THE STAR FORMATION NEWSLETTER

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

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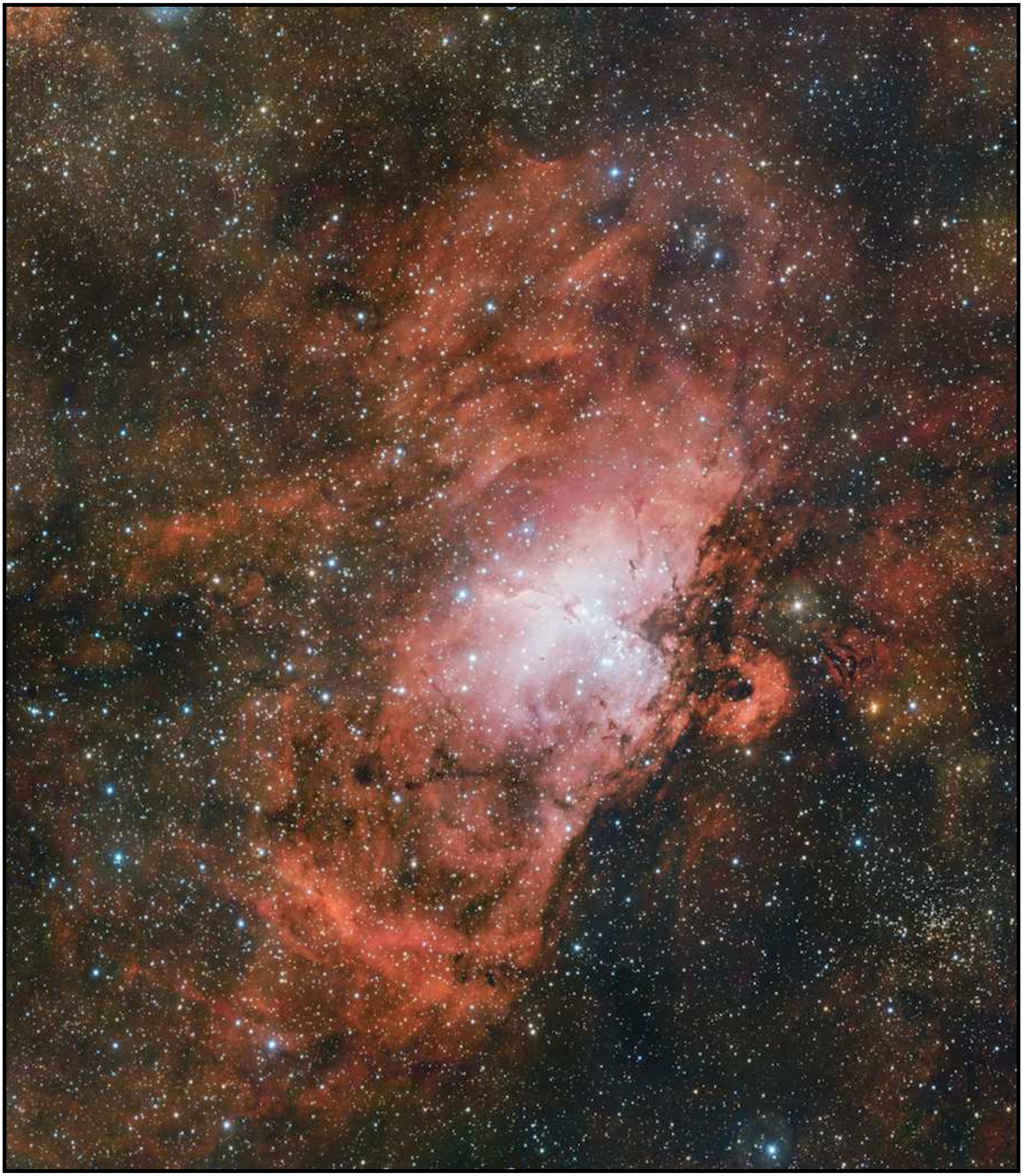

The Star Formation Newsletter

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.

Newsletter Archive

www.ifa.hawaii.edu/users/reipurth/newsletter.htm

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Cover Picture

Messier 16 is the bright HII region excited by the massive OB stars in the NGC 6611 cluster. The distance to M16 is about 1.7-1.8 kpc and the cluster is about 2-3 Myr old. Embedded in the HII region are the large elephant trunks seen in the now famous HST images of the region.

Image courtesy ESO.

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

The Star Formation Newsletter seeks a WEBMASTER

Are you one of those people with too much time on your hands and too much money in your pocket? Then go on reading.

The Star Formation Newsletter is a volunteer effort that I have invested time and energy in for the past 26 years, in recent years with the capable help from my Associate Editors Hsi-Wei Yen and Anna McLeod. Within our little team we have been able to solve almost all problems that arise within the production of the Newsletter, including a major change to the layout in 2012.

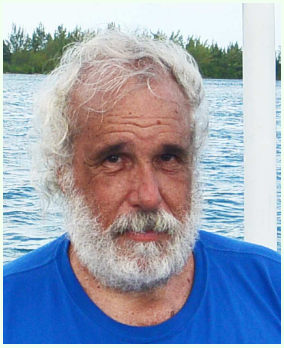
The Newsletter website, however, has not changed in all these years, and is now in clear need of a major revision and upgrade carried out by a competent webmaster. If you are an expert in webpages and want to volunteer for this task, please email me your interest at reipurth@ifa.hawaii.edu with a description of your experience in this area. A good knowledge of LaTeX is also desirable.

The bulk of the work will be a one-time update of the webpage, after which there will be a minimal workload of monthly maintenance.

Bo Reipurth

Alex Raga

in conversation with Bo Reipurth



Q: *What was the subject of your PhD and who was your adviser?*

A: My thesis work, from 1982 to 1985, was about bow shock models of Herbig-Haro objects. These objects were one of the interests of Karl-Heinz Böhm, my advisor at the University of Washington. His first paper on HH objects dates back to 1955, only a few years after their discovery. Karl-Heinz Böhm, who died 5 years ago, was a major influence in my life and, I suspect, in the life of many of his students. He provided a strong example of how to approach research, and also life in general, which within my limited abilities I have tried to emulate.

Q: *After your PhD you continued to work closely with Karl-Heinz Böhm, particularly related to the bright HH 1/2 objects. What were the main results?*

A: During my first postdoc, with Karl-Heinz, we explored time-dependent bow shock models. These models showed that one naturally produces the "broken-up bow shocks" observed in HH 1 and 2. I then helped Karl-Heinz, with J. Solf, A. Noriega-Crespo and other collaborators, on the interpretation of spatially-resolved optical and UV spectroscopy, mainly of HH 1/2, but also of other HH objects. This work, as well as contemporary work of P. Hartigan, J. Raymond and their collaborators, showed that it is relatively straightforward to explain the observed spatially-resolved emission line profiles with gasdynamical models of different degrees of sophistication, basically "1.5-dimensional" models calculated with a superposition of oblique shocks and fully axisymmetric or 3D gasdynamical models.

The other, less satisfying, result is that it is more difficult to model the observed line ratios. In order to model the spatially resolved line ratios of HH 1/2 one needs lower flow velocities than the ones implied by the observed line profiles, a somewhat bothersome result! If one looks at other HH objects, this result appears to be a general feature of HH objects, and is one of the important remaining problems in their interpretation.

Q: *For the past 30 years, you have published prolifically with your colleague Jorge Cantó. How did that start?*

A: In 1987 I attended a star formation conference in British Columbia, in which I met a group of most pleasant Mexican astronomers, including L. F. Rodríguez, M. Tapia and A. López. Alberto López asked me if I had met Jorge Cantó, which I had not, even though I had read most of his papers, and given my negative reply Alberto said that he would organize a workshop in Ensenada, Mexico so that we would meet, he thought that this would be an event of major importance in the lives of Jorge Cantó and I, because we would be friends and collaborators for the rest of our lives. I thought that this was a somewhat curious "premonition", but when the following year Alberto did organize the workshop I gladly participated.

The second day of the workshop Jorge and I had already become good friends - we shared the "black/white world-view" of descendants of Catalan anarchists! - and before the end of the workshop we had advanced on what would be our first paper together - out of a current number of 112 refereed joint papers. Some years later, in 1995, I moved to Mexico to work with Jorge at the UNAM, and here I have remained.

Q: *In 1990 you and your collaborators published a highly cited paper on Herbig-Haro jets with intrinsically variable sources. What were the key points?*

A: The work for this paper was mostly carried out during a 2-week workshop in Mérida in Venezuela organized by Nuria Calvet, now at the Univ. of Michigan, and all of the co-authors were participants of the workshop. The idea is that a time-dependent ejection with a velocity variability of supersonic amplitude leads to the formation of two-shock "internal working surfaces" or "heads" that travel down the jet beam. I think that we were quite lucky at the time, because - as is so often the case - clearly other researchers were aiming in the same direction (the names of Reipurth and Hartigan come to mind!). In this first paper, we realized that a variability with two "modes" - for example a short period mode and a long period mode or a sudden "turning on" - produced structures that looked like the HH 34 jet. Interpreting this beautiful object had been in our minds for quite a few years. Also, the model produced in a direct way the proper motions of the chain of knots of this object (which were published later, but had already been reported in conferences by Eislöffel, Mundt & Ray and by Heathcote & Reipurth).

We later realized that Martin Rees had published a paper back in 1978 pointing out that internal shocks in extra-galactic jets could be produced by "velocity irregularities", and that Mike Wilson in 1984 had studied this problem numerically. However, the idea of variable ejections really took off in the mid-1990's in the field of HH jets when high resolution HST images of HH 34 and HH 111, among others, showed that many of the knots along the jets looked like "small bow shocks" as expected for internal working surfaces produced by ejection velocity variabilities. This has now become the standard interpretation of HH jets.

An interesting feature of this interpretation is that HH jets therefore are a kind of "archaeological record" of the past ejection time-variability. This record, however, becomes more confused for the material ejected in the more distant past (which is now seen at larger distances from the source) because of the distortion (braking) resulting from the interaction of the outflow with the surrounding environment. Also, substantial "gaps" in the "archaeological jet record" appear because of the fact that material ejected over relatively extended periods merges to produce single internal working surfaces. These effects probably have analogues in "real archaeology".

Q: *You have for a long time been interested in the relation between jets and molecular outflows, a topic you have worked closely on with Sylvie Cabrit.*

A: The relation between HH jets and molecular outflows is a very interesting problem, with little theoretical progress being obtained over the last ~ 3 decades. This relative lack of progress is due to the fact that the process of entrainment into a coherent flow is very complicated. This process has defied researchers in fluid dynamics for more than a century. In HH jets, the presence of "internal working surfaces", resulting from an ejection variability, further complicates the entrainment process.

Over the years I have worked on this problem with Sylvie Cabrit and Jorge Cantó (I would like to note that the papers with Sylvie are among my best papers, a result of Sylvie's intelligence and higher standards). During the past year I have worked with Benoit Tabone, Sylvie Cabrit and Guillaume Pineau des Forêts on new entrainment models, devised for interpreting ALMA observations of the source regions of molecular outflows. The new observations of these regions with ALMA offer a fascinating possibility of making clear progress on understanding the process of entrainment of molecular material in HH flows.

Q: *About 20 years ago you developed a new 3D adaptive grid code, yguazú-a, to deal with gasdynamical problems, and you have used it extensively on a variety of problems. What were the new features of this code and key results?*

A: Around 1990-1991 I was a postdoc of Sam Falle at the University of Leeds in the UK. At that time, Sam Falle and Jack Giddings had developed a quite pioneering adaptive grid code ("cobra") for scientific and commercial applications. Learning from this code, I wrote a simpler 2D code ("coral" - named for the relatively puny american relative of the cobra snake), with which I played for a decade. When a decade later I started to do 3D simulations I decided to write a new 2/3D code with a different concept for the adaptive grid (actually, more similar to the cobra code of Falle and Giddings). We called this code "yguazú", which means "big water" in the South American Guaraní language.

Some versions of the "coral" and the "yguazú" codes are still being used today, because they included a number of features which work quite well, and a considerable amount of work is required to introduce them in more modern codes. Some of these features are a treatment of a many species non-equilibrium ionization/cooling network, and of the multi-wavelength radiative transfer of the direct stellar and the diffuse photoionizing radiation field. This latter feature has only been partially incorporated into our more modern codes!

The other positive result of the "yguazú" code is that a generation of young students and postdocs at the UNAM, among them Pablo Velázquez, Fabio De Colle, Verónica Lora, Alejandro Esquivel and Ary Rodríguez, used it to learn how to develop gasdynamic codes. These people, and their students, have developed a new generation of fixed and adaptive grid codes - appropriate for parallel machines - which are now the workhorses that we use for computing astrophysical gasdynamic simulations.

Q: *You have written a number of papers on jets with time dependent ejection directions and their relation to binarity of the sources. What are your main conclusions?*

A: The ejection of a jet from a stellar source in a binary system shows two main effects. The "inevitable" one is the effect of the orbital motion which, because of the time-dependent direction of the orbital velocity, produces periodic deviations in the ejection direction with a jet and counterjet "mirror symmetry". The presence of a binary companion can also produce a precession in the accretion disk which produces or collimates the outflow, and hence in the outflow itself. This results in deviations of the ejection direction with "point symmetry" between jet and counterjet. In principle, these two effects should be visible in an outflow system from a source in a binary system.

Precession-like, point-symmetric direction deviations are seen in a number of "giant" parsec scale HH outflows. Also, subtle mirror symmetric deviations are seen in the inner regions of some HH outflows. A simple, ballistic motion model can be used to derive the orbital parameters from the observed curvature of the jet/counterjet, which in the known examples give most reasonable stellar/substellar masses for the companion star. A panoply of observed shapes for the jet/counterjet can be obtained considering different orbital motion/precession combinations, non-circular binary orbits and motions of the outflow source in a multiple system. As far as I am aware, jets from multiple stars have still not been modeled.

Another interesting point is whether an elliptic (or more complex) orbital motion of an outflow source (in a binary or multiple system) can drive an ejection velocity/density variability in the jet. In your paper from 2000 you suggested that close passages of stellar companions of the source might lead to strong "outflow events" in the jet and counterjet system. Simulations of outflow systems in which such events take place have been calculated, but as far as I am aware the outflow ejection with perturbations from a stellar companion has still not been studied theoretically. This is probably not surprising given the continuing doubts that remain about the detailed nature of the HH jet production mechanism.

Q: *A rather different topic is your study of analytic solutions to wind-driven HII regions and Strömgren spheres.*

A: My current interest in expanding (and non-expanding) HII regions began because I am writing a book on the ISM. I tend to get bored writing chapters describing well known work, so then I begin to play around with variations (leading to at least partially new results). One of the things I tried was obtaining analytic solutions for the HII/HI transition at the outer edge of a stationary HII region. This is the problem of Strömgren, who in an absolutely beautiful paper from 1939 published two approximate analytic solutions for the transition. We found that it is possible to obtain better - though of course more complex - analytic solutions, and wrote a few papers on this ultra-traditional subject.

Looking at analytic solutions for an expanding HII region, I found a way to include in an approximate way the strong to weak transition of the outer shock, which is driven by the expansion. It is also possible to include the strong/weak shock transition in analytic solutions of a wind-driven HII region, and of an expanding supernova remnant. Jorge Cantó and I were quite excited in finding an approximate (analytic) version of the Sedov-Taylor expansion with a transition to the weak shock regime! Luckily, this paper did not raise interest in its military applications (retrospectively not surprising given the present ease of carrying out numerical simulations).

Q: *Recently you have pioneered the use of wavelets in the study of outflows. What are the benefits of this approach?*

A: Years after interacting with Dick Henriksen, who was the pioneer of using wavelet transforms in astrophysical applications, I started using wavelets for analyzing the structures of HH outflows. This was a natural extension of Henriksen's work on the observed structures of molecular clouds.

With the relatively recent availability of multi-epoch HST observations of a number of HH outflows, we started to try to have "automatic" proper motion determinations. By "automatic" I mean an algorithm which determines proper motions from two or more epochs without having to choose by hand which regions have to be compared in the successive images. Such selection was an undesirable feature of the favoured "cross correlation method", first used in HH objects by Heathcote & Reipurth. We first tried covering the images with "cross correlation boxes" (or "tiles"), but found that this introduces a series of complications. The next idea was to convolve the frames with a wavelet function of a chosen size, and to then find corresponding peaks in the successive degraded resolution, convolved images.

The referee of our first paper on this method pointedly - and correctly - said that degrading the resolution of the images and then finding peaks was not an impressively innovative method for calculating proper motions. However, I am personally very happy with the (Python) software that I have been working on, with which one can find proper motions from sets of images in an extremely rapid way, without having to go through the previous choice "by hand" of boxes containing coherent structures that appear in the successive frames. With the current "wavelet proper motion" method, one only chooses a size for the wavelet, and there it goes!

Q: *What are you currently working on?*

A: The past few years I have put a considerable amount of effort into analyzing new HST images of HH objects together with my collaborators. I have come to realize that with HST observations one enters a Faustian pact in which in order to obtain scientific progress (i.e., the HST images) one trades away one's soul (i.e., one dedicates a couple of years' work to them). I think that the results that we have obtained have been worth it! I am currently working on a similar Faustian pact with the interpretation of ALMA observations together with Sylvie Cabrit and a number of other collaborators, and I am steeling myself for life with the sword of Damocles (i.e., JWST) which is starting to hang above our heads.

Abstracts of recently accepted papers

Revealing the dust grain size in the inner envelope of the Class I protostar Per-emb-50

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A good constraint of when the growth of dust grains from sub-micrometer to millimeter sizes occurs, is crucial for planet formation models. This provides the first step towards the production of pebbles and planetesimals in protoplanetary disks. Currently, it is well established that Class II objects have large dust grains. However, it is not clear when in the star formation process this grain growth occurs. We use multi-wavelength millimeter observations of a Class I protostar to obtain the spectral index of the observed flux densities $\alpha_{\rm mm}$ of the unresolved disk and the surrounding envelope. Our goal is to compare our observational results with visibility modeling at both wavelengths simultaneously. We present data from NOEMA at 2.7 mm and SMA at 1.3 mm of the Class I protostar, Per-emb-50. We model the dust emission with a variety of parametric and radiative transfer models to deduce the grain size from the observed emission spectral index. We find a spectral index in the envelope of Per-emb-50 of $\alpha_{\rm env}$=3.3$\pm$0.3, similar to the typical ISM values. The radiative transfer modeling of the source confirms this value of $\alpha_{\rm env}$ with the presence of dust with a $a_{\rm max}\leq 100\,\mu$m. Additionally, we explore the backwarming effect, where we find that the envelope structure affects the millimeter emission of the disk. Our results reveal grains with a maximum size no larger than 100 μm in the inner envelope of the Class I protostar Per-emb-50, providing an interesting case to test the universality of millimeter grain growth expected in these sources.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/1901.05021.pdf

Resolved young binary systems and their disks

Rachel L. Akeson[1], Eric L. N. Jensen[2], John Carpenter[3], Luca Ricci[4], Stefan Laos[5], Natasha F. Nogueira[2] and Emma M. Suen-Lewis[2]

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We have conducted a survey of young single and multiple systems in the Taurus-Auriga star-forming region with the Atacama Large Millimeter Array (ALMA), substantially improving both the spatial resolution and sensitivity with which individual protoplanetary disks in these systems have been observed. These ALMA observations can resolve binary separations as small as 25–30 AU and have an average 3σ detection level of 0.35 mJy, equivalent to a disk mass of 4×10^{-5} $M_\odot$ for an M3 star. Our sample was constructed from stars that have an infrared excess and/or signs of accretion and have been classified as Class II. For the binary and higher order multiple systems observed, we detect

$\lambda = 1.3$ mm continuum emission from one or more stars in all of our target systems. Combined with previous surveys of Taurus, our 21 new detections increase the fraction of millimeter-detected disks to over 75% in all categories of stars (singles, primaries, and companions) earlier than spectral type M6 in the Class II sample. Given the wealth of other information available for these stars, this has allowed us to study the impact of multiplicity with a much larger sample. While millimeter flux and disk mass are related to stellar mass as seen in previous studies, we find that both primary and secondary stars in binary systems with separations of 30 to 4200 AU have lower values of millimeter flux as a function of stellar mass than single stars. We also find that for these systems, the circumstellar disk around the primary star does not dominate the total disk mass in the system and contains on average 62% of the total mass.

Accepted by Astrophysical Journal

https://lanl.arxiv.org/pdf/1901.05029

The Disk Substructures at High Angular Resolution Project (DSHARP). I. Motivation, Sample, Calibration, and Overview

Sean Andrews[1], Jane Huang[1], Laura Pérez[2], Andrea Isella[3], Cornelis Dullemond[4], Nicolás Kurtovic[2], Viviana Guzmán[5,6], John Carpenter[5], David Wilner[1], Shangjia Zhang[7], Zhaohuan Zhu[7], Tilman Birnstiel[8], Xue-Ning Bai[9], Myriam Benisty[10,11], Meredith Hughes[12], Karin Öberg[1] and Luca Ricci[13]

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We introduce the Disk Substructures at High Angular Resolution Project (DSHARP), one of the initial Large Programs conducted with the Atacama Large Millimeter/submillimeter Array (ALMA). The primary goal of DSHARP is to find and characterize substructures in the spatial distributions of solid particles for a sample of 20 nearby protoplanetary disks, using very high resolution (∼0.035 arcseconds, or 5 au, FWHM) observations of their 240 GHz (1.25 mm) continuum emission. These data provide a first homogeneous look at the small-scale features in disks that are directly relevant to the planet formation process, quantifying their prevalence, morphologies, spatial scales, spacings, symmetry, and amplitudes, for targets with a variety of disk and stellar host properties. We find that these substructures are ubiquitous in this sample of large, bright disks. They are most frequently manifested as concentric, narrow emission rings and depleted gaps, although large-scale spiral patterns and small arc-shaped azimuthal asymmetries are also present in some cases. These substructures are found at a wide range of disk radii (from a few astronomical units to more than 100 au), are usually compact ($\lesssim$10 au), and show a wide range of amplitudes (brightness contrasts). Here we discuss the motivation for the project, describe the survey design and the sample properties, detail the observations and data calibration, highlight some basic results, and provide a general overview of the key conclusions that are presented in more detail in a series of accompanying articles. The DSHARP data — including visibilities, images, calibration scripts, and more – are released for community use at https://almascience.org/alma-data/lp/DSHARP

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https://arxiv.org/pdf/1812.04040.pdf

Magnetic Field Structure of Dense Cores using Spectroscopic Methods

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We develop a new "core field structure" (CFS) model to predict the magnetic field strength and magnetic field fluctuation profile of dense cores using gas kinematics. We use spatially resolved observations of the nonthermal velocity dispersion from the Green Bank Ammonia survey along with column density maps from SCUBA-2 to estimate the magnetic field strength across seven dense cores located in the L1688 region of Ophiuchus. The CFS model predicts the profile of the relative field fluctuation, which is related to the observable dispersion in direction of the polarization vectors. Within the context of our model we find that all the cores have a transcritical mass-to-flux ratio.

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https://arxiv.org/pdf/1901.09537

The statistical properties of stars and their dependence on metallicity

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We report the statistical properties of stars and brown dwarfs obtained from four radiation hydrodynamical simulations of star cluster formation, the metallicities of which span a range from 1/100 to 3 times the solar value. Unlike previous similar investigations of the effects of metallicity on stellar properties, these new calculations treat dust and gas temperatures separately and include a thermochemical model of the diffuse interstellar medium. The more advanced treatment of the interstellar medium gives rise to very different gas and dust temperature distributions in the four calculations, with lower metallicities generally resulting in higher temperatures and a delay in the onset of star formation. Despite this, once star formation begins, all four calculations produce stars at similar rates and many of the statistical properties of their stellar populations are difficult to distinguish from each other and from those of observed stellar systems. We do find, however, that the greater cooling rates at high gas densities due to the lower opacities at low metallicities increase the fragmentation on small spatial scales (disc, filament, and core fragmentation). This produces an anti-correlation between the close binary fraction of low-mass stars and metallicity similar to that which is observed, and an increase in the fraction of protostellar mergers at low metallicities. There are also indications that at lower metallicity close binaries may have lower mass ratios and the abundance of brown dwarfs to stars may increase slightly. However, these latter two effects are quite weak and need to be confirmed with larger samples.

Accepted by MNRAS

Preprint at: https://arxiv.org/pdf/1901.03713
Animations available at: http://www.astro.ex.ac.uk/people/mbate/Animations/

Disentangling the spatial substructure of Cygnus OB2 from Gaia DR2

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For the first time, we have explored the spatial substructure of the Cygnus OB2 association using parallaxes from the recent second Gaia data release. We find significant line-of-sight substructure within the association, which we quantify using a parameterised model that reproduces the observed parallax distribution. This inference approach is necessary due to the non-linearity of the parallax-distance transformation and the asymmetry of the resulting probability distribution. By using a Markov Chain Monte Carlo ensemble sampler and an unbinned maximum likelihood test we identify two different stellar groups superposed on the association. We find the main Cygnus OB2 group at $\sim$1760 pc, further away than recent estimates have envisaged, and a foreground group at $\sim$1350 pc. We also calculate individual membership probabilities and identify outliers as possible non-members of the association.

Accepted by MNRAS

http://arxiv.org/pdf/1901.02959

The Disk Substructures at High Angular Resolution Project (DSHARP): V. Interpreting ALMA maps of protoplanetary disks in terms of a dust model

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The Disk Substructures at High Angular Resolution Project (DSHARP) is the largest homogeneous high-resolution (∼0.”035, or ∼ 5 au) disk continuum imaging survey with ALMA so far. In the coming years, many more disks will be mapped with ALMA at similar resolution. Interpreting the results in terms of the properties and quantities of the emitting dusty material is, however, a very non-trivial task. This is in part due to the uncertainty in the dust opacities, an uncertainty which is not likely to be resolved any time soon. It is also partly due to the fact that, as the DSHARP survey has shown, these disk often contain regions of intermediate to high optical depth, even at millimeter wavelengths and at relatively large radius in the disk. This makes the interpretation challenging, in particular if the grains are large and have a large albedo. On the other hand, the highly structured features seen in the DSHARP survey, of which strong indications were already seen in earlier observations, provide a unique opportunity to study the dust growth and dynamics. To provide continuity within the DSHARP project, its follow-up projects, and projects by other teams interested in these data, we present here the methods and opacity choices used within the DSHARP collaboration to link the measured intensity I_ν to dust surface density Σ_d.

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The Spatial Evolution of Young Massive Clusters I. A New Tool to Quantitatively Trace Stellar Clustering

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Aims. To present the new novel statistical clustering tool ‘INDICATE’ which assesses and quantifies the degree of spatial clustering of each object in a dataset, discuss its applications as a tracer of morphological stellar features in star forming regions, and to look for these features in the Carina Nebula (NGC 3372).
Results. We successfully recover known stellar structure of the Carina Nebula, including the 5 young star clusters in this region. Four sub-clusters contain no, or very few, stars with a degree of association above random which

suggests they may be fluctuations in the field rather than real clusters. In addition we find: (1) Stars in the NW and SE regions have significantly different clustering tendencies, which is reflective of differences in the apparent star formation activity in these regions. Further study is required to ascertain the physical origin of the difference; (2) The different clustering properties between these two regions are even more pronounced for OB stars; (3) There are no signatures of classical mass segregation present in the SE region — massive stars here are not spatially concentrated together above random; (4) Stellar concentrations are more frequent around massive stars than typical for the general population, particularly in the Tr14 cluster; (5) There is a relation between the concentration of OB stars and the concentration of (lower mass) stars around OB stars in the centrally concentrated Tr14 and Tr15, but no such relation exists in Tr16. We conclude this is due to the highly sub-structured nature of Tr16.
Conclusions. INDICATE is a powerful new tool employing a novel approach to quantify the clustering tendencies of individual objects in a dataset within a user-defined parameter space. As such it can be used in a wide array of data analysis applications.

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Surveys of Clumps, Cores, and Condensations in Cygnus X: I. a New Catalog of 0.1 pc Massive Dense Cores

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Using infrared to (sub)millimeter data from *Spitzer*, *Herschel*, the James Clerk Maxwell Telescope, and the IRAM 30-m telescope, we conducted an unbiased survey of the massive dense cores (MDCs) in the Cygnus X molecular cloud complex, aimed at characterizing the physical conditions of high-mass star formation (HMSF) at $\sim$0.1 pc scales. We created $5^\circ \times 6^\circ$ images of the 70–1200 μm dust continuum, gas column density, and dust temperature of Cygnus X. A spatial relation between the dense regions ($A_\mathrm{v} \geq 15$) and the developed H II regions was found, indicating the impact of the latter on the global structures of Cygnus X. With a 35-$M_\odot$ mass threshold implied by HMSF signposts, we identified 151 MDCs with sizes of $\sim$0.1 pc, masses of 35–1762 $M_\odot$, and temperatures of 8–35 K. Our MDC sample is statistically complete in Cygnus X and is three times larger than that in Motte et al. (2007). The MDCs were classified into IR-bright/IR-quiet ones based on their mid-infrared fluxes and a large "IR-quiet" proportion (90%) was found in our sample. Two possible scenarios were proposed to interpret this: accelerated HMSF and the incapability of HMSF of the IR-quiet MDCs. We also found 26 starless MDCs by their lack of compact emissions at 21–70 μm wavelengths, of which the most massive ones are probably the best candidates of initial HMSF sites in Cygnus X.

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The Orion Region: Evidence of enhanced cosmic-ray density in a stellar wind forward shock interaction with a high density shell

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Context. In recent years, an in-depth γ-ray analysis of the Orion region has been carried out by the AGILE and Fermi-LAT (Large Area Telescope) teams with the aim of estimating the H_2–CO conversion factor, $X_{\rm CO}$. The comparison of the data from both satellites with models of diffuse γ-ray Galactic emission unveiled an excess at (l,b)=[213.9, -19.5], in a region at a short angular distance from the OB star κ-Ori. Possible explanations of this excess are scattering of the so-called "dark gas", non-linearity in the H_2-CO relation, or Cosmic-Ray (CR) energization at the κ-Ori wind

shock.
Aims. Concerning this last hypothesis, we want to verify whether cosmic-ray acceleration or re-acceleration could be triggered at the κ-Ori forward shock, which we suppose to be interacting with a star-forming shell detected in several wavebands and probably triggered by high energy particles.
Methods. Starting from the AGILE spectrum of the detected γ-ray excess, showed here for the first time, we developed a valid physical model for cosmic-ray energization, taking into account re-acceleration, acceleration, energy losses, and secondary electron contribution.
Results. Despite the characteristic low velocity of an OB star forward shock during its "snowplow" expansion phase, we find that the Orion γ-ray excess could be explained by re-acceleration of pre-existing cosmic rays in the interaction between the forward shock of κ-Ori and the CO-detected, star-forming shell swept-up by the star expansion. According to our calculations, a possible contribution from freshly accelerated particles is sub-dominant with respect the re-acceleration contribution. However, a simple adiabatic compression of the shell could also explain the detected γ-ray emission. Futher GeV and TeV observations of this region are highly recommended in order to correctly identify the real physical scenario.

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Upper limits on CH_3OH in the HD 163296 protoplanetary disk: evidence for a low gas-phase CH_3OH/H_2CO ratio

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Methanol (CH_3OH) is at the root of organic ice chemistry in protoplanetary disks. However, its weak emission has made detections difficult. To date, gas-phase CH_3OH has been detected in only one Class II disk, TW Hya. We use the Atacama Large Millimeter/submillimeter Array (ALMA) to search for a total of four CH_3OH emission lines in bands 6 and 7 toward the disk around the young Herbig Ae star HD 163296. The disk-averaged column density of methanol and its related species formaldehyde (H_2CO) are estimated assuming optically thin emission in local thermodynamic equilibrium. We compare these results to the gas-phase column densities of the TW Hya disk. No targeted methanol lines were detected individually nor after line stacking. The 3σ disk-integrated intensity upper limits are <51 mJy km s^{-1} for the band 6 lines and <26 mJy km s^{-1} for the band 7 lines. The band 7 lines provide the strictest 3σ upper limit on disk-averaged column density with $N_{\rm avg} < 5.0 \times 10^{11}$ cm^{-2}. The methanol-to-formaldehyde ratio is CH_3OH/H_2CO <0.24 in the HD 163296 disk compared to a ratio of 1.27 in the TW Hya disk. Differences in the stellar irradiation of Herbig disks compared to T Tauri disks likely influence the gaseous methanol and formaldehyde content. Possible reasons for the lower HD 163296 methanol-to-formaldehyde ratio include: a higher than expected gas-phase formation of H_2CO in the HD 163296 disk, uncertainties in the grain surface formation efficiency of CH_3OH and H_2CO, and differences in the disk structure and/or CH_3OH and H_2CO desorption processes that release the molecules from ice mantles back into the gas phase. These results provide observational evidence that the gas-phase chemical complexity found in disks may be strongly influenced by the spectral type of the host star.

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Determining the presence of characteristic fragmentation length-scales in filaments

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Theories suggest that filament fragmentation should occur on a characteristic fragmentation length-scale. This fragmentation length-scale can be related to filament properties, such as the width and the dynamical state of the filament. Here we present a study of a number of fragmentation analysis techniques applied to filaments, and their sensitivity to characteristic fragmentation length-scales. We test the sensitivity to both single-tier and two-tier fragmentation, i.e. when the fragmentation can be characterised with one or two fragmentation length-scales respectively. The nearest neighbour separation, minimum spanning tree separation and two-point correlation function are all able to robustly detect characteristic fragmentation length-scales. The Fourier power spectrum and the N^{th} nearest neighbour technique are both poor techniques, and require very little scatter in the core spacings for the characteristic length-scale to be successfully determined. We develop a null hypothesis test to compare the results of the nearest neighbour and minimum spanning tree separation distribution with randomly placed cores. We show that a larger number of cores is necessary to successfully reject the null hypothesis if the underlying fragmentation is two-tier, $N > 20$. Once the null is rejected we show how one may decide if the observed fragmentation is best described by single-tier or two-tier fragmentation, using either Akaike's information criterion or the Bayes factor. The analysis techniques, null hypothesis tests, and model selection approaches are all included in a new open-source Python/C library called FragMent.

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A distant OB association around RAFGL 5475

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Context: Observations of the galactic disk at mid-infrared and longer wavelengths reveal a wealth of structures indicating the existence of complexes of recent massive star formation. However, little or nothing is known about the stellar component of those complexes.
Aims: We have carried out observations aiming at the identification of early-type stars in the direction of the bright infrared source RAFGL 5475, around which several interstellar medium structures usually associated with the presence of massive stars have been identified. Our observations have the potential of revealing the suspected but thus far unknown stellar component of the region around RAFGL 5475.
Methods: We have carried out near-infrared imaging observations (JHK_S bands) designed to reveal the presence of early-type stars based on their positions in color-color and color-magnitude diagrams centered on the location of RAFGL 5475. We took into account the possibility that candidates found might belong to a foreground population physically related either to M16 or M17, two giant HII regions lying midway between the Sun and RAFGL 5475.
Results: The near-infrared color-color diagram shows clear evidence for the presence of a moderately obscured population of early-type stars in the region imaged. By studying the distribution of extinction in their direction and basic characteristics of the interstellar medium we show that these new early-type stars are most likely associated with RAFGL 5475.
Conclusions: By investigating the possible existence of massive early-type stars in the direction of RAFGL 5475 we have discovered the existence of a new OB association. A very preliminary assessment of its contents suggests the presence of several O-type stars, some of them likely to be associated with structures in the interstellar medium. The new association is located at 4 kpc from the Sun in the Scutum-Centaurus arm.

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http://www.eso.org/~fcomeron/RAFGL5475.pdf

Physics of Planet Trapping with Applications to HL Tau

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We explore planet formation in the HL Tau disk and possible origins of the prominent gaps and rings observed by ALMA. We investigate whether dust gaps are caused by dynamically trapped planetary embryos at the ice lines of abundant volatiles. The global properties of the HL Tau disk (total mass, size) at its current age are used to constrain an evolving analytic disk model describing its temperature and density profiles. By performing a detailed analysis of the planet-disk interaction for a planet near the water ice line including a rigorous treatment of the dust opacity, we confirm that water is sufficiently abundant (1.5×10^{-4} molecules per H) to trap planets at its ice line due to an opacity transition. When the abundance of water is reduced by 50% planet trapping disappears. We extend our analysis to other planet traps: the heat transition, dead zone edge, and the CO_2 ice line and find similar trapping. The formation of planets via planetesimal accretion is computed for dynamically trapped embryos at the water ice line, dead zone, and heat transition. The end products orbit in the inner disk ($R < 3$ AU), unresolved by ALMA, with masses that range between sub-Earth to 5 Jupiter masses. While we find that the dust gaps correspond well with the radial positions of the CO_2 , CH_4 , and CO ice lines, the planetesimal accretion rates at these radii are too small to build large embryos within 1 Myr.

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Age Determination in Upper Scorpius with Eclipsing Binaries

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The Upper Scorpius OB association is the nearest region of recent massive star formation and thus an important benchmark for investigations concerning stellar evolution and planet formation timescales. We present nine eclipsing binaries (EBs) in Upper Scorpius, three of which are newly reported here and all of which were discovered from *K2* photometry. Joint fitting of the eclipse photometry and radial velocities from newly acquired Keck-I/HIRES spectra yields precise masses and radii for those systems that are spectroscopically double-lined. The binary orbital periods in our sample range from 0.6–100 days, with total masses ranging from 0.2–8 $M_\odot$. At least 33% of the EBs reside in hierarchical multiples, including two triples and one quadruple. We use these EBs to develop an empirical mass–radius relation for pre-main-sequence stars, and to evaluate the predictions of widely-used stellar evolutionary models. We report evidence for an age of 5–7 Myr which is self-consistent in the mass range of 0.3–5 $M_\odot$ and based on the fundamentally-determined masses and radii of EBs. Evolutionary models including the effects of magnetic fields imply an age of 9–10 Myr. Our results are consistent with previous studies that indicate many models systematically underestimate the masses of low-mass stars by 20–60% based on H–R diagram analyses. We also consider the dynamical states of several binaries and compare with expectations from tidal dissipation theories. Finally, we identify RIK 72 b as a long-period transiting brown dwarf ($M = 59.2 \pm 6.8\ M_{\rm Jup}$, $R = 3.10 \pm 0.31\ R_{\rm Jup}$, $P \approx 97.8$ days) and an ideal benchmark for brown dwarf cooling models at 5–10 Myr.

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Star-disc (mis-)alignment in Rho Oph and Upper Sco: insights from spatially resolved disc systems with K2 rotation periods

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The discovery of close in, giant planets (hot Jupiters) with orbital angular momentum vectors misaligned with respect to the rotation axis of their host stars presents problems for planet formation theories in which planets form in discs with angular momentum vectors aligned with that of the star. Violent, high eccentricity migration mechanisms purported to elevate planetary orbits above the natal disc plane predict populations of proto-hot Jupiters which have not been observed with Kepler. Alternative theories invoking primordial star-disc misalignments have recently received more attention. Here, the relative alignment between stars and their protoplanetary discs is assessed for the first time for a sample of 20 pre-main sequence stars. Recently published rotation periods derived from high quality, long duration, high cadence K2 light curves for members of the Rho Ophiuchus and Upper Scorpius star forming regions are matched with high angular resolution observations of spatially resolved discs and projected rotational velocities to determine stellar rotation axis inclination angles which are then compared to the disc inclinations. Ten of the fifteen systems for which the stellar inclination could be estimated are consistent with star-disc alignment while five systems indicate potential misalignments between the star and its disc. The potential for chance misalignment of aligned systems due to projection effects and characteristic measurement uncertainties is also investigated. While the observed frequency of apparent star-disc misalignments could be reproduced by a simulated test population in which 100 percent of systems are truly aligned, the distribution of the scale of inferred misalignment angles could not.

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Simulations of the dynamics of the debris disks in the systems Kepler-16, Kepler-34, and Kepler-35

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The long-term dynamics of planetesimals in debris discs in models with parameters of binary star systems Kepler-16, Kepler-34 and Kepler-35 with planets is investigated. Our calculations have shown the formation of a stable coorbital with the planet ring is possible for Kepler-16 and Kepler-35 systems. In Kepler-34 system, significant eccentricities of the orbits of the binary and planets can to prevent the formation of such a structure. Detection circumbinary annular structures in observations of systems binary stars can be evidence of the existence of planets, retaining coorbital rings from dust and planetesimals.

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The Disk Substructures at High Angular Resolution Project (DSHARP) VI: Dust trapping in thin-ringed protoplanetary disks

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A large fraction of the protoplanetary disks observed with ALMA display multiple well-defined and nearly perfectly circular rings in the continuum, in many cases with substantial peak-to-valley contrast. The DSHARP campaign shows that several of these rings are very narrow in radial extent. In this paper we test the hypothesis that these dust rings are caused by dust trapping in radial pressure bumps, and if confirmed, put constraints on the physics of the dust trapping mechanism. We model this process analytically in 1D, assuming axisymmetry. By comparing this model to the data, we find that all rings are consistent with dust trapping. Based on a plausible model of the dust temperature we find that several rings are narrower than the pressure scale height, providing strong evidence for dust trapping. The rings have peak absorption optical depth in the range between 0.2 and 0.5. The dust masses stored in each of these rings is of the order of tens of Earth masses, though much ambiguity remains due to the uncertainty of the dust opacities. The dust rings are dense enough to potentially trigger the streaming instability, but our analysis cannot give proof of this mechanism actually operating. Our results show, however, that the combination of very low $\alpha_{\rm turb} \ll 5\times10^{-4}$ and very large grains $a_{\rm grain} \gg 0.1\,{\rm cm}$ can be excluded by the data for all the rings studied in this paper.

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Hints for a Turnover at the Snow Line in the Giant Planet Occurrence Rate

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The orbital distribution of giant planets is crucial for understanding how terrestrial planets form and predicting yields of exoplanet surveys. Here, we derive giant planets occurrence rates as a function of orbital period by taking into account the detection efficiency of the *Kepler* and radial velocity (RV) surveys. The giant planet occurrence rates for *Kepler* and RV show the same rising trend with increasing distance from the star. We identify a break in the RV giant planet distribution between ∼2-3 au — close to the location of the snow line in the Solar System — after which the occurrence rate decreases with distance from the star. Extrapolating a broken power-law distribution to larger semi-major axes, we find good agreement with the $\sim 1\%$ planet occurrence rates from direct imaging surveys. Assuming a symmetric power law, we also estimate that the occurrence of giant planets between $0.1-100\,{\rm au}$ is $26.6^{+7.5}_{-5.4}\%$ for planets with masses 0.1-20 $M_{\rm J}$ and decreases to $6.2^{+1.5}_{-1.2}\%$ for planets more massive than Jupiter. This implies that only a fraction of the structures detected in disks around young stars can be attributed to giant planets. Various planet population synthesis models show good agreement with the observed distribution, and we show how a quantitative comparison between model and data can be used to constrain planet formation and migration mechanisms.

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Multiwavelength study of the G345.5+1.5 region

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The star formation process requires the dust and gas present in the Milky Way to self-assemble into dense reservoirs of neutral material where the new generation of stars will emerge. Star forming regions are usually studied in the context of Galactic surveys but dedicated observations are sometimes needed when to go beyond them. A better understanding of the star formation process in the Galaxy goes through the study of several regions. This allows to increase the sample of objects (clumps, cores, stars) for further statistical works and deeper follow-up studies can be undertaken. Here, we studied the G345.5+1.5 region located slightly above the Galactic plane to understand its star formation properties. We combine LABOCA and ^{12}CO(4−3) transition line (NANTEN2) observations complemented with the Hi-GAL and *Spitzer*-GLIMPSE surveys to study the star formation towards this region. We used the *Clumpfind* algorithm to extract the clumps from the 870 μm and the ^{12}CO(4−3) data. Radio emission at 36 cm is used to estimate the number of H II regions and to remove the contamination from the free-free emission at 870 μm. We employed color-color diagrams and spectral energy distribution (SED) slopes to distinguish between prestellar and protostellar clumps. We studied the boundness of the clumps through the virial parameter. Finally, we estimated the star formation efficiency (SFE) and star formation rate (SFR) of the region and used the Schmidt-Kennicutt diagram to compare its ability to form stars with other regions of the Galactic plane. Among the 13 radio sources found using the MGPS-2 catalog, 7 of them are found to be associated with H II regions corresponding to late B/early O stars. We found 45 870 μm-clumps with diameters between 0.4 and 1.2 pc and masses between 43 $M_\odot$ and 3923 $M_\odot$, and 107 ^{12}CO clumps having diameters between 0.4 pc and 1.3 pc and masses between 28 $M_\odot$ and 9433 $M_\odot$. More than 50% of the clumps are protostellar and bounded and are able to host (massive) star formation. An high SFR and SFR density (Σ_{SFR}) values are associated to the region with a star formation efficiency (SFE) of a few percent. With submillimeter, CO transition and short wavelength infrared observations, our study reveals a population of massive stars, protostellar and bound starless clumps towards G345.5+1.5. This region is therefore actively forming stars and its location in the starburst quadrant of Schmidt-Kennicutt diagram is comparable to other star-forming regions found within the Galactic plane.

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Constraining the Rate of Protostellar Accretion Outbursts in the Orion Molecular Clouds

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Outbursts due to dramatic increases in the mass accretion rate are the most extreme type of variability in young stellar objects. We searched for outbursts among 319 protostars in the Orion molecular clouds by comparing 3.6, 4.5, and 24 μm photometry from the *Spitzer Space Telescope* to 3.4, 4.6, and 22 μm photometry from the *Wide-field Infrared Survey Explorer* (*WISE*) obtained $\sim$ 6.5 yr apart. Sources that brightened by more than two standard deviations above the mean variability at all three wavelengths were marked as burst candidates, and they were inspected visually to check for false positives due primarily to the reduced angular resolution of *WISE* compared to *Spitzer*. We recovered the known burst V2775 Ori (HOPS 223) as well as a previously unknown burst, HOPS 383, which we announced in an earlier paper. No other outbursts were found. With observations over 6.5 yr, we estimate an interval of about

1000 yr between bursts with a 90% confidence interval of 690 to 40,300 yr. The most likely burst interval is shorter than those found in studies of optically revealed young stellar objects, suggesting that outbursts are more frequent in protostars than in pre-main-sequence stars that lack substantial envelopes.

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Orion Source I's disk is salty

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We report the detection of NaCl, KCl, and their ^{37}Cl and ^{41}K isotopologues toward the disk around Orion Source I. About 60 transitions of these molecules were identified. This is the first detection of these molecules in the interstellar medium not associated with the ejecta of evolved stars. It is also the first ever detection of the vibrationally excited states of these lines in the ISM above $v = 1$, with firm detections up to $v = 6$. The salt emission traces the region just above the continuum disk, possibly forming the base of the outflow. The emission from the vibrationally excited transitions is inconsistent with a single temperature, implying the lines are not in LTE. We examine several possible explanations of the observed high excitation lines, concluding that the vibrational states are most likely to be radiatively excited via rovibrational transitions in the 25-35 μm (NaCl) and 35-45 μm (KCl) range. We suggest that the molecules are produced by destruction of dust particles. Because these molecules are so rare, they are potentially unique tools for identifying high-mass protostellar disks and measuring the radiation environment around accreting young stars.

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Distributed star formation throughout the Galactic Center cloud Sgr B2

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We report ALMA observations with resolution ≈ 0.5 arcsec at 3 mm of the extended Sgr B2 cloud in the Central Molecular Zone (CMZ). We detect 271 compact sources, most of which are smaller than 5000 AU. By ruling out alternative possibilities, we conclude that these sources consist of a mix of hypercompact H IIregions and young stellar objects (YSOs). Most of the newly detected sources are YSOs with gas envelopes that, based on their luminosities, must contain objects with stellar masses $M_* \gtrsim 8\ M_\odot$. Their spatial distribution spread over a $\sim 12 \times 3$ pc region demonstrates that Sgr B2 is experiencing an extended star formation event, not just an isolated 'starburst' within the protocluster regions. Using this new sample, we examine star formation thresholds and surface density relations in Sgr B2. While all of the YSOs reside in regions of high column density ($N(H_2) \gtrsim 2 \times 10^{23}$ cm^{-2}), not all regions of high column density contain YSOs. The observed column density threshold for star formation is substantially higher than that in solar vicinity clouds, implying either that high-mass star formation requires a higher column density or that any star formation threshold in the CMZ must be higher than in nearby clouds. The relation between the surface density of gas and stars is incompatible with extrapolations from local clouds, and instead stellar densities in Sgr B2 follow a linear $\Sigma_* - \Sigma_{gas}$ relation, shallower than that observed in local clouds. Together, these points suggest that a higher volume density threshold is required to explain star formation in CMZ clouds.

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A high cluster formation efficiency in the Sagittarius B2 complex

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The fraction of stars forming in compact, gravitationally bound clusters (the 'cluster formation efficiency' or CFE) is an important quantity for deriving the spatial clustering of stellar feedback and for tracing star formation using stellar clusters across the Universe. Observations of clusters in nearby galaxies have revealed a strong dependence of the CFE on the local gas density, indicating that more stars form in star clusters when the star formation rate surface density is higher. Previously, it has not been possible to test this relation at very young ages and in clusters with individual stars resolved due to the universally-low densities in the cluster-forming regions in the Local Group. This has even led to the suggestion that the CFE increases with distance from the Sun, which would suggest an observational bias. However, the Central Molecular Zone of the Milky Way hosts clouds with densities that are orders of magnitude higher than anywhere else in the Local Group. We report a measurement of the CFE in the highest-density region in the Galaxy, Sgr B2, based on ALMA observations of high-mass young stellar objects. We find that over a third of the stars ($37 \pm 7\%$) in Sgr B2 are forming in bound clusters. This value is consistent with the predictions of environmentally-dependent models for the CFE and is inconsistent with a constant CFE in the Galaxy.

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A Keplerian disk around Orion Source I, a $\sim 15\ M_\odot$ YSO

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We report ALMA long-baseline observations of Orion Source I with resolution 0.03-0.06 arcsec (12-24 AU) at 1.3 and 3.2 mm. We detect both continuum and spectral line emission from Source I's disk. We also detect a central weakly resolved source that we interpret as a hot spot in the inner disk, which may indicate the presence of a binary system. The high angular resolution and sensitivity of these observations allow us to measure the outer envelope of the rotation curve of the $H_2O\ 5_{5,0} - 6_{4,3}$ line, which gives a mass $M_I \approx 15 \pm 2\ M_\odot$. We detected several other lines that more closely trace the disk, but were unable to identify their parent species. Using centroid-of-channel methods on these other lines, we infer a similar mass. These measurements solidify Source I as a genuine high-mass protostar system and support the theory that Source I and the Becklin Neugebauer Object were ejected from the dynamical decay of a multiple star system ~500 years ago, an event that also launched the explosive molecular outflow in Orion.

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Fundamental properties of the pre-main sequence eclipsing stars of MML 53 and the mass of the tertiary

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We present the most comprehensive analysis to date of the Upper Centaurus Lupus eclipsing binary MML 53 (2.097892 d), and for the first time, confirm the bound-nature of the third star (~9 yr orbit). Our analysis uses new and archival spectra and time-series photometry. We determined the temperature of the primary star to be 4880±100 K. The study of the close binary incorporated treatment of spots and dilution by the tertiary in the light curves, allowing for the robust measurement of the masses of the eclipsing components within 1% ($M_1 = 1.0400 \pm 0.0067$ and $M_2 = 0.8907 \pm 0.0058\ M_\odot$), their radii within 4.5% ($R_1 = 1.283 \pm 0.043$ and $R_2 = 1.107 \pm 0.049\ R_\odot$), and the secondary temperature (4379±100 K). From the analysis of the eclipse timings, and the change in systemic velocity of the eclipsing binary and the radial velocities of the third star, we measured the mass of the outer companion to be 0.7 $M_\odot$ within 20%. The age we derived from the evolution of the temperature ratio between the eclipsing components is fully consistent with previous estimates of the age of UCL (16±2 Myr). At this age, the tightening of the MML 53 eclipsing binary has already occurred, thus supporting close-binary formation mechanisms that act early in their evolution. The eclipsing stars roughly follow the same theoretical isochrone, but appear to be inflated in radius (by

20% for the primary and 10% for the secondary). However, our primary radius measurement of is in full agreement with the independent measurement of the secondary of NP Per which has the same mass and a similar age. The eclipsing stars of MML 53 are found to be larger but not cooler than predicted by non-magnetic models, it is not clear what is the mechanism that is causing the radius inflation given that activity, spots and/or magnetic fields slowing their contraction, require the inflated stars to be cooler to remain in thermal equilibrium.

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Blobs, spiral arms, and a possible planet around HD 169142

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Young planets are expected to cause perturbations in protostellar disks that may be used to infer their presence. Clear detection of still-forming planets embedded within gas-rich disks is rare. HD 169142 is a very young Herbig Ae-Be star surrounded by a pre-transitional disk, composed of at least three rings. While claims of sub-stellar objects around this star have been made previously, follow-up studies remain inconclusive. We used SPHERE at ESO VLT to obtain a sequence of high-contrast images of the immediate surroundings of this star over about three years. This enables a photometric and astrometric analysis of the structures in the disk. While we were unable to definitively confirm the previous claims of a massive sub-stellar object at $0.''1$–$0.''15$ from the star, we found both spirals and blobs within the disk. The spiral pattern may be explained as due to the presence of a primary, a secondary, and a tertiary arm excited by a planet of a few Jupiter masses lying along the primary arm, likely in the cavities between the rings. The blobs orbit the star consistently with Keplerian motion, allowing a dynamical determination of the mass of the star. While most of these blobs are located within the rings, we found that one of them lies in the cavity between the rings, along the primary arm of the spiral design. This blob might be due to a planet that might also be responsible for the spiral pattern observed within the rings and for the cavity between the two rings. The planet itself is not detected at short wavelengths, where we only see a dust cloud illuminated by stellar light, but the planetary photosphere might be responsible for the emission observed in the K band. The mass of this putative planet may be constrained using photometric and dynamical arguments; it should be between 1 and 4 Jupiter masses. The brightest blobs are found at the 1:2 resonance with this putative planet

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The Disk Substructures at High Angular Resolution Program (DSHARP). VIII. The Rich Ringed Substructures in the AS 209 Disk

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We present a detailed analysis of the high angular resolution (0.″037, corresponding to 5 au) observations of the 1.25 mm continuum and ^{12}CO 2–1 emission from the disk around the T Tauri star AS 209. AS 209 hosts one of the most unusual disks from the Disk Substructures at High Angular Resolution Project sample, the first high angular resolution Atacama Large Millimeter Array survey of disks, as nearly all of the emission can be explained with concentric Gaussian rings. In particular, the dust emission consists of a series of narrow and closely spaced rings in the inner ∼60 au, two well-separated bright rings in the outer disk, centered at 74 and 120 au, and at least two fainter emission features at 90 and 130 au. We model the visibilities with a parametric representation of the radial surface brightness profile, consisting of a central core and seven concentric Gaussian rings. Recent hydrodynamical simulations of low-viscosity disks show that super-Earth planets can produce the multiple gaps seen in AS 209 millimeter continuum emission. The ^{12}CO line emission is centrally peaked and extends out to ∼300 au, much farther than the millimeter dust emission. We find axisymmetric, localized deficits of CO emission around four distinct radii, near 45, 75, 120, and 210 au. The outermost gap is located well beyond the edge of the millimeter dust emission, and therefore cannot be due to dust opacity and must be caused by a genuine CO surface density reduction, due either to chemical effects or depletion of the overall gas content.

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PTF 14jg: The Remarkable Outburst and Post-Burst Evolution of a Previously Anonymous Galactic Star

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We report the outbursting source iPTF 14jg, which prior to the onset of its late 2013 eruption, was a faint, unstudied, and virtually uncatalogued star. The salient features of the iPTF 14jg outburst are: *(i)* projected location near the W4 H II region and radial velocity consistent with physical association; *(ii)* a lightcurve that underwent a ∼6-7 mag optical (R-band) through mid-infrared (L-band) brightening on a few month time scale, that peaked and then faded by ?3 mag, but plateaued still >3.5 mag above quiescence by ∼8 months post-peak, lasting to at least four years after eruption; *(iii)* strong outflow signatures, with velocities reaching ∼530 km/s; *(iv)* a low gravity and broad (∼100-150 km/s FWHM) optical absorption line spectrum that systematically changes its spectral type with wavelength; *(v)* lithium; and *(vi)* ultraviolet and infrared excess. We tentatively identify the outburst as exhibiting characteristics of a young star FU Ori event. However, the burst would be unusually hot, with an absorption spectrum exhibiting high-excitation (∼11,00015,000 K) lines in the optical, and no evidence of CO in the near-infrared, in addition to exhibiting an unusual lightcurve. We thus also consider alternative scenarios including various forms of novae, nuclear burning instabilities, massive star events, and mergers - finding them all inferior to the atypically hot FU Ori star classification. The source eventually may be interpreted as a new category of young star outburst with larger amplitude and shorter rise time than most FU Ori-like events. Continued monitoring of the lightcurve and the spectral evolution will reveal its true nature.

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Nonlinear outcome of gravitational instability in an irradiated protoplanetary disc

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Using local three dimensional radiation hydrodynamics simulations, the nonlinear outcome of gravitational instability in an irradiated protoplanetary disc is investigated in a parameter space of the surface density Σ and the radius r. Starting from laminar flow, axisymmetric self-gravitating density waves grow first. Their self-gravitating degree becomes larger when Σ is larger or the cooling time is shorter at larger radii. The density waves eventually collapse owing to non-axisymmetric instability, which results in either fragmentation or gravito-turbulence after a transient phase. The boundaries between the two are found at $r \sim 75$ AU as well as at the Σ that corresponds to the initial Toomre's parameter of ∼0.2. The former boundary corresponds to the radius where the cooling time becomes short, approximating unity. Even when gravito-turbulence is established around the boundary radius, such a short cooling time inevitably makes the fluctuation of Σ large enough to trigger fragmentation. On the other hand, when Σ is beyond the latter boundary (i.e. the initial Toomre's parameter is less than ∼0.2), the initial laminar flow is so unstable against self-gravity that it evolves into fragmentation regardless of the radius or, equivalently, the cooling time. Runaway collapse follows fragmentation when the mass concentration at the centre of a bound object is high enough that the temperature exceeds the H2 dissociation temperature.

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The Disk Substructures at High Angular Resolution Project (DSHARP). II. Characteristics of Annular Substructures

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The Disk Substructures at High Angular Resolution Project used ALMA to map the 1.25 millimeter continuum of protoplanetary disks at a spatial resolution of ? 5 au. We present a systematic analysis of annular substructures in the 18 single-disk systems targeted in this survey. No dominant architecture emerges from this sample; instead, remarkably diverse morphologies are observed. Annular substructures can occur at virtually any radius where millimeter continuum emission is detected and range in widths from a few au to tens of au. Intensity ratios between gaps and adjacent rings range from near-unity to just a few percent. In a minority of cases, annular substructures co-exist with other types of substructures, including spiral arms (3/18) and crescent-like azimuthal asymmetries (2/18). No clear trend is observed between the positions of the substructures and stellar host properties. In particular, the absence of an obvious association with stellar host luminosity (and hence the disk thermal structure) suggests that substructures do not occur preferentially near major molecular snowlines. Annular substructures like those observed in DSHARP have long been hypothesized to be due to planet-disk interactions. A few disks exhibit characteristics particularly suggestive of this scenario, including substructures in possible mean-motion resonance and double gap features reminiscent of hydrodynamical simulations of multiple gaps opened by a planet in a low-viscosity disk.

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The Disk Substructures at High Angular Resolution Project (DSHARP). III. Spiral Structures in the Millimeter Continuum of the Elias 27, IM Lup, and WaOph 6 Disks

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We present an analysis of ALMA 1.25 millimeter continuum observations of spiral structures in three protoplanetary disks from the Disk Substructures at High Angular Resolution Project. The disks around Elias 27, IM Lup, and WaOph 6 were observed at a resolution of ∼40−60 mas (∼6−7 au). All three disks feature $m = 2$ spiral patterns in conjunction with annular substructures. Gas kinematics established by ^{12}CO $J = 2 - 1$ observations indicate that the continuum spiral arms are trailing. The arm-interarm intensity contrasts are modest, typically less than 3. The Elias 27 spiral pattern extends throughout much of the disk, and the arms intersect the gap at R∼69 au. The spiral pattern in the IM Lup disk is particularly complex-it extends about halfway radially through the disk, exhibiting pitch angle variations with radius and interarm features that may be part of ring substructures or spiral arm branches. Spiral arms also extend most of the way through the WaOph 6 disk, but the source overall is much more compact than the other two disks. We discuss possible origins for the spiral structures, including gravitational instability and density waves induced by a stellar or planetary companion. Unlike the millimeter continuum counterparts of many of the disks

with spiral arms detected in scattered light, these three sources do not feature high-contrast crescent-like asymmetries or large (R >20 au) emission cavities. This difference may point to multiple spiral formation mechanisms operating in disks.

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First long-term activity study of AU Microscopii: a possible chromospheric cycle

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M stars are ideal targets to search for Earth-like planets. However, they usually have high levels of magnetic activity, which could affect their habitability and make difficult the detection of exoplanets orbiting around them. Unfortunately, long-term variability of dM stars has not been extensively studied, due to their low intrinsic brightness. For this reason, in 1999 we started the HKα project, which systematically observes the spectra of a large number of stars, in particular dM stars, at the Complejo Astronomico El Leoncito (CASLEO). In this work, we study the long-term activity of the young active dM1 star AU Microscopii. We analyze the Mount Wilson index S derived from CASLEO spectra obtained between 2004 and 2016, which we complement with the S-index derived from HARPS, FEROS and UVES public spectra. We also analyze the simultaneous photometric counterpart provided by the ASAS public database for this star between 2000 and 2009, and our own photometry. In both totally independent time series, we detect a possible activity cycle of period around 5 years. We also derived a precise rotation period for this star $P_{\rm rot} = 4.85$ days, consistent with the literature. This activity cycle reflects that an $\alpha\Omega$ dynamo could be operating in this star.

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Water delivery by pebble accretion to rocky planets in habitable zones in evolving disks

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The Earth's ocean mass is only 2.3×10^{-4} of the whole planet mass. Even including water in the interior, it would be at most 10^{-3}–10^{-2}. Ancient Mars may have had a similar or slightly smaller water fraction. It is important to clarify the water delivery mechanism to rocky planets in habitable zones in exoplanetary systems, as well as that to the Earth and Mars. Here, we consider water delivery to planets by icy pebbles after the snowline inwardly passes the planetary orbits and derive the water mass fraction ($f_{\rm water}$) of the final planet as a function of disk parameters and discuss the parameters that reproduce $f_{\rm water}$ comparable to that inferred for the Earth and ancient Mars. We calculate the growth of icy pebbles and their radial drift with a 1D model, and accretion of icy pebbles onto planets, by simultaneously solving the snowline migration and the disk dissipation, to evaluate $f_{\rm water}$ of the planets. We find that $f_{\rm water}$ is regulated by the total mass ($M_{\rm res}$) of icy dust materials preserved in the outer disk regions at the timing ($t = t_{\rm snow}$) of the snowline passage of the planetary orbit. Because $M_{\rm res}$ decays rapidly after the pebble formation front reaches the disk outer edge (at $t = t_{\rm pff}$), $f_{\rm water}$ is sensitive to the ratio $t_{\rm snow}/t_{\rm pff}$, which is determined by the disk parameters. We find $t_{\rm snow}/t_{\rm pff} < 10$ or > 10 is important. Deriving an analytical formula for $f_{\rm water}$ that reproduces the numerical results, we find that $f_{\rm water}$ of a rocky planet near 1 au is $\sim 10^{-4}$–10^{-2}, in the disks with initial disk size $\sim$30–50 au and the initial disk mass accretion rate $\sim (10^{-8}$–$10^{-7})$ $M_\odot$ yr^{-1}. Because these disks may be median or slightly compact/massive disks, the water fraction of rocky planets in habitable zones may be often similar to that of

the Earth, if the icy pebble accretion is responsible for the water delivery.

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The Disk Substructures at High Angular Resolution Project (DSHARP). IX. A High-definition Study of the HD 163296 Planet-forming Disk

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The Atacama Large Millimeter/submillimeter Array observations of protoplanetary disks acquired by the Disk Substructure at High Angular Resolution Project resolve the dust and gas emission on angular scales as small as 3 astronomical units, offering an unprecedented detailed view of the environment where planets form. In this Letter, we present and discuss observations of the HD 163296 protoplanetary disk that imaged the 1.25 mm dust continuum and 12CO J = 2-1 rotational line emission at a spatial resolution of 4 and 10 au, respectively. The continuum observations resolve and allow us to characterize the previously discovered dust rings at radii of 68 and 100. They also reveal new small-scale structures, such as a dark gap at 10 au, a bright ring at 15 au, a dust crescent at a radius of 55 au, and several fainter azimuthal asymmetries. The observations of the CO and dust emission provide information about the vertical structure of the disk and allow us to directly constrain the dust extinction optical depth at the dust rings. Furthermore, the observed asymmetries in the dust continuum emission corroborate the hypothesis that the complex structure of the HD 163296 disk is the result of the gravitational interaction with yet-unseen planets.

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How planetary growth outperforms migration

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Planetary migration is a major challenge for planet-formation theories. The speed of type-I migration is proportional to the mass of a protoplanet, while the final decade of growth of a pebble-accreting planetary core takes place at a rate that scales with the mass to the two-thirds power. This results in planetary growth tracks (i.e., the evolution of the mass of a protoplanet versus its distance from the star) that become increasingly horizontal (migration-dominated) with the rising mass of the protoplanet. It has been shown recently that the migration torque on a protoplanet is reduced proportional to the relative height of the gas gap carved by the growing planet. Here we show from 1D simulations of planet–disc interaction that the mass at which a planet carves a 50% gap is approximately 2.3 times the pebble isolation mass. Our measurements of the pebble isolation mass from 1D simulations match published 3D

results relatively well, except at very low viscosities ($\alpha < 10^{-3}$) where the 3D pebble isolation mass is significantly higher, possibly due to gap edge instabilities that are not captured in 1D. The pebble isolation mass demarks the transition from pebble accretion to gas accretion. Gas accretion to form gas-giant planets therefore takes place over a few astronomical units of migration after reaching first the pebble isolation mass and, shortly after, the 50% gap mass. Our results demonstrate how planetary growth can outperform migration both during core accretion and during gas accretion, even when the Stokes number of the pebbles is small, St $\sim$ 0.01, and the pebble-to-gas flux ratio in the protoplanetary disc is in the nominal range of 0.01–0.02. We find that planetary growth is very rapid in the first million years of the protoplanetary disc and that the probability for forming gas-giant planets increases with the initial size of the protoplanetary disc and with decreasing turbulent diffusion.

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Classical T-Tauri stars with VPHAS+: II: NGC 6383 in Sh 2-012

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This paper presents optical ($ugri$Hα)–infrared (JHKs,3.6–8.0μm) photometry, and *Gaia* astrometry of 55 Classical T-Tauri stars (CTTS) in the star-forming region Sh 2-012, and its central cluster NGC 6383. The sample was identified based on photometric Hα emission line widths, and has a median age of 2.8±1.6 Myr, with a mass range between 0.3–1 $M_\odot$. 94% of CTTS with near-infrared cross-matches fall on the near-infrared T-Tauri locus, with all stars having mid-infrared photometry exhibiting evidence for accreting circumstellar discs. CTTS are found concentrated around the central cluster NGC 6383, and towards the bright rims located at the edges of Sh 2-012. Stars across the region have similar ages, suggestive of a single burst of star formation. Mass accretion rates ($\dot{M}_{acc}$) estimated via Hα and u-band line intensities show a scatter (0.3 dex) similar to spectroscopic studies, indicating the suitability of Hα photometry to estimate $\dot{M}_{acc}$. Examining the variation of $\dot{M}_{acc}$ with stellar mass (M_*), we find a smaller intercept in the $\dot{M}_{acc}$-M_* relation than oft-quoted in the literature, providing evidence to discriminate between competing theories of protoplanetary disc evolution.

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The Disk Substructures at High Angular Resolution Project (DSHARP): IV. Characterizing substructures and interactions in disks around multiple star systems.

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To characterize the substructures induced in protoplanetary disks by the interaction between stars in multiple systems, we study the 1.25 mm continuum and the ^{12}CO($J = 2-1$) spectral line emission of the triple systems HT Lup and AS 205, at scales of ≈ 5 au, as part of the "Disk Substructures at High Angular Resolution Project" (DSHARP). In the continuum emission, we find two symmetric spiral arms in the disk around AS 205 N, with pitch angle of 14°, while the southern component AS 205 S, itself a spectroscopic binary, is surrounded by a compact inner disk and a bright ring at a radius of 34 au. The ^{12}CO line exhibits clear signatures of tidal interactions, with spiral arms, extended arc-like emission, and high velocity gas, possible evidence of a recent close encounter between the disks in the AS 205 system, as these features are predicted by hydrodynamic simulations of fly-by encounters. In the HT Lup system, we detect continuum emission from all three components. The primary disk, HT Lup A, also shows two-armed symmetric spiral structure with a pitch angle of 4°, while HT Lup B and C, located at 25 and 434 au in projected separation from HT Lup A, are barely resolved with ~ 5 and ~ 10 au in diameter, respectively. The gas kinematics for the closest pair indicates a different sense of rotation for each disk, which could be explained by either a counter rotation of the two disks in different, close to parallel, planes, or by a projection effect of these disks with a close to 90° misalignment between them.

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Extremely high excitation SiO lines in disk-outflow system in Orion Source I

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We present high-resolution images of the submillimeter SiO line emissions of a massive young stellar object Orion Source I using the Atacama Large Millimeter/ Submillimeter Array (ALMA) at band 8. We detected the 464 GHz SiO v=4 J=11–10 line in Source I, which is the first detection of the SiO v=4 line in star-forming regions, together with the 465 GHz ^{29}SiO v=2 J=11–10 and the 428 GHz SiO v=2 J=10–9 lines with a resolution of 50 AU. The ^{29}SiO v=2 J=11–10 and SiO v=4 J=11–10 lines have compact structures with the diameter of <80 AU. The spatial and velocity distribution suggest that the line emissions are associated with the base of the outflow and the surface of the edge-on disk. In contrast, SiO v=2 J=10–9 emission shows a bipolar structure in the direction of northeast-southwest low-velocity outflow with ∼200 AU scale. The emission line exhibits a velocity gradient along the direction of the disk elongation. With the assumption of the ring structure with Keplerian rotation, we estimated the lower limit of the central mass to be 7 solar mass and the radius of 12 AU< r <26 AU.

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The potential of combining MATISSE and ALMA observations: Constraining the structure of the innermost region in protoplanetary discs

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In order to study the initial conditions of planet formation, it is crucial to obtain spatially resolved multi-wavelength observations of the innermost region of protoplanetary discs. We evaluate the advantage of combining observations with MATISSE/VLTI and ALMA to constrain the radial and vertical structure of the dust in the innermost region of circumstellar discs in nearby star-forming regions. Based on a disc model with a parameterized dust density distribution, we apply 3D radiative-transfer simulations to obtain ideal intensity maps. These are used to derive the corresponding wavelength-dependent visibilities we would obtain with MATISSE as well as ALMA maps simulated with `CASA`.

Within the considered parameter space, we find that constraining the dust density structure in the innermost 5 au around the central star is challenging with MATISSE alone, whereas ALMA observations with reasonable integration times allow us to derive significant constraints on the disc surface density. However, we find that the estimation of the different disc parameters can be considerably improved by combining MATISSE and ALMA observations. For example, combining a 30-minute ALMA observation (at 310 GHz with an angular resolution of 0.03 arcsec) for MATISSE observations in the L and M bands (with visibility accuracies of about 3 %) allows the radial density slope and the dust surface density profile to be constrained to within $\Delta\alpha = 0.3$ and $\Delta(\alpha - \beta) = 0.15$, respectively. For an accuracy of $\sim$1 % even the disc flaring can be constrained to within $\Delta\beta = 0.1$. To constrain the scale height to within 5 au, M band accuracies of 0.8 % are required. While ALMA is sensitive to the number of large dust grains settled to the disc midplane we find that the impact of the surface density distribution of the large grains on the observed quantities is small.

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Gas flow around a planet embedded in a protoplanetary disc: the dependence on the planetary mass

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The three-dimensional structure of the gas flow around a planet is thought to influence the accretion of both gas and solid materials. In particular, the outflow in the mid-plane region may prevent the accretion of the solid materials and delay the formation of super-Earths' cores. However, it is not yet understood how the nature of the flow field and outflow speed change as a function of the planetary mass. In this study, we investigate the dependence of gas flow around a planet embedded in a protoplanetary disc on the planetary mass. Assuming an isothermal, inviscid gas disc, we perform three-dimensional hydrodynamical simulations on the spherical polar grid, which has a planet located at its centre. We find that gas enters the Bondi or Hill sphere at high latitudes and exits through the mid-plane region of the disc regardless of the assumed dimensionless planetary mass $m = R_{\rm Bondi}/H$, where $R_{\rm Bondi}$ and H are the Bondi radius of the planet and disc scale height, respectively. The altitude from where gas predominantly enters the envelope varies with the planetary mass. The outflow speed can be expressed as $|u_{\rm out}| = \sqrt{3/2} m c_{\rm s} (R_{\rm Bondi} \leq R_{\rm Hill})$ or $|u_{\rm out}| = \sqrt{3/2} (m/3)^{1/3} c_{\rm s} (R_{\rm Bondi} \geq R_{\rm Hill})$, where $c_{\rm s}$ is the isothermal sound speed and $R_{\rm Hill}$ is the Hill radius. The outflow around a planet may reduce the accretion of dust and pebbles onto the planet when $m \gtrsim \sqrt{\rm St}$, where St is the Stokes number. Our results suggest that the flow around proto-cores of super-Earths may delay their growth and, consequently, help them to avoid runaway gas accretion within the lifetime of the gas disc.

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Surveying the Giant HII Regions of the Milky Way with *SOFIA*: I. W 51 A

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We discuss the first results from our mid-infrared imaging survey of Milky Way Giant HII regions with our detailed analysis of W 51 A, which is one of the largest GHII regions in our Galaxy. We used the FORCAST instrument on *SOFIA* to obtain 20 and 37 μm images of the central $10' \times 20'$ area, which encompasses both of the G49.5-0.4 and G49.4-0.3 sub-regions. Based on these new data, and in conjunction with previous multi-wavelength observations, we conjecture on the physical nature of several individual sources and sub-components within W 51 A. We find that extinction seems to play an important role in the observed structures we see in the near- to mid-infrared, both globally and locally. We used the *SOFIA* photometry combined with *Spitzer*-IRAC and *Herschel*-PACS photometry data to construct spectral energy distributions (SEDs) of sub-components and point sources detected in the *SOFIA* images. We fit those SEDs with young stellar object models, and found 41 sources that are likely to be massive young stellar objects, many of which are identified as such in this work for the first time. Close to half of the massive young stellar objects do not have detectable radio continuum emission at cm wavelengths, implying a very young state of formation. We derived luminosity-to-mass ratio and virial parameters of the extended radio sub-regions of W 51 A to estimate their relative ages.

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Magnetized interstellar molecular clouds: II. The Large-Scale Structure and Dynamics of Filamentary Molecular Clouds

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Ideal MHD high resolution AMR simulations with driven turbulence and self-gravity have been performed that demonstrate the formation of long filamentary molecular clouds at the converging location of large-scale turbulence flow, bounded by gravity, and the magnetic field helps shaping and reinforcing the long filamentary appearance. The main filamentary cloud has a length of ~4.4 pc. Instead of a monolithic cylindrical structure, the main cloud is shown to be a collection of fiber/web-like sub-structures similar to filamentary clouds such as L1495. Unless the line-of-sight is close to the mean field direction, the large-scale magnetic field and striations in the simulation are found roughly perpendicular to the long axis of the main cloud, similar to 1495. This provides strong support for a large-scale moderately strong magnetic field surrounding L1495. We find that the projection effect from observations can lead to incorrect interpretations of the true three-dimensional physical shape, size, and velocity structure of the clouds. Helical magnetic field structures found around filamentary clouds that are interpreted from Zeeman observations can be explained by a simple bending of the magnetic field that pierces through the cloud. We demonstrate that two dark clouds form a T-shape configuration which are strikingly similar to the Infrared dark cloud SDC13 leading to the interpretation that SDC13 results from a collision of two long filamentary clouds. We show that a moderately strong magnetic field ($\mathcal{M}_{\rm A} \sim 1$) is crucial for maintaining a long and slender filamentary cloud for a long period of time ~0.5 million years.

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Magma ascent in planetesimals: control by grain size

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Rocky planetesimals in the early solar system melted internally and evolved chemically due to radiogenic heating from ^{26}Al. Here we quantify the parametric controls on magma genesis and transport using a coupled petrological and fluid mechanical model of reactive two-phase flow. We find the mean grain size of silicate minerals to be a key control on magma ascent. For grain sizes larger than ≈ 1 mm, melt segregation produces distinct radial structure and chemical stratification. This stratification is most pronounced for bodies formed at around 1 Myr after formation of Ca,Al-rich inclusions. These findings suggest a link between the time and orbital location of planetesimal formation and their subsequent structural and chemical evolution. According to our models, the evolution of partially molten planetesimal interiors falls into two categories. In the *magma ocean* scenario, the whole interior of a planetesimal experiences nearly complete melting, which would result in turbulent convection and core-mantle differentiation by the rainfall mechanism. In the *magma sill* scenario, segregating melts gradually deplete the deep interior of the radiogenic heat source. In this case, magma may form melt-rich layers beneath a cool and stable lid, while core formation would proceed by percolation. Our findings suggest that grain sizes prevalent during the internal heating stage governed magma ascent in planetesimals. Regardless of whether evolution progresses toward a *magma ocean* or *magma sill* structure, our models predict that temperature inversions due to rapid ^{26}Al redistribution are limited to bodies formed earlier than ≈ 1 Myr after CAIs. We find that if grain size was smaller than ≈ 1 mm during peak internal melting, only elevated solid–melt density contrasts (such as found for the reducing conditions in enstatite chondrite compositions) would allow substantial melt segregation to occur.

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A water budget dichotomy of rocky protoplanets from ^{26}Al-heating

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In contrast to the water-poor planets of the inner Solar System, stochasticity during planetary formation and order-of-magnitude deviations in exoplanet volatile contents suggest that rocky worlds engulfed in thick volatile ice layers are the dominant family of terrestrial analogues among the extrasolar planet population. However, the distribution of compositionally Earth-like planets remains insufficiently constrained, and it is not clear whether the Solar System is a statistical outlier or can be explained by more general planetary formation processes. Here we use numerical models of planet formation, evolution and interior structure to show that a planets bulk water fraction and radius are anti-correlated with initial ^{26}Al levels in the planetesimal-based accretion framework. The heat generated by this short-lived radionuclide rapidly dehydrates planetesimals before their accretion onto larger protoplanets and yields a system-wide correlation of planetary bulk water abundances, which, for instance, can explain the lack of a clear orbital trend in the water budgets of the TRAPPIST-1 planets. Qualitatively, our models suggest two main scenarios for the formation of planetary systems: high-^{26}Al systems, like our Solar System, form small, water-depleted planets, whereas those devoid of ^{26}Al predominantly form ocean worlds. For planets of similar mass, the mean planetary transit radii of the ocean planet population can be up to about 10% larger than for planets from the ^{26}Al-rich formation scenario.

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Star Formation Rates of Massive Molecular Clouds in the Central Molecular Zone

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We investigate star formation at very early evolutionary phases in five massive clouds in the inner 500 pc of the Galaxy, the Central Molecular Zone. Using interferometer observations of H2O masers and ultra-compact H II regions, we find evidence of ongoing star formation embedded in cores of 0.2 pc scales and $\gtrsim 10^5$ cm^{-3} densities. Among the five clouds, Sgr C possesses a high (9%) fraction of gas mass in gravitationally bound and/or protostellar cores, and follows the dense ($\gtrsim 10^4$ cm^{-3}) gas star formation relation that is extrapolated from nearby clouds. The other four clouds have less than 1% of their cloud masses in gravitationally bound and/or protostellar cores, and star formation rates 10 times lower than predicted by the dense gas star formation relation. At the spatial scale of these cores, the star formation efficiency is comparable to that in Galactic disk sources. We suggest that the overall inactive star formation in these Central Molecular Zone clouds could be because there is much less gas confined in gravitationally bound cores, which may be a result of the strong turbulence in this region and/or the very early evolutionary stage of the clouds when collapse has only recently started.

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A gap in HD 92945's broad planetesimal disc revealed by ALMA

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In the last few years, multiwavelength observations have revealed the ubiquity of gaps/rings in circumstellar discs. Here we report the first ALMA observations of HD 92945 at 0.86 mm, that reveal a gap at about 73±3 au within a broad disc of planetesimals that extends from 50 to 140 au. We find that the gap is 20^{+10}_{-8} au wide. If cleared by a planet in situ, this planet must be less massive than 0.6 $M_{\rm Jup}$, or even lower if the gap was cleared by a planet that formed early in the protoplanetary disc and prevented planetesimal formation at that radius. By comparing opposite sides of the disc we also find that the disc could be asymmetric. Motivated by the asymmetry and the fact that planets might be more frequent closer to the star in exoplanetary systems, we show that the gap and asymmetry could be produced by two planets interior to the disc through secular resonances. These planets excite the eccentricity of bodies at specific disc locations, opening radial gaps in the planetesimal distribution. New observations are necessary to confirm if the disc is truly asymmetric, thus favouring the secular resonance model, or if the apparent asymmetry is due to a background galaxy, favouring the in-situ planet scenario. Finally, we also report the non-detection of CO

and HCN gas confirming that no primordial gas is present. The CO and HCN non-detections are consistent with the destruction of volatile-rich Solar System-like comets.

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On the physical nature of accretion disc viscosity

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We use well-established observational evidence to draw conclusions about the fundamental nature of the viscosity in accretion discs. To do this, we first summarise the observational evidence for the value of the dimensionless accretion disc viscosity parameter α, defined by Shakura & Sunyaev (1973, 1976). We find that, for fully ionized discs, the value of ? is readily amenable to reliable estimation and that the observations are consistent with the hypothesis that $\alpha \sim 0.2$–0.3. In contrast in discs that are not fully ionized, estimates of the value of α are generally less direct and the values obtained are generally <0.01 and often $\ll 0.01$. We conclude that this gives us crucial information about the nature of viscosity in accretion discs. First, in fully ionized discs the strength of the turbulence is always limited by being at most trans-sonic. This implies that it is necessary that credible models of the turbulence reflect this fact. Second, the smaller values of α found for less ionized, and therefore less strongly conducting, discs imply that magnetism plays a dominant role. This provides important observational support for the concept of magneto-rotational instability (MRI) driven hydromagnetic turbulence.

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On the Ubiquity and Stellar Luminosity Dependence of Exocometary CO Gas: Detection around M Dwarf TWA 7

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Millimeter observations of CO gas in planetesimal belts show a high detection rate around A stars, but few detections for later type stars. We present the first CO detection in a planetesimal belt around an M star, TWA 7. The optically thin CO (J=3-2) emission is co-located with previously identified dust emission from the belt, and the emission velocity structure is consistent with Keplerian rotation around the central star. The detected CO is not well shielded against photodissociation, and must thus be continuously replenished by gas release from exocomets within the belt. We analyze in detail the process of exocometary gas release and destruction around young M dwarfs and how this process compares to earlier type stars. Taking these differences into account, we find that CO generation through exocometary gas release naturally explains the increasing CO detection rates with stellar luminosity, mostly because the CO production rate from the collisional cascade is directly proportional to stellar luminosity. More luminous stars will therefore on average host more massive (and hence more easily detectable) exocometary CO disks, leading to the higher detection rates observed. The current CO detection rates are consistent with a ubiquitous release of exocometary gas in planetesimal belts, independent of spectral type.

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Thermal balance and comparison of gas and dust properties of dense clumps in the Hi-GAL survey

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We present a comparative study of physical properties derived from gas and dust emission in a sample of 1068 dense Galactic clumps. The sources are selected from the crossmatch of the Hi-GAL survey with 16 catalogues of NH_3 line emission in its lowest inversion (1,1) and (2,2) transitions. The sample covers a large range in masses and bolometric luminosities, with surface densities above $\Sigma = 0.1$ g cm^{-2} and with low virial parameters $\alpha < 1$. The comparison between dust and gas properties shows an overall agreement between T_{kin} and T_{dust} at volumetric densities $n \geq 1.2 \times 10^4$ cm^{-3}, and a median fractional abundance $\chi(NH_3) = 1.46 \times 10^{-8}$. While the protostellar clumps in the sample have small differences between T_{kin} and T_{dust}, prestellar clumps have a median ratio $T_{kin}/T_{dust} = 1.24$, suggesting that these sources are thermally decoupled. A correlation is found between the evolutionary tracer L/M and the parameters T_{kin}/T_{dust} and $\chi(NH_3)$ in prestellar sources and protostellar clumps with $L/M < 1$ $L_\odot$ $M_\odot{}^{-1}$. In addition, a weak correlation is found between non-thermal velocity dispersion and the L/M parameter, possibly indicating an increase of turbulence with protostellar evolution in the interior of clumps. Finally, different processes are discussed to explain the differences between gas and dust temperatures in prestellar candidates, and the origin of non-thermal motions observed in the clumps.

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The Rotation-Disk Connection in Young Brown Dwarfs: Strong Evidence for Early Rotational Braking

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We use Kepler/K2 lightcurves to measure rotation periods of brown dwarfs and very low mass stars in the Upper Scorpius star-forming region. Our sample comprises a total of 104 periods. Depending on the assumed age of Upper Scorpius, about a third of them are for brown dwarfs. The median period is 1.28 d for the full sample and 0.84 d for the probable brown dwarfs. With this period sample, we find compelling evidence for early rotational braking in brown dwarfs, caused by the interaction between the central object and the disk. The median period for objects with disks is at least 50% longer than for those without. Two brown dwarfs show direct signs of 'disk-locking' in their lightcurves, in the form of dips that recur on a timescale similar to the rotation period. Comparing the period samples for brown dwarfs at different ages, there is a clear need to include rotational braking into period evolution tracks between 1 and 10 Myr. A locked period over several Myr followed by spin-up due to contraction fits the observational data. We conclude that young brown dwarfs are affected by the same rotational regulation as stars, though they start off with significantly faster rotation, presumably set by initial conditions.

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Temperature Structure in the Inner Regions of Protoplanetary Disks: Inefficient Accretion Heating by Energy Dissipation Profile of Nonideal Magnetohydrodynamics

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Gas temperature in protoplanetary disks (PPDs) is determined by a combination of irradiation heating and accretion heating, with the latter conventionally attributed to turbulent dissipation. However, recent studies have suggested that the inner disk (a few AU) is largely laminar with accretion primarily driven by magnetized disk winds, as a result of non-ideal magnetohydrodynamic (MHD) effects from weakly ionized gas, suggesting an alternative heating mechanism by Joule dissipation. We perform local stratified MHD simulations including all three non-ideal MHD effects (Ohmic, Hall, and ambipolar diffusion), and investigate the role of Joule heating and the resulting disk vertical temperature profiles. We find that in the inner disk, as Ohmic and ambipolar diffusion strongly suppress electrical current around the midplane, Joule heating primarily occurs at several scale heights above the midplane, making midplane temperature much lower than that with the conventional viscous heating model. Including the Hall effect, Joule heating is enhanced/reduced when magnetic fields threading the disks are aligned/anti-aligned with the disk rotation, but is overall ineffective. Our results further suggest that the midplane temperature in inner PPDs is almost entirely determined by irradiation heating, unless viscous heating can trigger thermal ionization in the disk innermost region to self-sustain MRI turbulence.

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A 10-$M_\odot$ YSO with a Keplerian disk and a nonthermal radio jet

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We previously observed the star-forming region G16.59−0.05 through interferometric observations of both thermal and maser lines, and identified a high-mass young stellar object (YSO) which is surrounded by an accretion disk and drives a nonthermal radio jet. We performed high-angular-resolution (beam FWHM $\sim 0\farcs15$) 1.2-mm continuum and line observations towards G16.59−0.05 with the Atacama Large Millimeter Array (ALMA). The main dust clump, with size $\sim 10^4$ au, is resolved into four relatively compact (diameter ∼2000 au) millimeter (mm) sources. The source harboring the high-mass YSO is the most prominent in molecular emission. By fitting the emission profiles of several unblended and optically thin transitions of CH_3OCH_3 and CH_3OH, we derived gas temperatures inside the mm-sources in the range 42–131 K, and calculated masses of 1–5 $M_\odot$. A well-defined Local Standard of Rest velocity ($V_{\rm LSR}$) gradient is detected in most of the high-density molecular tracers at the position of the high-mass YSO, pinpointed by compact 22-GHz free-free emission. This gradient is oriented along a direction forming a large (∼70 degree) angle with the radio jet, traced by elongated 13-GHz continuum emission. The butterfly-like shapes of the P-V plots and the linear pattern of the emission peaks of the molecular lines at high velocity confirm that this $V_{\rm LSR}$ gradient is due to rotation of the gas in the disk surrounding the high-mass YSO. The disk radius is ∼500 au, and the $V_{\rm LSR}$ distribution along the major axis of the disk is well reproduced by a Keplerian profile around a central mass of 10 ± 2 $M_\odot$. The position of the YSO is offset by $\gtrsim 0\farcs1$ from the axis of the radio jet and the dust emission peak. To explain this displacement we argue that the high-mass YSO could have moved from the center of the parental mm source owing to dynamical interaction with one or more companions.

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Disruption of the Orion Molecular Core 1 by the stellar wind of the massive star Θ^1 Ori C

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Massive stars inject mechanical and radiative energy into the surrounding environment, which stirs it up, heats the gas, produces cloud and intercloud phases in the interstellar medium, and disrupts molecular clouds (the birth sites of new stars). Stellar winds, supernova explosions and ionization by ultraviolet photons control the lifetimes of molecular clouds. Theoretical studies predict that momentum injection by radiation should dominate that by stellar winds, but this has been difficult to assess observationally. Velocity-resolved large-scale images in the fine-structure line of ionized carbon ([C II]) provide an observational diagnostic for the radiative energy input and the dynamics of the interstellar medium around massive stars. Here we report observations of a one-square-degree region (about 7 pc in diameter) of Orion molecular core — the region nearest to Earth that exhibits massive-star formation — at a resolution of $16''$ (0.03 pc) in the [C II] line at 1.9 THz (158 μm). The results reveal that the stellar wind originating from the massive star Θ^1 Orionis C has swept up the surrounding material to create a bubble roughly four pc in diameter with a 2,600-solar-mass shell, which is expanding at 13 km s^{-1}. This finding demonstrates that the mechanical energy from the stellar wind is converted very efficiently into kinetic energy of the shell and causes more disruption of the Orion molecular core 1 than do photo-ionization and evaporation or future supernova explosions.

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Understanding formation of young, distributed low-mass stars and clusters in the W4 cloud complex

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It is well known that most of the stars form in rich clusters. However, recent Spitzer observations have shown that a significant number of stars also form in distributed mode, origin of which is not well understood. In this work, we aim to investigate clustered and distributed mode of star formation in the W4 complex. To do so, we identified and characterized the young stellar population associated with the region using homogeneous infra-red data-sets obtained from 2MASS, GLIMPSE, MIPS and WISE surveys. We make stellar surface density and minimum spanning tree maps to identify young clusters, and use *Spitzer* images to identify irradiated structures, such as elephant trunk-like structures (ETLSs) and pillars in the region. The surface density distribution of the young stellar objects (YSOs) reveals three new clusterings and $\sim$50% distributed protostars in the HII region. The clusters are of low-mass nature but significantly younger than the central cluster IC 1805. We identified $\sim$38 ETLSs in the region, a majority of which consist of one or a few stars at their tips. We find these stars are low-mass ($< 2\ M_\odot$) YSOs, located at the outskirts (> 17 pc) of the cluster IC 1805 and are part of scattered distributed population. We argued that the star formation in the ETLSs of W4 is going on possibly due to triggering effect of expanding W4 bubble. Although high-resolution photometric and spectroscopic data would be required to confirm the scenario, nonetheless, we discuss the implications of this scenario for our understanding of distributed low-mass star formation in cloud complexes as opposed to other

mechanisms such as turbulent fragmentation and dynamical ejection.

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The Disk Substructures at High Angular Resolution Project (DSHARP): X. Multiple rings, a misaligned inner disk, and a bright arc in the disk around the T Tauri star HD 143006

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We present a detailed analysis of new ALMA observations of the disk around the T-Tauri star HD 143006, which at 46 mas (7.6 au) resolution reveal new substructures in the 1.25 mm continuum emission. The disk resolves into a series of concentric rings and gaps together with a bright arc exterior to the rings that resembles hydrodynamics simulations of a vortex, and a bridge-like feature connecting the two innermost rings. Although our ^{12}CO observations at similar spatial resolution do not show obvious substructure, they reveal an inner disk depleted of CO emission. From the continuum emission and the CO velocity field we find that the innermost ring has a higher inclination than the outermost rings and the arc. This is evidence for either a small ($\sim 8°$) or moderate ($\sim 41°$) misalignment between the inner and outer disk, depending on the specific orientation of the near/far sides of the inner/outer disk. We compare the observed substructures in the ALMA observations with recent scattered light data from VLT/SPHERE of this object. In particular, the location of narrow shadow lanes in the SPHERE image combined with pressure scale height estimates, favor a large misalignment of about 41°. We discuss our findings in the context of a dust-trapping vortex, planet-carved gaps, and a misaligned inner disk due to the presence of an inclined companion to HD 143006.

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Infrared imaging of high-mass young stellar objects: Evidence of multiple shocks and of a new proto-star/star eclipsing system

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We present deep near- and mid-infrared images of six high-mass young stellar objects (YSOs) in order to help understand the physical mechanisms of their formation. We have searched for shocked H_2 emission around such massive protostars. All but one of these regions exhibit series of molecular hydrogen emission knots, either in perfect alignment or in more complex configurations. In the case of the Class I object Mol 7, the protostars driving a couple of highly bipolar collimated outflows appear to be members of a binary or multiple system. A similar scenario appears to apply

to Mol 143. The protostar Mol 12 drives a large low-collimated bipolar outflow with a number of H_2 emission nebulosities. In two other methanol cores studied here, we also found shocked molecular hydrogen knots driven by highly embedded YSOs, some of them in clusters. From their near-IR to millimetre-wavelength spectral energy distributions, we derived stellar masses and temperatures, extinctions, luminosities, disk masses, and accretion rates. We provide photometric evidence that the dense dust core housing Mol 12, a Class I YSO, has eclipsed the light of an early-type main-sequence star. The latter is probably a physical companion to the proto-star, as indicated by both having nearly identical coordinates and parallaxes as measured by Gaia (DR2) in the case of the star and by VLBI techniques in the case of the of the water maser associated to the YSO. This eclipse lasted about 15 years (1985-2000) and amounted to $\Delta A_V \simeq 22$. Since the year 2002, no further significant variations have been recorded.

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ftp://ftp.astrosen.unam.mx/iauname/mt/preprints/persiandtapiawappdx.pdf

Massive and low-mass protostars in massive "starless" cores

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The infrared dark clouds (IRDCs) G11.11−0.12 and G28.34+0.06 are two of the best-studied IRDCs in our Galaxy. These two clouds host clumps at different stages of evolution, including a massive dense clump in both clouds that is dark even at 70 and 100 μm. Such seemingly quiescent massive dense clumps have been speculated to harbor cores that are precursors of high-mass stars and clusters. We observed these two "prestellar" regions at 1 mm with the Submillimeter Array (SMA) with the aim of characterizing the nature of such cores. We show that the clumps fragment into several low- to high-mass cores within the filamentary structure of the enveloping cloud. However, while the overall physical properties of the clump may indicate a starless phase, we find that both regions host multiple outflows. The most massive core though 70 μm dark in both clumps is clearly associated with compact outflows. Such low-luminosity, massive cores are potentially the earliest stage in the evolution of a massive protostar. We also identify several outflow features distributed in the large environment around the most massive core. We infer that these outflows are being powered by young, low-mass protostars whose core mass is below our detection limit. These findings suggest that low-mass protostars have already formed or are coevally formed at the earliest phase of high-mass star formation.

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A deep X-ray view of the Class I YSO Elias 29 with XMM-Newton and NuSTAR

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We investigated the X-ray characteristics of the Class I YSO Elias 29 with joint XMM-Newton and NuSTAR observations of 300 ks and 450 ks, respectively. These are the first observations of a very young (<1 Myr) stellar object in a band encompassing simultaneously both soft and hard X-rays. In addition to the hot Fe complex at 6.7 keV, we

observed fluorescent emission from Fe at ∼6.4 keV, confirming the previous findings. The line at 6.4 keV is detected during quiescent and flaring states and its flux is variable. The equivalent width is found varying in the ≈0.15–0.5 keV range. These values make unrealistic a simple model with a centrally illuminated disk and suggest a role of the cavity containing Elias 29 and possibly reverberation processes that could occur in it. We observed two flares, with duration of 20 ks and 50 ks, respectively. We systematically observed an increase of $N_{\rm H}$ during the flares of a factor five. This behavior has been observed during flares previously detected in Elias 29 with XMM-Newton and ASCA. The phenomenon hints that the flaring regions could be buried under the accretion streams and at high stellar latitudes, as the X-rays from flares pass through gas denser than the gas along the line of sight of the quiescent corona. In a different scenario, a contribution from scattered soft photons to the primary coronal emission could mimic a shallower $N_{\rm H}$ in the quiescent spectrum. In the spectrum of the full NuSTAR exposure, we detect hard X-ray emission in the band ≈20–80 keV in excess with respect to the thermal emission. The hard X-ray emission could be due to a population of energetic electrons accelerated by the magnetic field along the accretion streams. These particles could concur to pumping up the Fe fluorescence of cold Fe of the disk along with X-ray photons with $E > 7.11$ keV.

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A pilot survey of the binarity of Massive Young Stellar Objects with K band adaptive optics

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We present the first search for binary companions of Massive Young Stellar Objects (MYSOs) using AO-assisted K band observations, with NaCo at the VLT. We have surveyed 32 MYSOs from the RMS catalogue, probing the widest companions, with a physical separation range of 400–46,000 au, within the predictions of models and observations for multiplicity of MYSOs. Statistical methods are employed to discern whether these companions are physical rather than visual binaries. We find 18 physical companions around 10 target objects, amounting to a multiplicity fraction of 31±8% and a companion fraction of 53±9%. For similar separation and mass ratio ranges, MYSOs seem to have more companions than T Tauri or O stars, respectively. This suggests that multiplicity increases with mass and decreases with evolutionary stage. We compute very rough estimates for the mass ratios from the K band magnitudes, and these appear to be generally larger than 0.5. This is inconsistent with randomly sampling the IMF, as predicted by the binary capture formation theory. Finally, we find that MYSOs with binaries do not show any different characteristics to the average MYSO in terms of luminosity, distance, outflow or disc presence.

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The Gaia-ESO Survey: age spread in the star forming region NGC 6530 from the HR diagram and gravity indicators

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In very young clusters, the stellar age distribution is the empirical proof of the duration of star cluster formation and thus it gives indications of the physical mechanisms involved in the star formation process. Determining the amount of interstellar extinction and the correct reddening law are crucial steps to derive fundamental stellar parameters and in particular accurate ages from the HR diagram. In this context, we derived accurate stellar ages for NGC 6530, the young cluster associated with the Lagoon Nebula to infer the star formation history of this region. We use the *Gaia*-ESO survey observations of the Lagoon Nebula, together with photometric literature data and *Gaia* DR2 kinematics, to derive cluster membership and fundamental stellar parameters. Using spectroscopic effective temperatures, we analyze the reddening properties of all objects and derive accurate stellar ages for cluster members. We identified 652 confirmed and 9 probable members. The reddening inferred for members and non-members allows us to distinguish foreground objects, mainly main-sequence (MS) stars, and background objects, mainly giants. This classification is in agreement with the distances inferred from *Gaia* DR2 parallaxes for these objects. The foreground and background stars show a spatial pattern that allows us to trace the three-dimensional structure of the nebular dust component. Finally, we derive stellar ages for 382 confirmed cluster members for which we obtained the individual reddening values. In addition, we find that the gravity-sensitive γ index distribution for the M-type stars is correlated with stellar age. For all members with $T_{\rm eff} < 5500\,K$, the mean logarithmic age is 5.84 (units of years) with a dispersion of 0.36 dex. The age distribution of stars with accretion and/or disk (CTTSe) is similar to that of stars without accretion and without disk (WTTSp). We interpret this dispersion as evidence of a real age spread since the total uncertainties on age determinations, derived from Monte Carlo simulations, are significantly smaller than the observed spread. This conclusion is supported by the evidence of a decreasing of the gravity-sensitive γ index as a function of stellar ages. The presence of a small age spread is also supported by the spatial distribution and the kinematics of old and young members. In particular, members with accretion and/or disk, formed in the last 1 Myr, show evidence of subclustering around the cluster center, in the Hourglass Nebula and in the M8-E region, suggesting a possible triggering of star formation events by the O-type star ionization fronts.

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The HH34 jet/counterjet system at 1.5 and 4.5 μm

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We present a (previously unpublished) 1.5 μm archival HST image of the HH 34 Herbig-Haro jet, in which the northern counterjet is seen at an unprecedented angular resolution of $\sim 0.1''$ (this counterjet had only been imaged previously at lower resolution with Spitzer). The jet/counterjet structure observed in this image shows evidence of low-amplitude, point-symmetric deviations from the outflow axis, indicating the presence of a precession in the ejection direction. We use the ratios between the 1.5 and 4.5 μm intensities of the emitting knots (from the HST image and from a previously published 4.5 μm Spitzer image) to obtain an estimate of the spatial dependence of the optical extinction to the HH 34 jet/counterjet system. We find evidence for extinction from a central, dense core surrounding the outflow source and from a more extended region in the foreground of the HH 34 counterjet.

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

MHD simulations of the formation and propagation of protostellar jets to observational length scales

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We present 2.5-D global, ideal MHD simulations of magnetically and rotationally driven protostellar jets from Keplerian accretion discs, wherein only the initial magnetic field strength at the inner radius of the disc, $B_{\rm i}$, is varied. Using the AMR-MHD code AZEuS, we self-consistently follow the jet evolution into the observational regime ($> 10^3$ AU) with a spatial dynamic range of $\sim 6.5 \times 10^5$. The simulations reveal a three-component outflow: 1) A hot, dense, super-fast and highly magnetised 'jet core'; 2) a cold, rarefied, trans-fast and highly magnetised 'sheath' surrounding the jet core and extending to a tangential discontinuity; and 3) a warm, dense, trans-slow and weakly magnetised shocked ambient medium entrained by the advancing bow shock. The simulations reveal power-law relationships between $B_{\rm i}$ and the jet advance speed, $v_{\rm jet}$, the average jet rotation speed, $\langle v_\varphi \rangle$, as well as fluxes of mass, momentum, and kinetic energy. Quantities that do not depend on $B_{\rm i}$ include the plasma-β of the transported material which, in all cases, seems to asymptote to order unity. Jets are launched by a combination of the 'magnetic tower' and 'bead-on-a-wire' mechanisms, with the former accounting for most of the jet acceleration—even for strong fields—and continuing well beyond the fast magnetosonic point. At no time does the leading bow shock leave the domain and, as such, these simulations generate large-scale jets that reproduce many of the observed properties of protostellar jets including their characteristic speeds and transported fluxes.

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The G332 molecular cloud ring: I. Morphology and physical characteristics

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We present a morphological and physical analysis of a Giant Molecular Cloud (GMC) using the carbon monoxide isotopologues (^{12}CO, ^{13}CO, C^{18}O $^3P_2 \rightarrow {}^3P_1$) survey of the Galactic Plane (Mopra CO Southern Galactic Plane Survey), supplemented with neutral carbon maps from the HEAT telescope in Antarctica. The giant molecular cloud structure (hereinafter the ring) covers the sky region $332° < l < 333°$ and $b = \pm 0.°5$ (hereinafter the G332 region). The mass of the ring and its distance are determined to be respectively $\sim 2 \times 10^5\ M_\odot$ and ~3.7 kpc from Sun. The dark molecular gas fraction, estimated from the ^{13}CO and [CI] lines, is ~17% for a CO $T_{\rm ex}$ between [10, 20 K]. Comparing the [CI] integrated intensity and $N(\rm H_2)$ traced by ^{13}CO and ^{12}CO, we define an $X_{\rm CI}^{809}$ factor, analogous to the usual $X_{\rm CO}$, through the [CI] line. $X_{\rm CI}^{809}$ ranges between $[1.8, 2.0] \times 10^{21}$ cm^{-2} K^{-1} km^{-1} s. We examined local variation in $X_{\rm CO}$ and $T_{\rm ex}$ across the cloud, and find in regions where the star formation activity is not in an advanced state, an increase in the mean and dispersion of the $X_{\rm CO}$ factor as the excitation temperature decreases. We present a catalogue of C^{18}O clumps within the cloud. The star formation (SF) activity ongoing in the cloud shows a correlation with $T_{\rm ex}$, [CI] and CO emissions, and anti-correlation with $X_{\rm CO}$, suggesting a North-South spatial gradient in the SF activity. We propose a method to disentangle dust emission across the Galaxy, using HI and ^{13}CO data. We describe Virtual Reality (VR) and Augmented Reality (AR) data visualisation techniques for the analysis of radio astronomy data.

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The SOMA Radio Survey. I. Comprehensive SEDs Of High-Mass Protostars From Infrared To Radio And The Emergence Of Ionization Feedback

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We study centimeter continuum emission of eight high- and intermediate-mass protostars that are part of the SOFIA Massive (SOMA) Star Formation Survey, thus building extended spectral energy distributions (SEDs) from the radio to the infrared. We discuss the morphology seen in the centimeter continuum images, which are mostly derived from archival VLA data, and the relation to infrared morphology. We use the SEDs to test new models of high-mass star formation including radiative and disk-wind feedback and associated free-free and dust continuum emission (Tanaka, Tan, & Zhang 2016). We show that interferometric data of the centimeter continuum flux densities provide additional, stringent tests of the models by constraining the ionizing luminosity of the source and help to break degeneracies encountered when modeling the infrared-only SEDs, especially for the protostellar mass. Our derived parameters are consistent with physical parameters estimated by other methods such as dynamical protostellar masses. We find a few examples of additional stellar sources in the vicinity of the high-mass protostars, which may be low-mass young stellar objects. However, the stellar multiplicity of the regions, at least as traced by radio continuum emission, appears to be relatively low.

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Implications of a hot atmosphere/corino from ALMA observations towards NGC1333 IRAS 4A1

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We report high angular resolution observations of NGC1333 IRAS4A, a protostellar binary including A1 and A2, at 0.84 mm with the Atacama Large Millimeter/submillimeter Array. From the continuum observations, we suggest that the dust emission from the A1 core is optically thick, and A2 is predominantly optically thin. The A2 core, exhibiting a forest of spectral lines including complex molecules, is a well known hot corino as suggested by previous works. More importantly, we report, for the first time, the solid evidence of complex organic molecules (COMs), including CH_3OH, $^{13}CH_3OH$, CH_2DOH, CH_3CHO associated with the A1 core seen in absorption. The absorption features mostly arise from a compact region around the continuum peak position of the A1 core. Rather than originating from a larger common envelope surrounding the protobinary, the COM features are associated with individual cores A1 and A2. Considering the signatures observed in both continuum and spectral lines, we propose two possible scenarios for IRAS 4A1 — the COM absorption lines may arise from a hot-corino-like atmosphere at the surface of an optically-thick circumstellar disk around A1, or the absorption may arise from different layers of a temperature-stratified dense envelope.

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Discovery of a sub-Keplerian disk with jet around a 20 $M_\odot$ young star. ALMA observations of G023.01-00.41

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It is well established that Solar-mass stars gain mass via disk accretion, until the mass reservoir of the disk is exhausted and dispersed, or condenses into planetesimals. Accretion disks are intimately coupled with mass ejection via polar cavities, in the form of jets and less collimated winds, which allow mass accretion through the disk by removing a substantial fraction of its angular momentum. Whether disk accretion is the mechanism leading to the formation of stars with much higher masses is still unclear. Here, we are able to build a comprehensive picture for the formation of an O-type star, by directly imaging a molecular disk which rotates and undergoes infall around the central star, and drives a molecular jet which arises from the inner disk regions. The accretion disk is truncated between 2000–3000 au, it has a mass of about a tenth of the central star mass, and is infalling towards the central star at a high rate ($6 \times 10^{-4}\,M_\odot\,yr^{-1}$), as to build up a very massive object. These findings, obtained with the Atacama Large Millimeter/submillimeter Array at 700 au resolution, provide observational proof that young massive stars can form via disk accretion much like Solar-mass stars.

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Protostellar Outflows at the EarliesT Stages (POETS). II. A possible radio synchrotron jet associated with the EGO G035.02+0.35

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Centimeter continuum observations of protostellar jets have revealed the presence of knots of shocked gas where the flux density decreases with frequency. This spectrum is characteristic of nonthermal synchrotron radiation and implies the presence of both magnetic fields and relativistic electrons in protostellar jets. Here, we report on one of the few detections of nonthermal jet driven by a young massive star in the star-forming region G035.02+0.35. We made use of the NSF's Karl G. Jansky Very Large Array (VLA) to observe this region at C, Ku, and K bands with the A- and B-array configurations, and obtained sensitive radio continuum maps down to a rms of $10\,\mu Jy\,beam^{-1}$. These observations allow for a detailed spectral index analysis of the radio continuum emission in the region, which we interpret as a protostellar jet with a number of knots aligned with extended $4.5\,\mu m$ emission. Two knots clearly

emit nonthermal radiation and are found at similar distances, of approximately 10,000 au, each side of the central young star, from which they expand at velocities of hundreds $km\,s^{-1}$. We estimate both the mechanical force and the magnetic field associated with the radio jet, and infer a lower limit of $0.4 \times 10^{-4}\,M_{\odot}\,yr^{-1}\,km\,s^{-1}$ and values in the range 0.7–1.3 mG, respectively.

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Clumpy dust rings around non-accreting young stars

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We investigate four young, but non-accreting, very low mass stars in Orion, which show irregular eclipses by circumstellar dust. The eclipses are not recurring periodically, are variable in depth, lack a flat bottom, and their duration is comparable to the typical timescale between eclipses. The dimming is associated with reddening consistent with dust extinction. Taken together this implies the presence of rings around these four stars, with radii ranging from 0.01 to 40 AU, comprised of optically thin dust clouds. The stars also show IR excess indicating the presence of evolved circumstellar disks, with orders of magnitude more material than needed for the eclipses. However, the rings need to cover an opening angle of about 20 degrees to explain how common these variable stars are in the coeval population in the same region, which is more extended than a typical disk. Thus, we propose that the rings may not be part of the disks, but instead separate structures with larger scale heights. To be sustained over years, the rings need to be replenished by dust from the disk or gravitationally bound to an object (e.g., planets or planetesimals). These four stars belong to a growing and diverse class of post-T Tauri stars with dips or eclipses in their lightcurves. Dusty rings with scale heights exceeding those of disks may be a common phenomenon at stellar ages between 5 and 10 Myr, in the transition from accretion disks to debris disks. These structures could be caused by migrating planets and may be signposts for the presence of young planetary systems.

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Is Molecular Cloud Turbulence Driven by External Supernova Explosions?

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We present high-resolution ($\sim$ 0.1 pc), hydrodynamical and magneto-hydrodynamical simulations to investigate whether the observed level of molecular cloud (MC) turbulence can be generated and maintained by external supernova (SN) explosions. The MCs are formed self-consistently within their large-scale galactic environment following the non-equilibrium formation of H_2 and CO including (self-) shielding and important heating and cooling processes. The MCs inherit their initial level of turbulence from the diffuse ISM, where turbulence is injected by SN explosions. However, by systematically exploring the effect of individual SNe going off outside the clouds, we show that at later stages the importance of SN driven turbulence is decreased significantly. This holds for different MC masses as well as MCs with and without magnetic fields. The SN impact also decreases rapidly with larger distances. Nearby SNe ($d \sim 25$ pc) boost the turbulent velocity dispersions of the MC by up to 70 per cent (up to a few km s^{-1}). For $d > 50$ pc, however, their impact decreases fast with increasing d and is almost negligible. For all probed distances the gain in velocity dispersion decays rapidly within a few 100 kyr. This is significantly shorter than the average timescale for a MC to be hit by a nearby SN under solar neighbourhood conditions ($\sim$ 2 Myr). Hence, at these conditions SNe are

not able to sustain the observed level of MC turbulence. However, in environments with high gas surface densities and SN rates like the Central Molecular Zone, observed elevated MC dispersions could be triggered by external SNe.

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SILCC-Zoom: Polarization and depolarization in molecular clouds

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We present synthetic dust polarisation maps of 3D magneto-hydrodynamical simulations of molecular clouds before the onset of stellar feedback. The clouds are modelled within the SILCC-Zoom project and are embedded in their galactic environment. The radiative transfer is carried out with POLARIS for wavelengths from 70 μm to 3 mm at a resolution of 0.12 pc, and includes self-consistently calculated alignment efficiencies for radiative torque alignment. We explore the reason of the observed depolarisation in the center of molecular clouds: We find that dust grains remain well aligned even at high densities ($n > 10^3$ cm^{-3}) and visual extinctions ($A_V > 1$). The depolarisation is rather caused by strong variations of the magnetic field direction along the LOS due to turbulent motions. The observed magnetic field structure thus resembles best the mass-weighted, line-of-sight averaged field structure. Furthermore, it differs by only a few 1° for different wavelengths and is little affected by the spatial resolution of the synthetic observations. Noise effects can be reduced by convolving the image. Doing so, for $\lambda \geq 160$ μm the observed magnetic field traces reliably the underlying field in regions with intensities $I \geq 2$ times the noise level and column densities above 1 M$_\odot$ pc^{-2}. Here, typical deviations are $\leq 10°$. The observed structure is less reliable in regions with low polarisation degrees and possibly in regions with large column density gradients. Finally, we show that a simplified and widely used method without self-consistent dust alignment efficiencies can provide a good representation of the observable polarisation structure with deviations below 5°.

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Multicomponent kinematics in a massive filamentary IRDC

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To probe the initial conditions for high-mass star and cluster formation, we investigate the properties of dense filaments within the infrared dark cloud G035.39–00.33 (IRDC G035.39) in a combined Very Large Array (VLA) and the Green Bank Telescope (GBT) mosaic tracing the NH_3(1,1) and (2,2) emission down to 0.08 pc scales. Using agglomerative hierarchical clustering on multiple line-of-sight velocity component fitting results, we identify seven extended velocity-coherent components in our data, likely representing spatially coherent physical structures, some exhibiting complex gas motions. The velocity gradient magnitude distribution peaks at its mode of 0.35 km s^{-1} pc^{-1}and has a long tail extending into higher values of $1.5 - 2$ km s^{-1} pc^{-1}, and is generally consistent with those found toward the same cloud in other molecular tracers and with the values found towards nearby low-mass dense cloud cores at the same

scales. Contrary to observational and theoretical expectations, we find the non-thermal ammonia line widths to be systematically narrower (by about 20%) than those of N_2H^+ $(1-0)$ line transition observed with similar resolution. If the observed ordered velocity gradients represent the core envelope solid-body rotation, we estimate the specific angular momentum to be about 2×10^{21} cm^2 s^{-1}, similar to the low-mass star-forming cores. Together with the previous finding of subsonic motions in G035.39, our results demonstrate high levels of similarity between kinematics of a high-mass star-forming IRDC and the low-mass star formation regime.

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Histogram of oriented gradients: a technique for the study of molecular cloud formation

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We introduce the histogram of oriented gradients (HOG), a tool developed for machine vision that we propose as a new metric for the systematic characterization of spectral line observations of atomic and molecular gas and the study of molecular cloud formation models. In essence, the HOG technique takes as input extended spectral-line observations from two tracers and provides an estimate of their spatial correlation across velocity channels. We characterized HOG using synthetic observations of HI and ^{13}CO $(J=1\rightarrow 0)$ emission from numerical simulations of magnetohydrodynamic (MHD) turbulence leading to the formation of molecular gas after the collision of two atomic clouds. We found a significant spatial correlation between the two tracers in velocity channels where $v_{\rm HI} \approx v_{\rm 13CO}$, almost independent of the orientation of the collision with respect to the line of sight. Subsequently, we used HOG to investigate the spatial correlation of the HI, from The HI/OH/recombination line survey of the inner Milky Way (THOR), and the ^{13}CO $(J=1\rightarrow 0)$ emission from the Galactic Ring Survey (GRS), toward the portion of the Galactic plane $33°75 \leq l \leq 35°25$ and $|b| \leq 1°25$. We found a significant spatial correlation between the two tracers in extended portions of the studied region. Although some of the regions with high spatial correlation are associated with HI self-absorption (HISA) features, suggesting that it is produced by the cold atomic gas, the correlation is not exclusive to this kind of region. The HOG results derived for the observational data indicate significant differences between individual regions: some show spatial correlation in channels around $v_{\rm HI} \approx v_{\rm 13CO}$ while others present spatial correlations in velocity channels separated by a few kilometers per second. We associate these velocity offsets to the effect of feedback and to the presence of physical conditions that are not included in the atomic-cloud-collision simulations, such as more general magnetic field configurations, shear, and global gas infall.

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Pebble accretion in class 0/I YSOs as a possible pathway for early planet formation

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Recent theoretical works suggest that the pebble accretion process is important for planet formation in protoplanetary disks, because it accelerates the growth of planetary cores. While several observations reveal axisymmetric sharp gaps in very young disks, which may be indicative of the existence of planets. We investigate the possibility of planet formation via pebble accretion in much earlier phases, the gravitationally unstable disks of class 0/I young stellar objects. We find that under the conditions of the class 0/I disks, the pebble accretion timescales can be shorter compared to the typical protoplanetary disks due to larger gas and dust accretion rate, but also find that the accretion timescale is not always a decreasing function of the gas accretion rate. By using estimated accretion timescales, we give a required initial mass to form cores of gas giants within the lifetime of class 0/I phases under several parameters, such as radial distances from the host star, gas accretion rates, and dust-to-gas mass ratio. In the most optimistic case, for example the dust-to-gas mass ratio is $f = 3f_{\rm solar}$, $\sim 10^{-4}$ $M_\oplus$ objects at 10 au can grow to 10 $M_\oplus$ cores during the typical lifetime of the class 0/I phases, 0.5 Myr.

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Survey Observations to Study Chemical Evolution from High-Mass Starless Cores to High-Mass Protostellar Objects II. HC_3N and N_2H^+

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We have carried out survey observations of molecular emission lines from HC_3N, N_2H^+, CCS, and *cyclic*-C_3H_2 in the 81−94 GHz band toward 17 high-mass starless cores (HMSCs) and 28 high-mass protostellar objects (HMPOs) with the Nobeyama 45-m radio telescope. We have detected N_2H^+ in all of the target sources except one and HC_3N in 14 HMSCs and in 26 HMPOs. We investigate the $N(N_2H^+)/N(HC_3N)$ column density ratio as a chemical evolutionary indicator of massive cores. Using the Kolmogorov-Smirnov (K-S) test and Welch's t test, we confirm that the $N(N_2H^+)/N(HC_3N)$ ratio decreases from HMSCs to HMPOs. This tendency in high-mass star-forming regions is opposite to that in low-mass star-forming regions. Furthermore, we found that the detection rates of carbon-chain species (HC_3N, HC_5N, and CCS) in HMPOs are different from those in low-mass protostars. The detection rates of cyanopolyynes (HC_3N and HC_5N) are higher and that of CCS is lower in high-mass protostars, compared to low-mass protostars. We discuss a possible interpretation for these differences.

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ATLASGAL — Molecular fingerprints of a sample of massive star forming clumps

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We have conducted a 3-mm molecular-line survey towards 570 high-mass star-forming clumps, using the Mopra telescope. The sample is selected from the 10,000 clumps identified by the ATLASGAL survey and includes all of the most important embedded evolutionary stages associated with massive star formation, classified into five distinct categories (quiescent, protostellar, young stellar objects, HII regions and photo-dominated regions). The observations were performed in broadband mode with frequency coverage of 85.2 to 93.4 GHz and a velocity resolution of $\sim$0.9 km s^{-1}, detecting emission from 26 different transitions. We find significant evolutionary trends in the detection rates, integrated line intensities, and abundances of many of the transitions and also identify a couple of molecules that appear to be invariant to changes in the dust temperature and evolutionary stage (N_2H^+ (1–0) and HN^{13}C (1–0)). We use the K-ladders for CH_3C_2H (5–4) and CH_3CH (5–4) to calculate the rotation temperatures and find $\sim$1/3 of the quiescent clumps have rotation temperatures that suggest the presence of an internal heating source. These sources may constitute a population of very young protostellar objects that are still dark at 70 μm and suggest that the fraction of truly quiescent clumps may only be a few per cent. We also identify a number of line ratios that show a strong correlation with the evolutionary stage of the embedded objects and discuss their utility as diagnostic probes of evolution.

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Protoplanetary disk rings and gaps across ages and luminosities

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Since the discovery of the multi-ring structure of the HL Tau disk, ALMA data suggest that the dust continuum emission of many, if not all, protoplanetary disks consists of rings and gaps, no matter their spectral type or age. The origin of these gaps so far remains unclear. We present a sample study of 16 disks with multiple ring-like structures in the continuum, using published ALMA archival data, to compare their morphologies and gap locations in a systematic way. The 16 targets range from early to late type stars, from <0.5 Myr to >10 Myr, from $\sim$0.2 to 40 $L_\odot$ and include both full and transitional disks with cleared inner dust cavities. Stellar ages are revised using new *Gaia* distances. Gap locations are derived using a simple radial fit to the intensity profiles. Using a radiative transfer model, the temperature profiles are computed. The gap radii generally do not correspond to the orbital radii of snow lines of the most common molecules. A snow line model can likely be discarded as a common origin of multi-ring systems. In addition, there are no systematic trends in the gap locations that could be related to resonances of planets. Finally, the outer radius of the disks decreases for the oldest disks in the sample, indicating that if multi-ring disks evolve in a similar way, outer dust rings either dissipate with the gas or grow into planetesimal belts.

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ALMA study of the HD 100453 AB system and the tidal interaction of the companion with the disk

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Context: The complex system HD 100453 AB with a ring-like circumprimary disk and two spiral arms, one of which is pointing to the secondary, is a good laboratory to test spiral formation theories.
Aims: To resolve the dust and gas distribution in the disk around HD 100453 A and to quantify the interaction of HD 100453 B with the circumprimary disk.
Methods: Using ALMA band 6 dust continuum and CO isotopologue observations we study the HD 100453 AB system with a spatial resolution of 0.09" $\times$ 0.17" at 234 GHz. We use SPH simulations and orbital fitting to investigate the tidal influence of the companion on the disk.
Results: We resolve the continuum emission around HD 100453 A into a disk between 0.22" and 0.40" with an inclination of 29.5 degrees and a position angle of 151.0 degrees, an unresolved inner disk, and excess mm emission cospatial with the northern spiral arm which was previously detected using scattered light observations. We also detect CO emission from 7 au (well within the disk cavity) out to 1.10", i.e., overlapping with HD 100453 B at least in projection. The outer CO disk PA and inclination differ by up to 10 degrees from the values found for the inner CO disk and the dust continuum emission, which we interpret as due to gravitational interaction with HD 100453 B. Both the spatial extent of the CO disk and the detection of mm emission at the same location as the northern spiral arm are in disagreement with the previously proposed near co-planar orbit of HD 100453 B.
Conclusions: We conclude that HD 100453 B has an orbit that is significantly misaligned with the circumprimary disk. Because it is unclear whether such an orbit can explain the observed system geometry we highlight an alternative scenario that explains all detected disk features where another, (yet) undetected, low mass close companion within the disk cavity, shepherds a misaligned inner disk whose slowly precessing shadows excite the spiral arms.

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Imaging the disc rim and a moving close-in companion candidate in the pre-transitional disc of V1247 Orionis

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V1247 Orionis harbours a pre-transitional disc with a partially cleared gap. Earlier interferometric and polarimetric observations revealed strong asymmetries both in the gap region and in the outer disc. The presence of a companion was inferred to explain these asymmetric structures and the ongoing disc clearing. Using an extensive set of multi-wavelength and multi-epoch observations we aimed to identify the origin of the previously detected asymmetries. We have observed V1247 Ori at three epochs spanning $\sim$ 678 days using sparse aperture masking interferometry with Keck/NIRC2 and VLT/NACO. In addition, we search for signs of accretion through VLT/SPHERE-ZIMPOL spectral differential imaging in Hα and R-band continuum. Our SMA sub-millimetre interferometry in 880 μm continuum and in the CO(3-2) line allows us to constrain the orientation and direction of rotation of the outer disc. We find the L'-band emission to be dominated by static features which trace forward-scattered dust emission from the inner edge of the outer disc located to the north-east. In H- and K-band, we see evidence for a companion candidate that moved systematically by 45° within the first $\sim$345 days. The separation of the companion candidate is not well constrained, but the observed position angle change is consistent with Keplerian motion of a body located on a 6 au orbit. From the SMA CO moment map, the location of the disc rim, and the detected orbital motion, we deduced the three-dimensional orientation of the disc. We see no indication of accretion in Hα and set upper limits for an accreting companion. The measured contrast of the companion candidate in H and K is consistent with an actively accreting protoplanet. Hence, we identify V1247 Ori as a unique laboratory for studying companion-disc interactions and disc clearing.

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https://www.aanda.org/articles/aa/pdf/2019/01/aa30215-16/aa30215-16.html

Chemical network reduction in protoplanetary disks

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Protoplanetary disks (PPDs) are characterized by different kinds of gas dynamics and chemistry, which are coupled via ionization, heating and cooling processes, as well as advective and turbulent transport. However, directly coupling gas dynamics with time-dependent chemistry is prohibitively computationally expensive when using comprehensive chemical reaction networks. In this paper, we evaluate the utility of a species-based network reduction method in different disk environments to produce small chemical networks that reproduce the abundances of major species found in large gas-phase chemistry networks. We find that the method works very well in disk midplane and surfaces regions, where approximately 20–30 gas phase species, connected by $\sim$50–60 gas phase reactions, are sufficient to reproduce the targeted ionization fraction and chemical abundances. Most species of the reduced networks, including major carriers of oxygen, carbon and nitrogen, also have similar abundances in the reduced and complete network models. Our results may serve as an initial effort for future hydrodynamic/magnetohydrodynamic simulations of PPDs incorporating time-dependent chemistry in appropriate regions. Accurately modeling the abundances of major species at intermediate disk heights, however, will require much more extended network incorporating gas-grain chemistry and are left for future studies.

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Signs of outflow feedback from a nearby young stellar object on the protostellar envelope around HL Tau

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Aims. HL Tau is a Class I–II protostar embedded in an infalling and rotating envelope and possibly associated with a planet forming disk, and it is co-located in a 0.1 pc molecular cloud with two nearby young stellar objects with projected distance of ∼20 arcsec–30 *arcsec* (2800–4200 au) to HL Tau. Our observations with the Atacama Large Millimeter/Submillimeter Array (ALMA) revealed two arc-like structures on a 1000 au scale connected to the disk, and their kinematics could not be explained with any conventional model of infalling and rotational motions. In this work, we investigate the nature of these arc-like structures connected to the HL Tau disk.
Methods. We conducted new observations in the ^{13}CO and C^{18}O (3–2; 2–1) lines with the James Clerk Maxwell Telescope and the IRAM 30m telescope, and obtained the data with the 7-m array of the Atacama Compact Array (ACA). With the single-dish, ACA, and ALMA data, we analyzed the gas motions on both 0.1 pc and 1000 au scales in the HL Tau region. We constructed new kinematical models of an infalling and rotating envelope with the consideration of relative motion between HL Tau and the envelope.
Results. By including the relative motion between HL Tau and its protostellar envelope, our kinematical model can explain the observed velocity features in the arc-like structures. The morphologies of the arc-like structures can also be explained with an asymmetric initial density distribution in our model envelope. In addition, our single-dish results support that HL Tau is located at the edge of a large-scale (0.1 pc) expanding shell driven by the wind or outflow from XZ Tau, as suggested in the literature. The estimated expanding velocity of the shell is comparable to the relative velocity between HL Tau and its envelope in our kinematical model. These results hints that the large-scale expanding motion likely impacts the protostellar envelope around HL Tau and affects its gas kinematics. We found that the mass infalling rate from the envelope onto the HL Tau disk can be decreased by a factor of two due to this impact by the large-scale expanding shell.

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An unbiased spectral line survey observation toward the low-mass star-forming region L1527

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An unbiased spectral line survey toward a solar-type Class 0/I protostar, IRAS 04368+2557, in L1527 has been carried out in the 3 mm band with the Nobeyama 45 m telescope. L1527 is known as a warm carbon-chain chemistry (WCCC) source, which harbors abundant unsaturated organic species such as C_nH ($n = 3,\ 4,\ 5, \ldots$) in a warm and dense region near the protostar. The observation covers the frequency range from 80 to 116 GHz. A supplementary observation has also been conducted in the 70 GHz band to observe fundamental transitions of deuterated species. In total, 69 molecular species are identified, among which 27 species are carbon-chain species and their isomers, including their minor isotopologues. This spectral line survey provides us with a good template of the chemical composition of the WCCC source.

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First detection of the pre-biotic molecule glycolonitrile (HOCH2CN) in the interstellar medium

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Theories of a pre-RNA world suggest that glycolonitrile ($HOCH_2CN$) is a key species in the process of ribonucleotide assembly, which is considered as a molecular precursor of nucleic acids. In this Letter, we report the first detection of this pre-biotic molecule in the interstellar medium (ISM) by using ALMA data obtained at frequencies between 86.5 GHz and 266.5 GHz toward the Solar-type protostar IRAS16293-2422 B. A total of 15 unblended transitions of $HOCH_2CN$ were identified. Our analysis indicates the presence of a cold (T_{ex}=24±8 K) and a warm (T_{ex}=158±38 K) component meaning that this molecule is present in both the inner hot corino and the outer cold envelope of IRAS16293 B. The relative abundance with respect to H_2 is $(6.5\pm0.6)\times10^{-11}$ and $\geq(6\pm2)\times10^{-10}$ for the warm and cold components respectively. Our chemical modelling seems to underproduce the observed abundance for both the warm and cold component under various values of the cosmic-ray ionisation rate (ζ). Key gas phase routes for the formation of this molecule might be missing in our chemical network.

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The Disk Substructures at High Angular Resolution Project (DSHARP). VII. The PlanetDisk Interactions Interpretation

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The Disk Substructures at High Angular Resolution Project (DSHARP) provides a large sample of protoplanetary disks with substructures that could be induced by young forming planets. To explore the properties of planets that may be responsible for these substructures, we systematically carry out a grid of 2D hydrodynamical simulations, including both gas and dust components. We present the resulting gas structures, including the relationship between the planet mass, as well as (1) the gaseous gap depth/width and (2) the sub/super-Keplerian motion across the gap.

We then compute dust continuum intensity maps at the frequency of the DSHARP observations. We provide the relationship between the planet mass, as well as (1) the depth/width of the gaps at millimeter intensity maps, (2) the gap edge ellipticity and asymmetry, and (3) the position of secondary gaps induced by the planet. With these relationships, we lay out the procedure to constrain the planet mass using gap properties, and study the potential planets in the DSHARP disks. We highlight the excellent agreement between observations and simulations for AS 209 and the detectability of the young solar system analog. Finally, under the assumption that the detected gaps are induced by young planets, we characterize the young planet population in the planet masssemimajor axis diagram. We find that the occurrence rate for >5 M_J planets beyond 5-10 au is consistent with direct imaging constraints. Disk substructures allow us to probe a wide-orbit planet population (Neptune to Jupiter mass planets beyond 10 au) that is not accessible to other planet searching techniques.

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Anchoring Magnetic Fields in Turbulent Molecular Clouds II - from 0.1 to 0.01 parsec

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We (Li et al. 2009; Paper-I) compared the magnetic field directions inferred from polarimetry data obtained from 100-pc scale inter-cloud media (ICM) and from sub-pc scale molecular cloud cores. The highly correlated result led us to conclude that cloud turbulence must be sub-Alfvenic. Here we extend the study with 0.01-pc cores observed by interferometers. The inferred field directions at this scale significantly deviate from that of the surrounding ICM. An obvious question to ask is whether this high-resolution result contradicts the sub-Alfvenic picture concluded earlier. We performed MHD simulations of a slightly super-critical (magnetic criticality = 2) clouds with Alfvenic Mach number MA=0.63, which can reproduce the Paper-I results, and observed the development towards smaller scales. Interestingly, all subregions hosting cores with $n_{\mathrm{H}_2} > 10^5$ cc^{-1} (the typical density observed by interferometers) possess MA=2–3. Not too surprisingly, these slightly super-Alfvenic cores result in B-field orientation offsets comparable to the interferometer observations. The result suggests that gravity can concentrate (and maybe also contribute to, which takes more study to confirm) turbulent energy and create slightly super-Alfvenic cores out from sub-Alfvenic clouds. The results of our simulations also agree with the observed velocity-scale (Kauffmann et al. 2013), mass-scale (Lombardi et al. 2010) and field strength-density (Li et al. 2015; Crutcher et al. 2010) relations.

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Inclined massive planets in a protoplanetary disc: gap opening, disc breaking, and observational signatures

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We carry out 3D hydrodynamical simulations to study planet-disc interactions for inclined high-mass planets, focusing on the disc's secular evolution induced by the planet. We find that, when the planet is massive enough and the induced gap is deep enough, the disc inside the planet's orbit breaks from the outer disc. The inner and outer discs precess around the system's total angular momentum vector independently at different precession rates, which causes significant disc misalignment. We derive the analytical formulae, which are also verified numerically, for: (1) the relationship between the planet mass and the depth/width of the induced gap, (2) the migration and inclination damping rates for massive inclined planets, and (3) the condition under which the inner and outer discs can break and undergo differential precession. Then, we carry out Monte Carlo radiative transfer calculations for the simulated broken discs. Both disc shadowing in near-infrared images and gas kinematics probed by molecular lines [e.g. from the Atacama Large Millimeter/submillimeter Array (ALMA)] can reveal the misaligned inner disc. The relationship between the rotation rate of the disc shadow and the precession rate of the inner disc is also provided. Using our disc breaking condition, we conclude that the disc shadowing due to misaligned discs should be accompanied by deep gaseous gaps (e.g. in Pre/Transitional discs). This scenario naturally explains both the disc shadowing and deep gaps in several systems (e.g. HD 100453, DoAr 44, AA Tau, and HD 143006) and these systems should be the prime targets for searching young massive planets ($>M_J$) in discs.

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The VMC Survey - XXXII. Pre-main-sequence populations in the Large Magellanic Cloud

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Detailed studies of intermediate- and low-mass pre-main-sequence (PMS) stars outside the Galaxy have so far been conducted only for small targeted regions harbouring known star formation complexes. The VISTA Survey of the Magellanic Clouds (VMC) provides an opportunity to study PMS populations down to solar masses on a galaxy-wide scale. Our goal is to use near-infrared data from the VMC survey to identify and characterise PMS populations down to $\sim$1 M$_\odot$ across the Magellanic Clouds. We present our colour−magnitude diagram method, and apply it to a $\sim 1.5\,\mathrm{deg}^2$ pilot field located in the Large Magellanic Cloud. The pilot field is divided into equal-size grid elements. We compare the stellar population in every element with the population in nearby control fields by creating $K_s/(Y-K_s)$ Hess diagrams; the observed density excesses over the local field population are used to classify the stellar populations. Our analysis recovers all known star formation complexes in this pilot field (N 44, N 51, N 148, and N 138) and for the first time reveals their true spatial extent. In total, around 2260 PMS candidates with ages $\lesssim$10 Myr are found in the pilot field. PMS structures, identified as areas with a significant density excess of PMS candidates, display a power-law distribution of the number of members with a slope of -0.86 ± 0.12. We find a clustering of the young stellar populations along ridges and filaments where dust emission in the far-infrared (FIR) (70 μm – 500 μm) is bright. Regions with young populations lacking massive stars show a lower degree of clustering and are usually located in the outskirts of the star formation complexes. At short FIR wavelengths (70 μm, 100 μm) we report a strong dust emission increase in regions hosting young massive stars, which is less pronounced in regions populated only by less massive ($\lesssim$4 M$_\odot$) PMS stars.

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Thermal Evolution of Forming Planets
Isotope Enrichment, Differentiation & Volatile Retention

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Ph.D degree awarded: October 2018

Discoveries of extrasolar planets in the last decades raise the question of how common Earth-like worlds with clement surface environments are within the galaxy. Because astronomical observations are ultimately limited in providing a complete picture of the planetary census, a comprehensive understanding of planetary systems' formation and evolution can deliver valuable insights into key physical and chemical properties that cannot be probed by remote sensing alone. In order to understand how terrestrial worlds are formed and distributed, I investigate in this thesis the early evolution of planetary systems and the interior dynamics and volatile retention of rocky protoplanets.

To place the solar system in the context of the extrasolar planet population, I model the enrichment of protoplanetary disks with short-lived radionuclides, namely ^{26}Al and ^{60}Fe, in typical star-forming environments. I find their distribution to be dichotomous: many planetary systems with zero or negligible abundances, and fewer systems with levels comparable to the early solar system. Further, I quantify the parametric controls on interior evolution and volatile loss of planetesimals that accrete to form terrestrial planets. I derive the primary thermochemical regimes for the build-up of internal magma oceans, core segregation, chemical differentiation, and volatile retention. Matching planetesimal interior evolution with meteoritic evidence, I constrain the accretion dynamics and reprocessing of planetary materials in the early solar system, in order to gain a better understanding of planetary assembly. Finally, by extrapolating the derived mechanisms to the exoplanet population, I demonstrate the primary influence of short-lived radionuclides on the efficiency of volatile delivery to terrestrial planets: enriched systems with solar-like or higher levels tend to form water-depleted planets, while not- or barely-enriched systems dominantly form ocean worlds.

My findings provide a direct link between the star-forming birth environment of planetary systems and the compositional make-up and long-term evolution of rocky planets that form in them. The system-to-system deviations in the abundance of short-lived radionuclides across young star-forming regions qualitatively distinguish planetary systems' formation and evolution, and control the distribution and prevalence of terrestrial planets with Earth-like bulk compositions.

Thesis link: https://doi.org/10.3929/ethz-b-000298059

New Jobs

Tenure track position at Lund University in observations and characterisation of exoplanets

Lund Observatory at Lund University is recruiting a person into a tenure-track faculty position in observational studies of exoplanets. The Associate Senior Lecturer will conduct research on the detection of exoplanets, in studies of exoplanet atmospheres or in the characterization of exoplanet host stars, with the purpose of understanding the planetary system.

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Information about Lund Observatory:
http://www.astro.lu.se/
http://www.astro.lu.se/Research/

Inquiries about position: Professor Anders Johansen (anders@astro.lu.se)

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More information is available here:
PhD position: https://jobportal.ku.dk/phd/?show=148817
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Closing date for receipt of applications: Wednesday 20 March 2019

PhD position in numerical studies of protostellar disks

Applications are invited for a PhD position in numerical studies of protostellar disks in the Astrophysics group of Prof. Manuel Guedel at the Institute of Astrophysics, University of Vienna, Vienna. The position is funded by the FWF grant "The chemodynamical evolution of circumstellar disks with non-solar metallicities". The successful candidate will study the chemical evolution of young protostellar disks using sophisticated thermochemical codes (ProDIMO, ANDES) in tight collaboration with chemodynamical studies of protostellar disks led by Dr. Eduard Vorobyov. The project is focused 1) on the implications of low metal content for the chemical and dynamical evolution of young circumstellar disks, 2) on the role of gravitational instability and fragmentation in sub-solar and low-metallicity disks, 3) on the character of protostellar accretion at non-solar metallicities, and 4) on making predictions for observational campaigns of low-metallicity star-forming regions.

The successful applicant should have a background in astrophysics and/or astrochemistry, and also basic knowledge of Fortran, IDL, and Python is desirable. Her/his tasks will involve modification and improvement of astrochemical codes, as well as performance and analysis of chemical and chemodynamical simulations of circumstellar disks. The candidate should hold a MSc. degree in physics, astronomy or a related field. The appointment will be for three years. The salary is based on the Austrian scale for PhD students (75% employment, gross annual salary 37,680). The University of Vienna is an equal opportunity employer in accordance with Austrian laws.

Closing date for application is February 18, 2019, but search will continue until the position is filled. Applicants should send a single PDF file containing a short resume, educational record, and a statement of research interests. Please, also arrange for two letters of recommendation to be sent to Dr. Eduard Vorobyov. The preferable starting date is June-July 2019. For further questions, please, contact Dr. Eduard Vorobyov at eduard.vorobiev(at)univie.ac.at

Postdoctoral Fellow Position: Time-domain and/or Exoplanetary/Substellar Astronomy

Prof. Stanimir Metchev at the University of Western Ontario (UWO) and Centre for Planetary Science and Exploration (CPSX), Canada, invites applications for a Postdoctoral Fellow. Two areas of expertise are sought, and applicants with qualifications in either or both areas are invited to apply.

The first area of expertise is time-domain astronomy and automation of telescopic observations. The successful applicant will be expected to aid with the commissioning and operations of an array of three 0.5m robotic telescopes equipped with rapid-imaging cameras for detecting stellar occultations by Kuiper Belt Objects or transiting extrasolar planets. Strong computer programming expertise is required. Background in systems automation, data management, or image analysis would be advantageous.

The second area of expertise is exoplanetary or brown dwarf astrophysics. The successful applicant will be expected to lead aspects of on-going programs with the Spitzer Space Telescope and TESS. Background in precision photometry, spectroscopy, or time series analysis would be advantageous.

The candidate will be expected to actively pursue additional ground-based observations in support of one or both of the above programs. Depending on interest, additional opportunities for collaboration with Metchev's group exist in the fields of brown dwarfs, exoplanets, circumstellar debris disks, or solar system astronomy.

UWO has access to all Canadian national telescopes, including Gemini, the CHFT, ALMA, and a slew of 1-2 metre-class telescopes. Metchev's team also regularly uses other facilities, including Spitzer, TESS, Hubble, Magellan, NOAO telescopes, NASA/IRTF, and McDonald Observatory.

Candidates must have a doctoral degree in Astronomy or a related field. The start date is flexible, but preferably no later than September 1, 2019. Candidates should submit a curriculum vitae, a 2-3-page statement of research experience and interests, and the names and contacts of three references directly to Prof. Metchev. The position is open until filled. For full consideration, complete applications should be received by March 1, 2019.

For further information, please contact Prof. Metchev (smetchev@uwo.ca).

Moving ... ??

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

Second Announcement
Workshop on Polarization in Protoplanetary Disks and Jets

Abstract submission by 28th February 2019

May 20-24, 2019 - Sant Cugat del Vallès, Catalonia Spain

https://sites.google.com/view/sant-cugat-forum-astrophysics/next-session

The study of the formation and evolution of protoplanetary disks around young stars saw a tremendous boost by the advent of ALMA and the development of new capabilities in the infrared and radio telescopes, thanks to the huge combined improvement in sensitivity, angular resolution, and image fidelity. However, the role of magnetic fields in the formation and evolution of disks around young stars is still a poorly understood topic. Are protoplanetary disks and protostellar jets magnetized? Polarimetric observations are the primary means to obtain information regarding the magnetic fields. However, this technique can be hampered by other polarization mechanisms such as dust selfscattering, radiation alignment of aspherical grains or anisotropic resonant scattering of linear polarization of molecular lines. The main goal of this focused meeting is to bring together observers and theoreticians interested in the study of magnetic fields in protoplanetary disks and protostellar jets as well as polarization mechanisms to review the current state of the research and explore effective means to probe magnetic fields.

Confirmed Invited Speakers: Carlos Carrasco-González, Benoît Comenrçon, Paulo Cortes, Christian Fendt, Martin Houde, Akimasa Kataoka, Ana'́elle Maury, Ya-Wen Tang, Zhaohuan Zhu

Important Dates:
Close Abstract submission: February 28, 2019
Close Early Registration and payment: April 30, 2019

The number of participants is limited to about 70

The Scientific Organizing Committee: Maria Teresa Beltran, Gemma Busquet, Jean Francois Donati, Josep Miquel Girart, Shih-Ping Lai, Aina Palau, Mayra Osorio, Wouter Vlemmings, Qizhou Zhang

Cloudy workshop 2019

Registration is now open for the Cloudy workshop to be held from 2019 May 20 to May 24 at the University of Kentucky. Cloudy is a large-scale code that simulates the microphysics of matter exposed to ionizing radiation. It calculates the atomic physics, chemistry, radiation transport, and dynamics problems simultaneously and self-consistently, building from a foundation of individual atomic and molecular processes. The result is a prediction of the conditions in the material and its observed spectrum. The workshop will cover observations, theory, and application of Cloudy to a wide variety of astronomical environments. This includes the theory of diffuse matter and quantitative spectroscopy, the science of using spectra to make physical measurements. We will use Cloudy to simulate such objects as AGB stars, Active Galactic Nuclei, Starburst galaxies, and the intergalactic medium. The sessions will consist of a mix of textbook study, using Osterbrock & Ferland, 'Astrophysics of Gaseous Nebulae and Active Galactic Nuclei', application of Cloudy to a variety of astrophysical problems, and projects organized by the participants. No prior experience with Cloudy is assumed although some knowledge of spectroscopy and the physics of the interstellar medium is useful.

To register please visit http://cloud9.pa.uky.edu/~gary/cloudy/CloudySummerSchool/

Smoothed Particle Hydrodynamics International Workshop
June 25 - 27, 2019 - Exeter, UK

Dear colleagues:

It is for me a pleasure to invite you to the 2019 edition of the SPHERIC international workshop, devoted to the promotion and development of the Smoothed Particle Hydrodynamics method, that will take place in Exeter (UK) from the 25th to the 27th of June 2019.

The SPHERIC Workshop is the definitive global meeting focussed on the Smoothed Particle Hydrodynamics (SPH) computational method and related meshless particle approaches. Some examples of the research topics that will be covered during the workshop will be:

* Interaction with solids and complex structures * Free surface flows and moving boundaries * Multi-phase flows and multiple continua * Viscosity and turbulence modelling * Incompressible flows * Astrophysics * Maritime and naval architecture applications * Hydraulic applications * Microfluidics * Disaster simulations * Solids and Fracture Mechanics

Before the main workshop, the optional training day on the 24th of June will provide an intensive theoretical and hands-on introduction to state-of-the-art SPH. This is ideal for students beginning their work in the field, but will also be of interest to seasoned researchers who want to explore specific themes in depth, or experience latest developments in SPH software.

The registration process and call for abstract submission is now open. The deadline for abstract submission is the 18th of February. Contributions from all areas and applications of the SPH method are extremely welcome. All the relevant deadlines and detailed information can be found at the conference webpage:

http://spheric2019.co.uk/

Please, feel free to circulate this email amongst your colleagues and do not hesitate to contact me if you have any doubt. Thanks a lot for your time and looking forward to see you in Exeter.

Kind regards,

Pablo Loren-Aguilar

Chair of the 2019 SPHERIC international workshop on Smoothed Particle Hydrodynamics

Partially Ionised Plasmas in Astrophysics - PIPA2019
3 - 7 June 2019, Palma de Mallorca, Spain

http://solar1.uib.es/pipa2019/

The Partially Ionised Plasmas in Astrophysics meetings are a series of conferences whose core subject is the study of partial ionisation effects in any Astrophysical context.

PIPA2019, the 3rd meeting of the series, will be organised in Palma de Mallorca (Spain) in the period 03 07 June 2019. The meeting is hosted by the Solar Physics group of the University of the Balearic Islands, Spain.

The meeting aims to broaden and strengthen the collaboration of scientists working in partially ionised plasmas in space (e.g., solar chromosphere, interstellar medium, protostellar discs, planetary magnetospheres and ionospheres, etc.) and to develop common scientific interests that could enhance cross-collaborations between scientists working in this field.

The meeting will focus on (but is not limited to) the following topics:

Partially ionised plasmas in the solar atmosphere - Electrodynamics of planetary magnetospheres - Astrophysical partially ionised plasmas

The format of this edition will be similar to that of the previous ones: a 5-day informal-style meeting with significant time for discussions. The meeting will take place in the hotel Amic Miraflores, located 6.5 km from Palma de Mallorcas airport and 8 km from downtown Palma.

Second Announcement

Gaia's view of pre-Main Sequence evolution. Linking the T Tauri and Herbig Ae/Be stars

Leeds, UK 18-21 June 2019

Abstract Submission 15 April 2019

The Herbig Ae/Be stars bridge the gap in mass between the lower mass T Tauri stars and the higher mass Massive Young Stellar Objects. By linking the low and high mass stars, the Herbig Ae/Be stars are crucial in finding similarities and differences between the formation processes in both regimes. The time is ripe for experts to come together and discuss their latest results on star formation. The time is also ripe to probe the links between the T Tauri stars and Herbig Ae/Be stars in more detail and a major aim of the workshop is to bring the respective communities together to compare and contrast the properties, appearance and formation mechanisms of both types of object

The registration is now open at https://starry-project.eu/final-conference/

Topics include:

Pre-Main sequence evolution models and observations
T Tauri stars, Herbig Ae/Be stars, related objects and their links
Evolution of the circumstellar disks
Accretion, theory, observations, episodic accretion
Magnetic fields
The circumstellar environment, disks, outflows, planets
Clusters and multiplicity
Gaia and other modern facilities

Confirmed invited speakers are:

Evelyne Alecian, France
Allessandro Bressan, Italy
Sean Brittain, USA
Jerome Bouvier, France
Nuria Calvet, USA
Antonio Garufi, Italy
Lee Hartmann, USA
Lynne Hillenbrand, USA
Alcione Mora, Spain
James Muzerolle, USA
Antonella Natta, Ireland
Christian Schneider, Germany

The SOC consists of René Oudmaijer, UK (chair); Ricardo Pérez Martinez, Spain; Deborah Baines, Spain; Ignacio Mendiguta, Spain; Willem-Jan de Wit, ESO Chile; John Fairlamb, USA; Gaitee Hussain, ESO Germany

More information is to be found on the conference web-site https://starry-project.eu/final-conference/

Exploring the Infrared Universe: The Promise of SPICA

Crete, Greece, 20-23 May 2019

http://www.spica2019.org/

Science rationale:
The infrared wavelength range is key to understand the origin and evolution of galaxies, stars and planetary systems, which are obscured by dust during a large part of their life cycles. With a large cold mirror and a sensitive suite of instruments, SPICA, in 2018 selected as a candidate for ESAs Cosmic Visions program, stands poised to revolutionize these fields by providing ultra-deep spectroscopy in the 12-230 μm range, as well as imaging (17–37 μm and 100–350 μm) and polarimetry (100–350 μm). With launch planned for 2030, SPICA will provide a huge leap in capabilities over previous infrared space missions, and complement current and upcoming facilities, filling the spectral gap between JWST and ALMA. We would like to invite the international astronomical community to participate in the conference, *Exploring the Infrared Universe: The Promise of SPICA*, which will take place on the island of Crete on 20–23 May 2019. At this conference, participants will learn about the capabilities and current design of SPICA, which includes a significant Guest Observer program, while discussing the exciting scientific promise of the mission. Up to date information about the SPICA mission and its instruments can be found at http://www.spica-mission.org, in addition to links to a set of whitepapers recently published in the journal PASA, that focus on some of the science enabled by SPICA.

Topics to be addressed:

- Galaxy evolution
- Metals and dust across cosmic time
- Star formation and the baryon cycle in galaxies
- Galactic star formation
- Formation of habitable planets
- Debris disks, planetary systems, and the Solar system

Confirmed invited speakers:
Susanne Aalto, Michihiro Takami, Françoise Combes, Bill Dent, Edith Falgarone, Davide Fedele, Andrea Ferrara, Javier Goicoechea, Masateru Ishiguro, Patrick Koch, Leon Koopmans, Diane Cormier, Roberto Maiolino, Margaret Meixner, Thomas Müller, Tohru Nagao, Klaus Pontoppidan, Alexandra Pope, Peter Roelfsema

Scientific organizing committee:
Lee Armus, Martin Giard, Sue Madden, Marc Audard, Matt Griffin, Mikako Matsuura, Vassilis Charmandaris, Doug Johnstone, Stefanie Milam, Carlotta Gruppioni, Inga Kamp, Paco Najarro, Yasuo Doi , Hidehiro Kaneda, Takashi Onaka, Eiichi Egami, Ciska Kemper, Luigi Spinoglio, David Elbaz, Kotaro Kohno, Floris van der Tak (chair) Jan Tauber

Local organizing committee:
Margaret Balothiari, Vassilis Charmandaris (chair), Evangelia Ntormousi, Raphael Skalidis, Kostas Tassis

Summary of Upcoming Meetings

Planet Formation and Evolution
27 February - 1 March 2019, Rostock, Germany
http://pfe2019.stat.physik.uni-rostock.de

Dusting the Universe
4 - 8 March 2019, Tucson, USA
http://www.noao.edu/meetings/dust2019/

Chemical Abundances in Gaseous Nebulae
11 - 14 March 2019, São José Dos Campos, Brazil
https://www.univap.br/universidade/instituto-de-pesquisa/agenda-e-eventos/chemical-abundances-in-gaseous-neb

New Quests in Stellar Astrophysics IV. Astrochemistry, astrobiology and the Orign of Life
31 March - 5 April 2019, Puerto Vallarta, Mexico
http://www.inaoep.mx/puerto19

New Horizons in Planetary Systems
13 - 17 May 2019 - Victoria, Canada
http://go.nrao.edu/NewHorizons

Exploring the Infrared Universe: The Promise of SPICA
20 - 23 May 2019, Crete, Greece
http://www.spica2019.org

Workshop on Polarization in Protoplanetary Disks and Jets
20 - 24 May 2019, Sant Cugat del Vallès, Catalonia, Spain
http://sites.google.com/view/sant-cugat-forum-astrophysics/next-session

Cloudy Workshop
20 - 24 May 2019, University of Kentucky, USA
http://cloud9.pa.uky.edu/~gary/cloudy/CloudySummerSchool/

Star Clusters: from the Milky Way to the Early Universe
27 - 31 May 2019, Bologna, Italy
http://iausymp351.oas.inaf.it/

Partially Ionised Plasmas in Astrophysics
3 - 7 June 2019, Palma de Mallorca, Spain
http://solar1.uib.es/pipa2019/

Zooming in on Star Formation - A tribute to Åke Nordlund
9 - 14 June 2019, Nafplio, Greece
http://www.nbia.dk/nbia-zoomstarform-2019

From Stars to Planets II: Connecting our Understanding of Star and Planet Formation
17 - 20 June 2019, Gothenburg, Sweden
http://cosmicorigins.space/fstpii

Gaia's View of Pre-Main Sequence Evolution. Linking the T Tauri and Herbig Ae/Be Stars
18 - 21 June 2019, Leeds, UK
https://starry-project.eu/final-conference

Gordon Conference on Origins of Solar Systems: Meteoritical, Spacecraft and Astrophysical Perspectives on the Assembly and Composition of Planets
23 - 28 June 2019
https://www.grc.org/origins-of-solar-systems-conference/2019/

Astrochemistry: From nanometers to megaparsecs - A Symposium in Honour of John H. Black
24 - 28 June 2019, Gothenburg, Sweden
https://www.chalmers.se/en/conference/JHBlacksymp2019/

Smoothed Particle Hydrodynamics International Workshop
25 - 27 June 2019, Exeter, UK
http://spheric2019.co.uk/

Great Barriers in Planet Formation
21 - 26 July 2019 Palm Cove, Australia
https://dustbusters.bitbucket.io/great-barriers-2019/

Celebrating the first 40 Years of Alexander Tielens' Contribution to Science: The Physics and Chemistry of the ISM
2 - 6 september 2019, Avignon, France https://tielens2019.sciencesconf.org

The Pleiades and friends: stellar associations in the GAIA era
9 - 13 September 2019, Coruña, Spain
http://www.laeff.cab.inta-csic.es/projects/pleiades2019/main/index.php

Crete III - Through dark lanes to new stars Celebrating the career of Prof. Charles Lada
23 - 27 September 2019 Crete, Greece
http://crete3.org

COOL STARS 21: Cambridge Workshop on Cool Stars, Stellar Systems and the Sun
21 -26 June 2020, Toulouse, France
https://coolstars21.github.io/

Abstract submission deadline

The deadline for submitting abstracts and other submissions is the first day of the month.