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Abstracts of recently accepted papers

Solar Flares and Coronal Mass Ejections: A Statistically Determined Flare Flux - CME Mass Correlation

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In an effort to examine the relationship between flare flux and corresponding CME mass, we temporally and spatially correlate all X-ray flares and CMEs in the LASCO and GOES archives from 1996 to 2006. We cross-reference 6,733 CMEs having well-measured masses against 12,050 X-ray flares having position information as determined from their optical counterparts. For a given flare, we search in time for CMEs which occur 10-80 minutes afterward, and we further require the flare and CME to occur within $\pm 45°$ in position angle on the solar disk. There are 826 CME/flare pairs which fit these criteria. Comparing the flare fluxes with CME masses of these paired events, we find CME mass increases with flare flux, following an approximately log-linear, broken relationship: in the limit of lower flare fluxes, log(CME mass) $\propto$ 0.68×log(flare flux), and in the limit of higher flare fluxes, log(CME mass) $\propto$ 0.33×log(flare flux). We show that this broken power-law, and in particular the flatter slope at higher flare fluxes, may be due to an observational bias against CMEs associated with the most energetic flares: halo CMEs. Correcting for this bias yields a single power-law relationship of the form log(CME mass) $\propto$ 0.70× log(flare flux). This function describes the relationship between CME mass and flare flux over at least 3 dex in flare flux, from $\approx 10^{-7}-10^{-4}$ W m^{-2}.

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`http://www.astro.lsa.umich.edu/~aarnio/preprints/AarnioSola2010.pdf`

On the propensity of the formation of massive clumps via fragmentation of driven shells

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Early type massive stars drive thin, dense shells whose edges often show evidence of star-formation. The possibility of fragmentation of these shells, leading to the formation of putative star-forming clumps is examined with the aid of semi-analytic arguments. We also derive a mass-spectrum for clumps condensing out of these shells by performing Monte-Carlo simulations of the problem. By extending on results from our previous work on the stability of thin, dense shells, we argue that clump-mass estimated by other authors in the past, under a set of simplifying assumptions, are several orders of magnitude smaller than those calculated here. Using the expression for the fastest growing unstable mode in a shock-confined shell, we show that fragmentation of a typical shell can produce clumps with a typical mass $\gtrsim 10^3$ M$_\odot$. It is likely that such clumps could spawn a second generation of massive and/or intermediate-mass stars which could in turn, trigger the next cycle of star-formation. We suggest that the ratio of shell thickness-to-radius evolves only weakly with time. Calculations have been performed for stars of seven spectral types, ranging from B1 to O5. We separately consider the stability of supernova remnants.

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The end of star formation in Chamaeleon I ? A LABOCA census of starless and protostellar cores

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Context. Chamaeleon I is the most active region in terms of star formation in the Chamaeleon molecular cloud complex. Although it is one of the nearest low-mass star forming regions, its population of prestellar and protostellar cores is not known and a controversy exists concerning its history of star formation.

Aims. Our goal is to search for prestellar and protostellar cores and characterize the earliest stages of star formation in this cloud.
Methods. We used the bolometer array LABOCA at the APEX telescope to map the cloud in dust continuum emission at 870 μm with a high sensitivity. This deep, unbiased survey was performed based on an extinction map derived from 2MASS data. The 870 μm map is compared with the extinction map and $C^{18}O$ observations, and decomposed with a multiresolution algorithm. The extracted sources are analysed by carefully taking into account the spatial filtering inherent in the data reduction process. A search for associations with young stellar objects is performed using *Spitzer* data and the SIMBAD database.
Results. Most of the detected 870 μm emission is distributed in five filaments. We identify 59 starless cores, one candidate first hydrostatic core, and 21 sources associated with more evolved young stellar objects. The estimated 90% completeness limit of our survey is 0.22 $M_\odot$ for the starless cores. The latter are only found above a visual extinction threshold of 5 mag. They are less dense than those detected in other nearby molecular clouds by a factor of a few on average, maybe because of the better sensitivity of our survey. The core mass distribution is consistent with the IMF at the high-mass end but is overpopulated at the low-mass end. In addition, at most 17% of the cores have a mass larger than the critical Bonnor-Ebert mass. Both results suggest that a large fraction of the starless cores may not be prestellar in nature. Based on the census of prestellar cores, Class 0 protostars, and more evolved young stellar objects, we conclude that the star formation rate has decreased with time in this cloud.
Conclusions. The low fraction of candidate prestellar cores among the population of starless cores, the small number of Class 0 protostars, the high global star formation efficiency, the decrease of the star formation rate with time, and the low mass per unit length of the detected filaments all suggest that we may be witnessing the end of the star formation process in Chamaeleon I.

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Ice and Dust in the Quiescent Medium of Isolated Dense Cores

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The relation between ices in the envelopes and disks surrounding YSOs and those in the quiescent interstellar medium is investigated. For a sample of 31 stars behind isolated dense cores, ground-based and *Spitzer* spectra and photometry in the 1-25 μm wavelength range are combined. The baseline for the broad and overlapping ice features is modeled, using calculated spectra of giants, H_2O ice and silicates. The adopted extinction curve is derived empirically. Its high resolution allows for the separation of continuum and feature extinction. The extinction between 13-25 μm is $\sim$50% relative to that at 2.2 μm. The strengths of the 6.0 and 6.85 μm absorption bands are in line with those of YSOs. Thus, their carriers, which, besides H_2O and CH_3OH, may include NH_4^+, HCOOH, H_2CO and NH_3, are readily formed in the dense core phase, before stars form. The 3.53 μm C-H stretching mode of solid CH_3OH was discovered. The CH_3OH/H_2O abundance ratios of 5-12% are larger than upper limits in the Taurus molecular cloud. The initial ice composition, before star formation occurs, therefore depends on the environment. Signs of thermal and energetic processing that were found toward some YSOs are absent in the ices toward background stars. Finally, the peak optical depth of the 9.7 μm band of silicates relative to the continuum extinction at 2.2 μm is significantly shallower than in the diffuse interstellar medium. This extends the results of Chiar et al. (2007) to a larger sample and higher extinctions.

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VLT integral field spectroscopy of embedded protostars: using near-infrared emission lines as tracers of accretion and outflow

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Context: We present near-infrared spectroscopy of the Forbidden Emission Line (FEL) and Molecular Hydrogen Emission Line (MHEL) regions at the bases of Herbig-Haro (HH) jets from seven embedded protostars: SVS 13 (the HH 7-11 progenitor), HH 26-IRS, HH 34-IRS, HH 72-IRS, HH 83-IRS, HH 300-IRS (IRAS 04239+2436) and HH 999-IRS (IRAS 06047-1117).
Methods: The Integral Field Spectrograph, SINFONI, on the European Southern Observatory's Very Large Telescope (VLT) was used to characterise jet parameters in these formative regions, where the jets are collimated and accelerated.
Results: We find considerable differences in the spectra of HH 83-IRS when compared to the other six sources; CO

bandhead and atomic permitted lines from Ca I, Na I, Mg I and Al I are observed in emission in all but HH 83-IRS, where they are detected in absorption. It is likely that this source is more evolved than the others (or at the very least considerably less active). Strong CO bandhead emission is also detected in emission in the other six sources, while extended H_2 ro-vibrational and [Fe II] forbidden emission lines trace the outflows (only the HH jet from HH 83-IRS is undetected). CO bandhead and Brγ emission peaks are in most cases coincident with the jet source continuum position, consistent with excitation in an accretion disk or accretion flow. However, in the closest source, HH 300-IRS, we do find evidence for excitation in the outflow: here the emission peak is offset by 3.6($\pm$0.7) AU along the flow axis. We also note a correlation between CO and Mg I, Na I and Ca I intensities, which supports the idea that these atomic permitted lines are associated with accretion disks. From H_2 and [Fe II] images we measure jet widths and derive upper limits to flow component opening angles. Although we do not find that the ionised [Fe II] component is consistently narrower than the H_2 flow component, we do find that narrower H_2 and/or [Fe II] flow components are associated with higher radial velocities (as reported in the literature). Flow opening angles, over the first few hundred AU in each source, are measured to be in the range 21°–42° in both H_2 and [Fe II]. Finally, from our 3-D data we are also able to map the extinction and electron density at the base of the outflows from some of our targets: within a few hundred AU, both decrease sharply with distance from the source.
Conclusions: It seems clear that collimated atomic *and* molecular jets, which may initially exhibit a wide opening angle, are a feature of outflows from Class I protostars, Class II T Tauri stars, and possibly even Class 0 sources, and that these jets can be traced to within a few hundred AU of the driving source. A common jet collimation and acceleration mechanism seems inescapable for all stages of low mass star formation.

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http://www.jach.hawaii.edu/∼cdavis/

Was a cloud-cloud collision the trigger of the recent star formation in Serpens?

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The complexity of the ISM is such that it is unlikely that star formation is initiated in the same way in all molecular clouds. While some clouds seem to collapse on their own, others may be triggered by an external event such as a cloud/flow collision forming a gravitationally unstable enhanced density layer. This work tests cloud-cloud collisions as the triggering mechanism for star formation in the Serpens Main Cluster as has been suggested by previous work. A set of smoothed particle hydrodynamics (SPH) simulations of the collision between two cylindrical clouds are performed and compared to (sub)millimetre observations of the Serpens Main Cluster. A configuration has been found which reproduces many of the observed characteristics of Serpens, including some of the main features of the peculiar velocity field. The evolution of the velocity with position throughout the model is similar to that observed and the column density and masses within the modeled cloud agree with those measured for the SE sub-cluster. Furthermore, our results also show that an asymmetric collision provides the ingredients to reproduce lower density filaments perpendicular to the main structure, similar to those observed. In this scenario, the formation of the NW sub-cluster of Serpens can be reproduced only if there is a pre-existing marginally gravitationally unstable region at the time the collision occurs. This work supports the interpretation that a collision between two clouds may have been the trigger of the most recent burst of star formation in Serpens. It not only explains the complicated velocity structure seen in the region, but also the temperature differences between the north (in "isolated" collapse) and the south (resulting from the shock between the clouds). In addition it provides an explanation for the sources in the south having a larger spread in age than those in the north.

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The UKIRT Widefield Infrared Survey for H_2

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We present the goals and preliminary results of an unbiased, near-infrared, narrow-band imaging survey of the First Galactic Quadrant ($10° < l < 65°$; $-1.3° < b < +1.3°$). This area includes most of the Giant Molecular Clouds and massive star forming regions in the northern hemisphere. The survey is centred on the 1-0 S(1) ro-vibrational line of H_2, a proven tracer of hot, dense molecular gas in star-forming regions, around evolved stars, and in supernova remnants. The observations complement existing and upcoming photometric surveys (Spitzer-GLIMPSE, UKIDSS-GPS, JCMT-JPS, AKARI, Herschel Hi-GAL, etc.), though we probe a dynamically active component of star formation not covered by these broad-band surveys. Our narrow-band survey is currently more than 60 % complete. The median seeing in our images is 0.73". The images have a $5\,\sigma$ detection limit of point sources of K$\sim$18 mag and the surface brightness limit is $10^{-19}\,\mathrm{W\,m^{-2}\,arcsec^{-2}}$ when averaged over our typical seeing. Jets and outflows from both low and high mass Young Stellar Objects are revealed, as are new Planetary Nebulae and - via a comparison with earlier K-band observations acquired as part of the UKIDSS GPS - numerous variable stars. With their superior spatial resolution, the UWISH2 data also have the potential to reveal the true nature of many of the Extended Green Objects found in the GLIMPSE survey.

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http://astro.kent.ac.uk/∼df/

Dense core formation in supersonic turbulent converging flows

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We use numerical hydrodynamic simulations to investigate prestellar core formation in the dynamic environment of giant molecular clouds (GMCs), focusing on planar post-shock layers produced by colliding turbulent flows. A key

goal is to test how core evolution and properties depend on the velocity dispersion in the parent cloud; our simulation suite consists of 180 models with inflow Mach numbers $\mathcal{M} \equiv v/c_s = 1.1 - 9$. At all Mach numbers, our models show that turbulence and self-gravity collect gas within post-shock regions into filaments at the same time as overdense areas within these filaments condense into cores. This morphology, together with the subsonic velocities we find inside cores, is similar to observations. We extend previous results showing that core collapse develops in an "outside-in" manner, with density and velocity approaching the Larson-Penston asymptotic solution. The time for the first core to collapse depends on Mach number as $t_{\rm coll} \propto \mathcal{M}^{-1/2}\rho_0^{-1/2}$, for ρ_0 the mean pre-shock density, consistent with analytic estimates. Core building takes 10 times as long as core collapse, which lasts a few $\times 10^5$ yrs, consistent with observed prestellar core lifetimes. Core shapes change from oblate to prolate as they evolve. To define cores, we use isosurfaces of the gravitational potential. We compare to cores defined using the potential computed from projected surface density, finding good agreement for core masses and sizes; this offers a new way to identify cores in observed maps. Cores with masses varying by three orders of magnitude ($\sim 0.05 - 50 M_\odot$) are identified in our high-$\mathcal{M}$ simulations, with a much smaller mass range for models having low $\mathcal{M}$. We halt each simulation when the first core collapses; at that point, only the more massive cores in each model are gravitationally bound, with $E_{\rm th} + E_g < 0$. Stability analysis of post-shock layers predicts that the first core to collapse will have mass $M \propto v^{-1/2}\rho_0^{-1/2}T^{7/4}$, and that the minimum mass for cores formed at late times will have $M \propto v^{-1}\rho_0^{-1/2}T^2$, for T the temperature. From our simulations, the median mass lies between these two relations. At the time we halt the simulations, the M vs. v relation is shallower for bound cores than unbound cores; with further evolution the small cores may evolve to become bound, steeping the M vs. v relation.

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The Dynamical State of Filamentary Infrared Dark Clouds

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The dense, cold gas of Infrared Dark Clouds (IRDCs) is thought to be representative of the initial conditions of massive star and star cluster formation. We analyze ^{13}CO $J = 1 - 0$ line emission data from the Galactic Ring Survey of Jackson et al. for two filamentary IRDCs, comparing the mass surface densities derived from ^{13}CO, $\Sigma_{\rm 13CO}$, with those derived from mid-infrared small median filter extinction mapping, $\Sigma_{\rm SMF}$, by Butler & Tan. After accounting for molecular envelopes around the filaments, we find approximately linear relations between $\Sigma_{\rm 13CO}$ and $\Sigma_{\rm SMF}$, i.e. an approximately constant ratio $\Sigma_{\rm 13CO}/\Sigma_{\rm SMF}$ in the clouds. There is a variation of about a factor of two between the two clouds. We find evidence for a modest decrease of $\Sigma_{\rm 13CO}/\Sigma_{\rm SMF}$ with increasing Σ, which may be due to a systematic decrease in temperature, increase in importance of high ^{13}CO opacity cores, increase in dust opacity, or decrease in ^{13}CO abundance due to depletion in regions of higher column density. We perform ellipsoidal and filamentary virial analyses of the clouds, finding that the surface pressure terms are dynamically important and that globally the filaments may not yet have reached virial equilibrium. Some local regions along the filaments appear to be close to virial equilibrium, although still with dynamically important surface pressures, and these appear to be sites where star formation is most active.

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Hunting for millimeter flares from magnetic reconnection in pre-main sequence spectroscopic binaries

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Context. Recent observations of the low-mass pre-main sequence (PMS), eccentric spectroscopic binaries DQ Tau and V773 Tau A reveal that their millimeter spectrum is occasionally dominated by flares from non-thermal emission processes. The transient activity is believed to be synchrotron in nature, resulting from powerful magnetic reconnection events when the separate magnetic structures of the binary components are briefly capable of interacting and forced to reorganize, typically near periastron.
Aims. We conducted the first systematic study of the millimeter variability toward a sample of 12 PMS spectroscopic binaries with the aim to characterize the proliferation of flares amongst sources likely to experience similar interbinary reconnection events. The source sample consists entirely of short-period, close-separation binaries that possess either a high orbital eccentricity ($e > 0.1$) or a circular orbit ($e \approx 0$).
Methods. Using the MAMBO2 array on the IRAM 30m telescope, we carried out continuous monitoring at 1.25 mm (240 GHz) over a 4-night period during which all of the high-eccentricity binaries approached periastron. We also obtained simultaneous optical VRI measurements, since a strong link is often observed between stellar reconnection events (traced via X-rays) and optical brightenings.
Results. UZ Tau E is the only source to be detected at millimeter wavelengths, and it exhibited significant variation ($F_{1.25\mathrm{mm}} = 87$–179 mJy); it is also the only source to undergo strong simultaneous optical variability ($\Delta R \approx 0.9$ mag). The binary possesses the largest orbital eccentricity in the current sample, a predicted factor in star-star magnetic interaction events. With orbital parameters and variable accretion activity similar to DQ Tau, the millimeter behavior of UZ Tau E draws many parallels to the DQ Tau model for colliding magnetospheres. However, on the basis of our observations alone, we cannot determine whether the variability is repetitive, or if it could also be due to variable free-free emission in an ionized wind.
Conclusions. UZ Tau E brings the number of known millimeter-varying PMS sources to 3 out of a total of 14 monitored binaries now in the literature. Important factors in the non-detection of the rest of our targets are the coarse time-sampling and limited millimeter sensitivity of our survey. We recommend that future studies concentrate on close-by targets, and obtain millimeter and optical data points with better temporal resolution.

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http://www.aanda.org/articles/aa/pdf/forth/aa15917-10.pdf

Inner disc rearrangement revealed by dramatic brightness variations in the young star PV Cep

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Young Sun-like stars at the beginning of the pre-main sequence (PMS) evolution are surrounded by accretion discs and remnant protostellar envelopes. Photometric and spectroscopic variations of these stars are driven by interactions of the star with the disc. Time scales and wavelength dependence of the variability carry information on the physical mechanisms behind these interactions. We conducted multi-epoch, multi-wavelength study of PV Cep, a strongly variable, accreting PMS star. By combining our own observations from 2004–2010 with archival and literature data, we show that PV Cep started a spectacular fading in 2005, reaching an I_{C}-band amplitude of 4 mag. Analysis of variation of the optical and infrared fluxes, colour indices, and emission line fluxes suggests that the photometric decline in 2005–2009 resulted from an interplay between variable accretion and circumstellar extinction: since the central luminosity of the system is dominated by accretion, a modest drop in the accretion rate could induce the drastic restructuring of the inner disc. Dust condensation in the inner disc region might have resulted in the enhancement of the circumstellar extinction.

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Shocked water in the Cep E protostellar outflow

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Previous far-infrared observations at low-angular resolution have reported the presence of water associated with low-velocity outflow shocks and protostellar envelopes. The outflow driven by the intermediate-mass class 0 protostar Cep E is among the most luminous outflows detected so far. Using the IRAM 30m telescope, we searched for and detected the p-H_2O $3_{13} - 2_{20}$ line emission at 183 GHz in the Cep E star-forming core. The emission arises from high-velocity gas close to the protostar, which is unresolved in the main beam of the telescope. Complementary observations at 2 arcsec resolution with the Plateau de Bure interferometer helped establish the origin of the emission detected and the physical conditions in the emitting gas. The water line profile and its spatial distribution are very similar to those of SiO. We find that the H_2O emission arises from warm (~ 200 K), dense ($(1-2) \times 10^6$ cm^{-3}) gas, and its abundance is enhanced by one to two orders of magnitude with respect to the protostellar envelope. We detect water emission in strong shocks from the high-velocity jet at 1000 AU from the protostar. Despite the large beam size of the telescope, such emission should be detectable with *Herschel*.

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The puzzle of the cluster-forming core mass-radius relation and why it matters

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We highlight how the mass-radius relation of cluster-forming cores combined with an external tidal field can influence infant weight-loss and disruption likelihood of clusters at the end of their violent relaxation, namely, when their dynamical response to the expulsion of their residual star-forming gas is over. Specifically, building on the cluster N-body model grid of Baumgardt & Kroupa (2007), we study how the relation between the bound fraction of stars staying in clusters at the end of violent relaxation and the cluster-forming core mass is affected by the slope and normalization of the core mass-radius relation. Assuming mass-independent star formation efficiency and gas-expulsion time-scale τ_{GExp}/τ_{cross} and a given external tidal field, it is found that constant surface density cores and constant radius cores have the potential to lead to the preferential removal of high- and low-mass clusters, respectively. In contrast, constant volume density cores result in mass-independent cluster infant weight-loss, as suggested by some observations. These trends result from how core volume density and core mass scale with each other. Infant weight-loss is quantified for cluster-forming cores with either number density $n_{H2,core} \simeq 6 \times 10^4\, cm^{-3}$, or surface density $\Sigma_{core} \simeq 0.5\, g.cm^{-2}$, or radius $r_{core} = 0.3$ pc. Our modelling includes predictions about the evolution of high-mass cluster-forming cores (say $m_{core} > 10^5\, M_\odot$), a regime not yet covered by the observations. We show how, for a given external tidal field, the core mass-radius diagram constitutes a straightforward diagnostic tool to assess whether the tidal field influences the fate of clusters after gas expulsion.

An overview of various issues directly affected by the nature of the core mass-radius relation is presented. In relation with the tidal field impact, these are the evolution of the cluster mass function at young ages (i.e. over the first $\simeq 30$ Myr), and our ability to reconstruct the star formation history of galaxies from their cluster age distribution. Independently of the tidal field impact, the slope and/or normalization of the cluster-forming core mass-radius relation also influences the mass-metallicity relation of old globular clusters predicted by self-enrichment models, and the duration of cluster violent relaxation.

Finally, we emphasize that observational mass-radius data-sets of dense gas regions must be handled with caution as they may be the imprint of the molecular tracer used to map them, rather than reflecting cluster formation conditions.

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From the molecular-cloud- to the embedded-cluster-mass function with a density threshold for star formation

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The mass function $dN \propto m^{-\beta_0} dm$ of molecular clouds and clumps is shallower than the mass function $dN \propto m^{-\beta_\star} dm$ of young star clusters, gas-embedded and gas-free alike, as their respective mass function indices are $\beta_0 \simeq 1.7$ and $\beta_\star \simeq 2$. We demonstrate that such a difference can arise from different mass-radius relations for the embedded-clusters and the molecular clouds (clumps) hosting them. In particular, the formation of star clusters with a constant mean *volume* density in the central regions of molecular clouds of constant mean *surface* density steepens the mass function from clouds to embedded-clusters. This model is observationally supported since the mean surface density of molecular clouds is approximately constant, while there is a growing body of evidence, in both Galactic and extragalactic environments, that efficient star-formation requires a hydrogen molecule number density threshold of $n_{th} \simeq 10^{4-5}\, cm^{-3}$.

Adopting power-law volume density profiles of index p for spherically symmetric molecular clouds (clumps), we define two zones within each cloud (clump): a central cluster-forming region, actively forming stars by virtue of a local number density higher than n_{th}, and an outer envelope inert in terms of star formation. We map how much the slope of the cluster-forming region mass function differs from that of their host-clouds (clumps) as a function of their respective mass-radius relations and of the cloud (clump) density index. We find that for constant surface density clouds with density index $p \simeq 1.9$, a cloud mass function of index $\beta_0 = 1.7$ gives rise to a cluster-forming region mass function of index $\beta \simeq 2$. Our model equates with defining two distinct SFEs: a global mass-varying SFE averaged over the whole cloud (clump), and a local mass-independent SFE measured over the central cluster-forming region. While the global SFE relates the mass function of clouds to that of embedded-clusters, the local SFE rules cluster evolution after residual star-forming gas expulsion. That the cluster mass function slope does not change through early cluster evolution implies a mass-independent local SFE and, thus, the same mass function index for cluster-forming regions and embedded-clusters, that is, $\beta = \beta_\star$. Our model can therefore reproduce the observed cluster mass function index $\beta_\star \simeq 2$.

For the same model parameters, the radius distribution also steepens from clouds (clumps) to embedded-clusters, which contributes to explaining observed cluster radius distributions.

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http://xxx.lanl.gov/abs/1101.0813

The Interplay of Magnetic Fields, Fragmentation and Ionization Feedback in High-Mass Star Formation

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Massive stars disproportionately influence their surroundings. How they form has only started to become clear recently through radiation gas dynamical simulations. However, until now, no simulation has simultaneously included both magnetic fields and ionizing radiation. Here we present the results from the first radiation-magnetohydrodynamical (RMHD) simulation including ionization feedback, comparing an RMHD model of a 1000 $M_\odot$ rotating cloud to earlier radiation gas dynamical models with the same initial density and velocity distributions. We find that despite starting

with a strongly supercritical mass to flux ratio, the magnetic field has three effects. First, the field offers locally support against gravitational collapse in the accretion flow, substantially reducing the amount of secondary fragmentation in comparison to the gas dynamical case. Second, the field drains angular momentum from the collapsing gas, further increasing the amount of material available for accretion by the central, massive, protostar, and thus increasing its final mass by about 50% from the purely gas dynamical case. Third, the field is wound up by the rotation of the flow, driving a tower flow. However, this flow never achieves the strength seen in low-mass star formation simulations for two reasons: gravitational fragmentation disrupts the circular flow in the central regions where the protostars form, and the expanding $H\ II$ regions tend to further disrupt the field geometry. Therefore, ionizing radiation is likely to dominate outflow dynamics in regions of massive star formation.

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He-like ions as practical astrophysical plasma diagnostics: From stellar coronae to active galactic nuclei

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We review X-ray plasma diagnostics based on the line ratios of He-like ions. Triplet/singlet line intensities can be used to determine electronic temperature and density, and were first developed for the study of the solar corona. Since the launches of the X-ray satellites Chandra and XMM-Newton, these diagnostics have been extended and used (from C V to Si XIII) for a wide variety of astrophysical plasmas such as stellar coronae, supernova remnants, solar system objects, active galactic nuclei, and X-ray binaries. Moreover, the intensities of He-like ions can be used to determine the ionization process(es) at work, as well as the distance between the X-ray plasma and the UV emission source for example in hot stars. In the near future thanks to the next generation of X-ray satellites (e.g., Astro-H and IXO), higher-Z He-like lines (e.g., iron) will be resolved, allowing plasmas with higher temperatures and densities to be probed. Moreover, the so-called satellite lines that are formed closed to parent He-like lines, will provide additional valuable diagnostics to determine electronic temperature, ionic fraction, departure from ionization equilibrium and/or from Maxwellian electron distribution.

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http://arxiv.org/abs/1101.3184
http://www.springerlink.com

Formation of planetary cores at Type I migration traps

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One of the longstanding unsolved problems of planet formation is how solid bodies of a few decimeters in size can "stick" to form large planetesimals. This is known as the "meter size barrier". In recent years it has become increasingly clear that some form of "particle trapping" must have played a role in overcoming the meter size barrier. Particles can be trapped in long-lived local pressure maxima, such as those in anticyclonic vortices, zonal flows or those believed to occur near ice lines or at dead zone boundaries. Such pressure traps are the ideal sites for the formation of planetesimals and small planetary embryos. Moreover, they likely produce large quantities of such bodies in a small region, making it likely that subsequent N-body evolution may lead to even larger planetary embryos. The goal of this Letter is to show that this indeed happens, and to study how efficient it is. In particular, we wish to find out if rocky/icy bodies as

large as 10 $M_\oplus$ can form within 1 Myr, since such bodies are the precursors of gas giant planets in the core accretion scenario.

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Dense gas and the nature of the outflows

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We present the results of the observations of the $(J,K) = (1,1)$ and the $(J,K) = (2,2)$ inversion transitions of the NH_3 molecule toward a large sample of 40 regions with molecular or optical outflows, using the 37 m radio telescope of the Haystack Observatory. We detected NH_3 emission in 27 of the observed regions, which we mapped in 25 of them. Additionally, we searched for the $6_{16} - 5_{23}$ H_2O maser line toward six regions, detecting H_2O maser emission in two of them, HH265 and AFGL 5173. We estimate the physical parameters of the regions mapped in NH_3 and analyze for each particular region the distribution of high density gas and its relationship with the presence of young stellar objects. In particular, we identify the deflecting high-density clump of the HH270/110 jet. We were able to separate the NH_3 emission from the L1641-S3 region into two overlapping clouds, one with signs of strong perturbation, probably associated with the driving source of the CO outflow, and a second, unperturbed clump, which is probably not associated with star formation. We systematically found that the position of the best candidate for the exciting source of the molecular outflow in each region is very close to an NH_3 emission peak. From the global analysis of our data we find that in general the highest values of the line width are obtained for the regions with the highest values of mass and kinetic temperature. We also found a correlation between the nonthermal line width and the bolometric luminosity of the sources, and between the mass of the core and the bolometric luminosity. We confirm with a larger sample of regions the conclusion of Anglada et al. (1997) that the NH_3 line emission is more intense toward molecular outflow sources than toward sources with optical outflow, suggesting a possible evolutionary scheme in which young stellar objects associated with molecular outflows progressively lose their neighboring high-density gas, weakening both the NH_3 emission and the molecular outflow in the process, and making optical jets more easily detectable as the total amount of gas decreases.

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Searching for Young M Dwarfs with GALEX

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The census of young moving groups in the solar neighborhood is significantly incomplete in the low-mass regime. We have developed a new selection process to find these missing members based on the *GALEX* All-Sky Imaging Survey (AIS). For stars with spectral types ≥K5 ($R - J \geq 1.5$) and younger than ≈300 Myr, we show that near-UV (NUV) and far-UV (FUV) emission is greatly enhanced above the quiescent photosphere, analogous to the enhanced X-ray emission of young low-mass stars seen by *ROSAT* but detectable to much larger distances with *GALEX*. By combining *GALEX* data with optical (HST Guide Star Catalog) and near-IR (2MASS) photometry, we identified an initial sample of 34 young M dwarf candidates in a 1000 sq. deg. region around the ≈10-Myr TW Hydra Association (TWA). Low-resolution spectroscopy of 30 of these found 16 which had Hα in emission, which were then followed-up at high resolution to search for spectroscopic evidence of youth and to measure their radial velocities. Four objects have low surface gravities, photometric distances and space motions consistent with TWA, but the non-detection of Li indicates they may be too old to belong to this moving group. One object (M3.5, 93±19 pc) appears to be the first known accreting low-mass member of the ≈15 Myr Lower Centaurus Crux OB association. Two objects exhibit all the characteristics of the known TWA members, and thus we designate them as TWA 31 (M4.2, 110±11 pc) and TWA 32 (M6.3, 53±5 pc). TWA 31 shows extremely broad (447 km s^{-1}) Hα emission, making it the sixth member of TWA found to have ongoing accretion. TWA 32 is resolved into a 0.6 arcsec binary in Keck laser guide star adaptive optics imaging. Our search should be sensitive down to spectral types of at least M4–M5 in TWA and thus the small numbers of new member is puzzling. This might indicate TWA has an atypical mass function or that the presence of lithium absorption may be too restrictive a criteria for selecting young low-mass stars.

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The Galactic Magnetic Field's Effect in Star-Forming Region

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We investigate the effect of the Milky Way's magnetic field in star forming regions using archived 350 μm polarization data on 52 galactic sources from the Hertz polarimeter module. The polarization angles and percentages for individual telescopes beams were combined in order to produce a large-scale average for each source and for complexes of sources. In more than 80% of the sources, we find that this large-scale magnetic field is a meaningful average implying a continuity of scale and magnetic fields. The average polarization angles were analyzed with respect to the galactic coordinates in order to find a correlation between polarization percentage, polarization angle, intensity, and galactic location. No correlation was found, which suggests that the star forming process quickly decouples from the large-scale galactic magnetic field. Finally, we show that the magnetic field direction of the complexes are consistent with a random distribution on the sky.

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http://arxiv.org/pdf/1012.3702v1

A parsec-scale outflow from the luminous YSO IRAS 17527-2439

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Imaging observations of IRAS 17527-2439 are obtained in the near-IR JHK photometric bands and in a narrow-band filter centred at the wavelength of the H_2 1-0 S(1) line. The continuum-subtracted H_2 image is used to identify outflows. The data obtained in this study are used in conjunction with Spitzer, AKARI, and IRAS data. A parsec-scale bipolar outflow is discovered in our H_2 line image, which is supported by the detection in the archival Spitzer images. The H_2 image exhibits signs of precession of the main jet and shows tentative evidence for a second outflow. These suggest the possibility of a companion to the outflow source. There is a strong component of continuum emission in the direction of the outflow, which supports the idea that the outflow cavity provides a path for radiation to escape, thereby reducing the radiation pressure on the accreted matter. The bulk of the emission observed close to the outflow in the WFCAM and Spitzer bands is rotated counter clockwise with respect to the outflow traced in H_2, which may be due to precession. The YSO driving the outflow is identified in the Spitzer images. The spectral energy distribution

(SED) of the YSO is studied using available radiative transfer models. A model fit to the SED of the central source tells us that the YSO has a mass of 12.23 $M_\odot$ and that it is in an early stage of evolution.

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http://arxiv.org/abs/1101.1510

Orion KL: The hot core that is not a "Hot Core"

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We present sensitive high angular resolution submillimeter and millimeter observations of torsionally/vibrationally highly excited lines of the CH_3OH, HC_3N, SO_2, and CH_3CN molecules and of the continuum emission at 870 and 1300 μm from the Orion KL region, made with the Submillimeter Array (SMA). These observations plus recent SMA CO J=3-2 and J=2-1 imaging of the explosive flow originating in this region, which is related to the non-hierarchical disintegration of a massive young stellar system, suggest that the molecular Orion "Hot Core" is a pre-existing density enhancement heated from the outside by the explosive event – unlike in other hot cores we do not find any self-luminous submillimeter, radio or infrared source embedded in the hot molecular gas. Indeed, we do not observe filamentary CO flow structures or "fingers" in the shadow of the hot core pointing away from the explosion center. The low-excitation CH_3CN emission shows the typical molecular heart-shaped structure, traditionally named the Hot Core, and is centered close to the dynamical origin of the explosion. The highest excitation CH_3CN lines are all arising from the northeast lobe of the heart-shaped structure, *i. e.* from the densest and most highly obscured parts of the Extended Ridge. The torsionally excited CH_3OH and vibrationally excited HC_3N lines appear to form a shell around the strongest submillimeter continuum source. All of these observations suggest the southeast and southwest sectors of the explosive flow to have impinged on a pre-existing very dense part of the Extended Ridge, thus creating the bright Orion KL Hot Core. However, additional theoretical and observational studies are required to test this new heating scenario.

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Discovery of an Expanding Molecular Bubble in Orion BN/KL

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During their infancy, stars are well known to expel matter violently in the form of well-defined, collimated outflows. A fairly unique exception is found in the Orion BN/KL star-forming region where a poorly collimated and somewhat disordered outflow composed of numerous elongated "finger-like" structures was discovered more than 30 years ago. In this letter, we report the discovery in the same region of an even more atypical outflow phenomenon. Using $^{13}CO(2\text{-}1)$ line observations made with the Submillimeter Array (SMA), we have identified there a 500 to 1,000 years old, expanding, roughly spherically symmetric bubble whose characteristics are entirely different from those of known outflows associated with young stellar objects. The center of the bubble coincides with the initial position of a now defunct massive multiple stellar system suspected to have disintegrated 500 years ago, and with the center of symmetry of the system of molecular fingers surrounding the Kleinmann-Low nebula. We hypothesize that the bubble is made up of gas and dust that used to be part of the circumstellar material associated with the decayed multiple system. The Orion hot core, recently proposed to be the result of the impact of a shock wave onto a massive dense core, is located toward the south-east quadrant of the bubble. The supersonic expansion of the bubble, and/or the impact of some low-velocity filaments provide a natural explanation for its origin.

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Extremely Large and Hot Multilayer Keplerian Disk Around the O-type Protostar W51N: The Precursors of the HCH II Regions?

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We present sensitive high angular resolution ($0.57''$-$0.78''$) SO, SO_2, CO, C_2H_5OH, HC_3N, and $HCOCH_2OH$ line observations at millimeter and submillimeter wavelengths of the young O-type protostar W51 North made with the Submillimeter Array (SMA). We report the presence of a large (of about 8000 AU) and hot molecular circumstellar disk around this object, which connects the inner dusty disk with the molecular ring or toroid reported recently, and confirms the existence of a single bipolar outflow emanating from this object. The molecular emission from the large disk is observed in layers with the transitions characterized by high excitation temperatures in their lower energy states (up to 1512 K) being concentrated closer to the central massive protostar. The molecular emission from those transitions with low or moderate excitation temperatures are found in the outermost parts of the disk and exhibits an inner cavity with an angular size of around $0.7''$. We modeled all lines with a Local Thermodynamic Equilibrium (LTE) synthetic spectra. A detail study of the kinematics of the molecular gas together with a LTE model of a circumstellar disk shows that the innermost parts of the disk are also Keplerian plus a contracting velocity. The emission of the $HCOCH_2OH$ reveals the possible presence of a warm "companion" located to the northeast of the disk, however its nature is unclear. The emission of the SO and SO_2 is observed in the circumstellar disk as well as in the outflow. We suggest that the massive protostar W51 North appears to be in a phase before the presence of a Hypercompact or an Ultracompact HII (HC/UCHII) region, and propose a possible sequence on the formation of the massive stars.

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Transitional and Pre-Transitional disks: Gap Opening by Multiple Planets ?

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We use two-dimensional hydrodynamic simulations of viscous disks to examine whether dynamically-interacting multiple giant planets can explain the large gaps (spanning over one order of magnitude in radius) inferred for the transitional and pre-transitional disks around T Tauri stars. In the absence of inner disk dust depletion, we find that it requires three to four giant planets to open up large enough gaps to be consistent with inferences from spectral energy distributions, because the gap width is limited by the tendency of the planets to be driven together into 2:1 resonances. With very strong tidal torques and/or rapid planetary accretion, fewer planets can also generate a large cavity interior to the locally formed gap(s) by preventing outer disk material from moving in. In these cases, however, the reduction of surface density produces a corresponding reduction in the inner disk accretion rate onto the star; this makes it difficult to explain the observed accretion rates of the pre/transitional disks. We find that even with four planets in disks, additional substantial dust depletion is required to explain observed disk gaps/holes. Substantial dust settling and growth, with consequent significant reductions in optical depths, is inferred for typical T Tauri disks in any case, and an earlier history of dust growth is consistent with the hypothesis that pre/transitional disks are explained by the presence of giant planets. We conclude that the depths and widths of gaps, and disk accretion

rates in pre/transitional disks cannot be reproduced by a planet-induced gap opening scenario alone. Significant dust depletion is also required within the gaps/holes. Order of magnitude estimates suggest the mass of small dust particles ($< 1\mu$m) relative to the gas must be depleted to $10^{-5} - 10^{-2}$ of the interstellar medium value, implying a very efficient mechanism of small dust removal or dust growth.

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http://arxiv.org/abs/1012.4395

Abstracts of recently accepted major reviews

Dynamics of Protoplanetary Disks

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Protoplanetary disks are quasi-steady structures whose evolution and dispersal determine the environment for planet formation. I review the theory of protoplanetary disk evolution and its connection to observations. Substantial progress has been made in elucidating the physics of potential angular momentum transport processes - including self-gravity, the magnetorotational instability, baroclinic instabilities, and magnetic braking - and in developing testable models for disk dispersal via photoevaporation. The relative importance of these processes depends upon the initial mass, size and magnetization of the disk, and subsequently on its opacity, ionization state, and external irradiation. Disk dynamics is therefore coupled to star formation, pre-main-sequence stellar evolution, and dust coagulation during the early stages of planet formation, and may vary dramatically from star to star. The importance of validating theoretical models is emphasized, with the key observations being those that probe disk structure on the scales, between 1 AU and 10 AU, where theory is most uncertain.

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http://arxiv.org/abs/1011.1496

Postdoctoral position for the Variable Young Stellar Objects Survey (VYSOS) at the University of Hawaii

The NASA Astrobiology Center at the University of Hawaii invites applications for a postdoctoral position in Astrophysics, to work at the VYSOS project led by Prof. Bo Reipurth. The position is initially for 2 years assuming a satisfactory performance review after the first year. Extensions are possible depending on the availability of funds.

The successful candidate will have a PhD in astronomy and experience in working with young stars and star formation, or time-variable stellar phenomenae, as documented by refereed publications. The VYSOS project is based on two robotic telescopes located at the Mauna Loa Observatory on the Big Island of Hawaii. One is a widefield 5.3-inch apochromatic refractor and the other is a 20-inch Ritchey-Chretien telescope. Every clear night the two telescopes monitor star forming regions along the Galactic plane. The goals are to find and analyse eclipsing pre-main sequence binaries and FUor and EXor events, to monitor and characterize the irregular variability of T Tauri stars, to determine rotation periods of weakline T Tauri stars in order to understand the angular momentum evolution during the pre-main sequence phase, to find and study pulsating young stars, and to develop statistics of flare events in young stars of different masses. Analysis of the photometric data will be supported by spectroscopic data obtained at the Mauna Kea Observatory. The successful candidate is expected to do research based on the VYSOS data base, and it is important that he/she must have practical experience in dealing with telescopes, detectors, and computers so as to be able to carry out regular maintenance of the telescopes. A facility with software and experience in handling very large data sets are advantageous.

The position is available immediately, and preference will be given to candidates who can start soon. The successful candidate will be paid a monthly stipend of US$5000, and will be offered the possibility to buy into certain health plans offered by the University of Hawaii. The Institute for Astronomy at the University of Hawaii at Manoa operates facilities on Oahu, on the Big Island of Hawaii, and on Maui. The present position is based in Hilo on the Big Island of Hawaii at the foot of the Mauna Loa and Mauna Kea volcanoes.

Candidates must send a complete curriculum vitae including a full list of publications, as well as a statement of previous experience and current professional interests, and arrange for two letters of recommendation to be sent to reipurth@ifa.hawaii.edu.

Review of applications will begin on March 1, but applications submitted thereafter will be fully considered until the post is filled.

Please send applications and inquiries by email to Prof. Bo Reipurth (reipurth@ifa.hawaii.edu).

The University of Hawaii is an EEO/AA employer and encourages applications from women and minorities.

Origin of clusters - Post-doctoral Researcher (4 years) UNIVERSITY OF VIENNA

The Institute of Astronomy at the University of Vienna is seeking highly qualified applicants for a 4 year postdoctoral position in the field of star formation, more specifically on the origins of stellar clusters. Creativeness, motivation, and expertise with radio and/or IR observations of molecular clouds and young clusters are especially welcome, although all excellent applicants working on Galactic and extra-galactic Star Formation will be considered. The applicant will be part of a new research group led by Prof. João Alves. Participation in teaching activities at a modest level is expected.

The Institute is undergoing a major new development with the establishment of three new chairs in astrophysics. It offers a stimulating research environment with a large staff working in various areas of astrophysics. As a member state of ESO and ESA, Austria has access to their first-class facilities. The department is involved in, or is planning participation in major observatories of ESO (VLT instrumentation, E-ELT) and ESA/JAXA/NASA (Spica, Plato, Euclid, JWST). The beautiful city of Vienna scored highest in the world for overall quality of living according to a Mercer's 2010 survey.

Review of applications starts March 1st, 2011 and will continue until the position is filled. Applications should include CV, publication list, and a brief description of past research and future plans. These documents must be submitted electronically as a PDF file to joao.alves@univie.ac.at. Three letters of reference should be sent directly by the referees to the same address.

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/newsletter.htm.

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.

Extra-Solar Planets

The Detection, Formation, Evolution, and Dynamics of Planetary Systems

Edited by B.A. Steves, M. Hendry, and A.C. Cameron

This textbook, aimed at graduate students, provides an excellent reference volume for all students and researchers interested in studying the detection, formation, evolution and dynamics of planetary systems. Based on the lectures of the Scottish Universities Summer School of the same name, the book is written by internationally renowned scientists working at the forefront of the field. The textbook reviews current research and contains useful teaching on the latest tools and methods of analysis for investigating extra-solar planetary systems

The book contains the following chapters:

Section I: Detection of Extra-Solar Planets: Methods and Observations

1. Detection of Extra-Solar Planets in Wide-Field Transit Surveys

by *Andrew Collier Cameron*

1. Introduction
2. Observations and data reduction
3. Zero-point correction and data weights
4. Removal of correlated systematic errors
5. Characterising red noise
6. Transit-search algorithms
7. Estimation of system parameters
8. Markov-chain Monte-Carlo modelling
9. Candidate selection
10. Conclusions

2. The Theory of Planet Detection by Gravitational Microlensing: Blips and Dips from the Gravitational Bending of Light

by *Martin Dominik*

1. Gravitational bending of light
2. Gravitational microlensing
3. Microlensing event rate
4. Where to find planets
5. Binary microlenses
6. Planetary microlensing

3. The Practice of Planet Detection by Gravitational Microlensing: Studying Cool Planets around Low-Mass Stars

by *Martin Dominik*

1. Gravitational microlensing events
2. Microlensing planet searches
3. Detection efficiency and abundance limits
4. The first planet detections
5. Probing planet parameter space
6. Planetary census
7. Planets of Earth mass and below

4. Modelling Spectroscopic and Polarimetric Signatures of Exoplanets

by *Daphne Stam*

1. Introduction
2. Describing and calculating planetary radiation
3. Flux and polarization spectra
4. Summary

Section II: Formation and Evolution of Planetary Systems

5. Proto-planetary Discs - Current Problems and Directions

by *J.S. Greaves*

1. Introduction
2. Disc properties
3. Effects of planet foration in discs
4. Summary

6. Debris Discs and Planetary Environments

by *J.S. Greaves*

1. Introduction
2. Disc observations
3. Theoretical interpretation
4. Planetary signatures
5. Astrobiological implications
6. Summary and future

7. Dynamical Evolution of Planetary Systems

by *Eric Ford*

1. Planet formation
2. New wrinkles to planet formation theory
3. Multiple planet systems
4. Future tests of planet formation models

8. Late Stages of Solar System Formation and Implications for Extra-Solar Systems

by *Kleomenis Tsiganis*

1. Formation stages of planetary systems
2. Planet migration
3. Probing the history of the solar system
4. Implications for extra-solar systems
5. Summary

Section III: Dynamics of Planetary Systems

9. A Brief Account of Mutual Planetary Perturbations

by *P.J. Message*

1. Introduction
2. Review of Kepler two-body motion
3. Perturbed elliptic motion
4. The canonical form of the equations of motion

10. Fundamentals of Regularozation in Celestial Mechanics and Linear Pertubation Theories

by *Jörg Waldvogel*

1. Introduction
2. Planar Kepler motion
3. The Levi-Cita transformation
4. Spatial regularization with quaternions
5. The perturbed spatial Kepler problem
6. Conclusions

11. Mechanisms for the Production of Chaos in Dynamical Systems

by *Massimiliano Guzzo*

1. Introduction
2. The homoclinic tangle of hyperbolic saddle points
3. The Smale horseshoe
4. Chaotic dynamics in the homoclinic tangles
5. From chaos to diffusion in two dimensional systems
6. Diffusion in higher dimensional systems: the Arnold's model for diffusion
7. Arnold diffusion in a quasi integrable 4D system
8. An application to our planetary system

12. Extra-Solar Multiplanet Systems

by *S. Ferraz-Mello, C. Beauge, and T.A. Michtchenko*

1. Introduction
2. Class I. Planets in close orbits
3. Class II. Non-resonant planets with significant secular dynamics
4. Class III. Weakly-interacting planet pairs
5. Equations of motion for N planets
6. Reduction of the Hamiltonian equations
7. Action-angle variables: Delaunay elements
8. Keplerian elements
9. Kepler's third law
10. Conservation of angular momentum

13. The Stability of Terrestrial Planets in Planetary Systems

by *R. Dvorak, E. Pilat-Lohinger, R. Schwartz, and Ch. Lhotka*

1. Introduction
2. The dynamical models
3. Numerical methods and analysis of results
4. Regions of motion of terrestrial planets in habitable zones
5. Summary

14. Did the Two Earth Poles Move Widely 13,000 Years ago?
An Astrodynamical Study of the Earth's Rotation

by *Christian Marchal*

1. Introduction
2. Why this study?
3. The matrix M_c before the melting of the last ice age
4. Are such fast and large moves of the poles possible?
5. The age of natural disasters
6. Conclusion

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