THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar/planetary evolution and molecular clouds

No. 289 — 14 January 2017 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

The Star Formation Newsletter

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star and planet 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). Additionally, the Newsletter brings short overview articles on objects of special interest, physical processes or theoretical results, the early solar system, as well as occasional interviews.

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Cover Picture

The Aquila Rift contains numerous highly structured molecular clouds. One is Lynds 604, which contains the reflection nebula and shock structure known as GGD 30 and HH 172. The region is seen in this multi-filter image, which has North left and East up.

Image courtesy Adam Block/Mount Lemmon SkyCenter/University of Arizona (http://www.adamblockphotos.com)

Submitting your abstracts

Latex macros for submitting abstracts and dissertation abstracts (by e-mail to reipurth@ifa.hawaii.edu) are appended to each Call for Abstracts. You can also submit via the Newsletter web interface at http://www2.ifa.hawaii.edu/star-formation/index.cfm

Maria Kun

in conversation with Bo Reipurth

Q: *What was your PhD about?*

A: It dealt with a study of the space distribution of stars and diffuse matter in the region of IC 1396, part of the Cepheus OB2 association, based on our own objective prism spectral classification and photographic UBV photometric observations. The stellar association was a direct path to my interest in star-forming regions. I defended my thesis in 1977 at the Eötvös University in Budapest. My supervisor was Lajos G. Balázs. Actually it was not a PhD, but a Dr.Univ. degree. According to the system of science qualification in Hungary in those days, researchers of my age had to defend further (C.Sc.) theses at the Hungarian Academy of Sciences. My C.Sc. thesis included results on the distribution of extinction over the whole area of the Cepheus OB2 association, Hα emission stars in the region of IC 1396 and in a few dark clouds, preliminary studies of color-color diagrams of IRAS point sources for the same fields, and a description of the Cepheus Bubble, discovered in the IRAS Skyflux images.

Q: *Hungary has undergone a tremendous evolution, politically and scientifically. What were the facilities available to you during your PhD?*

A: The telescopes of the Konkoly Observatory were available. There were two major research groups at the Konkoly Observatory. The group of variable star researchers had well-founded traditions. Their studies were based on photoelectric photometric observations. The work of the other, smaller group focusing on stellar statistics was based on observations with the 60/90/180 cm Schmidt telescope, equipped with objective prisms and standard broad-band filters. I belonged to this latter group, led by Béla A. Balázs and later by Lajos G. Balázs. The large field of view of the telescope was suitable for studying star clusters and other stellar groups and Galactic regions. First of all I mastered spectral classification on photographic plates, and applied spectral types, magnitudes and color indices for studying distances of dark clouds. Red-sensitive photographic plates, combined with a red filter and objective prism, opened new opportunities for studying star-forming regions. I started a search for Hα emission stars towards a few dark clouds, detected in formaldehyde absorption line by N. H. Dieter in 1973. These clouds were the earliest examples of molecular clouds. I misclassified several late-type stars as Hα emission object before I gained sufficient experience, as it turned out later when I had opportunity to observe the spectra of these stars with longslit spectrographs. Communication with the world outside Hungary was difficult before 1988. But in January 1988, as the transition towards democracy gained speed, Hungarian citizens could apply for a passport valid for all countries. Interactions with the West increased, and the first CCD camera appeared in our observatory in 1993.

Q: *You are a leading expert on the Cepheus Flare Region and have written extensively about it. What has attracted you to this region of the sky that was previously ignored?*

A: An interesting cloud in the Cepheus flare region, L1251, was one of the first targets of my objective prism Hα observations. Lebrun's paper on the CO mapping of the whole Cepheus Flare region was published in 1986. Reading this paper I realized that this was a region where I could do something useful even with the modest equipment available in those times. There was a large, apparently coherent molecular cloud complex, practically without distance data and without systematic studies of the young stellar population. Being the mother of three children I was not really mobile in those years and tried to get the best out of the available facilities. I decided to determine cloud distances using Wolf diagrams (plotting logarithms of star numbers against distance moduli), and therefore started an objective prism spectroscopic mapping of the whole area. The field of view of our Schmidt telescope was 19 square degrees. I observed an area of some 200 square degrees of the Cepheus flare region, classified the spectral types of more than 3000 stars, and constructed Wolf diagrams using objective prism spectral types and V magnitudes given in the Guide Star Catalog. This massive data collection required observations over quite a few seasons. It turned out that the region was much more complicated than I had initially expected: the clouds were located at different distances. Later the discovery of the Cepheus Flare Shell by Olano and co-workers in 2006 confirmed this result. I performed a photographic Hα survey over the same area, to identify possible T Tauri stars, and by that time the IRAS Point source Catalog was also available for identifying young stellar objects. In 1988, with my new passport, I visited the SRON in Groningen, thanks to the kind invitation by Paul Wesselius, and learned the use of the Groningen Image Processing System, developed for IRAS data. Thus the optical depth and temperature structure of the Cepheus Flare region over the IRAS wavelengths were also included in the first paper. Later the European OPTICON trans-national access project allowed me to apply for observing times on telescopes outside Hungary, and obtain longslit spectra to determine the real nature of the Hα stars and refine the distance structure of the region. In a few years the Gaia parallaxes of the optically visible young stars will certainly further refine the line-of-sight structure of this star-forming region.

Q: *Over many years you have been interested in young eruptive variables, notably the peculiar object PV Cep. What do you think is happening to this star?*

A: I joined the programme of studying eruptive young stars initiated by Peter Ábrahám and Ágnes Kóspál around 2004. PV Cep was then in a bright state, and its optical spectrum pointed to a strongly accreting young star. Then, between 2005 and 2006, its optical brightness dropped some four magnitudes, and the spectacular nebula RNO 125 disappeared. We monitored the variations of the brightness, colors, accretion- and wind-tracer optical spectral lines, and the shape of the nebula during the dim period between 2005 and 2010. We utilized, among others, the opportunities offered by the OPTICON access project. The shape of the nebula changed dramatically as the star dimmed and the Hα and Ca II emission line fluxes dropped: suggesting that due to the declining brightness, dust accumulated close to the star, and cast shadows onto previously illuminated parts of the cirumstellar environment. Analysis of the variation of the optical and infrared fluxes, color indices, and emission line fluxes suggested that the photometric decline in 2005–2009 resulted from an interplay between variable accretion and circumstellar extinction. The accretion rate of PV Cep, although it dropped during the fading, remained significantly higher than the typical pre-main sequence values. We found that the central luminosity of the system is dominated by accretion, and a modest drop in the accretion rate could induce drastic restructuring of the inner disk.

Q: *In a series of recent papers you have investigated star formation in the L1340 dark cloud. What have you learnt?*

A: The story of L1340 began in the 1990's. We had a decade-long collaboration project with Yasuo Fukui and his colleagues. They started ^{13}CO mapping of the Milky Way at the radioastronomy laboratory of Nagoya University. We selected a few interesting, but poorly studied clouds for distance determination and star formation studies. L1340 was picked out as a prominent object in the ^{13}CO map of the Cassiopeia region. It is apparenty an isolated, small cloud at a galactic latitude of +11.5 degrees. We presented the ^{13}CO and C^{18}O maps, the first distance determination (revised later), and a list of candidate young stellar objects in our first paper in 1994. Five years later I had an opportunity to observe spectra of the Hα emission stars using the 2.2-m telescope of the Calar Alto Observatory. To my surprise, one of them was invisible in the acquisition image, that is, it was at least five magnitude fainter than a few years before. By that time our telescopes were equipped with CCD cameras, and we kept an eye on the position of the disappeared star. It reappeared in 2002. During the next decade we collected several spectra, a long optical light curve and a few infrared data and found that this star (now V1180 Cas) was a strongly accreting T Tauri star, in some respects similar to PV Cep and V1647 Ori. Another surprise of the first spectroscopic observing run was that a bright IRAS source in L1340, 02224+7227 exhibited an absorption spectrum, with sharp, strong Balmer absorption lines, without any of the typical T Tauri characteristics. A closer inspection suggested that it was an FU Ori-like spectrum. Unfortunately no evidence of its pre-outburst epoch can be found in photometric archives. We also mapped L1340 in the ammonia line with Jan Wouterloot and Viktor Tóth in 1997. *Spitzer* has also mapped L1340. My recent papers present the young stars identified in the IRAC and MIPS images, and Hα emission stars. L1340 is quite a unique and remarkable star forming region, some 160 pc above the Galactic plane, apparently far from giant molecular clouds and other star forming regions. Its most massive young star has a B4 spectral type. The extinction map, constructed from SDSS star count data, shows that most of the volume of L1340 is quite transparent. The opaque clumps are very small. In spite of the low average column density, the *Spitzer* and SCUBA data reveal a number of Class 0 protostars. L1340 is probably an extremely transient type of star-forming region. It may be that more stars are born in similar structures than we can assess from available data.

Q: *What are you currently working on?*

A: I retired last year, and continue working at the Konkoly Observatory as a professor emerita. I am involved in interesting on-going researches. We have collected years-long optical light curves and multi-epoch spectroscopic data of several young stars with Class I or Flat spectral energy distribution, similar to PV Cep and V1180 Cas, and these data await analysis. The Gaia parallaxes will be interesting for constructing three-dimensional structures of large star-forming regions, like the Cepheus Bubble.

Abstracts of recently accepted papers

X-Shooter spectroscopy of young stellar objects in Lupus: Accretion properties of class II and transitional objects.

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The mass accretion rate, $\dot{M}_{\rm acc}$, is a key quantity for the understanding of the physical processes governing the evolution of accretion discs around young low-mass ($M_\star \lesssim 2.0 M_\odot$) stars and substellar objects (YSOs). We present here the results of a study of the stellar and accretion properties of the (almost) complete sample of class II and transitional YSOs in the Lupus I, II, III and IV clouds, based on spectroscopic data acquired with the VLT/X-Shooter spectrograph. Our study combines the dataset from our previous work with new observations of 55 additional objects. We have investigated 92 YSO candidates in total, 11 of which have been definitely identified with giant stars unrelated to Lupus. The stellar and accretion properties of the 81 bona fide YSOs, which represent more than 90% of the whole class II and transition disc YSO population in the aforementioned Lupus clouds, have been homogeneously and self-consistently derived, allowing for an unbiased study of accretion and its relationship with stellar parameters.
The accretion luminosity, $L_{\rm acc}$, increases with the stellar luminosity, $L_\star$, with an overall slope of $\sim$1.6, similar but with a smaller scatter than in previous studies. There is a significant lack of strong accretors below $L_\star \approx 0.1 L_\odot$, where $L_{\rm acc}$ is always lower than $0.01\,L_\star$. We argue that the $L_{\rm acc}$-$L_\star$ slope is not due to observational biases, but is a true property of the Lupus YSOs. The $\log\dot{M}_{\rm acc}$–$\log M_\star$ correlation shows a statistically significant evidence of a break, with a steeper relation for $M_\star \lesssim 0.2\,M_\odot$ and a flatter slope for higher masses. The bimodality of the $\dot{M}_{\rm acc}$–$M_\star$ relation is confirmed with four different evolutionary models used to derive the stellar mass. The bimodal behaviour of the observed relationship supports the importance of modelling self-gravity in the early evolution of the more massive discs, but other processes, such as photo-evaporation and planet formation during the YSO's lifetime, may also lead to disc dispersal on different timescales depending on the stellar mass.
The sample studied here more than doubles the number of YSOs with homogeneously and simultaneously determined $L_{\rm acc}$ and luminosity, $L_{\rm line}$, of many permitted emission lines. Hence, we also refined the empirical relationships between $L_{\rm acc}$ and $L_{\rm line}$ on a more solid statistical basis.

Accepted by Astronomy and Astrophysics

http://arxiv.org/pdf/1612.07054

On the impact of the magnitude of Interstellar pressure on physical properties of Molecular Cloud

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Recently reported variations in the typical physical properties of Galactic and extra-Galactic molecular clouds (MCs), and in their ability to form stars have been attributed to local variations in the magnitude of interstellar pressure. Inferences from these surveys have called into question two long-standing beliefs that the MCs: (1) are Virialised entities and (2) have approximately constant surface density i.e., the validity of the Larson's third law. In this work we invoke the framework of cloud-formation via collisions between warm gas flows. Post-collision clouds forming in these realisations cool rapidly and evolve primarily via the interplay between the Non-linear Thin Shell Instability (NTSI), and the self-gravity. Over the course of these simulations we traced the temporal evolution of the surface density of the assembled clouds, the fraction of dense gas, the distribution of gas column density (NPDF), and the Virial nature of the assembled clouds. We conclude, these physical properties of MCs not only exhibit temporal variation, but their respective peak-magnitude also increases in proportion with the magnitude of external pressure, $P_{\rm ext}$. The velocity dispersion in assembled clouds appears to follow the power-law, $\sigma_{\rm gas} \propto {P_{\rm ext}}^{0.23}$. Also, the power-law tail at higher densities becomes shallower with increasing magnitude of external pressure, for magnitudes, $P_{\rm ext}/k_B \lesssim 10^7$ K cm^{-3}, at higher magnitudes such as those typically found in the Galactic CMZ ($P_{\rm ext}/k_B > 10^7$ K cm^{-3}), the power-law shows significant steepening. Thus while our results are broadly consistent with inferences from various recent observational surveys, it appears, MCs hardly exhibit a unique set of properties, but rather a wide variety, that can be reconciled with a range of magnitudes of pressure between 10^4 K cm^{-3} – 10^8 K cm^{-3}.

Accepted by MNRAS

http://arxiv.org/pdf/1612.05690

EXor outbursts from disk amplification of stellar magnetic cycles

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EXor outbursts - moderate-amplitude disk accretion events observed in Class I and Class II protostellar sources - have time scales and amplitudes that are consistent with the viscous accumulation and release of gas in the inner disk near the dead zone boundary. We suggest that outbursts are indirectly triggered by stellar dynamo cycles, via poloidal magnetic flux that diffuses radially outward through the disk. Interior to the dead zone the strength of the net field modulates the efficiency of angular momentum transport by the magnetorotational instability. In the dead zone changes in the polarity of the net field may lead to stronger outbursts because of the dominant role of the Hall effect in this region of the disk. At the level of simple estimates we show that changes to kG-strength stellar fields could stimulate disk outbursts on 0.1 AU scales, though this optimistic conclusion depends upon the uncertain efficiency of net flux transport through the inner disk. The model predicts a close association between observational tracers of stellar magnetic activity and EXor events.

Accepted by ApJL

http://arxiv.org/pdf/1612.01532

Hall-effect Mediated Magnetic Flux Transport in Protoplanetary Disks

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The global evolution of protoplanetary disks (PPDs) has recently been shown to be largely controlled by the amount of poloidal magnetic flux threading the disk, which is further controlled by the poorly understood process of magnetic flux transport. In weakly ionized gas as in PPDs, magnetic flux is largely frozen in the electron fluid, except when resistivity is large. When the disk is largely laminar, we show that the relative drift between the electrons and ions (the Hall-drift), and the ions and neutral fluids (ambipolar-drift) can play a dominant role on the transport of magnetic flux. Using two-dimensional simulations that incorporate the Hall effect and ambipolar diffusion (AD) with prescribed diffusivities, we show that when large-scale poloidal field is aligned with disk rotation, the Hall effect rapidly drags magnetic flux inward at the midplane region, while it slowly pushes flux outward above/below the midplane. This leads to a highly radially elongated field configuration as a global manifestation of the Hall-shear instability. This field configuration further promotes rapid outward flux transport by AD at the midplane, leading to instability saturation. In quasi-steady state, magnetic flux is transported outward at approximately the same rate at all heights, and the rate is comparable to the Hall-free case. For anti-aligned field polarity, the Hall effect consistently transports magnetic flux outward, leading to a largely vertical field configuration in the midplane region. The field lines in the upper layer first bend radially inward and then outward to launch a disk wind. Overall, the net rate of outward flux transport is about twice faster than the aligned case. In addition, the rate of flux transport increases with increasing disk magnetization. The absolute rate of transport is sensitive to disk microphysics which remains to be explored in future studies.

Accepted by ApJ

http://arxiv.org/pdf/1612.03912

Ionisation in Turbulent Magnetic Molecular Clouds I. Effect on Density and Mass-to-Flux Ratio Structures

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Context: Previous studies show that the physical structures and kinematics of a region depend significantly on the ionisation fraction. These studies have only considered these effects in non-ideal magnetohydrodynamic simulations with microturbulence. The next logical step is to explore the effects of turbulence on ionised magnetic molecular clouds and then compare model predictions with observations to assess the importance of turbulence in the dynamical evolution of molecular clouds.
Aims: In this paper, we extend our previous studies of the effect of ionisation fractions on star formation to clouds that include both non-ideal magnetohydrodynamics and turbulence. We aim to quantify the importance of a treatment of the ionisation fraction in turbulent magnetised media and investigate the effect of the turbulence on shaping the clouds and filaments before star formation sets in. In particular, here we investigate how the structure, mass and width of filamentary structures depend on the amount of turbulence in ionised media and the initial mass-to-flux ratio.
Methods: To determine the effects of turbulence and mass-to-flux ratio on the evolution of non-ideal magnetised clouds with varying ionisation profiles, we have run two sets of simulations. The first set assumes different initial turbulent Mach values for a fixed initial mass-to-flux ratio. The second set assumes different initial mass-to-flux ratio values for a fixed initial turbulent Mach number. Both sets explore the effect of using one of two ionisation profiles: Step-Like (SL) or Cosmic Ray only (CR-only). We compare the resulting density and mass-to-flux ratio structures both qualitatively and quantitatively via filament and core masses and filament fitting techniques (Gaussian and Plummer profiles.)
Results: We find that even with almost no turbulence, filamentary structure still exists although at lower density contours. Comparison of simulations show that for turbulent Mach numbers above 2, there is little structural difference between the SL and CR-only models, while below this threshold the ionisation structure significantly affects the formation of filaments. This holds true for both sets of models. Analysis of the mass within cores and filaments show that the mass decreases as the degree of turbulence increases. Finally, observed filaments within the Taurus L1495/B213 complex are best reproduced by models with supercritical mass-to-flux ratios and/or at least mildly supersonic turbulence, however, our models show that the sterile fibres observed within Taurus may occur in highly ionised,subcritical environments.
Conclusions: From the analysis of the simulations, we conclude that in the presence of low turbulent velocities, the

ionisation structure of the medium still plays a role in shaping the structure of the cloud, however, above Mach 2, the differences between the two profiles become indistinguishable. However, differences may be present in the underlying velocity structure. Kinematics studies will be the focus of the next paper in this series. Regions with fertile fibres likely indicate a trans- or supercritical mass-to-flux ratio within the region while sterile fibres are likely subcritical and transient.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/1701.00791

HI-to-H_2 Transition Layers in the Star-Forming Region W43

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The process of atomic-to-molecular (HI-to-H_2) gas conversion is fundamental for molecular-cloud formation and star formation. 21 cm observations of the star-forming region W43 revealed extremely high HI column densities, of 120–180 $M_\odot$ pc^{-2}, a factor of 10–20 larger than predicted by HI-to-H_2 transition theories. We analyze the observed HI with an HI-to-H_2 transition theoretical model, and show that the theory-observation discrepancy cannot be explained by the intense radiation in W43, nor by variations of the assumed volume density or H_2 formation-rate coefficient. We show that the large observed HI columns are naturally explained by several (9–22) HI-to-H_2 transition layers, superimposed along the sightlines of W43. We discuss other possible interpretations such as a non-steady-state scenario, and inefficient dust absorption. The case of W43 suggests that HI thresholds reported in extra-galactic observations are probably not associated with a single HI-to-H_2 transition, but are rather a result of several transition layers (clouds) along the sightlines, beam-diluted with diffuse inter-cloud gas.

Accepted by ApJ

http://arxiv.org/pdf/1612.02428

Resolved images of a protostellar outflow driven by an extended disk wind

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Young stars are associated with prominent outflows of molecular gas. The ejection of gas via these outflows is believed to remove angular momentum from the protostellar system, thus permitting young stars to grow by accretion of material from the protostellar disk. The underlying mechanism for outflow ejection is not yet understood, but is believed to be closely linked to the protostellar disk. Assorted scenarios have been proposed to explain protostellar outflows; the main difference between these models is the region where acceleration of material takes place: close to the protostar itself ('X-wind', or stellar wind), in a larger region throughout the protostellar disk (disk wind), or at the interface between. Because of the limits of observational studies, outflow launching regions have so far only been probed by indirect extrapolation. Here we report observations of carbon monoxide toward the outflow associated with the TMC1A protostellar system. These data show that gas is ejected from a region extending up to a radial distance of 25 astronomical units from the central protostar, and that angular momentum is removed from an extended region of the disk. This demonstrates that the outflowing gas is launched by an extended disk wind from a Keplerian disk.

Accepted by Nature

https://arxiv.org/pdf/1612.05148

A continuum of accretion burst behavior in young stars observed by K2

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We present 29 likely members of the young ρ Oph or Upper Sco regions of recent star formation that exhibit "accretion burst" type light curves in K2 time series photometry. The bursters were identified by visual examination of their ∼80 day light curves, though all satisfy the $M < -0.25$ flux asymmetry criterion for burst behavior defined by Cody et al. (2014). The burst sources represent ≈9% of cluster members with strong infrared excess indicative of circumstellar material. Higher amplitude burster behavior is correlated with larger inner disk infrared excesses, as inferred from WISE $W1 - W2$ color. The burst sources are also outliers in their large H? emission equivalent widths. No distinction between bursters and non-bursters is seen in stellar properties such as multiplicity or spectral type. The frequency of bursters is similar between the younger, more compact ρ Oph region, and the older, more dispersed Upper Sco region. The bursts exhibit a range of shapes, amplitudes (∼10-700%), durations (∼1-10 days), repeat time scales (∼3-80 days), and duty cycles (∼10-100%). Our results provide important input to models of magnetospheric accretion, in particular by elucidating the properties of accretion-related variability in the low state between major longer duration events such as EX Lup and FU Ori type accretion outbursts. We demonstrate the broad continuum of accretion burst behavior in young stars – extending the phenomenon to lower amplitudes and shorter timescales than traditionally considered in the theory of pre-main sequence accretion history.

Accepted by AAS Journals

https://arxiv.org/pdf/1612.05599

Characterizing the properties of cluster precursors in the MALT90 survey

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In the Milky Way there are thousands of stellar clusters each harboring from a hundred to a million stars. Although clusters are common, the initial conditions of cluster formation are still not well understood. To determine the processes involved in the formation and evolution of clusters it is key to determine the global properties of cluster-forming clumps in their earliest stages of evolution. Here, we present the physical properties of 1,244 clumps identified from the MALT90 survey. Using the dust temperature of the clumps as a proxy for evolution we determined how the clump properties change at different evolutionary stages. We find that less-evolved clumps exhibiting dust temperatures lower than 20 K have higher densities and are more gravitationally bound than more-evolved clumps with higher dust temperatures. We also identified a sample of clumps in a very early stage of evolution, thus potential candidates for high-mass star-forming clumps. Only one clump in our sample has physical properties consistent with a young massive cluster progenitor, reinforcing the fact that massive proto-clusters are very rare in the Galaxy.

Accepted by MNRAS

https://arxiv.org/pdf/1611.09871v1.pdf

A Transient Transit Signature Associated with the Young Star RIK-210

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We find transient, transit-like dimming events within the K2 time series photometry of the young star RIK-210 in the Upper Scorpius OB association. These dimming events are variable in depth, duration, and morphology. High spatial resolution imaging revealed the star is single, and radial velocity monitoring indicated that the dimming events can not be due to an eclipsing stellar or brown dwarf companion. Archival and follow-up photometry suggest the dimming events are transient in nature. The variable morphology of the dimming events suggests they are not due to a single, spherical body. The ingress of each dimming event is always shallower than egress, as one would expect for an orbiting body with a leading tail. The dimming events are periodic and synchronous with the stellar rotation. However, we argue it is unlikely the dimming events could be attributed to anything on the stellar surface based on the observed depths and durations. Variable obscuration by a protoplanetary disk is unlikely on the basis that the star is not actively accreting and lacks the infrared excess associated with an inner disk. Rather, we explore the possibilities that the dimming events are due to magnetospheric clouds, a transiting protoplanet surrounded by circumplanetary dust and debris, eccentric orbiting bodies undergoing periodic tidal disruption, or an extended field of dust or debris near the corotation radius.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1612.03907

Multiple rings in the transition disk and companion candidates around RX J1615.3-3255. High contrast imaging with VLT/SPHERE

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Context. The effects of a planet sculpting the disk from which it formed are most likely to be found in disks that are in transition between being classical protoplanetary and debris disks. Recent direct imaging of transition disks has revealed structures such as dust rings, gaps, and spiral arms, but an unambiguous link between these structures and sculpting planets is yet to be found. *Aims.* We aim to find signs of ongoing planet-disk interaction and study the distribution of small grains at the surface of the transition disk around RX J1615.3-3255 (RX J1615).
Methods. We observed RX J1615 with VLT/SPHERE. From these observations, we obtained polarimetric imaging with ZIMPOL (R' band) and IRDIS (J), and IRDIS ($H2H3$) dual-band imaging with simultaneous spatially resolved spectra with the IFS (YJ).
Results. We image the disk for the first time in scattered light and detect two arcs, two rings, a gap and an inner disk with marginal evidence for an inner cavity. The shapes of the arcs suggest that they are probably segments of full rings. Ellipse fitting for the two rings and inner disk yield a disk inclination $i = 47 \pm 2°$ and find semi-major axes of $1.50 \pm 0.01''$ (278 au), $1.06 \pm 0.01''$ (196 au) and $0.30 \pm 0.01''$ (56 au), respectively. We determine the scattering surface height above the midplane, based on the projected ring center offsets. Nine point sources are detected between $2.1''$ and $8.0''$ separation and considered as companion candidates. With NACO data we recover four of the nine point sources, which we determine to be not co-moving, and therefore unbound to the system.
Conclusions. We present the first detection of the transition disk of RX J1615 in scattered light. The height of the rings indicate limited flaring of the disk surface, which enables partial self-shadowing in the disk. The outermost arc either traces the bottom of the disk or it is another ring with semi-major axis $\gtrsim 2.35''$ (435 au). We explore both scenarios, extrapolating the complete shape of the feature, which will allow us to distinguish between the two in future observations. The most attractive scenario, where the arc traces the bottom of the outer ring, requires the disk to be truncated at $r \approx 360$ au. If the closest companion candidate is indeed orbiting the disk at 540 au, then it would be the most likely cause for such truncation. This companion candidate, as well as the remaining four, all require follow up observations to determine if they are bound to the system.

Accepted by A&A (595, A114)

https://arxiv.org/pdf/1610.04038v1

BP Piscium: its flaring disk imaged with SPHERE/ZIMPOL

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Whether BP Piscium (BP Psc) is either a pre-main sequence T Tauri star at $d \approx 80$ pc, or a post-main sequence G giant at $d \approx 300$ pc is still not clear. As a first-ascent giant, it is the first to be observed with a molecular and dust disk.

Alternatively, BP Psc would be among the nearest T Tauri stars with a protoplanetary disk (PPD). We investigate whether the disk geometry resembles typical PPDs, by comparing polarimetric images with radiative transfer models. Our VLT/SPHERE/ZIMPOL observations allow us to perform Polarimetric Differential Imaging; Reference Star Differential Imaging; and Richardson-Lucy deconvolution. We present the first visible light polarization and intensity images of the disk of BP Psc. Our deconvolution confirms the disk shape as detected before, mainly showing the southern side of the disk. In polarized intensity the disk is imaged at larger detail and also shows the northern side, giving it the typical shape of high inclination flared disks. We explain the observed disk features by retrieving the large-scale geometry with MCMax radiative transfer modeling, which yields a strongly flared model, atypical for disks of T Tauri stars.

Accepted by MNRAS

https://arxiv.org/pdf/1610.06609v1

Glycolaldehyde in Perseus young solar analogs

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Context: The earliest evolutionary stages of low-mass protostars are characterised by the so-called hot-corino stage, when the newly born star heats the surrounding material and enrich the gas chemically. Studying this evolutionary phase of solar protostars may help understand the evolution of prebiotic complex molecules in the development of planetary systems.
Aims: In this paper we focus on the occurrence of glycolaldehyde ($HCOCH_2OH$) in young solar analogs by performing the first homogeneous and unbiased study of this molecule in the Class 0 protostars of the nearby Perseus star forming region.
Methods: We obtained sub-arcsec angular resolution maps at 1.3mm and 1.4mm of glycolaldehyde emission lines using the IRAM Plateau de Bure (PdB) interferometer in the framework of the CALYPSO IRAM large program.
Results: Glycolaldehyde has been detected towards 3 Class 0 and 1 Class I protostars out of the 13 continuum sources targeted in Perseus: NGC1333-IRAS2A1, NGC1333-IRAS4A2, NGC1333-IRAS4B1, and SVS13-A. The NGC1333 star forming region looks particularly glycolaldehyde rich, with a rate of occurrence up to 60%. The glycolaldehyde spatial distribution overlaps with the continuum one, tracing the inner 100 au around the protostar. A large number of lines (up to 18), with upper-level energies $E_{\rm u}$ from 37 K up to 375 K has been detected. We derived column densities $\geq 10^{15}$ cm^{-2} and rotational temperatures $T_{\rm rot}$ between 115 K and 236 K, imaging for the first time hot-corinos around NGC1333-IRAS4B1 and SVS13-A.
Conclusions: In multiple systems glycolaldehyde emission is detected only in one component. The case of the SVS13-A+B and IRAS4-A1+A2 systems support that the detection of glycolaldehyde (at least in the present Perseus sample) indicates older protostars (i.e. SVS13-A and IRAS4-A2), evolved enough to develop the hot-corino region (i.e. 100 K in the inner 100 au). However, only two systems do not allow us to firmly conclude whether the primary factor leading to the detection of glycolaldehyde emission is the environments hosting the protostars, evolution (e.g. low value of $L_{\rm submm}/L_{\rm int}$), or accretion luminosity (high $L_{\rm int}$).

Accepted by A&A

http://arxiv.org/pdf/1701.00724

What is the Mass of a Gap-Opening Planet?

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High contrast imaging instruments such as GPI and SPHERE are discovering gap structures in protoplanetary disks at an ever faster pace. Some of these gaps may be opened by planets forming in the disks. In order to constrain planet formation models using disk observations, it is crucial to find a robust way to quantitatively back out the properties of the gap-opening planets, in particular their masses, from the observed gap properties, such as their depths and widths. Combing 2D and 3D hydrodynamics simulations with 3D radiative transfer simulations, we investigate the morphology of planet-opened gaps in near-infrared scattered light images. Quantitatively, we obtain correlations that directly link intrinsic gap depths and widths in the gas surface density to observed depths and widths in images of disks at modest inclinations under finite angular resolution. Subsequently, the properties of the surface density gaps enable us to derive the disk scale height at the location of the gap h, and to constrain the quantity ${M_\mathrm{p}}^2/\alpha$, where M_p is the mass of the gap-opening planet and α characterizes the viscosity in the gap. As examples, we examine the gaps recently imaged by VLT/SPHERE, Gemini/GPI, and Subaru/HiCIAO in HD 97048, TW Hya, HD 169142, LkCa 15, and RX J1615.3-3255. Scale heights of the disks and possible masses of the gap-opening planets are derived assuming each gap is opened by a single planet. Assuming $\alpha = 10^{-3}$, the derived planet mass in all cases are roughly between 0.1–1 M_J.

Accepted by ApJ

http://arxiv.org/pdf/1612.04821

Statistical link between the structure of molecular clouds and their density distribution

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We introduce the concept of a class of equivalence of molecular clouds represented by an abstract spherically symmetric, isotropic object. This object is described by use of abstract scales in respect to a given mass density distribution. Mass and average density are ascribed to each scale and thus are linked to the density distribution: a power-law type and an arbitrary continuous one. In the latter case, we derive a differential relationship between the mean density at a given scale and the structure parameter which defines the mass-density relationship. The two-dimensional (2D) projection of the cloud along the line of sight is also investigated. Scaling relations of mass and mean density are derived in the considered cases of power-law and arbitrary continuous distributions. We obtain relations between scaling exponents in the 2D and 3D cases. The proposed classes of equivalence are representative for the general structure of real clouds with various types of column-density distributions: power law, lognormal or combination of both.

Accepted by MNRAS

http://arxiv.org/pdf/1612.00340

First determination of s-process element abundances in pre-main sequence clusters: Y, Zr, La, and Ce in IC 2391, the Argus association and IC 2602

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Several high-resolution spectroscopic studies have provided compelling observational evidence that open clusters display a decreasing trend of their barium abundances as a function of the cluster's age. Young clusters (ages $\sim$ 200 Myr) exhibit significant enhancement in the [Ba/Fe] ratios, at variance with solar-age clusters where the Ba content has been found to be [Ba/Fe] $\sim$ 0 dex. Different viable solutions have been suggested in the literature, nevertheless, a conclusive interpretation of such a peculiar trend has not been found. Interestingly, it is debated whether the other species produced with Ba via *s*-process reactions do follow the same trend with age. Pre-main sequence clusters ($\sim$10–50 Myr) show the most extreme behaviour in this respect: their [Ba/Fe] ratios can reach 0.65 dex, which higher than the solar value by a factor of four. Crucially, there are no investigations of the other *s*-process species for these young stellar populations. In this paper we present, the first determination of Y, Zr, La, and Ce in clusters IC 2391, IC 2602 and the Argus association. The main objective of our work is to ascertain whether these elements reveal the same enhancement as Ba. Our results indicate that, at variance with Ba, all the other *s*-process species exhibit a solar scaled pattern: these clusters confirm a similar trend discovered in the slightly older local associations (e.g., AB Doradus, Carina Near), where only Ba exhibit enhanced value with all other s process species being solar. We have discussed several possible explanations such as e.g., chromospheric effects, departures from the LTE approximation, or the activation of a different nucleosynthesis chain. We cannot currently provide the definite answer to this question and future investigations from theoretical and observational perspectives are sorely needed.

Accepted by A&A

http://arxiv.org/pdf/1612.06406

VLT Spectroscopic Analysis of HH 202. Implications on dust destruction and thermal inhomogeneities

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We present a long-slit spectroscopic analysis of Herbig-Haro 202 and the surrounding gas of the Orion Nebula using data from the Very Large Telescope. Given the characteristics of the Orion Nebula, it is the ideal object to study the mechanisms that play a role in the evolution of H II regions, notably dust destruction by interstellar shocks, which is a poorly understood subject. The use of long-slit allowed us to determine the spatial variation in its physical conditions and chemical abundances observing a broad area of the Orion Nebula; our results are consistent with those from previous studies albeit with improved uncertainties in some determinations. Special attention is paid to Iron (Fe) and Oxygen (O) abundances, which show a peak at the apex of the shock, allowing us to estimate that 57% of the dust is the destroyed at this position; we also calculate the amount of depletion of oxygen in dust grains, which amounts to 0.126±0.024 dex. Finally we show that O abundances determined from collisionally excited lines and recombination lines are irreconcilable at the center of the shock unless thermal inhomogeneities are considered along the line of sight in the form of the t^2 parameter proposed by Peimbert (1967).

Accepted by Revista Mexicana de Astronomía y Astrofísica

http://arxiv.org/pdf/1612.04925

Star formation towards the Galactic HII region RCW120

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The expansion of H II regions can trigger the formation of stars. An overdensity of young stellar objects (YSOs) is observed at the edges of H II regions but the mechanisms that give rise to this phenomenon are not clearly identified. Moreover, it is difficult to establish a causal link between H II-region expansion and the star formation observed at the edges of these regions. A clear age gradient observed in the spatial distribution of young sources in the surrounding might be a strong argument in favor of triggering. We aim to characterize the star formation observed at the edges of H II regions by studying the properties of young stars that form there. We aim to detect young sources, derive their properties and their evolution stage in order to discuss the possible causal link between the first-generation massive stars that form the H II region and the young sources observed at their edges. We have observed the Galactic H II region RCW 120 with *Herschel* PACS and SPIRE photometers at 70, 100, 160, 250, 350 and 500 μm. We produced temperature and H_2 column density maps and use the *getsources* algorithm to detect compact sources and measure their fluxes at *Herschel* wavelengths. We have complemented these fluxes with existing infrared data. Fitting their spectral energy distributions (SEDs) with a modified blackbody model, we derived their envelope dust temperature and envelope mass. We computed their bolometric luminosities and discuss their evolutionary stages. The *Herschel* data, with their unique sampling of the far infrared domain, have allowed us to characterize the properties of compact sources observed towards RCW 120 for the first time. We have also been able to determine the envelope temperature, envelope mass and evolutionary stage of these sources. Using these properties we have shown that the density of the condensations that host star formation is a key parameter of the star-formation history, irrespective of their projected distance to the ionizing stars.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1612.08862

3D Radiation Non-ideal Magnetohydrodynamical Simulations Of The Inner Rim In Protoplanetary Disks

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Many planets orbit within an AU of their stars, raising questions about their origins. Particularly puzzling are the planets found near the silicate sublimation front. We investigate conditions near the front in the protostellar disk around a young intermediate-mass star, using the first global 3-D radiation non-ideal MHD simulations in this context. We treat the starlight heating; the silicate grains sublimation and deposition at the local, time-varying temperature and density; temperature-dependent Ohmic dissipation; and various initial magnetic fields. The results show magnetorotational turbulence around the sublimation front at 0.5 AU. The disk interior to 0.8 AU is turbulent, with velocities exceeding 10% of the sound speed. Beyond 0.8 AU is the dead zone, cooler than 1000 K and with turbulence orders of magnitude weaker. A local pressure maximum just inside the dead zone concentrates solid particles, favoring their growth. Over many orbits, a vortex develops at the dead zones inner edge, increasing the disks thickness locally by around 10%. We synthetically observe the results using Monte Carlo transfer calculations, finding the sublimation front is near-infrared bright. The models with net vertical magnetic fields develop extended, magnetically-supported atmospheres that reprocess extra starlight, raising the near-infrared flux 20%.The vortex throws a nonaxisymmetric shadow on the outer disk. At wavelengths $> 2\mu$m, the flux varies several percent on monthly timescales. The variations are more regular when the vortex is present. The vortex is directly visible as an

arc at ultraviolet through near-infrared wavelengths, given sub-AU spatial resolution.

Accepted by ApJ

http://arxiv.org/pdf/1612.02740

On the fragmentation boundary in magnetised self-gravitating discs

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We investigate the role of magnetic fields in the fragmentation of self-gravitating discs using 3D global ideal magnetohydrodynamic simulations performed with the "phantom" smoothed particle hydrodynamics code.
For initially toroidal fields, we find two regimes. In the first, where the cooling time is greater than five times the dynamical time, magnetic fields reduce spiral density wave amplitudes, which in turn suppresses fragmentation. This is the case even if the magnetic pressure is only a tenth of the thermal pressure. The second regime occurs when the cooling time is sufficiently short that magnetic fields cannot halt fragmentation.
We find that magnetised discs produce more massive fragments, due to both the additional pressure exerted by the magnetic field, and the additional angular momentum transport induced by Maxwell stresses. The fragments are confined to a narrower range of initial semimajor axes than those in unmagnetised discs. The orbital eccentricity and inclination distributions of unmagnetised and magnetised disc fragments are similar. Our results suggest the fragmentation boundary could be at cooling times a factor of two lower than predicted by purely hydrodynamical models.

Accepted by MNRAS

http://arxiv.org/pdf/1612.06145

Fragmentation of Kozai-Lidov Disks

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We analyze the gravitational instability (GI) of a locally isothermal inclined disk around one component of a binary system. Such a disk can undergo global Kozai-Lidov (KL) cycles if the initial disk tilt is above the critical KL angle (of about 40°). During these cycles, an initially circular disk exchanges its inclination for eccentricity, and vice versa. Self-gravity may suppress the cycles under some circumstances. However, with hydrodynamic simulations including self-gravity we show that for a sufficiently high initial disk tilts and for certain disk masses, disks can undergo KL oscillations and fragment due to GI, even when the Toomre Q value for an equivalent undisturbed disk is well within the stable regime ($Q > 2$). We suggest that KL triggered disk fragmentation provides a mechanism for the efficient formation of giant planets in binary systems and may enhance fragmentation of disks in massive black hole binaries.

Accepted by ApJL

http://arxiv.org/pdf/1612.07673

BANYAN. IX. The Initial Mass Function and Planetary-Mass Object Space Density of the TW Hya Association

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A determination of the initial mass function (IMF) of the current, incomplete census of the 10 Myr-old TW Hya association (TWA) is presented. This census is built from a literature compilation supplemented with new spectra and 17 new radial velocities, as well as a re-analysis of Hipparcos data that confirmed HR 4334 (A2Vn) as a member. Though the dominant uncertainty in the IMF remains census incompleteness, a detailed statistical treatment is carried out to make the IMF determination independent of binning, while accounting for small number statistics. The currently known high-likelihood members are fitted by a log-normal distribution with a central mass of $0.21^{+0.11}_{-0.06}$ $M_{\odot}$ and a characteristic width of $0.8^{+0.2}_{-0.1}$ dex in the 12 $M_{\rm Jup}$–2 $M_{\odot}$ range, whereas a Salpeter power law with $\alpha = 2.2^{+1.1}_{-0.5}$ best describes the IMF slope in the 0.1–2 $M_{\odot}$ range. This characteristic width is higher than other young associations, which may be due to incompleteness in the current census of low-mass TWA stars. A tentative overpopulation of isolated planetary-mass members similar to 2MASS J11472421−2040204 and 2MASS J11193254−1137466 is identified: this indicates that there might be as many as 10^{+13}_{-5} similar members of TWA with hot-start model-dependent masses estimated at ∼5–7 $M_{\rm Jup}$, most of which would be too faint to be detected in 2MASS. Our new radial velocity measurements corroborate the membership of 2MASS J11472421−2040204, and secure TWA 28 (M8.5γ), TWA 29 (M9.5γ) and TWA 33 (M4.5e) as members. The discovery of 2MASS J09553336−0208403, a young L7-type interloper unrelated to TWA, is also presented.

Accepted by ApJS

http://arxiv.org/pdf/1612.02881

Star Formation In Nearby Clouds (SFiNCs): X-ray And Infrared Source Catalogs And Membership

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The Star Formation in Nearby Clouds (SFiNCs) project is aimed at providing detailed study of the young stellar populations and star cluster formation in nearby 22 star forming regions (SFRs) for comparison with our earlier MYStIX survey of richer, more distant clusters. As a foundation for the SFiNCs science studies, here, homogeneous data analyses of the Chandra X-ray and Spitzer mid-infrared archival SFiNCs data are described, and the resulting catalogs of over 15300 X-ray and over 1630000 mid-infrared point sources are presented. On the basis of their X-

ray/infrared properties and spatial distributions, nearly 8500 point sources have been identified as probable young stellar members of the SFiNCs regions. Compared to the existing X-ray/mid-infrared publications, the SFiNCs member list increases the census of YSO members by 6-200% for individual SFRs and by 40% for the merged sample of all 22 SFiNCs SFRs.

Accepted by The Astrophysical Journal Supplement Series

https://arxiv.org/pdf/1612.05282

Atomic Gas in Debris Discs

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We have conducted a search for optical circumstellar absorption lines in the spectra of 16 debris disc host stars. None of the stars in our sample showed signs of emission line activity in either H_α, Ca II or Na I, confirming their more evolved nature. Four stars were found to exhibit narrow absorption features near the cores of the photospheric Ca II and Na I D lines (when Na I D data were available). We analyse the characteristics of these spectral features to determine whether they are of circumstellar or interstellar origins. The strongest evidence for circumstellar gas is seen in the spectrum of HD 110058, which is known to host a debris disc observed close to edge-on. This is consistent with a recent ALMA detection of molecular gas in this debris disc, which shows many similarities to the β Pictoris system.

Accepted by MNRAS

https://arxiv.org/pdf/1612.05465

Deuteration of ammonia in the starless core Ophiuchus/H-MM1

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Ammonia and its deuterated isotopologues probe physical conditions in dense molecular cloud cores. The time-dependence of deuterium fractionation and the relative abundances of different nuclear spin modifications are supposed to provide a means of determining the evolutionary stages of these objects. We aim to test the current understanding of spin-state chemistry of deuterated species by determining the abundances and spin ratios of NH_2D, NHD_2 and ND_3 in a quiescent, dense cloud. Spectral lines of NH_3, NH_2D, NHD_2, ND_3 and N_2D^+ were observed towards a dense, starless core in Ophiuchus with the APEX, GBT and IRAM 30-m telescopes. The observations were interpreted using a gas-grain chemistry model combined with radiative transfer calculations. The chemistry model distinguishes

between the different nuclear spin states of light hydrogen molecules, ammonia and their deuterated forms. Different desorption schemes can be considered. High deuterium fractionation ratios with $NH_2D/NH_3 \sim 0.4$, $NHD_2/NH_2D \sim 0.2$ and $ND_3/NHD_2 \sim 0.06$ are found in the core. The observed *ortho/para* ratios of NH_2D and NHD_2 are close to the corresponding nuclear spin statistical weights. The chemistry model can approximately reproduce the observed abundances, but consistently predicts too low *ortho/para*-NH_2D, and too large *ortho/para*-NHD_2 ratios. The longevity of N_2H^+ and NH_3 in dense gas, which is prerequisite to their strong deuteration, can be attributed to the chemical inertia of N_2 on grain surfaces. The discrepancies between the chemistry model and the observations are likely to be caused by the fact that the model assumes complete scrambling in principal gas-phase deuteration reactions of ammonia, which means that all the nuclei are mixed in reactive collisions. If, instead, these reactions occur through proton hop/hydrogen abstraction processes, statistical spin ratios are to be expected. The present results suggest that while the deuteration of ammonia changes with physical conditions and time, the nuclear spin ratios of ammonia isotopologues do not probe the evolutionary stage of a cloud.

Accepted by A&A

https://arxiv.org/pdf/1604.05602v2

Spiral-driven accretion in protoplanetary discs - III tri-dimensional simulations

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Understanding how accretion proceeds in proto-planetary discs and more generally their dynamics is a crucial issue for explaining the conditions in which planets form. The role that accretion of gas from the surrounding molecular cloud onto the disc may have on its structure needs to be quantified. We perform tri-dimensional simulations using the Cartesian AMR code RAMSES of an accretion disc subject to infalling material. For the aspect ratio of $H/R \simeq 0.15$ and disk mass $M_d \simeq 10^{-2} M_\odot$ used in our study, we find that for typical accretion rates on the order of a few $10^{-7} M_\odot yr^{-1}$, values of the α parameter as high as a few 10^{-3} are inferred. The mass that is accreted in the inner part of the disc is typically at least 50% of the total mass that has been accreted onto the disc. Our results suggest that external accretion of gas at moderate values, onto circumstellar discs may trigger prominent spiral arms, reminiscent of recent observations made with various instruments, and lead to significant transport through the disc. If confirmed from observational studies, such accretion may therefore influence disc evolution.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1611.07376

Probes of turbulent driving mechanisms in molecular clouds from fluctuations in synchrotron intensity

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Previous studies have shown that star formation depends on the driving of molecular cloud turbulence, and differences in the driving can produce an order of magnitude difference in the star formation rate. The turbulent driving is characterised by the parameter ζ, with $\zeta = 0$ for compressive, curl-free driving (e.g. accretion or supernova explosions), and $\zeta = 1$ for solenoidal, divergence-free driving (e.g. Galactic shear). Here we develop a new method to measure ζ from observations of synchrotron emission from molecular clouds. We calculate statistics of mock synchrotron intensity images produced from magnetohydrodynamic simulations of molecular clouds, in which the driving was controlled to produce different values of ζ. We find that the mean and standard deviation of the log-normalised synchrotron intensity are sensitive to ζ, for values of ζ between 0 (curl-free driving) and 0.5 (naturally-mixed driving). We quantify the dependence of zeta on the direction of the magnetic field relative to the line of sight. We provide best-fit formulae for ζ in terms of the log-normalised mean and standard deviation of synchrotron intensity, with which ζ can be determined for molecular clouds that have similar Alfvénic Mach number to our simulations. These formulae are independent of the sonic Mach number. Signal-to-noise ratios larger than 5, and angular resolutions smaller than 5% of the cloud diameter, are required to apply these formulae. Although there are no firm detections of synchrotron emission from molecular clouds, by combining Green Bank Telescope and Very Large Array observations it should be possible to detect synchrotron emission from molecular clouds, thereby constraining the value of ζ.

Accepted by MNRAS

http://arxiv.org/pdf/1612.05672

$\mathcal{Q}^+$: Characterising the structure of young star clusters

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Many young star clusters appear to be fractal, i.e. they appear to be concentrated in a nested hierarchy of clusters within clusters. We present a new algorithm for statistically analysing the distribution of stars to quantify the level of sub-structure. We suggest that, even at the simplest level, the internal structure of a fractal cluster requires the specification of three parameters. (i) The 3D fractal dimension, $\mathcal{D}$, measures the extent to which the clusters on one level of the nested hierarchy fill the volume of their parent cluster. (ii) The number of levels, $\mathcal{L}$, reflects the finite ratio between the linear size of the large root-cluster at the top of the hierarchy, and the smallest leaf-clusters at the bottom of the hierarchy. (iii) The volume-density scaling exponent, $\mathcal{C} = -\mathrm{d}\ln[\delta n]/\mathrm{d}\ln[L]$ measures the factor by which the excess density, δn, in a structure of scale L, exceeds that of the background formed by larger structures; it is similar, but not exactly equivalent, to the exponent in Larson's scaling relation between density and size for molecular clouds. We describe an algorithm which can be used to constrain the values of $(\mathcal{D}, \mathcal{L}, \mathcal{C})$ and apply this method to artificial and observed clusters. We show that this algorithm is able to reliably describe the three dimensional structure of an artificial star cluster from the two dimensional projection, and quantify the varied structures observed in real and simulated clusters.

Accepted by MNRAS

https://arxiv.org/pdf/1611.10149

Gaps in Protoplanetary Disks as Signatures of Planets: III. Polarization

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Polarimetric observations of T Tauri and Herbig Ae/Be stars are a powerful way to image protoplanetary disks. However, interpretation of these images is difficult because the degree of polarization is highly sensitive to the angle of scattering of stellar light off the disk surface. We examine how disks with and without gaps created by planets appear in scattered polarized light as a function of inclination angle. Isophotes of inclined disks without gaps are distorted in polarized light, giving the appearance that the disks are more eccentric or more highly inclined than they truly are. Apparent gap locations are unaffected by polarization, but the gap contrast changes. In face-on disks with gaps, we find that the brightened far edge of the gap scatters less polarized light than the rest of the disk, resulting in slightly decreased contrast between the gap trough and the brightened far edge. In inclined disks, gaps can take on the appearance of being localized "holes" in brightness rather than full axisymmetric structures. Photocenter offsets along the minor axis of the disk in both total intensity and polarized intensity images can be readily explained by the finite thickness of the disk. Alone, polarized scattered light images of disks do not necessarily reveal intrinsic disk structure. However, when combined with total intensity images, the orientation of the disk can be deduced and much can be learned about disk structure and dust properties.

Accepted by ApJ

http://arxiv.org/pdf/1612.02854

Binaries among low-mass stars in nearby young moving groups

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The solar galactic neighbourhood contains a number of young co-moving associations of stars (so-called 'young moving groups') with ages of ∼10–150 Myr, which are prime targets for a range of scientific studies, including direct imaging planet searches. The late-type stellar population of such groups still remain in their pre-main sequence phase, and are thus well suited for purposes such as isochronal dating. Close binaries are particularly useful in this regard, since they allow for a model-independent dynamical mass determination. Here we present a dedicated effort to identify new close binaries in nearby young moving groups, through high-resolution imaging with the AstraLux Sur Lucky Imaging camera. We surveyed 181 targets, resulting in the detection of 61 companions or candidates, of which 38 are new discoveries. An interesting example of such a case is 2MASS J00302572−6236015 AB, which is a high-probability member of the Tucana-Horologium moving group, and has an estimated orbital period of less than 10 years. Among the previously known objects is a serendipitous detection of the deuterium burning boundary circumbinary companion 2MASS J01033563−5515561 (AB)b in the z'-band, thereby extending the spectral coverage for this object down to near-visible wavelengths.

Accepted by A&A

http://arxiv.org/pdf/1612.02443

Multiplicity and clustering in Taurus star-forming region. I. Unexpected ultra-wide pairs of high-order multiplicity in Taurus

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We collected the multiplicity data of stars in Taurus to build an up-to-date stellar/multiplicity catalog. After a general study of nearest-neighbor statistics on spatial random distribution, we introduce the one-point correlation Ψ function to complement the pair correlation function and define the spatial regimes departing from randomness in Taurus. We then perform a set of statistical studies to characterize the binary regime that prevails in Taurus. The Ψ function in Taurus has a scale-free trend with a similar exponent as the correlation function at small scale. It extends almost 3 decades up to ∼60 kAU showing a potential extended wide binary regime. This was hidden in the correlation function due to the clustering pattern blending. Distinguishing two stellar populations, single stars versus multiple systems (separation ≤1 kAU), within Class II/III stars observed at high angular resolution, we highlight a major spatial neighborhood difference between the two populations using nearest-neighbor statistics. The multiple systems are three times more likely to have a distant companion within 10 kAU when compared to single stars. We show that this is due to the presence of most probable physical ultra-wide pairs. These UWPs are biased towards high multiplicity and higher-stellar-mass components at shorter separations. The multiplicity fraction per ultra-wide pair with separation less than 10 kAU may be as high as 83.5±19.6%. We suggest that these young pre-main sequence UWPs may be pristine imprints of their spatial configuration at birth resulting from a cascade fragmentation scenario of the natal molecular core. They could be the older counterparts, at least for those separated by less than 10 kAU, to the ≤0.5 Myr prestellar cores/Class 0 multiple objects observed at radio/mm wavelengths.

Accepted by A&A

http://arxiv.org/pdf/1612.02098

Interferometric Evidence for Quantum Heated Particles in the Inner Region of Protoplanetary Disks around Herbig Stars

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To understand the chemical composition of planets, it is important to know the chemical composition of the region where they form in protoplanetary disks. Due to its fundamental role in chemical and biological processes, carbon is a key element to trace. We aim to identify the carriers and processes behind the extended NIR flux observed around several Herbig stars. We compare the extended NIR flux from objects in the PIONIER Herbig Ae/Be survey with their flux in the PAH features. HD 100453 is used as a benchmark case to investigate the influence of quantum heated particles, like PAHs or very small carbonaceous grains, in more detail. We use the Monte Carlo radiative transfer code MCMax to do a parameter study of the QHP size and scale- height and examine the influence of quantum heating on the amount of extended flux in the NIR visibilities. There is a correlation between the PAH feature flux of a disk and the amount of its extended NIR flux. We find that very small carbonaceous grains create the observed extended NIR flux around HD 100453 and still lead to a realistic SED. These results can not be achieved without using quantum heating effects, e.g. only with scattered light and grains in thermal equilibrium. It is possible to explain the extended NIR emission around Herbig stars with the presence of carbonaceous, quantum heated particles. Interferometric observations can be used to constrain the spatial distribution and typical size of carbonaceous material in the terrestrial planet forming region.

Accepted by A&A

https://arxiv.org/pdf/1612.06311

Brightness variations of the FUor-type eruptive star V346 Nor

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Decades after the beginning of its FU Orionis-type outburst, V346 Nor unexpectedly underwent a fading event of $\Delta K = 4.6$ mag around 2010. We obtained near-infrared observations and re-analyzed data from the VISTA/VVV survey to outline the brightness evolution. In our VLT/NaCO images, we discovered a halo of scattered light around V346 Nor with a size of about 0.04 arcsec (30 au). The VISTA data outlined a well-defined minimum in the light curve in late 2010/early 2011, and tentatively revealed a small-amplitude periodic modulation of 58 days. Our latest data points from 2016 demonstrate that the source is still brightening but has not yet reached the 2008 level. We used a simple accretion disk model with varying accretion rate and line-of-sight extinction to reproduce the observed near-infrared magnitudes and colors. We found that the flux changes of V346 Nor before 2008 were caused by a correlated change of extinction and accretion rate, while the minimum around 2010 was mostly due to decreasing accretion. The source reached a highest accretion rate of $\approx 10^{-4}\,M_\odot\,\mathrm{yr}^{-1}$ in 1992. A combination of accretion and extinction changes has been invoked in the literature to interpret the flux variations of certain embedded young eruptive stars.

Accepted by Astronomy & Astrophysics Letters

https://arxiv.org/pdf/1701.00250

A high-mass protobinary system with spatially resolved circumstellar accretion disks and circumbinary disk

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High-mass multiples might form via fragmentation of self-gravitational disks or alternative scenarios such as disk-assisted capture. However, only few observational constraints exist on the architecture and disk structure of high-mass protobinaries and their accretion properties. Here we report the discovery of a close (57.9 ± 0.2mas=170au) high-mass protobinary, IRAS17216-3801, where our VLTI/GRAVITY+AMBER near-infrared interferometry allows us to image the circumstellar disks around the individual components with 3 milliarcsecond resolution. We estimate the component masses to ~ 20 and $\sim 18 M_{\odot}$ and find that the radial intensity profiles can be reproduced with an irradiated disk model, where the inner regions are excavated of dust, likely tracing the dust sublimation region in these disks. The circumstellar disks are strongly misaligned with respect to the binary separation vector, which indicates that the tidal forces did not have time to realign the disks, pointing towards a young dynamical age of the system. We constrain the distribution of the Brγ and CO-emitting gas using VLTI/GRAVITY spectro-interferometry and VLT/CRIRES spectro-astrometry and find that the secondary is accreting at a higher rate than the primary. VLT/NACO imaging shows L'-band emission on $3-4\times$ larger scales than the binary separation, matching the expected dynamical truncation radius for the circumbinary disk. The IRAS17216-3801 system is $\sim 3\times$ more massive and $\sim 5\times$ more compact than other high-mass multiplies imaged at infrared wavelengths and the first high-mass protobinary system where circumstellar and circumbinary dust disks could be spatially resolved. This opens exciting new opportunities for studying star-disk interactions and the role of multiplicity in high-mass star formation.

Accepted by Astrophysical Journal Letters

http://arxiv.org/pdf/1612.07804

Synthetic Observations of Magnetic Fields in Protostellar Cores

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The role of magnetic fields in the early stages of star formation is not well constrained. In order to discriminate between different star formation models, we analyze 3D magnetohydrodynamic simulations of low-mass cores and explore the correlation between magnetic field orientation and outflow orientation over time. We produce synthetic observations of dust polarization at resolutions comparable to millimeter-wave dust polarization maps observed by the Combined Array for Research in Millimeter-wave Astronomy and compare these with 2D visualizations of projected magnetic field and column density. Cumulative distribution functions of the projected angle between the magnetic field and outflow show different degrees of alignment in simulations with differing mass-to-flux ratios. The distribution function for the less magnetized core agrees with observations finding random alignment between outflow and field orientations, while the more magnetized core exhibits stronger alignment. We find that fractional polarization increases when the system is viewed such that the magnetic field is close to the plane of the sky, and the values of fractional polarization are consistent with observational measurements. The simulation outflow, which reflects the underlying angular momentum of the accreted gas, changes direction significantly over the first ~ 0.1 Myr of evolution. This movement could lead to

the observed random alignment between outflows and the magnetic fields in protostellar cores.

Accepted by the Astrophysical Journal

http://arxiv.org/pdf/1611.08530

The Hawaii Infrared Parallax Program. II. Young Ultracool Field Dwarfs

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We present a large, uniform analysis of young (∼10–150 Myr) ultracool dwarfs, based on new high-precision IR parallaxes for 68 objects. We find that low-gravity (VL-G) late-M and L dwarfs form a continuous sequence in IR color-magnitude diagrams, separate from field objects and current theoretical models. VL-G objects also appear distinct from young substellar (brown dwarf and exoplanet) companions, suggesting the two populations have a different range of physical properties. In contrast, at the L/T transition, young, old, and peculiar objects all span a narrow range in near-IR absolute magnitudes. At a given spectral type, the IR absolute magnitudes of young objects can be offset from ordinary field dwarfs, with the largest offsets occurring in the Y and J bands for late-M dwarfs (brighter than the field) and mid/late-L dwarfs (fainter than the field). Overall, low-gravity (VL-G) objects have the most uniform photometric behavior while intermediate-gravity (INT-G) objects are more diverse, suggesting a third governing parameter beyond spectral type and gravity class. We examine the moving group memberships for all young ultracool dwarfs with parallaxes, changing/refuting the status of 23 objects and fortifying the status of another 28 objects. We use our resulting age-calibrated sample to establish empirical young isochrones and find a declining frequency of VL-G objects relative to INT-G objects with increasing age. Notable objects in our sample include high-velocity INT-G objects; very red, late-L dwarfs with high surface gravities; candidate disk-bearing members of the MBM20 cloud and β Pic moving group; and very young distant interlopers. Finally, we provide a comprehensive summary of the absolute magnitudes and spectral classifications of 102 young ultracool dwarfs, found in the field and as substellar companions to young stars.

Accepted by ApJ

http://arxiv.org/pdf/1612.02426

A Survey for New Members of the Taurus Star-Forming Region with the Sloan Digital Sky Survey

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Previous studies have found that ~ 1 deg^2 fields surrounding the stellar aggregates in the Taurus star-forming region exhibit a surplus of solar-mass stars relative to denser clusters like IC 348 and the Orion Nebula Cluster. To test whether this difference reflects mass segregation in Taurus or a variation in the IMF, we have performed a survey for members of Taurus across a large field (∼40 deg^2) that was imaged by the Sloan Digital Sky Survey (SDSS). We obtained optical and near-infrared spectra of candidate members identified with those images and the Two Micron All Sky Survey, as well as miscellaneous candidates that were selected with several other diagnostics of membership. We have classified 22 of the candidates as new members of Taurus, which includes one of the coolest known members (M9.75). Our updated census of members within the SDSS field shows a surplus of solar-mass stars relative to clusters, although it is less pronounced than in the smaller fields towards the stellar aggregates that were surveyed for previously measured mass functions in Taurus. In addition to spectra of our new members, we include in our study near-IR spectra of roughly half of the known members of Taurus, which are used to refine their spectral types and extinctions. We also present an updated set of near-IR standard spectra for classifying young stars and brown dwarfs

at M and L types.

Accepted by The Astronomical Journal (153, 46, 2017)

http://arxiv.org/pdf/1610.09412.pdf

Chemistry of TMC-1 with multiply deuterated species and spin chemistry of H_2, $H_2{}^+$, $H_3{}^+$ and their isotopologues

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Deuterated species are unique and powerful tools in astronomy since they can probe the physical conditions, chemistry, and ionization level of various astrophysical media. Recent observations of several deuterated species along with some of their spin isomeric forms have rekindled the interest for more accurate studies on deuterium fractionation. This paper presents the first publicly available chemical network of multiply deuterated species along with spin chemistry implemented on the latest state-of-the-art gas-grain chemical code 'NAUTILUS'. D/H ratios for all deuterated species observed at different positions of TMC-1 are compared with the results of our model, which considers multiply deuterated species along with the spin chemistry of light hydrogen bearing species H_2, $H_2{}^+$, $H_3{}^+$ and their isotopologues. We also show the differences in the modeled abundances of non-deuterated species after the inclusion of deuteration and spin chemistry in the model. Finally, we present a list of potentially observable deuterated species in TMC-1 awaiting detection.

Accepted by MNRAS

http://arxiv.org/pdf/1612.07845

Collisional parameters of planetesimal belts, precursor of debris disks, perturbed by a nearby giant planet

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Planetesimal belts are invoked to explain the prolonged existence of debris disks. Important parameters to model their collisional evolution and to compute the dust production rate are the intrinsic probability of collision P_i and the mean impact velocity U_c. If a planet orbits close to the belt, the values of both these parameters are affected by its secular perturbations yielding a strong correlation between eccentricity e and pericentre longitude ϖ. We adopt a new algorithm to compute both P_i and U_c in presence of various levels of secular correlation due to different ratios between proper and forced eccentricity. We tested this algorithm in a standard case with a Jupiter–sized planet orbiting inside a putative planetesimal belt finding that it is less collisionally active compared to a self–stirred belt because of the e–ϖ coupling. The eccentricity of the planet is an important parameter in determining the amount of dust production since the erosion rate is 10 times faster when the planet eccentricity increases from 0.1 to 0.6. Also the initial conditions of the belt (either warm or cold) and its average inclination strongly affects P_i and U_c and then its long term collisional evolution in presence of the planet. We finally apply our method to the planetesimal belts supposedly refilling the dust disks around HD 38529 and ϵ Eridani. In the most collisionally active configurations, only a small fraction of bodies smaller than 100 km are expected to be fragmented over a time–span of 4 Gyr.

Accepted by MNRAS

http://arxiv.org/pdf/1612.08635

The gravitational interaction between planets on inclined orbits and protoplanetary disks as the origin of primordial spin–orbit misalignments

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Many of the observed spin–orbit alignment properties of exoplanets can be explained in the context of the primordial disk misalignment model, in which an initially aligned protoplanetary disk is torqued by a distant stellar companion on a misaligned orbit, resulting in a precessional motion that can lead to large-amplitude oscillations of the spin–orbit angle. We consider a variant of this model in which the companion is a giant planet with an orbital radius of a few au. Guided by the results of published numerical simulations, we model the dynamical evolution of this system by dividing the disk into inner and outer parts—separated at the location of the planet—that behave as distinct, rigid disks. We show that the planet misaligns the inner disk even as the orientation of the outer disk remains unchanged. In addition to the oscillations induced by the precessional motion, whose amplitude is larger the smaller the initial inner-disk-to-planet mass ratio, the spin–orbit angle also exhibits a secular growth in this case—driven by ongoing mass depletion from the disk—that becomes significant when the inner disk's angular momentum drops below that of the planet. Altogether, these two effects can produce significant misalignment angles for the inner disk, including retrograde configurations. We discuss these results within the framework of the Stranded Hot Jupiter scenario and consider their implications, including to the interpretation of the alignment properties of debris disks.

Accepted by AJ

http://arxiv.org/pdf/1612.01985

Age of the magnetically active WW Psa and TX Psa members of the β Pictoris association

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There are a variety of different techniques available to estimate the ages of pre-main-sequence stars. Components of physical pairs, thanks to their strict coevality and the mass difference, such as the binary system analysed in this paper, are best suited to test the effectiveness of these different techniques. We consider the system WW Psa + TX Psa whose membership of the 25-Myr β Pictoris association has been well established by earlier works. We investigate which age dating technique provides the best agreement between the age of the system and that of the association. We have photometrically monitored WW Psa and TX Psa and measured their rotation periods as P = 2.37 d and P = 1.086 d, respectively. We have retrieved from the literature their Li equivalent widths and measured their effective temperatures and luminosities. We investigate whether the ages of these stars derived using three independent techniques, that is based on rotation, Li equivalent widths, and the position in the HR diagram are consistent with the age of the β Pictoris association. We find that the rotation periods and the Li contents of both stars are consistent with the distribution of other bona fide members of the cluster. On the contrary, the isochronal! fitting provides similar ages for both stars, but a factor of about four younger than the quoted age of the association, or about 30% younger when the effects of magnetic fields are included. We explore the origin of the discrepant age inferred from isochronal fitting, including the possibilities that either the two components may be unresolved binaries or that the basic stellar parameters of both components are altered by enhanced magnetic activity. The latter is found

to be the more reasonable cause, suggesting that age estimates based on the Li content is more reliable than isochronal fitting for pre-main-sequence stars with pronounced magnetic activity

Accepted by Astronomy and Astrophysics; DOI:

http://dx.doi.org/10.1051/0004-6361/201629797
http://arxiv.org/pdf/1612.04597

Lupus disks with faint CO isotopologues: low gas/dust or large carbon depletion?

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An era has started in which gas and dust can be observed independently in protoplanetary disks, thanks to the recent surveys with ALMA. The first near-complete high-resolution disk survey in both dust and gas in a single star-forming region has been carried out in Lupus, finding surprisingly low gas/dust ratios. The goal of this work is to fully exploit CO isotopologues observations in Lupus, comparing them with physical-chemical model results, in order to obtain gas masses for a large number of disks. We have employed physical-chemical models to analyze continuum and CO isotopologues observations of Lupus disks, including isotope-selective processes and freeze-out. Employing also the ALMA ^{13}CO-only detections, disk gas masses have been calculated for a total of 34 sources, expanding the sample of 10 disks studied by Ansdell et al. (2016), where also C^{18}O was detected. We confirm that overall gas-masses are very low, often smaller than 1 $M_{\rm J}$, if volatile carbon is not depleted. Accordingly, global gas/dust ratios predominantly between 1 and 10. Low CO-based gas masses and gas/dust ratios may indicate rapid loss of gas, or alternatively chemical evolution, e.g. via sequestering of carbon from CO to more complex molecules, or carbon locked up in larger bodies. Current ALMA observations cannot distinguish between these two hypotheses. We have simulated both scenarios, but chemical model results do not allow us to rule out one of the two. Assuming that all Lupus disks have evolved mainly due to viscous processes over the past few Myr, the observed correlation between the current mass accretion rate and dust mass found by Manara et al. (2016) implies a constant gas-to-dust ratio, which is close to 100 based on the observed $M_{\rm disk}/\dot{M}_{\rm acc}$ ratio. This in turn points to a scenario in which carbon depletion is responsible for the low CO isotopologue line luminosities.

Accepted by A&A

http://arxiv.org/pdf/1612.01538

The Scaling Relations and Star Formation Laws of Mini-starburst Complexes

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The scaling relations and star formation laws for molecular cloud complexes (MCCs) in the Milky Way are investigated. MCCs are mostly large ($R > 50$ pc), massive ($\sim 10^6 M_\odot$) gravitationally unbound cloud structures. We compare their masses Mgas, mass surface densities $\Sigma_{M_{gas}}$, radii R, velocity dispersions σ, star formation rates (SFRs), and

SFR densities Σ_{SFR} with those of structures ranging from cores, clumps, and giant molecular clouds, to MCCs, and galaxies, spanning eight orders of magnitudes in size and 13 orders of magnitudes in mass. This results in the following universal relations: $\sigma \sim R^{0.5}$, $M_{gas} \sim R^2$, $\Sigma_{SFR} \sim \Sigma_{M_{gas}}^{1.5}$, $SFR \sim {M_{gas}}^{0.9}$, and $SFR \sim \sigma^{2.7}$. Variations in the slopes and coefficients of these relations are found at individual scales, signifying different physics acting at different scales. Additionally, there are breaks at the MCC scale in the $\sigma - R$ relation and between starburst and normal star-forming objects in the SFR–M_{gas} and $\Sigma_{SFR} \sim \Sigma_{M_{gas}}$ relations. Therefore, we propose to use the Schmidt-Kennicutt diagram to distinguish starburst from normal star-forming structures by applying a $\Sigma_{M_{gas}}$ threshold of $\sim 100 M_\odot$ pc^{-2} and a Σ_{SFR} threshold of $1 M_\odot$ yr^{-1} pc^{-2}. Mini-starburst complexes are gravitationally unbound MCCs that have enhanced Σ_{SFR} (>1 $M_\odot$ yr^{-1} pc^{-2}), probably caused by dynamic events such as radiation pressure, colliding flows, or spiral arm gravitational instability. Because of dynamical evolution, gravitational boundedness does not play a significant role in regulating the star formation activity of MCCs, especially the mini-starburst complexes, which leads to the dynamical formation of massive stars and clusters. We emphasize the importance of understanding mini-starbursts in investigating the physics of starburst galaxies.

Accepted by ApJ

http://adsabs.harvard.edu/abs/2016ApJ...833...23N
http://arxiv.org/pdf/1605.01104

The hybrid disks: a search and study to better understand evolution of disks

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The increased sensitivity of millimeter-wave facilities now makes possible the detection of low amounts of gas in debris disks. Some of the gas-rich debris disks harbor peculiar properties, with possible pristine gas and secondary generated dust. The origin of the gas in these hybrid disks is strongly debated and the current sample is too sparse to understand this phenomenon. More detections are necessary to increase the statistics on this population. Lying at the final stages of evolution of proto-planetary disks and at the beginning of the debris disk phase, these objects could provide new insight into the processes involved in the making of planetary systems. We carried out a deep survey of the ^{12}CO(2–1) and ^{12}CO(3–2) lines with the APEX and IRAM radiotelescopes in young debris disks selected according to hybrid disk properties. The survey is complemented with a bibliographic study of the ratio between the emission of the gas and the continuum ($S_{\rm CO}/F_{\rm cont}$) in CTTS, Herbig Ae, WTTS, hybrid, and debris disks. Our sub-mm survey comprises 25 stars, including 17 new targets, and we increase the sensitivity limit by a factor 2 on eight sources compared to similar published studies. We report a 4σ tentative detection of a double-peaked ^{12}CO(2–1) line around HD23642; an eclipsing binary located in the Pleiades. We also reveal a correlation between the emission of the CO gas and the dust continuum from CTTS, Herbig Ae and few debris disks. The observed trend of the gas to dust flux ratio suggests a concurrent dissipation of the dust and gas components. Hybrid disks systematically lie above this trend, suggesting that these systems may witness a transient phase, when the dust has evolved more rapidly than the gas, with a flux ratio $S_{\rm CO}/F_{\rm cont}$ enhanced by a factor of between 10 and 100 compared to standard (proto-)planetary disks.

Accepted by A&A

http://arxiv.org/pdf/1612.06582

Young Stellar Populations in MYStIX Star Forming Regions: Candidate Protostars

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The Massive Young Star Forming Complex in Infrared and X-ray (MYStIX) project provides a new census on stellar members of massive star forming regions within 4 kpc. Here the MYStIX Infrared Excess catalog (MIRES) and Chandra-based X-ray photometric catalogs are mined to obtain high-quality samples of Class I protostars using criteria designed to reduce extragalactic and Galactic field star contamination. A total of 1,109 MYStIX Candidate Protostars (MCPs) are found in 14 star forming regions. Most are selected from protoplanetary disk infrared excess emission, but 20% are found from their ultrahard X-ray spectra from heavily absorbed magnetospheric flare emission. Two-thirds of the MCP sample is newly reported here. The resulting samples are strongly spatially associated with molecular cores and filaments on Herschel far-infrared maps. This spatial agreement and other evidence indicate that the MCP sample has high reliability with relatively few false positives from contaminating populations. But the limited sensitivity and sparse overlap among the infrared and X-ray subsamples indicate that the sample is very incomplete with many false negatives. Maps, tables, and source descriptions are provided to guide further study of star formation in these regions. In particular, the nature of ultrahard X-ray protostellar candidates without known infrared counterparts needs to be elucidated.

Accepted by ApJ (833, 193)

http://www.astro.psu.edu/mystix

HCN hyperfine ratio analysis of massive molecular clumps

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We report a new analysis protocol for HCN hyperfine data, based on the PYSPECKIT package, and results of using this new protocol to analyse a sample area of seven massive molecular clumps from the Census of High- and Medium-mass Protostars (CHaMP) survey, in order to derive maps of column density for this species. There is a strong correlation between the HCN integrated intensity, $I_{\rm HCN}$, and previously reported $I_{\rm HCO^+}$ in the clumps, but $I_{\rm N_2H^+}$ is not well correlated with either of these other two "dense gas tracers". The four fitted parameters from PYSPECKIT in this region fall in the range of $V_{\rm LSR}$ = 8-10 km/s, σ V = 1.2-2.2 km/s, $T_{\rm ex}$ = 4-15 K, and τ = 0.2-2.5 . These parameters allow us to derive a column density map of these clouds, without limiting assumptions about the excitation or opacity. A more traditional (linear) method of converting $I_{\rm HCN}$ to total mass column gives much lower clump masses than our results based on the hyperfine analysis. This is primarily due to areas in the sample region of low I, low $T_{\rm ex}$, and high τ . We conclude that there may be more dense gas in these massive clumps not engaged in massive star formation than previously recognized. If this result holds for other clouds in the CHaMP sample, it would have dramatic consequences for the calibration of the Kennicutt-Schmidt star formation laws, including a large increase in the gas depletion time-scale in such regions.

Accepted by MNRAS

https://arxiv.org/pdf/1612.08144

The stellar contents and star formation in the NGC 7538 region

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Deep optical photometric data on the NGC 7538 region were collected and combined with archival data sets from *Chandra*, 2MASS and *Spitzer* surveys in order to generate a new catalog of young stellar objects (YSOs) including those not showing IR excess emission. This new catalog is complete down to 0.8 $M_\odot$. The nature of the YSOs associated with the NGC 7538 region and their spatial distribution are used to study the star formation process and the resultant mass function (MF) in the region. Out of the 419 YSOs, ~91% have ages between 0.1 to 2.5 Myr and ~86% have masses between 0.5 to 3.5 $M_\odot$, as derived by spectral energy distribution fitting analysis. Around 24%, 62% and 2% of these YSOs are classified to be the Class I, Class II and Class III sources, respectively. The X-ray activity in the Class I, Class II and Class III objects is not significantly different from each other. This result implies that the enhanced X-ray surface flux due to the increase in the rotation rate may be compensated by the decrease in the stellar surface area during the pre-main sequence evolution. Our analysis shows that the O3V type high mass star 'IRS 6' might have triggered the formation of young low mass stars up to a radial distance of 3 pc. The MF shows a turn-off at around 1.5 $M_\odot$ and the value of its slope 'Γ' in the mass range $1.5 < M/M_\odot < 6$ comes out to be -1.76 ± 0.24, which is steeper than the Salpeter value.

Accepted by MNRAS

Does feedback help or hinder star formation? The effect of photoionisation on star formation in Giant Molecular Clouds

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We investigated the effect of photoionising feedback inside turbulent star-forming clouds, comparing the resultant star formation in both idealised profiles and more realistic cloud structures drawn from a global galaxy simulation. We performed a series of numerical simulations which compared the effect of star formation alone, photoionisation and photoionisation plus supernovae feedback. In the idealised cloud, photoionisation suppresses gas fragmentation at early times, resulting in the formation of more massive stars and an increase in the star formation efficiency. At later times, the dispersal of the dense gas causes the radiative feedback effect to switch from positive to negative as the star formation efficiency drops. In the cloud extracted from the global simulation, the initial cloud is heavily fragmented prior to the stellar feedback beginning and is largely structurally unaffected by the late injection of radiation energy. The result is a suppression of the star formation. We conclude that the efficiency of feedback is heavily dependent on the gas structure, with negative feedback dominating when the density is high.

Accepted by MNRAS

http://arxiv.org/pdf/1612.06381

Highly inclined and eccentric massive planets. II. Planet-planet interactions during the disc phase

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We aim to investigate the influence of the eccentricity and inclination damping due to planet-disc interactions on the final configurations of the systems, generalizing previous studies on the combined action of the gas disc and planet-planet scattering during the disc phase. Instead of the simplistic K-prescription, our n-body simulations adopt the damping formulae for eccentricity and inclination provided by the hydrodynamical simulations of our companion paper. We follow the evolution of 11000 numerical experiments of three giant planets in the late stage of the gas disc, exploring different initial configurations, planetary mass ratios and disc masses. The dynamical evolutions of the planetary systems are studied along the simulations, with emphasis on the resonance captures and inclination-growth mechanisms. Most of the systems are found with small inclinations ($\leq 10°$) at the dispersal of the disc. Even though many systems enter an inclination-type resonance during the migration, the disc usually damps the inclinations on a short timescale. Although the majority of the multiple systems in our results are quasi-coplanar, $\sim$5% of them end up with high mutual inclinations ($\geq 10°$). Half of these highly mutually inclined systems result from two- or three-body MMR captures, the other half being produced by orbital instability and/or planet-planet scattering. When considering the long-term evolution over 100 Myr, destabilization of the resonant systems is common, and the percentage of highly mutually inclined systems still evolving in resonance drops to 30%. Finally, the parameters of the final system configurations are in very good agreement with the semi-major axis and eccentricity distributions in the observations, showing that planet-planet interactions during the disc phase could have played an important role in sculpting planetary systems.

Accepted by A&A

http://arxiv.org/pdf/1612.02693

The Impact of Feedback During Massive Star Formation by Core Accretion

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We study feedback during massive star formation using semi-analytic methods, considering the effects of disk winds, radiation pressure, photoevaporation and stellar winds, while following protostellar evolution in collapsing massive gas cores. We find that disk winds are the dominant feedback mechanism setting star formation efficiencies (SFEs) from initial cores of $\sim$ 0.3–0.5. However, radiation pressure is also significant to widen the outflow cavity causing reductions of SFE compared to the disk-wind only case, especially for $> 100 M_\odot$ star formation at clump mass surface densities $\Sigma_{\rm cl} < 0.3\,{\rm g\,cm^{-2}}$. Photoevaporation is of relatively minor importance due to dust attenuation of ionizing photons. Stellar winds have even smaller effects during the accretion stage. For core masses $M_c \simeq 10$–$1000\,M_\odot$ and $\Sigma_{\rm cl} \simeq 0.1$–$3\,{\rm g\,cm^{-2}}$, we find the overall SFE to be $\bar{\varepsilon}_{*{\rm f}} = 0.31(R_c/0.1\,{\rm pc})^{-0.39}$, potentially a useful sub-grid star-formation model in simulations that can resolve pre-stellar core radii, $R_c = 0.057(M_c/60 M_\odot)^{1/2}(\Sigma_{\rm cl}/{\rm g\,cm^{-2}})^{-1/2}$ pc. The decline of SFE with M_c is gradual with no evidence for a maximum stellar-mass set by feedback processes up to stellar masses of $m_* \sim 300\,M_\odot$. We thus conclude that the observed truncation of the high-mass end of the IMF is shaped mostly by the pre-stellar core mass function or internal stellar processes. To form massive stars with the observed maximum masses of $\sim$ 150–$300 M_\odot$, initial core masses need to be $>$ 500–$1000\,M_\odot$. We also apply our feedback model to zero-metallicity primordial star formation, showing that, in the absence of dust, photoevaporation staunches accretion at $\sim 50\,M_\odot$. Our model implies radiative feedback is most significant at metallicities $\sim 10^{-2} Z_\odot$, since both radiation pressure and photoevaporation are effective in this regime.

Accepted by the Astrophysical Journal

https://arxiv.org/pdf/1610.08856v2.pdf

Accretion and Magnetic Reconnection in the Classical T Tauri Binary DQ Tau

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Binary star-formation theory predicts that close binaries ($a < 100$ AU) will experience periodic pulsed accretion events as streams of material form at the inner edge of a circumbinary disk, cross a dynamically cleared gap, and feed circumstellar disks or accrete directly onto the stars. The archetype for the pulsed-accretion theory is the eccentric, short-period, classical T Tauri binary DQ Tau. Low-cadence (∼daily) broadband photometry has shown brightening events near most periastron passages, just as numerical simulations would predict for an eccentric binary. Magnetic reconnection events (flares) during the collision of stellar magnetospheres near periastron could, however, produce the same periodic, broadband behavior when observed at a one-day cadence. To reveal the dominate physical mechanism seen in DQ Tau's low-cadence observations, we have obtained continuous, moderate-cadence, multi-band photometry over 10 orbital periods, supplemented with 27 nights of minute-cadence photometry centered on 4 separate periastron passages. While both accretion and stellar flares are present, the dominant timescale and morphology of brightening events are characteristic of accretion. On average, the mass accretion rate increases by a factor of 5 near periastron, in good agreement with recent models. Large variability is observed in the morphology and amplitude of accretion events from orbit-to-orbit. We argue this is due to the absence of stable circumstellar disks around each star, compounded by inhomogeneities at the inner edge of the circumbinary disk and within the accretion streams themselves. Quasi-periodic apastron accretion events are also observed, which are not predicted by binary accretion theory.

Accepted by ApJ

http://arxiv.org/pdf/1612.02431

The formation of secondary stellar generations in massive young star clusters from rapidly cooling shocked stellar winds

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We study a model of *rapidly cooling shocked stellar winds* in young massive clusters and estimate the circumstances under which secondary star formation, out of the reinserted winds from a first stellar generation (1G), is possible. We have used two implementations of the model: a highly idealized computationally inexpensive spherically symmetric semi-analytic model, and a complex three-dimensional radiation-hydrodynamic simulations, and they are in a good mutual agreement. The results confirm our previous findings that in a cluster with 1G mass $10^7\,M_\odot$ and half-mass radius 2.38 pc, the shocked stellar winds become thermally unstable, collapse into dense gaseous structures that partially accumulate inside the cluster, self-shield against ionizing stellar radiation and form the second generation (2G) of stars. We have used the semi-analytic model to explore a subset of the parameter space covering a wide range of the observationally poorly constrained parameters: the heating efficiency, $\eta_{\rm he}$, and the mass loading, $\eta_{\rm ml}$. The results show that the fraction of the 1G stellar winds accumulating inside the cluster can be larger than 50% if $\eta_{\rm he} \sim< 10\%$ which is suggested by the observations. Furthermore, for low $\eta_{\rm he}$, the model provides a self-consistent mechanism predicting 2G stars forming only in the central zones of the cluster. Finally, we have calculated the accumulated warm gas emission in the H30α recombination line, analyzed its velocity profile and estimated its intensity for super star clusters in interacting galaxies NGC4038/9 (Antennae) showing that the warm gas should be detectable with ALMA.

Accepted by ApJ

https://arxiv.org/pdf/1612.05027

CH as a Molecular Gas Tracer and C-Shock Tracer Across a Molecular Cloud Boundary in Taurus

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We present new observations of all three ground-state transitions of the methylidyne (CH) radical and all four ground-state transitions of the hydroxyl (OH) radical toward a sharp boundary region of the Taurus molecular cloud. These data were analyzed in conjunction with existing CO and dust images. The derived CH abundance is consistent with previous observations of translucent clouds ($0.8 \le A_v \le 2.1$ mag). The X(CH)-factor is nearly a constant at $(1.0 \pm 0.06) \times 10^{22}$ cm^{-2} K^{-1} km^{-1} s in this extinction range, with less dispersion than that of the more widely used molecular tracers CO and OH. CH turns out be a better tracer of total column density in such an intermediate extinction range than CO or OH. Compared with previous observations, CH is overabundant below 1 mag extinction. Such an overabundance of CH is consistent with the presence of a C-shock. CH has two kinematic components, one of which shifts from 5.3 to 6 km s^{-1}, while the other stays at 6.8 km s^{-1} when moving from outside toward inside of the cloud. These velocity behaviors exactly match with previous OH observation. The shifting of the two kinematic components indicates colliding streams or gas flow at the boundary region, which could be the cause of the C-shock.

Accepted by ApJ

http://iopscience.iop.org/article/10.3847/1538-4357/833/1/90
http://arxiv.org/pdf/1612.03145

The Class 0 Protostar BHR71: *Herschel* Observations and Dust Continuum Models

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We use *Herschel* spectrophotometry of BHR71, an embedded Class 0 protostar, to provide new constraints on its physical properties. We detect 645 (non-unique) spectral lines amongst all spatial pixels. At least 61 different spectral lines originate from the central region. A CO rotational diagram analysis shows four excitation temperature components, 43 K, 197 K, 397 K, and 1057 K. Low-J CO lines trace the outflow while the high-J CO lines are centered on the infrared source. The low-excitation emission lines of H_2O trace the large-scale outflow, while the high-excitation emission lines trace a small-scale distribution around the equatorial plane. We model the envelope structure using the dust radiative transfer code, HYPERION, incorporating rotational collapse, an outer static envelope, outflow cavity, and disk. The evolution of a rotating collapsing envelope can be constrained by the far-infrared/millimeter SED along with the azimuthally-averaged radial intensity profile, and the structure of the outflow cavity plays a critical role at shorter wavelengths. Emission at 20-40 μm requires a cavity with a constant-density inner region and a power-law density outer region. The best fit model has an envelope mass of 19 $M_\odot$ inside a radius of 0.315 pc and a central luminosity of 18.8 $L_\odot$. The time since collapse began is 24630-44000 yr, most likely around 36000 yr. The corresponding mass infall rate in the envelope (1.2×10^{-5} $M_\odot$ yr^{-1}) is comparable to the stellar mass accretion rate, while the mass loss rate estimated from the CO outflow is 20% of the stellar mass accretion rate. We find no evidence for episodic accretion.

Accepted by ApJ

https://arxiv.org/pdf/1701.00803

Abstracts of recently accepted major reviews

Forming Planets via Pebble Accretion

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The detection and characterisation of large populations of pebbles in protoplanetary discs has motivated the study of pebble accretion as a driver of planetary growth. This review covers all aspects of planet formation by pebble accretion, from dust growth over planetesimal formation to the accretion of protoplanets and fully-grown planets with gaseous envelopes. Pebbles are accreted at a very high rate, orders of magnitude higher than planetesimal accretion, and the rate decreases only slowly with distance from the central star. This allows planetary cores to start their growth in much more distant positions than their final orbits. The giant planets orbiting our Sun and other stars, including systems of wide-orbit exoplanets, can therefore be formed in complete consistency with planetary migration. We demonstrate how growth tracks of planetary mass versus semi-major axis can be obtained for all the major classes of planets by integrating a relatively simple set of governing equations.

Accepted by Annual Review of Earth and Planetary Sciences

New Jobs

ERC-funded postdoc position in star formation at Konkoly Observatory

The "Structured Accretion Disks" ERC-funded research group invites applicants to a postdoc position at Konkoly Observatory (Budapest, Hungary) on the topic of structure, composition, and chemistry of circumstellar disks around young eruptive stars. The ERC Starting Grant is awarded to Dr Agnes Kospal, and its aim is to provide realistic initial conditions for the planet formation process. The position is for three (2+1) years, available from July 2017. Applicants must have a PhD in astrophysics (or related discipline).

Applicants with interest and experience in computational astrophysics, hydrodynamical simulations, radiative transfer, and the physics of the circumstellar matter are encouraged to apply. The successful applicant will be expected to carry out independent research for this project and collaborate with other members of the ERC group, Konkoly Observatory, and its international partners. Konkoly Observatory has close connections to the Max Planck Institute for Astronomy (Heidelberg, Germany). The postdoc position comes with generous travel funds. The postdoc will have no teaching duties, although participation in supervising a PhD student is expected.

Konkoly Observatory is Hungary's largest astronomical research institute, located in a newly renovated building in a beautiful natural reserve area, half hour from the city center. The observatory has been dynamically expanding in recent years, including two ERC-funded projects and several international staff members. The observatory maintains telescopes at a Hungarian mountain station and astronomers regularly observe with international instrumentation as well.

Applications should be sent via e-mail to kospal@konkoly.hu in PDF format and must include a cover letter describing the applicant's background and motivation for applying for the job, a CV, a list of publications, and names, addresses, telephone numbers, and e-mail addresses of two or three reference persons.

Deadline to apply for the job: February 28, 2017

https://jobregister.aas.org/job_view?JobID=58325

Postdoctoral Position in Computational Astrophysics

The Research School of Astronomy and Astrophysics (RSAA) at the Australian National University (ANU) invites applications for a 3-year postdoctoral position in computational astrophysics in Dr Christoph Federrath's research group.

Dr Federrath's group is developing innovative techniques for star and cluster formation, molecular cloud evolution, and turbulent plasmas, with applications to star, planet and galaxy formation and evolution, first stars, interstellar medium, and cosmic structure formation. For this postdoctoral position we are especially looking for excellent early career researchers. The position is open to excellent applicants from all fields, and applicants with previous experience in computational hydrodynamics (grid-based and/or SPH), galaxy, star or planet formation, are especially encouraged to apply. This position further involves collaboration with P. Hopkins (Caltech), N. Schneider (Cologne), J. Kainulainen (MPIA), and V. Ossenkopf (Cologne).

RSAA has a long history of world-class research at the forefront of astronomy and astrophysics and is Australia's top astrophysics research institution. Federrath's group is embedded in a stimulating and vibrant environment consisting of a large number of faculty, postdocs, and PhD/Master students working on related topics. Our Distinguished

Visitor Program attracts world-class astronomers for long-term visits every year. Astronomers at RSAA have access to supercomputing facilities at ANU, and to Keck. Dr Federrath's group has additional access to world-class international supercomputing facilities and to observational data through established collaborations.

This 3-year position has a negotiable starting date around mid 2017. The starting salary is \$75,297–\$86,646 p.a., depending on experience, plus superannuation contribution of 17%.

In order to apply please upload the following documents submitted through `http://jobs.anu.edu.au/cw/en/job/514851/postdoctoral-position`:

1. A cover letter
2. A current curriculum vitae (CV) with an up to date publication list
3. A two (2) page description of your previous research
4. A three (3) page statement describing your future research plan
5. A statement addressing the selection criteria
6. Applicants should arrange for three (3) letters of recommendation to be sent directly to Christoph Federrath (christoph.federrath@anu.edu.au).

Application deadline is **15th February 2017**.
For more information please contact Christoph Federrath (christoph.federrath@anu.edu.au).

Included Benefits:
We offer a competitive remuneration and benefits package, a friendly and collaborative work environment, generous leave entitlements, flexible working arrangements, a relocation allowance, generous superannuation, salary packaging arrangements including child care, and the potential to support dual-career arrangements.

EWASS 2017 Symposium 4: Astrophysical Jets and Outflows - synergies from compact objects to protostars Prague, June 29-30, 2017

Abstract deadline is 8 March 2017, and late registration ends 26 June 2017.

More information: http://eas.unige.ch/EWASS/session.jsp?id=S4

Registration and abstract submission: http://eas.unige.ch/EWASS2017/

During this symposium we aim to discuss the latest advances, theoretical and observational, and future prospects in understanding the role of astrophysical jets and outflows in all types of sources, bringing together the different jet communities, from protostars, to accreting black holes (supermassive, stellar-mass and intermediate-mass), evolved stars, neutron stars, white dwarfs, gamma-ray bursts (GRBs), tidal disruption events (TDEs) and ultraluminous X-ray sources (ULXs). Common physics exists across the power scale of relativistic jets, starting with the Fundamental Plane of black hole activity, to more recent advancements linking jets in black holes to those in GRBs, CVs, YSOs, and TDEs. Furthermore, jets and outflows are regulators of feedback - in terms of star formation (especially in the case of protostellar jets) and of galaxy growth in the early Universe (AGN). **We have several talk and poster slots available and encourage anyone interested in contributing to submit their abstract for before 8 March 2017.**

The topics to be discussed include, but are not limited to

- Ubiquity and properties of jets/outflows from compact objects to protostars: possible synergies
- Jet formation/launching, inflow - outflow connection
- Composition, power, dynamics and chemistry of jets/outflows
- Interactions with surrounding medium and feedback on the driving system
- Future outlook and facilities

Current confirmed invited speakers include: Dr. Sylvie Cabrit (Observatoire de Paris LERMA), Dr. Claudio Codella (INAF Arcetri), Prof. Jonathan Ferreira (IPAG), Prof. Gabriele Ghisellini (INAF Brera), Prof. Sera Markoff (UvA), Dr. Francesca Panessa (IAPS-INAF), Prof. Tom Ray (DIAS), Dr. Daniel Tafoya (Chalmers), Dr. Sasha Tchekhovskoy (UC Berkeley)

On behalf of the symposium SOC,

Magnus Persson (Chalmers, co-chair), Dave Russell (NYU Abu Dhabi, co-chair) and Simone Migliari (ESAC, co-chair)

Spectroscopy with SOFIA: new results & future opportunities (SOFIA2017)

Schloss Ringberg, Tegernsee, Germany, March 5–8, 2017

Continuing on the success of the 2015 Ringberg meeting on spectroscopy with SOFIA at which about 70 participants discussed SOFIA results ranging from nearby star formation to the interstellar medium in nearby galaxies, SOFIA2017 aims at presenting new science results and looking into future science opportunities for the next years enabled by new instrumentation.

Several instruments on SOFIA allow unique spectroscopic studies of the physics and chemistry of the interstellar medium: GREAT covers with high spectral resolution selected FIR-windows between 1.2 and 4.7 THz (63–250 μm), which includes the major cooling lines from [CII] and [OI] of the interstellar medium, the latter even with arrays of 14 and 7 pixels, respectively. An extension to cover the 500-600 GHz frequency range is currently being built. In larger fields, these lines can be probed with the FIFI-LS integral field spectrometer (50-200 μm) at lower spectral resolution, while EXES covers even shorter wavelengths (from 4.5 to 28.3 μm), again with high spectral resolution, including the important H2 rotational transitions. The forthcoming third generation instrument HIRMES will cover 25-120 μm continuously with resolution of 10000-100000. Finally, FORCAST and FLITECAM allow low-resolution grism spectroscopy, including PAHs.

Given the rapid progress in instrument development, resulting in continuous upgrades and extensions of the existing detectors, as well as new science projects, it is timely to discuss new results from SOFIA and to look into science opportunities for the coming years, particularly in the area of FIR spectroscopy.

The conference venue, Ringberg Castle, will provide a unique setting for in-depth discussions on current and future unique science with SOFIA. In particular, sessions on new scientific results, on synergies with other observatories, and on new instruments enabling new science are envisioned. Even if you have no SOFIA-related results yourself, we invite you to attend so you can see and find out for yourself what SOFIA can do for you. We specifically encourage the attendance of graduate and PhD students, and will reserve a number of slots for them.

Updates on the registration and submission of abstracts will be given on the workshop website:

https://events.mpifr-bonn.mpg.de/indico/event/16/

Summary of Upcoming Meetings

Disks, Dynamos, and Data: Confronting MHD Accretion Theory with Observations
6 - 10 February 2017, Santa Barbara, USA
https://www.kitp.ucsb.edu/activities/disks-c17

The Physics of the ISM - 6 years of ISM-SPP 1573: what have we learned?
13 - 17 February 2017, Cologne, Germany
https://hera.ph1.uni-koeln.de/~ism2017/

Star Formation from Cores to Clusters
6 - 9 March 2017, Santiago, Chile
http://www.eso.org/sci/meetings/2017/star-formation2017.html

Astrochemistry VII - Through the Cosmos from Galaxies to Planets
20 - 24 March 2017, Puerto Varas, Chile
http://newt.phys.unsw.edu.au/IAUS332/

Formation and Dynamical Evolution of Exoplanets
26 - 31 March 2017, Aspen, USA
http://ciera.northwestern.edu/Aspen2017.php

Multi-Scale Star Formation
3 - 7 April 2017, Morelia, Mexico
http://www.irya.unam.mx/multi-scaleSF17/

Protoplanetary Disks and Planet Formation and Evolution
29 May - 23 June 2017, Garching bei München, Germany
http://www.munich-iapp.de/scientific-programme/programmes-2017/protoplanetary-disks/

Accretion, Differentiation and Early Evolution of Terrestrial Planets
29 May - 3 June 2017, Nice, France
https://www-n.oca.eu/morby/Accrete.html

Francesco's Legacy: Star Formation in Space and Time
6 - 9 June 2017, Firenze, Italy
http://www.arcetri.astro.it/sfst2017/

Gordon Research Seminar Origins of Solar Systems
17 - 18 June 2017, South Hadley, USA
https://www.grc.org/programs.aspx?id=17506

Gordon Research Conference Origins of Solar Systems: Making a Habitable Planet
18 - 23 June 2017, South Hadley, USA
https://www.grc.org/programs.aspx?id=12346

Planet Formation and Evolution 2017
25 - 27 September 2017, Jena, Germany
http://www.astro.uni-jena.de/~pfe2017

Cool Stars 20: Cambridge Workshop on Cool Stars, Stellar Systems and the Sun
29 July - 3 August 2018, Cambridge/Boston, USA
http://www.coolstars20.com

Other meetings: http://www1.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/meetings/