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Abstracts of recently accepted papers

First Science Observations with SOFIA/FORCAST: Properties of Intermediate-Luminosity Protostars and Circumstellar Disks in OMC-2

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We examine eight young stellar objects in the OMC-2 star forming region based on observations from the SOFIA/FORCAST early science phase, the *Spitzer Space Telescope*, the *Herschel Space Observatory*, 2MASS, APEX, and other results in the literature. We show the spectral energy distributions of these objects from near-infrared to millimeter wavelengths, and compare the SEDs with those of sheet collapse models of protostars and circumstellar disks. Four of the objects can be modelled as protostars with infalling envelopes, two as young stars surrounded by disks, and the remaining two objects have double-peaked SEDs. We model the double-peaked sources as binaries containing a young star with a disk and a protostar. The six most luminous sources are found in a dense group within a 0.15×0.25 pc region; these sources have luminosities ranging from 300 $L_\odot$ to 20 $L_\odot$. The most embedded source (OMC-2 FIR 4) can be fit by a class 0 protostar model having a luminosity of ~ 50 $L_\odot$ and mass infall rate of $\sim 10^{-4}$ $M_\odot$ yr^{-1}.

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Spectroscopy of new brown dwarf members of ρ Ophiuchi and an updated initial mass function

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Aims. To investigate the universality hypothesis of the initial mass function in the substellar regime, the population of the ρ Ophiuchi molecular cloud is analysed by including a new sample of low-mass spectroscopically confirmed members. To that end, we have conducted a large spectroscopic follow-up of young substellar candidates uncovered in our previous photometric survey.
Methods. The spectral types and extinction were derived for a newly found population of substellar objects, and its masses estimated by comparison to evolutionary models. A thoroughly literature search was conducted to provide an up-to-date census of the cluster, which was then used to derive the luminosity and mass functions, as well as the ratio of brown dwarfs to stars in the cluster. These results were then compared to other young clusters.
Results. It is shown that the study of the substellar population of the ρ Ophiuchi molecular cloud is hampered only by the high extinction in the cluster ruling out an apparent paucity of brown dwarfs. The discovery of 16 new members of ρ Ophiuchi, 13 of them in the substellar regime, reveals the low-mass end of its population and shows the success of our photometric candidate selection with the WIRCam survey. The study of the brown dwarf population of the cluster reveals a high disk fraction of 76^{+5}_{-8}%.
Conclusions. Taking the characteristic peak mass of the derived mass function and the ratio of brown dwarfs to stars into account, we conclude that the mass function of ρ Ophiuchi is similar to other nearby young clusters.

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http://arxiv.org/abs/1201.1912

The CHESS survey of the L1157-B1 shock: the dissociative jet shock as revealed by Herschel–PACS

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Outflows generated by protostars heavily affect the kinematics and chemistry of the hosting molecular cloud through strong shocks that enhance the abundance of some molecules. L1157 is the prototype of chemically active outflows, and a strong shock, called B1, is taking place in its blue lobe between the precessing jet and the hosting cloud. We present the Herschel-PACS 55–210 μm spectra of the L1157-B1 shock, showing emission lines from CO, H_2O, OH, and [OI]. The spatial resolution of the PACS spectrometer allows us to map the warm gas traced by far-infrared (FIR) lines with unprecedented detail. The rotational diagram of the high-$J_{\rm up}$ CO lines indicates high-excitation conditions ($T_{\rm ex} \simeq 210 \pm 10$ K). We used a radiative transfer code to model the hot CO gas emission observed with PACS and in the CO (13–12) and (10–9) lines measured by Herschel-HIFI. We derive $200< T_{\rm kin} <800$ K and $n \geq 10^5$ cm^{-3}. The CO emission comes from a region of about $7''$ located at the rear of the bow shock where the [OI] and OH emission also originate. Comparison with shock models shows that the bright [OI] and OH emissions trace a dissociative J-

type shock, which is also supported by a previous detection of [FeII] at the same position. The inferred mass-flux is consistent with the "reverse" shock where the jet is impacting on the L1157-B1 bow shock. The same shock may contribute significantly to the high–$J_{\rm up}$ CO emission.

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A simple model for the evolution of the dust population in protoplanetary disks

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Context: The global size and spatial distribution of dust is an important ingredient in the structure and evolution of protoplanetary disks and in the formation of larger bodies, such as planetesimals.
Aims: We aim to derive simple equations that explain the global evolution of the dust surface density profile and the upper limit of the grain size distribution and which can readily be used for further modeling or for interpreting of observational data.
Methods: We have developed a simple model that follows the upper end of the dust size distribution and the evolution of the dust surface density profile. This model is calibrated with state-of-the-art simulations of dust evolution, which treat dust growth, fragmentation, and transport in viscously evolving gas disks.
Results: We find very good agreement between the full dust-evolution code and the toy model presented in this paper. We derive analytical profiles that describe the dust-to-gas ratios and the dust surface density profiles well in protoplanetary disks, as well as the radial flux by solid material "rain out", which is crucial for triggering any gravity assisted formation of planetesimals. We show that fragmentation is the dominating effect in the inner regions of the disk leading to a dust surface density exponent of -1.5, while the outer regions at later times can become drift-dominated, yielding a dust surface density exponent of -0.75. Our results show that radial drift is not efficient in fragmenting dust grains. This supports the theory that small dust grains are resupplied by fragmentation due to the turbulent state of the disk.

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Chemical Processes in Protoplanetary Disks. II. On the Importance of Photochemistry and X-ray Ionization

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We investigate the impact of photochemistry and X-ray ionization on the molecular composition of, and ionization fraction in, a protoplanetary disk surrounding a typical T Tauri star. We use a sophisticated physical model, which includes a robust treatment of the radiative transfer of UV and X-ray radiation, and calculate the time-dependent chemical structure using a comprehensive chemical network. In previous work, we approximated the photochemistry and X-ray ionization, here, we recalculate the photoreaction rates using the explicit UV wavelength spectrum and wavelength-dependent reaction cross sections. We recalculate the X-ray ionization rate using our explicit elemental composition and X-ray energy spectrum. We find photochemistry has a larger influence on the molecular composition than X-ray ionization. Observable molecules sensitive to the photorates include OH, HCO^+, N_2H^+, H_2O, CO_2 and CH_3OH. The only molecule significantly affected by the X-ray ionization is N_2H^+ indicating it is safe to adopt existing approximations of the X-ray ionization rate in typical T Tauri star-disk systems. The recalculation of the photorates

increases the abundances of neutral molecules in the outer disk, highlighting the importance of taking into account the shape of the UV spectrum in protoplanetary disks. A recalculation of the photoreaction rates also affects the gas-phase chemistry due to the adjustment of the H/H_2 and C^+/C ratios. The disk ionization fraction is not significantly affected by the methods adopted to calculate the photochemistry and X-ray ionization. We determine there is a probable 'dead zone' where accretion is suppressed, present in a layer, $Z/R \lesssim 0.1$ - 0.2, in the disk midplane, within $R \approx 200$ AU.

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Radio Imaging of the NGC 2024 FIR 5/6 Region: a Hypercompact H II Region Candidate in Orion

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The NGC 2024 FIR 5/6 region was observed in the 6.9 mm continuum with an angular resolution of about 1.5 arcsec. The 6.9 mm continuum map shows four compact sources, FIR 5w, 5e, 6c, and 6n, as well as an extended structure of the ionization front associated with the optical nebulosity. FIR 6c has a source size of about 0.4 arcsec or 150 AU. The spectral energy distribution (SED) of FIR 6c is peculiar: rising steeply around 6.9 mm and flat around 1 mm. The possibility of a hypercompact H II region is explored. If the millimeter flux of FIR 6c comes from hot ionized gas heated by a single object at the center, the central object may be a B1 star of about 5800 solar luminosities and about 13 solar masses. The 6.9 mm continuum of FIR 6n may be a mixture of free-free emission and dust continuum emission. Archival data show that both FIR 6n and 6c exhibit water maser activity, suggesting the existence of shocked gas around them. The 6.9 mm continuum emission from FIR 5w has a size of about 1.8 arcsec or 760 AU. The SEDs suggest that the 6.9 mm emission of FIR 5w and 5e comes from dust, and the masses of the dense molecular gas are about 0.6 and 0.5 solar masses, respectively.

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Jet Rotation Investigated in the Near-Ultraviolet with HST/STIS

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We present results of the second phase of our near-ultraviolet investigation into protostellar jet rotation using HST/STIS. We obtain long-slit spectra at the base of five T Tauri jets to determine if there is a difference in radial velocity between the jet borders which may be interpreted as a rotation signature. These observations are extremely challenging and push the limits of current instrumentation, but have the potential to provide long-awaited observational support for the magneto-centrifugal mechanism of jet launching in which jets remove angular momentum from protostellar systems. We successfully detect all five jet targets (from RW Aur, HN Tau, DP Tau and CW Tau) in several near-ultraviolet emission lines, including the strong Mg II doublet. However, only RW Aur's bipolar jet presents sufficient signal-to-noise for analysis. The approaching jet lobe shows a difference of 10 km/s in a direction which agrees with the disk rotation sense, but is opposite to previously published optical measurements for the receding jet. The near-ultraviolet difference is not found six months later, nor is it found in the fainter receding jet. Overall, in the case of RW Aur, differences are not consistent with a simple jet rotation interpretation. Indeed, given the renowned complexity and variability of this system, it now seems likely that any rotation signature is confused by other influences, with the inevitable conclusion that RW Aur is not suited to a jet rotation study.

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Gas-grain models for interstellar anion chemistry

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Long-chain hydrocarbon anions C_nH^- ($n = 4, 6, 8$) have recently been found to be abundant in a variety of interstellar clouds. In order to explain their large abundances in the denser (prestellar/protostellar) environments, new chemical models are constructed that include gas-grain interactions. Models including accretion of gas-phase species onto dust grains and cosmic-ray-induced desorption of atoms are able to reproduce the observed anion-to-neutral ratios, as well as the absolute abundances of anionic and neutral carbon chains, with a reasonable degree of accuracy. Due to their destructive effects, the depletion of oxygen atoms onto dust results in substantially greater polyyne and anion abundances in high-density gas (with $n_{H_2} > 10^5$ cm^{-3}). The large abundances of carbon-chain-bearing species observed in the envelopes of protostars such as L1527 can thus be explained without the need for warm carbon-chain chemistry. The C_6H^- anion-to-neutral ratio is found to be most sensitive to the atomic O and H abundances and the electron density. Therefore, as a core evolves, falling atomic abundances and rising electron densities are found to result in increasing anion-to-neutral ratios. Inclusion of cosmic-ray desorption of atoms in high-density models delays freeze-out, which results in a more temporally-stable anion-to-neutral ratio, in better agreement with observations. Our models include reactions between oxygen atoms and carbon-chain anions to produce carbon-chain-oxide species C_6O, C_7O, HC_6O and HC_7O, the abundances of which depend on the assumed branching ratios for associative electron detachment.

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A study of deuterated water in the low-mass protostar IRAS16293-2422

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Context: Water is a primordial species in the emergence of life, and comets may have brought a large fraction to Earth to form the oceans. To understand the evolution of water from the first stages of star formation to the formation of planets and comets, the HDO/H_2O ratio is a powerful diagnostic.
Aims: Our aim is to determine precisely the abundance distribution of HDO towards the low-mass protostar IRAS16293-2422 and learn more about the water formation mechanisms by determining the HDO/H_2O abundance ratio.
Methods: A spectral survey of the source IRAS16293-2422 was carried out in the framework of the CHESS (Chemical HErschel Surveys of Star forming regions) Herschel Key program with the HIFI (Heterodyne Instrument for the Far-Infrared) instrument, allowing detection of numerous HDO lines. Other transitions have been observed previously with ground-based telescopes. The spherical Monte Carlo radiative transfer code RATRAN was used to reproduce the observed line profiles of HDO by assuming an abundance jump. To determine the H_2O abundance throughout the envelope, a similar study was made of the $H_2^{18}O$ observed lines, as the H_2O main isotope lines are contaminated by the outflows.
Results: It is the first time that so many HDO and $H_2^{18}O$ transitions have been detected towards the same source with high spectral resolution. We derive an inner HDO abundance ($T \geq 100$ K) of about 1.7×10^{-7} and an outer HDO abundance ($T < 100$ K) of about 8×10^{-11}. To reproduce the HDO absorption lines observed at 894 and 465 GHz, it is necessary to add an absorbing layer in front of the envelope. It may correspond to a water-rich layer created by the photodesorption of the ices at the edges of the molecular cloud. At a 3σ uncertainty, the HDO/H_2O ratio is 1.4-5.8% in the hot corino, whereas it is 0.2-2.2% in the outer envelope. It is estimated at ~4.8% in the added absorbing layer.

Conclusions: Although it is clearly higher than the cosmic D/H abundance, the HDO/H_2O ratio remains lower than the D/H ratio derived for other deuterated molecules observed in the same source. The similarity of the ratios derived in the hot corino and in the added absorbing layer suggests that water formed before the gravitational collapse of the protostar, contrary to formaldehyde and methanol, which formed later once the CO molecules had depleted on the grains.

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Rotating Disks and Non-Kinematic Double Peaks

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Double-peaked line profiles are commonly considered a hallmark of rotating disks, with the distance between the peaks a measure of the rotation velocity. However, double-peaks can arise also from radiative transfer effects in optically thick non-rotating sources. Utilizing exact solutions of the line transfer problem we present a detailed study of line emission from geometrically thin Keplerian disks. We derive the conditions for emergence of kinematic double peaks in optically thin and thick disks, and find that it is generally impossible to disentangle the effects of kinematics and line opacity in observed double-peaked profiles. Unless supplemented by additional information, a double-peaked profile alone is not a reliable indicator of a rotating disk. In certain circumstances, triple and quadruple profiles might be better indicators of rotation in optically thick disks.

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The clustered nature of star formation. Pre-main-sequence clusters in the star-forming region NGC 602/N90 in the Small Magellanic Cloud

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Located at the tip of the wing of the Small Magellanic Cloud (SMC), the star-forming region NGC 602/N90 is characterized by the HII nebular ring N90 and the young cluster of pre-main-sequence (PMS) and early-type main sequence stars NGC 602. We present a thorough cluster analysis of the stellar sample identified with HST/ACS camera in the region. We show that apart from the central cluster, low-mass PMS stars are congregated in thirteen additional small compact sub-clusters at the periphery of NGC 602. We find that the spatial distribution of the PMS stars is bimodal, with an unusually large fraction ($\sim$60%) of the total population being clustered, while the remaining is diffusely distributed in the inter-cluster area. From the corresponding color-magnitude diagrams we disentangle an age-difference of $\sim$2.5 Myr between NGC 602 and the compact sub-clusters which appear younger. The diffuse PMS population appears to host stars as old as those in NGC 602. Almost all detected PMS sub-clusters appear to be centrally concentrated. When the complete PMS stellar sample, including both clustered and diffused stars, is considered in our cluster analysis, it appears as a single centrally concentrated stellar agglomeration, covering the whole central area of the region. Considering also the hot massive stars of the system, we find evidence that this agglomeration is hierarchically structured. Based on our findings we propose a scenario, according to which the region

NGC 602/N90 experiences an active clustered star formation for the last 5 Myr. The central cluster NGC 602 was formed first and rapidly started dissolving into its immediate ambient environment, possibly ejecting also massive stars found away from its center. Star formation continued in sub-clusters of a larger stellar agglomeration, introducing an age-spread of the order of 2.5 Myr among the PMS populations.

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First Science Results From SOFIA/FORCAST: Super-Resolution Imaging of the S140 Cluster at 37 micron

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We present 37 μm imaging of the S140 complex of infrared sources centered on IRS1 made with the FORCAST camera on SOFIA. These observations are the longest wavelength imaging to resolve clearly the three main sources seen at shorter wavelengths, IRS 1, 2 and 3, and are nearly at the diffraction limit of the 2.5-m telescope. We also obtained a small number of images at 11 and 31 μm that are useful for flux measurement. Our images cover the area of several strong sub-mm sources seen in the area – SMM 1, 2, and 3 – that are not coincident with any mid-infrared sources and are not visible in our longer wavelength imaging either. Our new observations confirm previous estimates of the relative dust optical depth and source luminosity for the components in this likely cluster of early B stars. We also investigate the use of super-resolution to go beyond the basic diffraction limit in imaging on SOFIA and find that the van Cittert algorithm, together with the "multi-resolution" technique, provides excellent results.

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Gaps in Protoplanetary Disks as Signatures of Planets: I. Methodology and Validation

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We examine the observational consequences of partial gaps being opened by planets in protoplanetary disks. We model the disk using a static α-disk model with detailed radiative transfer, parametrizing the shape and size of the partially cleared gaps based on the results of hydrodynamic simulations. Shadowing and illumination by stellar irradiation at the surface of the gap leads to increased contrast as the gap trough is deepened by shadowing and cooling and the far gap wall is puffed up by illumination and heating. In calculating observables, we find that multiple scattering is important and derive an approximation to include these effects. A gap produced by a 200 $M_\oplus$(70 $M_\oplus$) planet at 10 AU can lower/raise the midplane temperature of the disk by up to $\sim -25/+29\%$ ($\sim -11/+19$) by shadowing in the gap trough and illumination on the far shoulder of the gap. At the distance of Taurus, this gap would be resolvable with $\sim 0.01''$ angular resolution. The gap contrast is most significant in scattered light and at thermal continuum wavelengths characteristic of the surface temperature, reducing or raising the surface brightness by up to an order of magnitude. Since gap size correlates with planet mass, this is a promising way of finding and determining the masses of planets embedded in protoplanetary disks.

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Coagulation Calculations of Icy Planet Formation at 15–150 AU: A Correlation Between the Maximum Radius and the Slope of the Size Distribution for Transneptunian Objects

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We investigate whether coagulation models of planet formation can explain the observed size distributions of transneptunian objects (TNOs). Analyzing published and new calculations, we demonstrate robust relations between the size of the largest object and the slope of the size distribution for sizes 0.1 km and larger. These relations yield clear, testable predictions for TNOs and other icy objects throughout the solar system. Applying our results to existing observations, we show that a broad range of initial disk masses, planetesimal sizes, and fragmentation parameters can explain the data. Adding dynamical constraints on the initial semimajor axis of 'hot' KBOs along with probable TNO formation times of 10–700 Myr restricts the viable models to those with a massive disk composed of relatively small (1–10 km) planetesimals.

Astron. J., 143, 63

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On the nature of the Herbig B[e] star binary system V921 Scorpii: Discovery of a close companion and relation to the large-scale bipolar nebula

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Belonging to the group of B[e] stars, V921 Scorpii is associated with a strong infrared excess and permitted and forbidden line emission, indicating the presence of low- and high-density circumstellar gas and dust. Many aspects of V921 Sco and other B[e] stars still remain mysterious, including their evolutionary state and the physical conditions resulting in the class-defining characteristics. In this paper, we employ VLTI/AMBER spectro-interferometry in order to reconstruct high-resolution ($\lambda/2B = 0.0013$ arcsec) model-independent interferometric images for three wavelength bands around 1.65, 2.0, and 2.3 μm. In our images, we discover a close (25.0 ± 0.8 milliarcsecond, corresponding to $\sim 29 \pm 0.9$ AU at 1.15 kpc) companion around V921 Sco. Between two epochs in 2008 and 2009, we measure orbital motion of $\sim 7°$, implying an orbital period of ~ 35 years (for a circular orbit). Around the primary star, we detect a disk-like structure with indications for a radial temperature gradient. The polar axis of this AU-scale disk is aligned with the arcminute-scale bipolar nebula in which V921 Sco is embedded. Using Magellan/IMACS imaging, we detect multi-layered arc-shaped sub-structure in the nebula, suggesting episodic outflow activity from the system with a period of ~ 25 years, roughly matching the estimated orbital period of the companion. Our study supports the hypothesis that the B[e] phenomenon is related to dynamical interaction in a close binary system.

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On the nature of the EXor accretion events: an unfrequent manifestation of a common phenomenology ?

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We present the results of a comparison between classical and newly identified EXor based on literature data and aimed at recognizing possible differences or similarities of both categories. Optical and near-IR two-color diagrams, modalities of fluctuations, and derived values of the mass accretion rates are indicative of strong similarities between the two samples. We demonstrate how the difference between the outburst and the quiescence spectral energy distribution of all the EXor can be well fitted with a single blackbody, as if an additional thermal component appears during the outbursting phase. Temperatures of this additional component span between 1000 and 4500 K, while the radii of the emitting regions (assumed to be a uniform disk) span between 0.01 and 0.1 AU, sizes typical of the inner portions of the circumstellar disk. Spots persisting up to 50% of the outburst duration, not exceeding the 10% of the stellar surface, and with temperatures compatible with the EXor mass accretion rates, are able to account for both the appearance of the additional thermal component and the dust sublimation in the inner structures of the disk. We also compare the EXor events with the most significant color and magnitude fluctuations of active T Tauri stars finding that (*i*) burst accretion phenomena should also be important for this latter class; (*ii*) EXor events could be more frequent then those accidentally discovered. Remarkable is the case of the source V2493 Cyg, a T Tauri star recently identified as a strong outbursting object: new optical and near-IR photometric and spectroscopic data are presented trying to clarify its EXor or FUor nature.

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Planetary Construction Zones in Occultation: Discovery of an Extrasolar Ring System Transiting a Young Sun-like Star and Future Prospects for Detecting Eclipses by Circumsecondary and Circumplanetary Disks

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The large relative sizes of circumstellar and circumplanetary disks imply that they might be seen in eclipse in stellar light curves. We estimate that a survey of $\sim 10^4$ young ($\sim$10 million year old) post-accretion pre-main sequence stars monitored for $\sim$10 years should yield at least a few deep eclipses from circumplanetary disks and disks surrounding low mass companion stars. We present photometric and spectroscopic data for a pre-main sequence K5 star (1SWASP J140747.93-394542.6 = ASAS J140748-3945.7), a newly discovered $\sim$0.9 $M_\odot$ member of the $\sim$16 Myr-old Upper Centaurus-Lupus subgroup of Sco-Cen at a kinematic distance of 128 ± 13 pc. This star exhibited a remarkably long, deep, and complex eclipse event centered on 29 April 2007 (as discovered in SuperWASP photometry, and with portions of the dimming confirmed by ASAS data). At least 5 multi-day dimming events of $>$0.5 mag are identified, with a $>$3.3 mag deep eclipse bracketed by two pairs of $\sim$1 mag eclipses symmetrically occurring $\pm$12 days and $\pm$26 days before and after. Hence, significant dimming of the star was taking place on and off over at least a $\sim$54 day period in 2007, and a strong $>$1 mag dimming event occurring over a $\sim$12 day span. We place a firm lower limit on the period of 850 days (i.e. the orbital radius of the eclipser must be $>$1.7 AU and orbital velocity must be $<$22 km/s). The shape of the light curve is similar to the lop-sided eclipses of the Be star EE Cep. We suspect that this new star is being eclipsed by a low-mass object orbited by a dense inner disk, further girded by at least 3 dusty rings of optical depths near unity. Between these rings are at least two annuli of near-zero optical depth (i.e. gaps), possibly cleared out by planets or moons, depending on the nature of the secondary. For possible periods in the range 2.33-200 yr, the estimated total ring mass is $\sim$8-0.4 M_{Moon}(if the rings have optical opacity similar to Saturn's rings), and the edge of the outermost detected ring has orbital radius $\sim$0.4-0.09 AU. In the new era of time-domain astronomy opened by surveys like SuperWASP, ASAS, etc., and soon to be revolutionized by LSST, discovering and characterizing eclipses by circumplanetary and circumsecondary disks will provide us with observational constraints on the conditions which spawn satellite systems around gas giant planets and planetary systems around stars.

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A molecular line study of the filamentary infrared dark cloud G304.74+01.32

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Context: Infrared dark clouds (IRDCs) are promising sites to study the earliest formation stages of stellar clusters and high-mass stars, and the physics of molecular-cloud formation and fragmentation.
Aims: The aim of this study is to better understand the physical and chemical properties of the filamentary IRDC G304.74+01.32 (hereafter, G304.74). In particular, we aim to investigate the kinematics and dynamical state of the cloud and clumps within it, and the amount of CO depletion.
Methods: All the submillimetre peak positions in the cloud identified from our previous LABOCA 870-μm map were observed in $C^{17}O(2-1)$ with APEX. These are the first line observations along the whole filament made so far. Selected positions were also observed in the $^{13}CO(2-1)$, $SiO(5-4)$, and $CH_3OH(5_k-4_k)$ transitions at ~ 1 mm wavelength.
Results: The $C^{17}O$ lines were detected towards all target positions at similar radial velocities. CO does not appear to be significantly depleted in the clumps; the largest depletion factors are only ~ 2. Two- to three methanol 5_k-4_k lines near ~ 241.8 GHz were detected towards all selected target positions, whereas $SiO(5-4)$ was seen in only one of these positions, namely SMM 3. In the band covering $SiO(5-4)$, we also detected $DCN(3-2)$ line towards SMM 3. The $^{13}CO(2-1)$ lines show blue asymmetric profiles, indicating large-scale infall motions. The clumps show trans- to supersonic non-thermal motions, and virial-parameter analysis suggests that most of them are gravitationally bound. The external pressure may also play a non-negligible role in the dynamics. The analysis suggests that the fragmentation of the filament into clumps is caused by "sausage"-type instability, in agreement with results from other IRDCs.
Conclusions: The uniform $C^{17}O$ radial velocities along the G304.74 cloud shows that it is a coherent filamentary structure. Although the clumps appear to be gravitationally bound, the ambient turbulent ram pressure may be an important factor in the cloud dynamics. This is qualitatively consistent with our earlier suggestion that the filament was formed by converging supersonic turbulent flows. The poloidal magnetic field could resist the radial cloud collapse, which conforms to the low infall velocites derived. The cloud may not be able to form high-mass stars on the basis of mass-size threshold, but "only" stellar clusters and/or intermediate-mass stars. The star-formation activity in the cloud, such as outflows, is likely responsible in releasing CO from the icy grain mantles back into the gas phase. Shocks related to outflows may have also injected CH_3OH, SiO, and DCN into the gas-phase in SMM 3.

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Evidence for Multiple Pathways to Deuterium Enhancements in Protoplanetary Disks

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The distributions of deuterated molecules in protoplanetary disks are expected to depend on the molecular formation pathways. We use observations of spatially resolved DCN emission from the disk around TW Hya, acquired during ALMA Science verification with a $\sim 3''$ synthesized beam, together with comparable DCO^+ observations from the Submillimeter Array, to investigate differences in the radial distributions of these species and hence differences in their formation chemistry. In contrast to DCO^+, which shows an increasing column density with radius, DCN is better fit by a model that is centrally peaked. We infer that DCN forms at a smaller radii and thus at higher temperatures than DCO^+. This is consistent with chemical network model predictions of DCO^+ formation from H_2D^+ at T<30 K and DCN formation from additional pathways involving CH_2D^+ at higher temperatures. We estimate a DCN/HCN abundance ratio of ~ 0.017, similar to the DCO^+/HCO^+ abundance ratio. Deuterium fractionation appears to be efficient at a range of temperatures in this protoplanetary disk. These results suggest caution in interpreting the range of deuterium fractions observed in Solar System bodies, as multiple formation pathways should be taken into account.

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Jet-driving protostars identified from infrared observations of the Carina Nebula complex

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Aims: Jets are excellent signposts for very young embedded protostars, so we want to identify jet-driving protostars as a tracer of the currently forming generation of stars in the Carina Nebula, which is one of the most massive galactic star-forming regions and which is characterised by particularly high levels of massive-star feedback on the surrounding clouds.
Methods: We used archive data to construct large ($\gtrsim$2 deg $\times$2 deg) *Spitzer* IRAC mosaics of the Carina Nebula and performed a spatially complete search for objects with excesses in the 4.5 μm band, typical of shock-excited molecular hydrogen emission. We also identified the mid-infrared point sources that are the likely drivers of previously discovered Herbig-Haro jets and molecular hydrogen emission line objects. We combined the *Spitzer* photometry with our recent *Herschel* far-infrared data to construct the spectral energy distributions, and used the Robitaille radiative-transfer modelling tool to infer the properties of the objects.
Results: The radiative-transfer modelling suggests that the jet sources are protostars with masses between $\sim 1\,M_{\odot}$ and $\sim 10\,M_{\odot}$ that are surrounded by circumstellar disks and embedded in circumstellar envelopes.
Conclusions: The estimated protostar masses $\leq 10\,M_{\odot}$ suggest that the current star-formation activity in the Carina Nebula is restricted to low- and intermediate-mass stars. More optical than infrared jets can be observed, indicating that star formation predominantly takes place close to the surfaces of clouds.

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Preprints can be obtained from http://arxiv.org/abs/1202.3636
and http://www.usm.uni-muenchen.de/people/preibisch/publications.html (high resolution)

The kinematics of HH 34 from HST images with a 9-year time baseline

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We study archival HST [S II] 6716+30 and Hα images of the HH 34 outflow, taken in 1998.71 and in 2007.83. The $\sim$ 9 yr time baseline and the high angular resolution of these observations allows us to carry out a detailed proper motion study. We determine the proper motions of the substructre of the HH 34S bow shock (from the [S II] and Hα frames) and of the aligned knots within $\sim 30''$ from the outflow source (only from the [S II] frames). We find that the present day motions of the knots along the HH 34 jet are approximately ballistic, and that these motions directly imply the formation of a major mass concentration in $\sim$ 900 yr, at a position similar to the one of the present day HH 34S bow shock. In other words, we find that the knots along the HH 34 jet will merge to form a more massive structure, possibly resembling HH 34S.

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http://www.nucleares.unam.mx/astroplasmas/

Fomalhaut debris disk emission at 7 millimeters: constraints on the collisional models of planetesimals

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We present new spatially resolved observations of the dust thermal emission at 7 mm from the Fomalhaut debris disk obtained with the Australia Telescope Compact Array. These observations provide the longest wavelength detection of the Fomalhaut debris disk to date. We combined the new data to literature sub-mm data to investigate the spectral index of the dust thermal emission in the sub-millimeter and constrained the q-slope of the power-law grain size distribution. We derived a value for $q = 3.48 \pm 0.14$ for grains with sizes around 1 mm. This is consistent with the classical prediction for a collisional cascade at the steady-state. The same value cannot be explained by more recent collisional models of planetesimals in which either the velocity distribution of the large bodies or their tensile strength is a strong function of the body size.

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Magnetic fields during the early stages of massive star formation – II. A generalised outflow criterion

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Numerical simulations of outflows formed during the collapse of 100 $M_\odot$ cloud cores are presented. We derive a generalised criterion from magnetohydrodynamical wind theory to analyse the launching mechanism of these outflows. The criterion is successfully applied to the whole outflow structure and cases with sub-Keplerian disc rotation. It allows us to decide whether an outflow is driven centrifugally or by the toroidal magnetic pressure. We show that quantities such as the magnetic field line inclination or the ratio of the toroidal to poloidal magnetic field alone are insufficient to determine the driving mechanism of outflows. By performing 12 simulations with variable initial rotational and magnetic energies we are able to study the influence of the initial conditions on the properties of outflows and jets around massive protostars in detail. Our simulations reveal a strong effect of the magnetic field strength on the morphology of outflows. In runs with weak fields or high rotational energies, well collimated, fast jets are observed whereas for strong fields poorly collimated, low-velocity outflows are found. We show that the occurrence of a fast jet is coupled to the existence of a Keplerian protostellar disc. Despite the very different morphologies all outflows are launched from the discs by centrifugal acceleration with the toroidal magnetic field increasingly contributing to the gas acceleration further away from the discs. The poor collimation of the outflows in runs with strong magnetic fields is a consequence of the weak hoop stresses. This in turn is caused by the slow build-up of a toroidal magnetic field due to strongly sub-Keplerian disc rotation. The mass and momentum outflow rates are of the order of 10^{-4} $M_\odot$ yr^{-1} and 10^{-4} $M_\odot$ km s^{-1} yr^{-1}, respectively. The mass ejection/accretion ratios scatter around a mean of 0.3 in accordance with observational and analytical results. Based on our results we suggest an evolutionary scenario for the earliest stage of massive star formation in which initially poorly collimated outflows develop which successively get better collimated during their evolution due to the generation of fast jets.

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Line Profiles of Cores within Clusters: I. The Anatomy of a Filament

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Observations are revealing the ubiquity of filamentary structures in molecular clouds. As cores are often embedded in filaments, it is important to understand how line profiles from such systems differ from those of isolated cores. We perform radiative transfer calculations on a hydrodynamic simulation of a molecular cloud in order to model line emission from collapsing cores embedded in filaments. We model two optically thick lines, CS(2-1) and HCN(1-0), and one optically thin line, N2H+(1-0), from three embedded cores. In the hydrodynamic simulation, gas self-gravity, turbulence, and bulk flows create filamentary regions within which cores form. Though the filaments have large dispersions, the N2H+(1-0) lines indicate subsonic velocities within the cores. We find that the observed optically thick line profiles of CS(2-1) and HCN(1-0) vary drastically with viewing angle. In over 50% of viewing angles, there is no sign of a blue asymmetry, an idealised signature of infall motions in an isolated spherical collapsing core. Profiles which primarily trace the cores, with little contribution from the surrounding filament, are characterised by a systematically higher HCN(1-0) peak intensity. The N2H+(1-0) lines do not follow this trend. We demonstrate that red asymmetric profiles are also feasible in the optically thick lines, due to emission from the filament or one-sided accretion flows onto the core. We conclude that embedded cores may frequently undergo collapse without showing a blue asymmetric profile, and that observational surveys including filamentary regions may underestimate the number of collapsing cores if based solely on profile shapes of optically thick lines.

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Complex Structure in Class 0 Protostellar Envelopes III: Velocity Gradients in Non-Axisymmetric Envelopes, Infall or Rotation?

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We present an interferometric kinematic study of morphologically complex protostellar envelopes based on observations of the dense gas tracers N_2H^+ and NH_3. The strong asymmetric nature of most envelopes in our sample leads us to question the common interpretation of velocity gradients as rotation, given the possibility of projection effects in the observed velocities. Several "idealized" sources with well-ordered velocity fields and envelope structures are now analyzed in more detail. We compare the interferometric data to position-velocity diagrams of kinematic models for spherical rotating collapse and filamentary rotating collapse. For this purpose, we developed a filamentary parametrization of the rotating collapse model to explore the effects of geometric projection on the observed velocity structures. We find that most envelopes in our sample have PV structures that can be reproduced by an infalling filamentary envelope projected at different angles within the plane of the sky. The infalling filament produces velocity shifts across the envelope that can mimic rotation, especially when viewed at single-dish resolutions and the axisymmetric rotating collapse model does not uniquely describe any dataset. Furthermore, if the velocities are assumed to reflect rotation, then the inferred centrifugal radii are quite large in most cases, indicating significant fragmentation potential or more likely another component to the line-center velocity. We conclude that ordered velocity gradients cannot be interpreted as rotation alone when envelopes are non-axisymmetric and that projected infall velocities likely dominate the velocity field on scales larger than 1000 AU.

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Cores in Infra-Red Dark Clouds (IRDCs) seen in the Hi-GAL survey between l=300° and l=330°

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We have used data taken as part of the *Herschel* infrared Galactic Plane survey (Hi-GAL) to study 3171 infrared-dark cloud (IRDC) candidates that were identified in the mid-infrared (8 μm) by *Spitzer* (we refer to these as '*Spitzer*-dark' regions). They all lie in the range l=300-330° and $|b|< 1°$. Of these, only 1205 were seen in emission in the far-infrared (250–500 μm) by *Herschel* (we call these '*Herschel*-bright' clouds). It is predicted that a dense cloud will not only be seen in absorption in the mid-infrared, but will also be seen in emission in the far-infrared at the longest *Herschel* wavebands (250–500 μm). If a region is dark at all wavelengths throughout the mid-infrared and far-infrared, then it is most likely to be simply a region of lower background infrared emission (a 'hole in the sky'). Hence, it appears that previous surveys, based on *Spitzer* and other mid-infrared data alone, may have over-estimated the total IRDC population by a factor $\sim$2. This has implications for estimates of the star formation rate in IRDCs in the Galaxy. We studied the 1205 *Herschel*-bright IRDCs at 250 μm, and found that 972 of them had at least one clearly defined 250-μm peak, indicating that they contained one or more dense cores. Of these, 653 (67 per cent) contained an 8-μm point source somewhere within the cloud, 149 (15 per cent) contained a 24-μm point source but no 8-μm source, and 170 (18 per cent) contained no 24-μm or 8-μm point sources. We use these statistics to make inferences about the lifetimes of the various evolutionary stages of IRDCs.

Accepted by MNRAS

http://arxiv.org/abs/1202.0395

Postdoctoral Positions in Theoretical Star and Planet Formation Lyon and Exeter

Two postdoc positions in theoretical astrophysics are available immediately: one in CRAL at the Ecole Normale Superieure de Lyon (ENS-Lyon, France), one in the astrophysics group of the University of Exeter (UK).

The successful applicants will be working on various theoretical aspects of **star or exoplanet formation, early evolution and internal physical processes, and of star-disk interaction**. The candidates are expected to have a strong expertise in (multi-D) computational astrophysics, including (magneto)hydrodynamics or radiative transfer.

The appointees will have access to large computing resources, including a new cluster ($\sim$1000 cores) entirely dedicated to the projects, national supercomputers (with guaranteed access to several Mhours CPU time per year) and the European Petascale computer from the PRACE project.

The salaries range from 28 to 32 keuros/yr and 24 to 27.5 kpounds/yr, respectively, depending on age and experience, plus some travel funds. The positions are subject to 1 year probationary period but can be extended up to 3 years subject to performance.

The positions are available immediately but arrangements for later start date can be made.

Applicants are invited to send their application material, including a CV, list of publications, recommendation letters and a detailed summary of research to G. Chabrier (preferentially by e-mail). Details on the positions can be directly asked to G. Chabrier.

Contact: G. Chabrier : chabrier@ens-lyon.fr

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).

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The Exoplanet Handbook

Michael Perryman

Since the discovery of the first exoplanet around 51 Peg twenty years ago, a total of 760 planets have been discovered, and around 7000 papers on exoplanets and their properties, formation, evolution and atmospheres have been published. The field has reached a high level of maturity, and as a result the last few years have seen the appearance of a large number of books devoted to exoplanets, many of them of high quality. One would therefore be excused to wonder if yet another book is needed. Examination of 'The Exoplanet Handbook' expels any such doubts. Michael Perryman has produced a remarkably detailed compilation of results covering observation, technology, and theory. While new exoplanets are discovered at a rapid pace, the observing methods employed develop much more slowly, and in the first half of the book detailed accounts are given of techniques based on radial velocities, astrometry, transits, microlensing, timings, and imaging. The second half is devoted to a discussion of the physical processes leading to the rich variety of exoplanets, both observationally and theoretically. The book is divided in chapters, sections, subsections, and subsubsections, which provides a clear structure, and facilitates its use as a true handbook. The text is dense and quite technical, with extensive references (a 72 page list of references is given at the end), and so the book primarily addresses the researcher and advanced student, while a beginning student will find gentler introductions elsewhere. The book was recently named winner of the PROSE Award in Cosmology and Astronomy for 2011.

The book contains the following chapters:

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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.

Summer school on Cloudy, and the physics and spectroscopy of the ISM

I am organizing a weeklong school on Cloudy, spectroscopy, and the physics of interstellar matter, to be held this summer in Lexington. This is in early planning stages and the details will depend on participant interest. Classes will include a mix of textbook study, based on Osterbrock & Ferland (2006), and hands-on experience running Cloudy. The specific examples we discuss will reflect the research interests of the participants.

The date is not yet set but is likely to be the last week of May 2012. Participants should have access to a copy of Osterbrock & Ferland and a laptop to run Cloudy or connect to other computers. This will be free of charge, but there is no financial support. If you think you might be interested or would like more information please contact me at gary at pa dot uky dot edu.

Gary J. Ferland

University of Kentucky

Fizeau exchange visitors program - call for applications

Dear colleagues!

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff). Applicants are strongly encouraged to seek also partial support from their home or host institutions.

The deadline for applications is the 15th of March for visits starting 1st of May.

Note that an early next call may be issued in June for visits starting in July.

Further informations and application forms can be found at www.european-interferometry.eu

The program is funded by OPTICON/FP7.

Please distribute this message also to potentially interested colleagues outside of the your community!

Looking forward to your applications, Josef Hron & Laszlo Mosoni (for the European Interferometry Initiative)