of low-mass star formation would be expected to have gas giants at those distances. Given that most stars are born in the former rather than in the latter regions, M dwarfs should have significantly more super-Earths than gas giants, as seems to be indicated by the microlensing surveys.

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Preprint available at http://www.dtm.ciw.edu/boss/ftp/mdwarf2

Rotational periods of T Tauri stars in Taurus-Auriga, south of Taurus-Auriga, and in MBM12

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Context. The ROSAT All-Sky Survey detected many young objects outside any known star forming region. Their formation is yet unclear.

Aims. In order to improve the knowledge about these X-ray bright objects we aimed at measuring their rotational properties, which are fundamental stellar parameters, and at comparing them to young objects inside molecular clouds.

Methods. We monitored photometric variations of 5 T Tauri stars in MBM12 and of 26 young objects in the Taurus-Auriga molecular cloud and south of it. Among the 26 young objects there are 17 weak-line T Tauri stars, 7 zero age main-sequence stars and 2 of unknown type. In addition, 2 main-sequence K-type stars were observed, and one comparison star turned out to be an eclipsing binary.

Results. We found periodic variations for most of the targets. The measured periods of the T Tauri stars range from 0.57 to 7.4 days. The photometric variation can be ascribed to rotational modulation caused by spots. For a few of the periodic variables, changes of the light curve profile within several weeks are reported. For one star such changes have been observed in data taken two years apart. The exceptions are two eclipsing systems. One so far unknown system - GSC2.2 N3022313162 - shows a light curve with full phase coverage having both primary and secondary minima well resolved. It has an orbital period of 0.59075 days. From our spectroscopic observations we conclude that it is a main sequence star of spectral type F2 $\pm$ 4. We further compared the off-cloud weak-line T Tauri stars to the weak-line T Tauri stars inside the molecular cloud in terms of rotational period distribution. Statistical analysis of the two samples shows that both groups are likely to have the same period distribution.

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Origin of the obliquities of the giant planets in mutual interactions in the early Solar System

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The origin of the spin-axis orientations (obliquities) of the giant planets is a fundamental issue because if the obliquities resulted from tangential collisions with primordial Earth-sized protoplanets, then they are related to the masses of the largest planetesimals out of which the planets form. A problem with this mechanism, however, is that the orbital planes of regular satellites would probably be uncorrelated with the obliquities, contrary to observations. Alternatively, they could have come from an external twist that affected the orientation of the Solar System plane; but in this model, the outer planets must have formed too rapidly, before the event that produced the twist. Moreover, the model cannot be quantitatively tested. Here I show that the present obliquities of the giant planets were probably achieved when Jupiter and Saturn crossed the 1:2 orbital resonance during a specific migration process: different migration scenarios cannot account for the large observed obliquities. The existence of the regular satellites of the giant planets does not represent a problem in this model because, although they formed soon after the planetary formation, they can follow the slow evolution of the equatorial plane it produces.

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Interstellar Chemistry Recorded in Organic Matter from Primitive Meteorites

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Organic matter in extraterrestrial materials has isotopic anomalies in hydrogen and nitrogen that suggest an origin in the presolar molecular cloud or perhaps in the protoplanetary disk. Interplanetary dust particles are generally regarded as the most primitive solar system matter available, in part because until recently they exhibited the most extreme isotope anomalies. However, we show that hydrogen and nitrogen isotopic compositions in carbonaceous chondrite organic matter reach and even exceed those found in interplanetary dust particles. Hence, both meteorites (originating from the asteroid belt) and interplanetary dust particles (possibly from comets) preserve primitive organics that were a component of the original building blocks of the solar system.

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Variability of the NGC 1333 IRAS 4A Outflow: Molecular Hydrogen and Silicon Monoxide Images

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The NGC 1333 region was observed in the H_2 1–0 $S(1)$ line. The H_2 images cover a $5' \times 7'$ region around IRAS 4. Numerous H_2 emission features were detected. The northeast-southwest bipolar outflow driven by IRAS 4A was studied by combining the H_2 images with SiO maps published previously. The SiO-H_2 outflows are continuous on the southwestern side but show a gap on the northeastern side. The southwestern outflow lobe curves smoothly, and the position angle increases with the distance from the driving source. The base and the outer tip of the northeastern outflow lobe are located at positions opposite to the corresponding parts of the southwestern lobe. This point-symmetry suggests that the outflow axis may be drifting or precessing clockwise in the plane of the sky and that the cause of the axis drift may be intrinsic to the outflow engine. The axis drift model is supported by the asymmetric lateral intensity profile of the SiO outflow. The axis drift rate is $\sim 0\overset{\circ}{.}011$ yr^{-1}. The middle part of the northeastern outflow does not exactly follow the point symmetry because of the superposition of two different kinds of directional variability: the axis drift of the driving source and the deflection by a dense core. The axis drift model provides a good explanation for the large deflection angle of the northeastern outflow. Other H_2 emission features around the IRAS 4 region are discussed briefly. Some of them are newly found outflows, and some are associated with outflows already known before.

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Preprint: `http://hanul.kasi.re.kr/~minho/Publications.html`

First evidence for molecular interfaces between outflows and ambient cloud in high-mass star forming regions?

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We present new observations of the CepA-East region of massive star formation and describe an extended and dynamically distinct feature not previously recognised. This feature is present in emission from H_2CS, OCS, CH_3OH, and HDO at –5.5 km s^{-1}, but is not traced by conventional tracers of star forming regions H_2S, SO_2, SO, CS. The feature is extended up to at least 0.1 pc. We show that the feature is neither a hot core nor a shocked outflow. However, the chemistry of the feature is consistent with predictions of a model of an eroding interface between a fast wind and a

dense core; mixing between the two media occurs in the interface on a timescale of 10-50 years. If these observations are confirmed by detailed maps and by detections in species also predicted to be abundant (e.g. HCO^+, H_2CO, and NH_3) this feature would be the first detection of such an interface in regions of massive star formation. An important implication of the model is that a significant reservoir of sulfur in grain mantles is required to be in the form of OCS.

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astro-ph/0605158 or http://www.arcetri.astro.it/∼codella/interface.pdf

The rich young cluster NGC 6530: a combined X-ray-optical-infrared study

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We present a combined X-ray, optical and IR (2MASS) study of NGC 6530, complementing our previous studies of this cluster. We consider different indicators of IR excesses, taken as indicator of circumstellar disks and therefore of pre-main-sequence status. We use reddening-free indices to ensure that our results are unaffected by highly irregular, differential reddening. More than the study of the JHK bands alone (33 IR-excess stars found), we find as useful a comparison between various optical and IR colors, finding overall 333 stars with optical-IR excess. In the field of the previously studied *Chandra* ACIS-I observation, we find 196 stars with optical-IR excess, of which 120 not previously found in X-rays. The total number of estimated cluster members becomes thus $\geq$ 1100. The estimated disk frequency in the ACIS field is $\sim$ 20%. By considering different optical-IR excess indices, we find only partially overlapping subsamples, corresponding to different characteristics of their spectral energy distributions (longer- or shorter-wavelength IR excesses, or blue-violet excess). In a region displaced towards north-west with respect to the known cluster center we find an unexpected concentration of stars with optical-IR excesses, most of which not detected in X-rays. The spectral energy distribution of some of these objects shows more extreme excesses with respect to most ordinary T Tauri stars, and suggests circumstellar disks with very small inner holes and high accretion rates; some objects are best interpreted as surrounded by reflection nebulosities, as found in some optically detected Class I objects in nearer star-forming regions. These reflection-nebulae candidates have the lowest X-ray detection rate among all subsamples considered here. Optical-IR excess stars in the north of NGC 6530 are nearly co-spatial with a sub-population of cluster stars older than central cluster stars. This leads to the conclusion that in these northern regions of NGC 6530, far from massive cluster stars, star formation (and disk evolution) has proceeded rather undisturbed over longer time scales than near cluster center, where most massive stars are found, and most stars are lacking substantial disks and strong accretion.

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http://www.astropa.unipa.it/Library/preprint.html

Cloud Fragmentation and Proplyd-like Features in H II Regions Imaged by the *Hubble Space Telescope*

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We have analyzed *Hubble Space Telescope* ACS and WFPC2 new and archival images of eight H II regions to look for new protoplanetary disks (proplyds) similar to those found in the Orion Nebula. We find a wealth of features similar in size (although many are larger) to the bright cusps around the Orion Nebula proplyds. None of them, however, contains a definitive central star. From this, we deduce that the new cusps may not be proplyds but instead fragments of molecular cloud material. Out of *all* the features found in the eight H II regions examined, only one, an apparent edge-on silhouette in M17, may have a central star. This feature might join the small number of bona fide proplyds found outside the Orion Nebula, in M8, M20, and possibly M16. In line with the results found recently by Smith et al., the paucity of proplyds outside the Orion Nebula can be explained by their transient nature, as well as by the specific environmental conditions under which they can be observed. Several fragments are seen as dark silhouettes against a bright background. We have reanalyzed those found in IC 2944 by Reipurth et al. and found new, similar ones in M16. None of these fragments contains a central star, and we exclude the possibility that they are disks. Reipurth et al. concluded that the IC 2944 silhouettes are not star forming. We argue here that their assumption of a constant optical depth for these fragments is not physical and that it is more likely that these fragments are star forming, a condition that is supported, although not proved, by their shapes and distributions. The process of cloud fragmentation *and* photoevaporation produces a large number of small fragments, while the size hierarchy expected in a photoevaporative environment would not favor small fragments. The size distributions observed will constrain any future theories of cloud fragmentation. One bright microjet candidate is found in M17, protruding from a large, limb-brightened fragment. A second, larger, jetlike feature, similar in shape and size to a Herbig-Haro jet, is found in Pismis 24. No central star appears to be associated with either of these jet candidates.

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The origins of the substellar companion to GQ Lupi

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The recently discovered substellar companion to GQ Lup possibly represents a direct test of current planet formation theories. We examine the possible formation scenarios for the companion to GQ Lup assuming it is a $\sim 2M_{Jup}$ object. We determine that GQ Lup B most likely was scattered into a large, eccentric orbit by an interaction with another planet in the inner system. If this is the case, several directly observable predictions can be made, including the presence of a more massive, secondary companion that could be detected through astrometry, radial velocity measurements, or sculpting in GQ Lup's circumstellar disk. This scenario requires a highly eccentric orbit for the companion already detected. These predictions can be tested within the next decade or so. Additionally, we look at scenarios of formation if the companion is a brown dwarf. One possible formation scenario may involve an interaction between a brown dwarf binary and GQ Lup. We look for evidence of any brown dwarfs that have been ejected from the GQ Lup system by searching the 2MASS all-sky survey.

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Full-Polarization Observations of OH Masers in Massive Star-forming Regions. II. Maser Properties and the Interpretation of Polarization

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We analyze full-polarization VLBA data of ground-state OH masers in 18 massive star-forming regions previously presented in a companion paper. We confirm results previously seen in the few individual sources studied at milliarcsecond angular resolution. The OH masers often arise in the shocked neutral gas surrounding ultracompact H II regions. Magnetic fields as deduced from OH maser Zeeman splitting are highly ordered on the scale of a source and on the maser clustering scale of $\sim 10^{15}$ cm, which appears to be universal. OH masers around ultracompact H II regions live $\sim 10^4$ yr before turning off abruptly, rather than weakening gradually. These masers have a wide range of polarization properties. At one extreme (e.g., W75 N), π-components are detected and the polarization position angles of maser spots show some organization. At the other extreme (e.g., W51 e1/e2), almost no linear polarization is detected and partial depolarization occurs. A typical source has properties intermediate to these two extremes, with no clear pattern in the distribution of polarization position angles. This can be explained if Faraday rotation in a typical OH maser source is large on a maser amplification length but small on a single (e-folding) gain length.

Increasing or decreasing Faraday rotation by a factor of ~ 5 among different sources can explain the observed variation in polarization properties. Pure π-components (in theory, 100% linearly polarized) are seldom seen. We suggest that almost all π-components acquire a significant amount of circular polarization from low-gain stimulated emission of a σ-component from velocity-coherent OH lying along the propagation path.

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Runaway collisions in young star clusters – I. Methods and tests

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We present the methods and preparatory work for our study of the collisional runaway scenario to form a very massive star (VMS, $M_\star > 400\ M_\odot$) at the centre of a young, compact stellar cluster. In the first phase of the process, a very dense central core of massive stars ($M_\star \simeq 30 - 120\ M_\odot$) forms through mass segregation and gravothermal collapse. This leads to a collisional stage, likely to result in the formation of a VMS (itself a possible progenitor for an intermediate-mass black hole) through a runaway sequence of mergers between the massive stars. In this paper, we present the runaway scenario in a general astrophysical context. We then explain the numerical method used to investigate it. Our approach is based on a Monte Carlo code to simulate the stellar dynamics of spherical star clusters, using a very large number of particles (a few 10^5 to several 10^6). Finally, we report on test computations carried out to ensure that our implementation of the important physics is sound. In a second paper, we present results from more than 100 cluster simulations realized to determine the conditions leading to the collisional formation of a VMS and the characteristics of the runaway sequences.

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Runaway collisions in young star clusters – II. Numerical results

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We present a new study of the collisional runaway scenario to form an intermediate-mass black hole (IMBH, $M_{BH} \geq 100\ M_\odot$) at the centre of a young, compact stellar cluster. The first phase is the formation of a very dense central core of massive stars ($M_\star \simeq 30 - 120\ M_\odot$) through mass segregation and gravothermal collapse. Previous work established the conditions for this to happen before the massive stars evolve off the main sequence (MS). In this and a companion paper, we investigate the next stage by implementing direct collisions between stars. Using a Monte Carlo stellar dynamics code, we follow the core collapse and subsequent collisional phase in more than 100 models with varying cluster mass, size, and initial concentration. Collisions are treated either as ideal, 'sticky-sphere' mergers or using realistic prescriptions derived from 3D hydrodynamics computations. In all cases for which the core collapse happens in less than the MS lifetime of massive stars ($\simeq$3 Myr), we obtain the growth of a single very massive star (VMS, $M_\star \simeq 400 - 4000\ M_\odot$) through a runaway sequence of mergers. Mass loss from collisions, even for velocity dispersions as high as $\sigma_v \sim 1000$ km s^{-1}, does not prevent the runaway. The region of cluster parameter space leading to runaway is even more extended than predicted in previous work because, in clusters with $\sigma_v > 300$ km s^{-1}, collisions accelerate (and, in extreme cases, drive) core collapse. Although the VMS grows rapidly to $\geq 1000 M_\odot$ in models exhibiting runaway, we cannot predict accurately its final mass. This is because the termination of the runaway process must eventually be determined by a complex interplay between stellar dynamics, hydrodynamics, and the stellar evolution of the VMS. In the vast majority of cases, we find that the time between successive collisions becomes much shorter than the thermal time-scale of the VMS. Therefore, our assumption that all stars return quickly to the MS after a collision must eventually break down for the runaway product, and the stellar evolution of the VMS becomes very uncertain.

For the same reason, the final fate of the VMS, including its possible collapse to an IMBH, remains unclear.

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Dust settling in local simulations of turbulent protoplanetary disks

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In this paper, we study the effect of MHD turbulence on the dynamics of dust particles in protoplanetary disks. We vary the size of the particles and relate the dust evolution to the turbulent velocity fluctuations. We performed numerical simulations using two Eulerian MHD codes, both based on finite difference techniques: ZEUS–3D and NIRVANA. These were local shearing box simulations incorporating vertical stratification. Both ideal and non ideal MHD simulations with midplane dead zones were carried out. The codes were extended to incorporate different models for the dust as an additional fluid component. Good agreement between results obtained using the different approaches was obtained. The simulations show that a thin layer of very small dust particles is diffusively spread over the full vertical extent of the disk. We show that a simple description obtained using the diffusion equation with a diffusion coefficient simply expressed in terms of the velocity correlations accurately matches the results. Dust settling starts to become apparent for particle sizes of the order of 1 to 10 centimeters for which the gas begins to decouple in a standard solar nebula model at $5.2AU$. However, for particles which are 10 centimeters in size, complete settling toward a very thin midplane layer is prevented by turbulent motions within the disk, even in the presence of a midplane dead zone of significant size. These results indicate that, when present, MHD turbulence affects dust dynamics in protoplanetary disks. We find that the evolution and settling of the dust can be accurately modelled using an advection diffusion equation that incorporates vertical settling. The value of the diffusion coefficient can be calculated from the turbulent velocity field when that is known for a time of several local orbits.

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Gravitational Collapse of Magnetized Clouds: I. Ideal MHD Accretion Flow

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We study the self-similar collapse of an isothermal magnetized rotating cloud in the ideal magnetohydrodynamic (MHD) regime. In the limit of small distance from the accreting protostar we find an analytic solution that corresponds to free-fall onto a central mass point. The density distribution is not spherically symmetric but depends on the mass loading of magnetic field lines, which can be obtained by matching our inner solution to an outer collapse solution previously computed by Allen, Shu & Li. The concentration of magnetic field trapped by the central mass point under field-freezing, independent on the details of the starting state, creates a split monopole configuration where the magnetic field strength increases as the inverse square of the distance from the center. Under such conditions, the inflow eventually becomes subalfvènic and the outward transfer of angular momentum by magnetic braking very efficient, thus preventing the formation of a centrifugally supported disk. Instead, the azimuthal velocity of the infalling gas decreases to zero at the center, and the gas spirals into the star. Therefore, the dissipation of dynamically important levels of magnetic field is a fundamental requisite for the formation of protoplanetary disks around young stars.

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SCUBA polarisation observations of the magnetic fields in the pre-stellar cores L1498 and L1517B

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We have mapped linearly polarized dust emission from the prestellar cores L1498 and L1517B with the James Clerk Maxwell Telescope (JCMT) using the Submillimetre Common User Bolometer Array (SCUBA) and its polarimeter (SCUBAPOL) at a wavelength of 850 μm. We use these measurements to determine the plane-of-sky magnetic field orientation in the cores. In L1498 we see a magnetic field across the peak of the core that lies at an offset of $\sim$19° $\pm$ 12° to the short axis of the core. This is similar to the offsets seen in previous observations of prestellar cores. To the southeast of the peak, in the filamentary tail of the core, we see that the magnetic field has rotated to lie almost parallel to the long axis of the filament. We hypothesise that the field in the core may have decoupled from the field in the filament that connects the core to the rest of the cloud. We use the Chandrasekhar-Fermi (CF) method to measure the plane-of-sky field strength in the core of L1498 to be $\sim$10 $\pm$ 7 μG.

In L1517B we see a more gradual turn in the field direction from the northern part of the core to the south. This appears to follow a twist in the filament in which the core is buried, with the field staying at a roughly constant $\sim$25° $\pm$ 6° offset to the short axis of the filament, consistent with previous observations of prestellar cores. Hence these two clouds in an apparently similar evolutionary state, that exhibit similar masses, morphologies and densities, have very different magnetic field configurations. We again use the CF method and calculate the magnetic field strength in L1517B to be $\sim$30 $\pm$ 10 μG. Both cores appear to be roughly virialised. Comparison with our previous work on somewhat denser cores shows that, for the denser cores, thermal and non-thermal (including magnetic) support are approximately equal, while for the lower density cores studied here, thermal support dominates.

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Outflows from the high-mass protostars NGC 7538 IRS1/2 observed with bispectrum speckle interferometry – Signatures of flow precession

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Context. NGC 7538 IRS1 is a high-mass (30 $M_\odot$) protostar with a CO outflow, an associated ultracompact HII region, and a linear methanol maser structure, which might trace a Keplerian-rotating circumstellar disk. The directions of the various associated axes are misaligned with each other.
Aims. We investigate the near-infrared morphology of the source to clarify the relations among the various axes.
Methods. K'-band bispectrum speckle interferometry was performed at two 6-meter-class telescopes—the BTA 6 m telescope and the 6.5 m MMT. Complementary IRAC images from the *Spitzer* Space Telescope Archive were used to relate the structures detected with the outflow at larger scales.
Results. High-dynamic range images show fan-shaped outflow structure in which we detect 18 stars and several blobs of diffuse emission. We interpret the misalignment of various outflow axes in the context of a disk precession model, including numerical hydrodynamic simulations of the molecular emission. The precession period is $\sim$ 280 years and its half-opening angle is $\sim$ 40°. A possible triggering mechanism is non-coplanar tidal interaction of an (undiscovered) close companion with the circumbinary protostellar disk. Our observations resolve the nearby massive protostar NGC 7538 IRS2 as a close binary with separation of 195 mas. We find indications for shock interaction between the

outflow activities in IRS1 and IRS2. Finally, we find prominent sites of star formation at the interface between two bubble-like structures in NGC 7538, suggestive of a triggered star formation scenario.
Conclusions. Indications of outflow precession have been discovered to date in a number of massive protostars, all with large precession angles ($\sim$ 20–45°). This might explain the difference between the outflow widths in low- and high-mass stars and add support to a common collimation mechanism.

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The Initial Mass Functions of Four Embedded Stellar Clusters

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We present near-infrared J, H, and K images of four embedded stellar clusters in the Galaxy. We find a significant fraction of pre-main-sequence stars present in at least one of the clusters. For the clusters dominated by main-sequence stars, we determine the initial mass function (IMF) both by using the K luminosity function and a global extinction correction and by deriving individual extinction corrections for each star based on their placement in the K versus $H-K$ color-magnitude diagram. Based on our IMFs we find a significant discrepancy between the mean IMF derived via the different methods, suggesting that taking individual extinctions into account is necessary to correctly derive the IMF for an embedded cluster.

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Mid-infrared source multiplicity within hot molecular cores traced by methanol masers

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We present high resolution, mid-infrared images toward three hot molecular cores signposted by methanol maser emission; G173.49+2.42 (S231, S233IR), G188.95+0.89 (S252, AFGL-5180) and G192.60-0.05 (S255IR). Each of the cores was targeted with Michelle on Gemini North using 5 filters from 7.9 to 18.5 μm. We find each contains both large regions of extended emission and multiple, luminous point sources which, from their extremely red colours ($F_{18.5}/F_{7.9} \geq 3$), appear to be embedded young stellar objects. The closest angular separations of the point sources in the three regions are 0.79, 1.00 and 3.33 arcsec corresponding to linear separations of 1,700, 1,800 and 6,000AU respectively. The methanol maser emission is found closest to the brightest MIR point source (within the assumed 1 arcsec pointing accuracy). Mass and luminosity estimates for the sources range from 3-22 $M_\odot$ and 50-40,000 $L_\odot$. Assuming the MIR sources are embedded objects and the observed gas mass provides the bulk of the reservoir from which the stars formed, it is difficult to generate the observed distributions for the most massive cluster members from the gas in the cores using a standard form of the IMF.

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Colliding Clouds: The Star Formation Trigger of the Stellar Cluster around BD +40 4124

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We present BIMA and SCUBA observations of the young cluster associated with BD +40 4124 in the dense molecular gas tracer CS $J = 2 \rightarrow 1$ and the continuum dust emission at $\lambda = 3.1$ mm and 850 μm. The dense gas and dust in the system are aligned in a long ridge morphology extending ~ 0.4 pc with 16 gas clumps of estimated masses ranging from 0.14 to 1.8 $M_\odot$. A north-south variation in the CS center line velocity can be explained with a two-cloud model. We posit that the BD +40 4124 stellar cluster formed from a cloud-cloud collision. The largest line widths occur near V1318 Cyg S, a massive star affecting its natal environment. In contrast, the dense gas near the other, more evolved, massive stars displays no evidence for disruption; the material must either be processed into the star, dissipate, or relax fairly quickly. The more evolved low-mass protostars are more likely to be found near the massive stars. If the majority of low-mass stars are coeval, the seemingly evolved low-mass protostars are not older: the massive stars have eroded their structures. Finally, at the highest resolution, the $\lambda = 3.1$ mm dust emission is resolved into a flattened structure 3100×1500 AU with an estimated mass of 3.4 $M_\odot$. The continuum and CS emission are offset by 1.1" from the southern binary source. A simple estimate of the extinction due to the continuum emission structure is $A_V \sim 700$ mag. From the offset and because the southern source is detected in the optical, the continuum emission is from a previously unknown very young, intermediate-mass, embedded stellar object.

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Optical imaging of L723: the structure of HH 223

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We imaged the Lynds 723 dark nebula (L723) with the aim of studying the morphology of the Herbig-Haro object HH 223 and other line-emission nebula detected in the region. We obtained deep narrow-band images in the Hα and [SII] lines and in the continuum nearby Hα of a field of $\sim 5'$ of the L723 dark nebula centered on HH 223. The Hα and [SII] images reveal the detailed morphology of HH 223, unresolved in previous optical images. Both images show a quite complex knotty, wiggling structure embedded in a low-emission nebula. Comparison between the [SII] and Hα fluxes of the knots are indicative of variations in the excitation conditions through HH 223. In addition, several other faint nebula are detected in Hα a few arcmin to the SE and to the NW of HH 223, all of them lying projected onto the east-west pair of lobes of the quadrupolar CO outflow. Comparison between the Hα and the continuum images confirms the HH-like nature of the Vrba object V83, while the Vrba objects V84 and V85 are identified as faint field stars.

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A deep photometric survey of the η Chamaeleontis cluster down to the brown dwarf-planet boundary

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We report the outcome of the deep optical/infrared photometric survey of the central region (33×33 arcmin^2 or 0.9 pc^2) of the η Chamaeleontis (η Cha) pre-main sequence star cluster. The completeness limits of the photometry are $I = 19.1$, $J = 18.2$ and $H = 17.6$, faint enough to reveal low-mass members down to the brown dwarf and planet boundary of $\approx 13 M_{Jup}$. We found no such low-mass members in this region. Our result combined with a previous shallower ($I = 17$) but larger area survey indicates that low-mass objects ($0.013 < M/M_\odot < 0.075$) were either not created in the η Cha cluster or lost due to the early dynamical history of the cluster and ejected to outside the surveyed areas.

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A Spitzer/IRAC Search for Substellar Companions of the Debris Disk Star ϵ Eridani

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We have used the InfraRed Array Camera (IRAC) onboard the Spitzer Space telescope to search for low mass companions of the nearby debris disk star ϵ Eridani. The star was observed in two epochs 39 days apart, with different focal plane rotation to allow the subtraction of the instrumental Point Spread Function, achieving a maximum sensitivity of 0.01 MJy/sr at 3.6 and 4.5 μm, and 0.05 MJy/sr at 5.8 and 8.0 μm. This sensitivity is not sufficient to directly detect scattered or thermal radiation from the ϵ Eridani debris disk. It is however sufficient to allow the detection of Jovian planets with mass as low as 1 M_J in the IRAC 4.5 μm band. In this band, we detected over 460 sources within the 5.70 arcmin field of view of our images. To test if any of these sources could be a low mass companion to ϵ Eridani, we have compared their colors and magnitudes with models and photometry of low mass objects. Of the sources detected in at least two IRAC bands, none fall into the range of mid-IR color and luminosity expected for cool, 1 Gyr substellar and planetary mass companions of ϵ Eridani, as determined by both models and observations of field M, L and T dwarf. We identify three new sources which have detections at 4.5 μm only, the lower limit placed on their [3.6]-[4.5] color consistent with models of planetary mass objects. Their nature cannot be established with the currently available data and a new observation at a later epoch will be needed to measure their proper motion, in order to determine if they are physically associated to ϵ Eridani.

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Disk Surface Density Transitions as Protoplanet Traps

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The tidal torque exerted by a protoplanetary disk with power-law surface density and temperature profiles onto an embedded protoplanetary embryo is generally a negative quantity that leads to the embryo inward migration. Here we investigate how the tidal torque balance is affected at a disk surface density radial jump. The jump has two consequences: (1) It affects the differential Lindblad torque. In particular, if the disk is merely empty on the inner side, the differential Lindblad torque almost amounts to the large negative outer Lindblad torque. (2) It affects the corotation torque, which is a quantity very sensitive to the local gradient of the disk surface density. In particular, if the disk is depleted on the inside and the jump occurs radially over a few pressure scale heights, the corotation torque is a positive quantity that is much larger than in a power-law disk. We show by means of customized numerical simulations of low-mass planets embedded in protoplanetary nebulae with a surface density jump that the second effect is dominant; that is, that the corotation torque largely dominates the differential Lindblad torque on the edge of a central depletion, even a shallow one. Namely, a disk surface density jump of about 50% over $3-5$ disk thicknesses suffices to cancel out the total torque. As a consequence, the type I migration of low-mass objects reaching the jump should be halted, and all these objects should be trapped there provided some amount of dissipation is present in the disk to prevent the corotation torque saturation. As dissipation is provided by turbulence, which induces a jitter of the planet semimajor axis, we investigate under which conditions the trapping process overcomes the trend of turbulence to induce stochastic migration across the disk. We show that a cavity with a large outer to inner surface density ratio efficiently traps embryos from 1 to 15 $M_{\oplus}$, at any radius up to 5 AU from the central object, in a disk that has same surface density profile as the minimum mass solar nebula (MMSN). Shallow surface density transitions require light disks to efficiently trap embryos. In the case of the MMSN, this could happen in the very central parts ($r < 0.03$ AU). We discuss where in a protoplanetary disk one can expect a surface density jump. This effect could constitute a solution to the well-known problem that the buildup of the first protogiant solid core in a disk takes much longer than its type I migration toward the central object.

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Kinematics of Protostellar Objects in the ρ Ophiuchus A Region

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We present the detection of infall, rotation and outflow kinematic signatures towards both a protostellar source, VLA 1623 and what was initially thought to be a pre-protostellar core, SM1N, in the ρ Ophiuchus A region. The kinematic signatures of early star formation were detected in the dense molecular gas surrounding the embedded sources using high signal-to-noise millimeter and submillimeter data. Centroid velocity maps made with HCO^+ J=4→3 and J=1→0 line emission exhibit the blue bulge signature of infall, which is predicted to be seen when infall motion dominates over rotational motion. Further evidence for infalling gas is found in the HCO^+ blue asymmetric line profiles and red asymmetric opacity profiles. We also performed CO J=3→2 and J=1→0 observations to determine the direction, orientation, and extent of molecular outflows, and report the discovery of a new bipolar outflow possibly driven by SM1N.

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Radio Constraints on Activity in Young Brown Dwarfs

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We report on searches for radio emission from three of the nearest known young brown dwarfs using the Very Large Array. We have obtained sensitive upper limits on 3.6cm emission from 2MASSW J1207334-393254, TWA 5B and SSSPM J1102-3431, all of which are likely members of the ∼8-Myr-old TW Hydrae association. We derive constraints on the magnetic field strength and the number density of accelerated electrons, under the assumption that young brown dwarf atmospheres are able to produce gyrosynchrotron emission, as seems to be indicated in older brown dwarfs. For the young brown dwarf TWA 5B, the ratio of its detected X-ray luminosity to the upper limit on radio luminosity places it within the expected range for young stars and older, active stars. Thus, its behavior is anomalous compared to older brown dwarfs, in which radio luminosity is substantially enhanced over the expected relationship. Our observations deepen the conundrum of magnetic activity in brown dwarfs, and suggest that a factor other than

age is more important for determining radio emission in cool substellar objects.

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RODEO: a new method for planet-disk interaction

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Aims. In this paper we describe a new method for studying the hydrodynamical problem of a planet embedded in a gaseous disk.

Methods. We use a finite volume method with an approximate Riemann solver (the Roe solver), together with a special way to integrate the source terms. This new source term integration scheme sheds new light on the Coriolis instability, and we show that our method does not suffer from this instability.

Results. The first results on flow structure and gap formation are presented, as well as accretion and migration rates. For $M_p < 0.1\ M_J$ and $M_p > 1.0\ M_J$ ($M_J =$ Jupiter's mass) the accretion rates do not depend sensitively on numerical parameters, and we find that within the disk's lifetime a planet can grow to $3 - 4\ M_J$. In between these two limits numerics play a major role, leading to differences of more than 50% for different numerical parameters. Migration rates are not affected by numerics at all as long as the mass inside the Roche lobe is not considered. We can reproduce the type I and type II migration for low-mass and high-mass planets, respectively, and the fastest moving planet of $0.1\ M_J$ has a migration time of only 2.0×10^4 yr.

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The Search for other Earths: limits on the giant planet orbits that allow habitable terrestrial planets to form

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Gas giant planets are far easier than terrestrial planets to detect around other stars, and are thought to form much more quickly than terrestrial planets. Thus, in systems with giant planets, the late stages of terrestrial planet formation are strongly affected by the giant planets' dynamical presence. Observations of giant planet orbits may therefore constrain the systems that can harbor potentially habitable, Earth-like planets. We present results of 460 N-body simulations of terrestrial accretion from a disk of Moon- to Mars-sized planetary embryos. We systematically vary the orbital semimajor axis of a Jupiter-mass giant planet between 1.6 and 6 AU, and eccentricity between 0 and 0.4. We find that for Sun-like stars, giant planets inside roughly 2.5 AU inhibit the growth of 0.3 Earth-mass planets in the habitable zone. If planets accrete water from volatile-rich embryos past 2-2.5 AU, then water-rich habitable planets can only form in systems with giant planets beyond 3.5 AU. Giant planets with significant orbital eccentricities inhibit both accretion and water delivery. The majority of the current sample of extra-solar giant planets appears unlikely to form habitable planets.

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

Spherical Accretion

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We compare different examples of spherical accretion onto a gravitating mass. Limiting cases include the accretion of a collisionally dominated fluid and the accretion of collisionless particles. We derive expressions for the accretion rate and density profile for semicollisional accretion, which bridges the gap between these limiting cases. Particle crossing of the Hill sphere during the formation of the outer planets is likely to have taken place in the semicollisional regime.

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Gravitational Collapse of Magnetized Clouds: II. The Role of Ohmic Dissipation

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We formulate the problem of magnetic field dissipation during the accretion phase of low-mass star formation, and we carry out the first step of an iterative solution procedure by assuming that the gas is in free-fall along radial field lines. This so-called "kinematic approximation" ignores the back reaction of the Lorentz force on the accretion flow. In quasi steady-state, and assuming the resistivity coefficient to be spatially uniform, the problem is analytically soluble in terms of Legendre's polynomials and confluent hypergeometric functions. The dissipation of the magnetic field occurs inside a region of radius inversely proportional to the mass of the central star (the "Ohm radius"), where the magnetic field becomes asymptotically straight and uniform. In our solution, the magnetic flux problem of star formation is avoided because the magnetic flux dragged in the accreting protostar is always zero. Our results imply that the effective resistivity of the infalling gas must be higher by several orders of magnitude than the microscopic electric resistivity, to avoid conflict with measurements of paleomagnetism in meteorites and with the observed luminosity of regions of low-mass star formation.

Accepted by The Astrophysical Journal

Silicate Emission Profiles from Low-Mass Protostellar Disks in the Orion Nebula: Evidence for Growth and Thermal Processing of Grains

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We present 8–13 μm low resolution spectra ($R \approx 100$) of 8 low-mass protostellar objects ("proplyds") in the Orion Nebula using the Long Wavelength Spectrometer (LWS) at the W. M. Keck Observatory. All but one of the sources in our sample show strong circumstellar silicate emission, with profiles that are qualitatively similar to those seen in some T Tauri and Herbig Ae/Be stars. The silicate profile in all cases is significantly flattened compared to the profile for typical interstellar dust, suggesting that the dominant emitting grains are significantly larger than those found in the interstellar medium. The 11.3-to-9.8 μm flux ratio—often used as an indicator of grain growth—is in the 0.8 to 1.0 range for all of our targets, indicating that the typical grain size is around a few microns in the surface layers of the attendant circumstellar disk for each object. Furthermore, the silicate profiles show some evidence of crystalline features, as seen in other young stellar objects. The results of our analysis show that the grains in the photoevaporating protostellar disks of Orion have undergone significant growth and perhaps some annealing, suggesting that grain evolution for these objects is not qualitatively different from other young stellar objects.

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http://homepage.mac.com/rshuping/Astro/

Dust-cooling–induced Fragmentation of Low-Metallicity Clouds

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We study the dynamical collapse and fragmentation of low-metallicity cloud cores using three-dimensional hydrodynamical calculations, and we devote particular attention to whether or not the cores fragment in the dust-cooling phase. The cores become elongated in the dust-cooling phase because they are unstable to nonspherical perturbation due to the sudden temperature decrease. In the metallicity range of 10^{-6} to 10^{-5} $Z_\odot$, cores with an initial axis ratio $\geq$2 reach a critical value of the axis ratio ($\geq$ 30) and fragment into multiple small clumps. This provides a possible mechanism to produce low-mass stars in ultra–metal-poor environments.

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Deuterium enhancement in $H_3{}^+$ in prestellar cores

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Deuterium enhancement of monodeuterated species has been recognized for more than 30 years as a result of the chemical fractionation that results from the difference in zero point energies of deuterated and hydrogenated molecules. The key reaction is the deuteron exchange in the reaction between HD, the reservoir of deuterium in dark interstellar clouds, and the $H_3{}^+$ molecular ion, leading to the production of the H_2D^+ molecule, and the low temperature in dark interstellar clouds favors this production. Furthermore, the presence of multiply deuterated species have incited our group to proceed further and consider the subsequent reaction of H_2D^+ with HD, leading to D_2H^+ (first detected by Vastel et al. 2004), which can further react with HD to produce $D_3{}^+$. In prestellar cores, where CO was found to be depleted (Bacmann et al. 2003), this production should be increased, as CO would normally destroy $H_3{}^+$. The first model including D_2H^+ and $D_3{}^+$ (Roberts, Herbst & Millar 2003) predicted that these molecules should be as abundant as H_2D^+ (see contribution by H. Roberts). The first detection of the D_2H^+ was made possible by the recent laboratory measurement by Hirao & Amano (2003) for the frequency of the fundamental line of the para-D_2H^+ (see contribution by T. Amano). Here we present observations of H_2D^+ and D_2H^+ towards a sample of dark clouds and prestellar cores and show how the distribution of ortho-H_2D^+ ($1_{1,0}$-$1_{1,1}$) can trace the deuterium factory in prestellar cores. We also present how future instrumentation will improve our knowledge concerning the deuterium enhancement of $H_3{}^+$.

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astro-ph/0605126

The magnetic field and confined wind of the O star θ^1 Orionis C

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Aims. In this paper we confirm the presence of a globally-ordered, kG-strength magnetic field in the photosphere of the young O star θ^1 Orionis C, and examine the properties of its optical line profile variations.

Methods. A new series of high-resolution MuSiCoS Stokes V and I spectra has been acquired which samples approximately uniformly the rotational cycle of θ^1 Orionis C. Using the Least-Squares Deconvolution (LSD) multiline technique, we have succeeded in detecting variable Stokes V Zeeman signatures associated with the LSD mean line profile. These signatures have been modeled to determine the magnetic field geometry. We have furthermore examined the profile variations of lines formed in both the wind and photosphere using dynamic spectra.

Results. Based on spectrum synthesis fitting of the LSD profiles, we determine that the polar strength of the magnetic dipole component is $1150 \leq B_d \leq 1800$ G and that the magnetic obliquity is $27° \leq \beta \leq 68°$, assuming $i = 45 \pm 20°$. The best-fit values for $i = 45°$ are $B_d = 1300 \pm 150$ G (1σ) and $\beta = 50° \pm 6°(1\sigma)$. Our data confirm the previous detection of a magnetic field in this star, and furthermore demonstrate the sinusoidal variability of the longitudinal field and accurately determine the phases and intensities of the magnetic extrema. The analysis of "photospheric" and "wind" line profile variations supports previous reports of the optical spectroscopic characteristics, and provides evidence for infall of material within the magnetic equatorial plane.

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Stellar Rotation: A Clue to the Origin of High Mass Stars?

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We present the results of a study aimed at assessing whether low and high mass stars form similarly. Our approach is (1) to examine the observed projected rotational velocities among a large sample of newly-formed stars spanning a range in mass between 0.2 and 50 $M_\odot$; and (2) to search for evidence of a discontinuity in rotational properties that might indicate a difference in the stellar formation process at some characteristic mass. Our database includes both recently published values of $v \sin i$ for young intermediate- and low- mass stars in Orion, as well as new observations of O stars located in young clusters and OB associations. We find that the median of the quantity v_{obs}/v_c (observed rotational speed/equatorial breakup velocity) is typically about 0.15 and shows no evidence of a discontinuity over the full range of stellar masses, while the quantity Jsini/M (derived angular momentum per unit mass) exhibits a slow, monotonic rise (J/M $\sim M^{0.3}$) with increasing mass with no evidence of a discontinuity. We suggest that these observations are most simply interpreted as indicative of a single stellar formation and angular momentum regulation mechanism: one that results in rotation rates well below breakup, and angular momenta per unit mass that differ systematically by no more than a factor of 3-4 over a mass range spanning a factor of 250.

Accepted by Astronomical Journal

X-ray and IR Point Source Identification and Characteristics In the Embedded, Massive Star-Forming Region RCW 38

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We report on results of a 96.7 ks *Chandra* observation of one of the youngest, most embedded and massive young stellar clusters studied in X-rays – RCW 38. We detect 460 sources in the field of which 360 are confirmed to be associated with the RCW 38 cluster. The cluster members range in luminosity from 10^{30} ergs s^{-1} to $10^{33.5}$ ergs s^{-1}. Over ten percent of the cluster members with over 100 counts exhibit flares while about 15% of cluster members with over 30 counts are variable. Of the sources identified as cluster members, 160 have near-infrared (NIR) counterparts either in the 2MASS database or detected via VLT observations. Of these about 20% appear to have optically thick disks. An additional 353 members are identified through NIR observations of which at least 50% possess optically thick disks. We fit over 100 X-ray sources as absorbed Raymond-Smith type plasmas and find the column to the cluster members varies from $10^{21.5}$ to 10^{23} cm^{-2}. We compare the gas to dust absorption signatures in these stars and find $N_{\rm H}= A_V \times 2 \times 10^{21} cm^{-2}$. We find that the cluster contains 31 candidate OB stars and is centered about 10″ (0.1 pc) west of the primary source of the ionization, the O5 star IRS 2. The cluster has a peak central density of about 400 X-ray sources pc $^{-2}$. We estimate that the total cluster membership exceeds 2000 stars.

Accepted by The Astronomical Journal

http://hea-www.harvard.edu/ swolk/PAPERS/RCW38_full.pdf or http://xxx.lanl.gov/abs/astro-ph/0605096

Star Formation in the Era of the Three Great Observatories

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This paper summarizes contributions and suggestions as presented at the Chandra Workshop Star Formation in the Era of Three Great Observatories conducted in July 2005. One of the declared goals of the workshop was to raise recognition within the star formation research community about the sensible future utilization of the space observatories Spitzer, Hubble, and Chandra in their remaining years of operation to tackle imminent questions of our understanding of stellar formation and the early evolution of stars. A white paper was generated to support the continuous and simultaneous usage of observatory time for star formation research. The contents of this paper have been presented and discussed at several other meetings during the course of 2005 and January 2006.

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http://xxx.lanl.gov/abs/astro-ph/0604384

Wave excitation in three-dimensional discs by external potential

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We study the excitation of density and bending waves and the associated angular momentum transfer in gaseous discs with finite thickness by a rotating external potential. The disc is assumed to be isothermal in the vertical direction and has no self-gravity. The disc perturbations are decomposed into different modes, each characterized by the azimuthal index m and the vertical index n, which specifies the nodal number of the density perturbation along the disc normal direction. The $n = 0$ modes correspond to the two-dimensional density waves previously studied by Goldreich & Tremaine and others. In a three-dimensional disc, waves can be excited at both Lindblad resonances (LRs; for modes with $n = 0, 1, 2, \ldots$) and vertical resonances (VRs; for the $n \geq 1$ modes only). The torque on the disc is positive for waves excited at outer Lindblad/vertical resonances and negative at inner Lindblad/vertical resonances. While the $n = 0$ modes are evanescent around corotation, the $n \geq 1$ modes can propagate into the corotation region where

they are damped and deposit their angular momenta. We have derived analytical expressions for the amplitudes of different wave modes excited at LRs and/or VRs and the resulting torques on the disc. It is found that for $n \geq 1$, angular momentum transfer through VRs is much more efficient than LRs. This implies that in some situations (e.g., a circumstellar disc perturbed by a planet in an inclined orbit), VRs may be an important channel of angular momentum transfer between the disc and the external potential. We have also derived new formulae for the angular momentum deposition at corotation and studied wave excitations at disc boundaries.

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Dissertation Abstracts

Near Infrared Study of the Star-forming Properties of the Rosette Complex

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Ph.D dissertation directed by: Elizabeth A. Lada

Ph.D degree awarded: February, 2006

The Rosette Complex is one of the most important astrophysical laboratories for the study of star formation. In this region we can study the interaction of an expanding HII region impulsed by the stellar winds from the large OB association NGC 2244 with a large remnant molecular cloud, which is known to host seven embedded clusters. As part of a large observational program to study the nature of young stellar populations in giant molecular clouds, we made a complete near-infrared imaging survey of the Rosette Complex using the detector FLAMINGOS. This survey is deep enough to detect stars near the brown dwarf limit, improving considerably over available databases. However, given the location of the Rosette Complex at a large distance from the Sun and at a latitude close to the galactic disk, the contamination of the survey data by field populations is high. In order to facilitate the detection of young populations, we combined a selection of cloud members by means of their infrared excess emission with a technique to detect star clusters using distances to nearest neighbors. This way we were able to con rm the seven clusters previously identified, and to discover four new clusters.

For every stellar cluster we determined for the first time their approximate extensions and number of members. We found that the fraction of stars in clusters in the Rosette Complex is close to 87%, which is similar to other clouds like Orion. However, the formation of clusters in the Rosette seems to be heavily influenced by the interaction with the expanding nebula, as evidenced by the fact that the core of the molecular cloud, coincident with the shock front of the expanding nebula contains 50% of the total cluster population. The clusters in the core are also more extended and more populated. Our study was complemented with a high resolution millimeter wavelength radio survey of the dense gas emission around the 8 most prominent clusters in the sample. We confirmed that all of the clusters observed are still embedded in what appear to be very compact parental clump remnants, but in many cases these gaseous envelopes are possibly becoming gravitationally unbound, due to the partial emergence of the young cluster stars. The dense gas maps show features characteristic of the interaction of clusters their local environment, particularly signi cant offsets of tracer emission peaks, possibly due to chemical differentiation effects. Our near-infrared observations also allowed us to construct an extinction map for the fields observed. The map shows an good agreement with ^{13}CO emission radio maps, and allowed us to identify the main molecular cores in the complex. Using the mass of stars in the clusters and the mass of the emission cores we calculated star formation efficiencies, which resulted to be significantly larger at the central core of the cloud. Also, extinction appears to be inversely proportional to the size of the clusters, but directly proportional to the fraction of IRX sources, which is suggestive of evolutive effects and a rapid dispersion of the gas after clusters are formed. The cluster emergence time scales could be similar and even shorter than the T Tauri phase of the stars.

http://www.cfa.harvard.edu/∼cromanzu/cromanzunigaphdthesis.pdf

New Jobs

Postdoctoral Research Assistant in infrared studies of star formation

A Postdoctoral level researcher is sought to carry out a programme related to a large scale survey of the Galactic Plane at infrared wavelengths, in the Department of Physics and Astronomy at the Open University, UK. The post will concentrate on studies of star formation and the structure of the Interstellar Medium. This three year (in the first instance) appointment is assist with the data reduction and scientific exploitation from the guaranteed time programmes of the recently launched AKARI (formerly known as ASTRO-F) infrared space telescope, and to contribute towards the development of a Galactic Plane survey atlas. AKARI was successfully launched last month, and is just about to commence its main survey operations.

The appointee will be expected to work in the Open University AKARI group to:

- develop visualisation, map making and data processing techniques to support the AKARI Galactic Plane Survey

- survey the diffuse galactic plane cirrus emission, studying dust agglomeration, emissivity and small scale structure

- conduct a survey of a complete sample of high mass star formation regions throughout the whole Galactic Plane, with the aim oc completing a complete sample of star formaing regions throughout the Galaxy

- study triggered star formation regions on galactic size scales

- map the population of Infrared Dark Clouds: Mass and Temperature

- make competitive bids for telescope time, and carry out ground based follow-up observations on international telescope facilities

- help to develop the science programmes and strategies for the 2008 launch European Space Agencys HERSCHEL mission

Full details of the job can be found at can be found at http://www.physics.open.ac.uk/jobs/jobopportunities.php, and details about the AKARI mission can be found at http://astrof.open.ac.uk/

The post is available immediately. **The closing date is 1st June 2006**, with interviews likely before the end of June. To discuss this post informally, please contact Professor Glenn White (contact details on our website)

Postdoctoral Research Fellow in Astronomy - Formation and Stability of Exoplanet systems

A Postdoctoral level researcher is sought to work in the Department of Physics and Astronomy at the Open University, UK, to carry out a programme aimed at determining the habitability of exoplanetary systems through computer modelling of the orbits of planets and smaller bodies within the systems, and to establish whether Earth-like planets in the habitable zone (HZ) could survive there at all, and, if so, remain habitable. The post will concentrate on:

- Giant planet shielding of earth-like exoplanets. It has been proposed that the Earth has benefited from the presence of Jupiter, because its gravitational field has reduced the rate of bombardment of the Earth by comets and other small bodies originating in the outer Solar System. A much higher rate of bombardment would have resulted in more frequent mass extinctions, perhaps stunting evolution to the extent that the complex creatures that abound today would not have developed, and perhaps even preventing a biosphere from developing.

Exoplanetary systems are highly varied, so the question arises, what range of giant masses, and what range of giant orbits, will provide effective shielding of an Earth-like planet in the HZ, against a specified population of bombarders. Very little work has been done on this. You will explore shielding through computer-based n-body orbital integration, using the MERCURY suite of integrators, which you will need to modify.

- The formation of Earth-like planets. Many of the known exoplanetary systems contain hot-Jupiters giant planets interior to the inner boundary of the HZ. They could not have formed there, but it is understood how they could have got there by inward migration during and after their formation. Migration would have scattered the embryos and smaller bodies in the inner circumstellar disc before terrestrial planet formation. The question is, could terrestrial planets subsequently form, particularly Earth-mass planets in the HZ? To answer this question you will need to implement different modifications to the MERCURY suite.

- The effects of secular resonances in creating stable orbits of exoplanets. Secular resonances, like mean-motion resonances, can create orbital stability in zones of instability, and vice versa. This is a rich field, and though much work has been done, there is much still to do, on otherwise promisingly habitable exoplanetary systems. This project will require no modification of the MERCURY suite.

Full details of the job can be found at can be found at http://www.physics.open.ac.uk/jobs/jobopportunities.php

The post is available immediately. **The closing date is 1st June 2006**, with interviews likely before the end of June. To discuss this post informally, please contact Professor Barrie Jones (contact details on our website)

ELBA 2006 : 2nd European School on Jets from Young Stars - High Angular Resolution Observations

Marciana Marina (Elba Island, Italy) 4-8 September 2006

This is the second of five schools dedicated to the study of jets from newborn stars, organised by the Marie Curie Research & Training Network **JETSET** (JET Simulations, Experiments and Theories). The aim of the school is to provide attendees with a background in modern high angular resolution techniques, illustrating how such methods have impacted on our understanding of young stars. The program includes presentations on: observing from space, e.g. with HST and in the future with JWST; observing from the ground with Adaptive Optics; use of Interferometers at millimeter and infrared wavelengths; Spectro-astrometry. The use of image analysis and spectral diagnostic techniques towards a first interpretation of the data will be discussed. A special session on high angular resolution studies of the inner regions of circumstellar disks, which play a fundamental role in jet launching, is also planned. Finally, two sessions on "Writing Proposals and Papers" and "Developing Public Outreach Skills" to help young researchers in advancing their careers will be provided.

The first JETSET school, I - Theoretical MHD Models and Constraints, took place near Grenoble in January 2006.
Forthcoming schools will cover the following topics :
III- Numerical MHD and Instabilities,
IV- Grid Technology and Applications to Astrophysics,
V- From Models to Observations and Experiments.
The observational results to be illustrated at the Elba school constitute a benchmark for analytic, numerical and radiative models of YSO jets. All young researchers working in the field are thus encouraged to attend.

Deadline for registration is June 25, 2006.

Early registration is advisable, however, because September is still the tourist season on Elba.

Logistics limit the number of participants to around 100. The school is open to postgraduate students and young researchers outside the network. Limited support may be available for such participants (although preference will be given to those proposing a contribution).

Registration forms and further information can be found at:

http://www.arcetri.astro.it/~elba06
or
http://www.jetsets.org/elba.html

Contact: Francesca Bacciotti (INAF - Osservatorio Astrofisico di Arcetri),
email: elba06@arcetri.astro.it

Preliminary Announcement

The 2007 Gordon Research Conference on Origins of Solar Systems

The 2007 Gordon Research Conference on Origins of Solar Systems will be held at Connecticut College in New London on 8-13 July 2007. This unique interdisciplinary meeting includes astronomers and astrophysicists interested in star and planet formation, planetary scientists and meteoriticists interested in the early history of the Solar System, and plasma and life scientists. This meeting is much broader than most conferences and many fruitful research collaborations have been initiated at Gordon conferences, encouraged by the relaxed pace of the meeting (the Chair has this experience himself).

If you are interested in the subject matter; if you would like to attend a meeting which is not packed solid with talks, but has a limited number of overview talks; if you would enjoy spending extended time reading posters (or would like to have plenty of time for people to look at your poster and even speak with you); and if you might like participating in evening beverage sessions with colleagues from a wide variety of backgrounds, this is the meeting for you.

The Chair and Vice-Chair of the 2007 Origins of Solar Systems conference are Lee Hartmann (Michigan) and Sara Russell (Natural History Museum, London). The program will be developed over the next couple of months. Information on registering, etc. will soon be available at http://www.grc.org.

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 .

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/ .

UCL Cumberland Lodge Meeting on Astrobiology

UNIVERSITY COLLEGE LONDON

DEPARTMENT OF PHYSICS AND ASTRONOMY

FIRST ANNOUNCEMENT
The 19th UCL Astronomy Colloquium: "Astrobiology" at Cumberland Lodge, Windsor Great Park, from 10-13 July 2005

Web page and registration details:
http://www.star.ucl.ac.uk/∼cl2006/LOC2006/home.html

The Colloquium's LOC:
Keith Horne (Director), Serena Viti (chair), Ofer Lahav, Peter Doel, Mike Barlow, Alan Aylward, Ian Crawford, Alan Willis

Selected topics include: - Extrasolar planets - Planet formation - Planet atmospheres - Astrochemistry - Extremophiles - Mars and Aurora

TIME
The meeting will start with lunch on Monday 10 July, and will conclude after breakfast on Thursday 13 July. A special conference dinner will be arranged for the night of Wednesday 12 July.

VENUE
Cumberland Lodge is a large 17th century country house situated in Windsor Great Park and is used by the King George VI and Queen Elizabeth Foundation of St Catherines - a body whose work is to provide courses and facilities for those concerned with higher education. The colloquium is residential in nature, providing ample opportunity for discussion outside formal meeting sessions. Cumberland Lodge provides first class accommodation and excellent cuisine. Its setting in Windsor Great Park offers splendid walks in a historical setting with a long association with the Royal Family, including Windsor Castle.

The Lodge has modern conference facilities and the main lecture room is well equipped with power point and overhead projector facilities and wireless internet access.

REGISTRATION:
To register visit http://www.star.ucl.ac.uk/∼cl2006/LOC2006/home.html
or email cl2006@star.ucl.ac.uk

PROGRAM:
The format of the meeting sessions will comprise a suite of invited review talks (∼45 minutes) and contributes talks (∼20 minutes), Please indicate, in the attached form, if you wish to make a contribution and provide a provisional title.

FEES:
There is no registration fee for this meeting. There is an all-inclusive charge of 420 pounds per person for the Colloquium, for 3 nights' accommodation and full board including conference dinner. There is a reduced rate of 180 pounds for students and for spouses. Hospitality provided by the UCL organisers includes a full, complimentary bar, together with wine with the evening meals, throughout the colloquium. Thus the above charges will cover all the living expenses of participants during the three nights stay at the Lodge for this residential meeting. Unfortunately the organisers are unable to defray the expenses of participants. Coach transport between Cumberland Lodge and Central London at the start and the end of the meeting will be provided free.

New Books

Astronomical Polarimetry
Current Status and Future Directions

Edited by Andy Adamson, Colin Aspin, Chris J. Davis & Takuya Fujiyoshi

These are the proceedings of a workshop held in Waikoloa, Hawai'i on 15-19 March 2004. The book provides an overview of polarimetric techniques, observations and the interpretation of polarimetry data at optical, infrared and millimeter wavelengths. Although encompassing many areas of astronomy, it includes a number of articles on star formation, circumstellar matter, disks, and the interstellar medium. Those relevant to this newsletter include:

*Polarimetry and Star Formation in the Submillimeter *B.C. Matthews*
Magnetic Fields and Star Formation - Observations Confront Theory *R. Crutcher*
Polarization Studies of Star-Forming Regions *S. Wolf et al.*
Circular Polarization Mapping of Protostellar Environments *G. Clayton et al.*
*Polarimetry of Circumstellar Disks Around T Tauri Stars *F. Menard*
HL Tau: 3-D Polarisation Modelling and Magnetic Field Structure *P. Lucas et al.*
A Dual Imaging Polarimetric Survey of YSO Environments using Gemini/Hokupa'a *D. Potter et al.*
Are there Aligned Grains Around Young Stellar Objects? *P. Bastien et al.*
Tracing the Magnetic Field in Molecular Clouds *Houde et al.*
A Polarization Survey of mm Methanol Masers H. Wiesemeyer et al.
Determining the B-Field Strength from Polarimetry of Dense Molecular Clouds *F. Heitsch*
Computational Intelligence Techniques for Submillimetre Polarization Modeling *J. Fiege*
*Circumstellar Disks in PMS and T Tauri Stars *M. Tamura et al.*
Spectropolarimetry of Young and Evolved Stars *R. Oudmaijer et al.*
Linear Line Polarimetry Modelling of Pre-main Sequence Stars *J. Vink et al.*
*Dust and Infrared Polarization Signatures *D. Aitken*
A Southern Optical/Infrared Survey of Interstellar Polarization *A. Magalhaes et al.*
Mid-Infrared Spectropolarimetry: Dust and Magnetic Fields *C. Wright et al.*
*Polarization Observations of Molecular Clouds *D. Whittet*
*Grain Alignment in Molecular Clouds *A. Lazarian*
Adaptive Optics Polarimetry of Herbig Ae/Be Stars *M. Perrin et al.*

* *Major reviews*

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