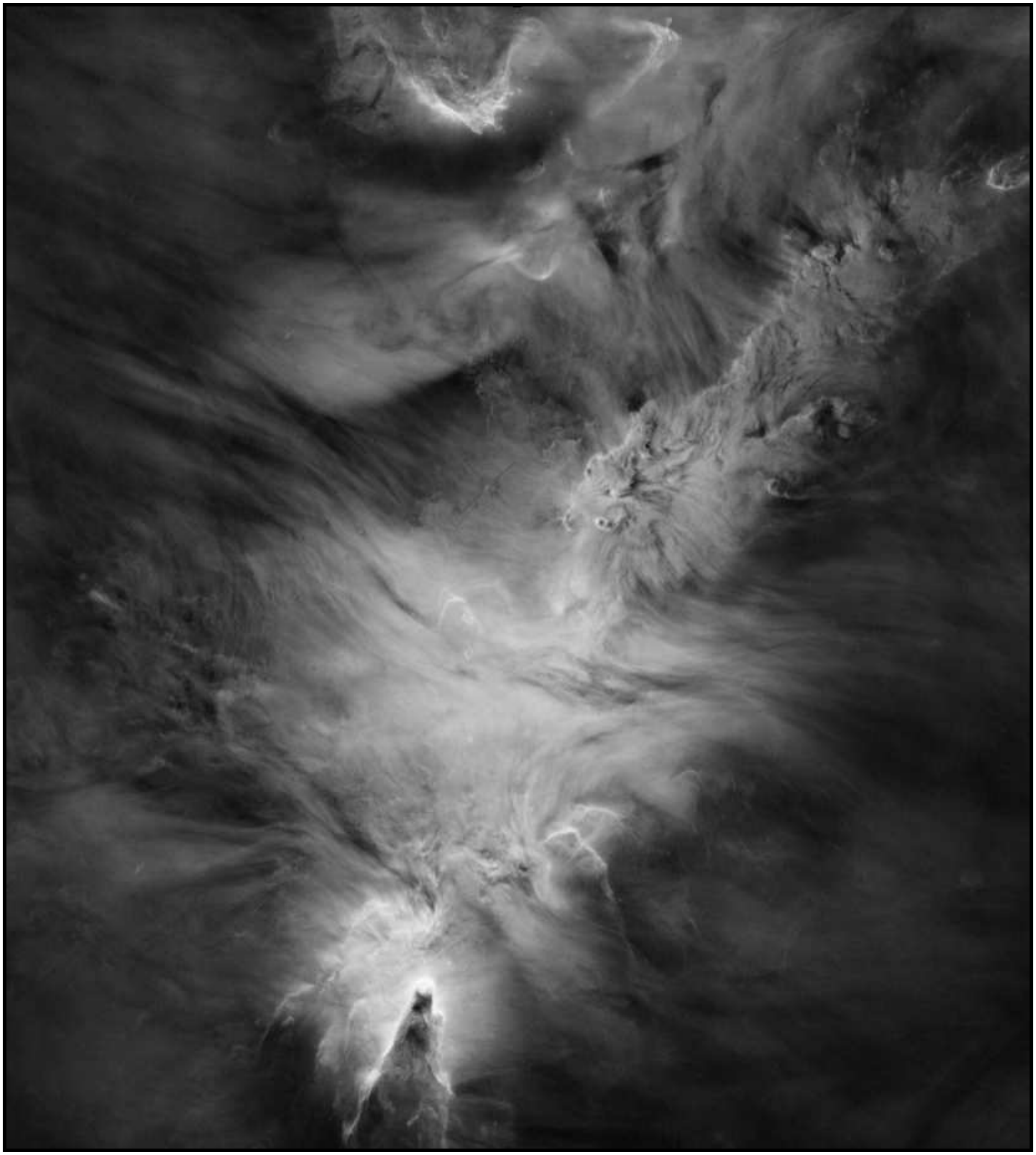
THE STAR FORMATION NEWSLETTER

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

No. 328 — 16 April 2020 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)



The Star Formation Newsletter

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star and planet formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals), *Abstracts of recently accepted major reviews* (not standard conference contributions), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star and planet formation and early solar system community), *New Jobs* (advertising jobs specifically aimed towards persons within the areas of the Newsletter), and *Short Announcements* (where you can inform or request information from the community). Additionally, the Newsletter brings short overview articles on objects of special interest, physical processes or theoretical results, the early solar system, as well as occasional interviews.

Newsletter Archive

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

List of Contents

Cover Picture

The NGC 2264 star forming region, seen here with the stars removed in order to appreciate better the intricate interaction between radiation and winds with the neutral clouds. The Cone Nebula is to the south, the 'Fox Fur' nebula to the right, and several Herbig-Haro bow shocks to the north. This is a 10 hour Hα exposure with a 20-inch ASA Newtonian telescope.

Image courtesy Stanislav Volskiy (https://volskiy.smugmug.com)

Submitting your abstracts

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

John Wood

in conversation with Bo Reipurth

Q: *You got your PhD in 1958 from the Massachusetts Institute of Technology on an analysis of over a hundred thin sections cut from stony meteorites. What were your results?*

A: Nobody had studied stony meteorites microscopically for many years. I'd always had a romance about astronomy, so I opted for that as my minor subject at MIT, not entirely to the liking of my thesis committee. This led to some Harvard astronomy courses, and acquaintance with Fred Whipple.

A happy circumstance led mineralogy Prof Cliff Frondel to show me a chest of old thin sections which had been cut from a collection of meteorites by J. Lawrence Smith in the 19th century. These were no more than a curiosity in the mineralogy department, so he was glad to lend them to me to examine at my leisure. Which I did, borrowing time from my thesis topic, which was ring dikes in the New Hampshire White Mountains and a study of their petrology by a new technique of rapid chemical analysis.

The latter program did not go well, and as my interest in it waned, the siren song of chondrites and chondrules grew louder. Eventually my thesis advisor, Gordon J. F. Macdonald, realized this and allowed me to switch my thesis topic to the petrology and origin of chondrites. It was obvious to me that there was a textural spectrum ranging from sharply defined chondrules embedded in fine-grained matrix to crystalline rocks with indistinct boundaries between chondrules and their surroundings. Macdonald drew my attention to a paper by G. Bain at Amherst College, who had studied a band of fossiliferous limestone that stretched through Vermont. At one end, where the rock had not been buried deeply, it contained sharply defined fossil invertebrates. At the other end, where the rock had been more deeply buried and thus hotter and more metamorphosed, the now-eroded limestone had become coarsely crystalline, like marble, and the fossils were barely recognizable as such. The analogy to the textural sequence in chondrites was obvious. I later wrote a paper on metamorphism in chondrites.

Q: *Today we take metamorphism in chondrites as a given, but at the time the idea ran into some resistance. In 1967 Van Schmus and you combined the metamorphism and chemistry of chondrites into a classification system that is a general tool today. Was that what finally convinced the community about metamorphism?*

A: I learned that colleague Randall Van Schmus had made the same discovery, and we collaborated in a program to study as many chondrite thin sections as we could find and classify the degree of metamorphism each displayed. The paper we published has become widely cited, and it convinced most workers.

Q: *Later you derived the cooling rates in differentiated bodies in the early solar system. What was the method you used and what rates did you find?*

A: In the 1960s, while I was post-doc'ing with Edward Anders in Chicago, I got interested in iron meteorites and read up on metallurgy. Clearly these meteorites had formed during melting in small bodies, when molten metallic nickel-iron in the parent material separated from silicate magma and sank to the centers of the planetesimals. As these cooled, the Fe-Ni phase diagram predicts that the solidified metal started out as the alloy taenite. With continued cooling, crystals of low-nickel kamacite would have precipitated from the higher-nickel taenite. As the kamacite crystals grew they had to push the Ni they were rejecting back into the remaining taenite, where it formed high-Ni zones. Nickel moved by solid-state diffusion from these zones into the residual lower-Ni taenite. I studied the final frozen-in Ni profiles in a series of iron meteorites, using an electron-probe microanalyzer. I called them M-profiles because they resembled that letter, with the high-Ni zones forming its shoulders and the low-Ni residual taenite forming the trough. The size of the M-profiles had to depend on the rate at which the metal cooled. M-profiles remained larger if the cooling was too slow for diffusion to allow Ni to flow in and fill the troughs. I studied the relationship between M-profile sizes and the amount of Ni that made it into the troughs.

Calculating the effect of cooling in such a system is an interesting problem in differential equations. I was never strong in mathematics, but happily I learned early on that you can cheat and use iterative numerical calculations to bypass formal math, and I became proficient in FORTRAN programming. Modeling the formation of the iron-meteorite M-profiles in this fashion, using experimentally-determined diffusion coefficients, I found that most of the meteorites I studied cooled at about 10C per million years; while others cooled more slowly, about 1C per million years. To relate cooling rates to the sizes of the planetary bodies the meteorites resided in required calculating planetary heat loss rates as a function of size, but this was not too hard; the problem of heat diffusion in a planet is analogous to the problem of nickel diffusion in taenite. The 10C/myr meteorites cooled in bodies 50-90 km in radius, the 1C/myr meteorites from bodies 130-260 km in radius. Those are asteroidal dimensions.

Q: *In 1969 the Allende meteorite fell in Mexico, and Ursula Marvin and you published the first analysis. Why is Allende so important in meteoritics?*

A: I believe it's because Allende was the first carbonaceous chondrite to be widely distributed to scientists for study. Carbonaceous chondrites are important because they have not experienced the degree of heating and metamorphism that I just talked about. Metamorphism has wiped out much of the evidence of early solar system events that we want to learn about. Allende allowed us to see it better.

Q: *In the early 1970s you were able to get and study lunar soil from the Apollo missions. This led to an unexpected and important new insight into the Moon. Please tell about the circumstances of this work.*

A: In the early 1960s, NASA wanted scientists to study the samples that they expected to be collected on the moon in the Apollo program, and they issued an invitation to qualified individuals to submit proposals to be lunar sample investigators. My history, described above, qualified me. By that time I was working at the Smithsonian Astrophysical Observatory in Cambridge, Mass. (where I spent the rest of my career) under Fred Whipple, who had encouraged me to set up a meteorite laboratory there. I submitted a proposal to NASA, and recruited two freshly-minted Ph.Ds, John Dickey from Princeton University and Ben Powell from Columbia, to work with me. They were joined in my group by Ursula Marvin, a mineralogist and x-ray diffraction expert, who was already at SAO.

In September 1969 approved lunar investigators were called to Houston to receive the samples that had been allocated to them, and I received two sieved samples of the lunar regolith (pulverized cratering debris that covered the moon). The most important sample turned out to be 11 grams of coarse lunar fines larger than 1-millimeter in size and mostly smaller than 2-mm. When my group examined it under a binocular microscope, we found to our surprise that it was not just a pulverized mineral dust, as I had pessimistically assumed it would be. Once rinsed in organic solvents, the coarse fines could be seen to consist of tiny miniature rocks, each with a distinctive texture and assemblage of minerals. We realized we had hundreds of separate and distinct lunar samples on our hands! So we set to work to study as many of those rock-ettes as we could in the time we had. Which was not much: NASA had decreed that on January 5, 1970, all of the lunar sample investigators were to convene in Houston, Texas, and present the results of their studies. Just 109 days after I picked up our sample.

Petrographers study rocks in thin sections: slivers of rock about 30 micrometers thick (a human hair is about that diameter) mounted on glass microscope slides, which are created by a rather tedious process of diamond sawing, grinding, and polishing on the surfaces of spinning laps. We made our own thin sections in our laboratory, 1676 of them, and studied them microscopically and in our electron microprobe. We learned that about half of the Mare Tranquillitatis regolith consists of soil breccias, which are volumes of fine lunar soil that had been crammed together and lithified by meteoroid impacts. About 5% of the particles were glasses: rock or soil that had been melted by the energy of an impact, which then cooled rapidly by radiation into space. Another 40% of the particles were crystalline igneous rocks. It might seem they would all be similar representatives of the basaltic rock that underlies Tranquillity Base, so the job of describing them would be simple, but that was not to be the case. Studies had shown that the debris from a cratering impact can travel great distances, so the soil particles that were collected at any point on the moon may have come from many different far-flung sources. Most of the igneous particles consisted of hardened basaltic lava (it had long been evident that the lunar maria must have been filled with lava); but many varieties of lava, differing in chemistry and texture.

However, another 3-4% of the igneous particles were something quite different and unexpected. They were white and anorthositic in chemical composition. Anorthosite is an igneous rock type rare on earth; an important anorthosite occurrence is in the Adirondack Mountains of New York. Anorthositic rocks consist principally of the mineral anorthite ($CaAl_2Si_2O_9$). No previous work had predicted that the moon would contain this surprising rock type.

Where might this light-colored component of anorthositic particles have come from? That question was not so hard to answer. The Apollo lander Eagle had set down on the edge of dark mare-basalt-filled Mare Tranquillitatis, only about 50 kilometers from the beginning of the light-colored lunar highlands or terrae. Impacts on the terra regolith surely would have scattered some of it over into the mare regolith. This must have been the source of the anorthositic fragments in our sample.

Did this unexpected composition hold for all of the light-colored terra rock that covered most of the moon, or just that corner of it? An earlier NASA unmanned mission to the moon, Surveyor 7, appeared to hold the answer to that question. Surveyor 7 carried a device, the alpha-scattering surface analyzer, which used the phenomenon of Rutherford scattering to measure the chemical composition of the surface on the ejecta blanket of the crater Tycho, whose dramatic rays circle the moon. Tycho is in lunar terra material far removed from Tranquillity Base. The result was consistent with an anorthositic composition for terra material there too.

Generalizing boldly, it seemed clear to us that a high-albedo anorthosite-rich crustal layer covers the whole moon, atop whatever lies beneath, except where giant impacts have blasted holes (mare basins) through it, which filled with basaltic lava.

The principle of isostasy (crustal buoyancy) allows the thickness of this layer to be estimated. Rock has plastic properties over long periods of time, meaning a heavy load on it pushes subcrustal rock aside, making room for the load to sink. Isostasy will allow a mountain range to stand only if the mountains are lighter (less dense) than the rock beneath them so they can ''float' in it. The light (specific gravity 2.9) lunar crust can float 3 kilometers above the denser interior (moon's overall specific gravity = 3.35), as is observed, only if the crustal thickness is about 25 kilometers. That's lot of anorthosite!

How could this layer of rare anorthite-rich rock have formed? The experimentally determined sequence of minerals that crystallize from a cooling silicate melt rich in magnesium and iron predicts that the mineral olivine appears first, followed by pyroxenes and calcic feldspar, then sodic feldspar. Olivine is dense, and it would tend to sink to the floor of a volume of magma during crystallization. On the other hand, crystallizing calcic feldspar (anorthite) is lighter, and under some circumstances it would tend to float rather than sink, accumulating at the top of the cooling magma. Such a process of separating minerals seems to be the only possible explanation for the concentration of anorthosite in the crust of the moon.

How much magma would have been needed to form the crust by this process of crystal fractionation? Assuming a plausible bulk chemical composition for the moon, it turns out most or all of the moon must have melted in order for 25 kilometers of anorthite crystals to float to the top. I later coined the term 'magma ocean' to describe this huge quantity of magma, and the term has caught on.

That's the story I told in my talk at the First Lunar Science Conference, and people found it convincing. Several other research groups had noticed and described the anorthositic particles in the lunar soil sample, but they didn't pursue their meaning.

Q: *The formation of chondrules has been the subject of much of your work. What are some of the key issues?*

A: Chondrules contain a mine of information about the early solar nebula, and I made it my life's work to understand it. Sadly, I failed. I wish I had time to try it over again.

It's a tough problem. You need to answer several central questions: why do some of the chondrules have olivine-rich compositions, similar to the average composition of chondrites, while in other cases the top of the igneous crystallization sequence (spoken of above), got skipped over during chondrule cooling, so that those melt droplets crystallized little or no olivine, and they were left with more feldspar-rich compositions? What hydrodynamic process size-sorted the chondrules after they were formed, reserving millimeter-scale objects for the asteroid belt and somehow disposing of larger silicate objects? I have wondered if the mighty gravity field of nearby Jupiter played some role in the things that happened.

Q: *You have had a lifelong interest in the interface between cosmochemistry and astrophysics, and have worked on and written extensively about this fertile area. Yet, the two communities still are quite separate. Why do you think that is, and how can we break down the barrier?*

A: I guess the problem is that their subject matter and cultures are just too disparate. The person who worked hardest to solve this problem was astrophysicist A. G. W. Cameron, who beginning in 1962 organized a series of Gordon Research Conferences on the Physics and Chemistry of Space. Al always made a point of mixing practitioners of as many relevant disciplines as possible into his programs. I was flattered to be on the first such program ("Formation and Properties of Chondrules"). BTW, George Herbig also spoke at this conference. I don't know how to break down the barrier. Maybe cosmochemists find astrophysics too arcane and difficult, and astrophysicists disrespect cosmochemistry as pedestrian. I've heard a physicist say "science is largely physics; everything else is stamp collecting".

Abstracts of recently accepted papers

Characterising lognormal fractional-Brownian-motion density fields with a Convolutional Neural Network

M L Bates[1], A P Whitworth[1] and O D Lomax[1,2]

[1] School of Physics and Astronomy, Cardiff University, Cardiff CF24 3AA, UK; [2] ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, Netherlands

E-mail contact: matthew.bates *at* astro.cf.ac.uk

In attempting to quantify statistically the density structure of the interstellar medium, astronomers have considered a variety of fractal models. Here we argue that, to properly characterise a fractal model, one needs to define precisely the algorithm used to generate the density field, and to specify – at least – three parameters: one parameter constrains the spatial structure of the field; one parameter constrains the density contrast between structures on different scales; and one parameter constrains the dynamic range of spatial scales over which self-similarity is expected (either due to physical considerations, or due to the limitations of the observational or numerical technique generating the input data). A realistic fractal field must also be noisy and non-periodic. We illustrate this with the exponentiated fractional Brownian motion (xfBm) algorithm, which is popular because it delivers an approximately lognormal density field, and for which the three parameters are, respectively, the power spectrum exponent, β, the exponentiating factor, $\mathcal{S}$, and the dynamic range, $\mathcal{R}$. We then explore and compare two approaches that might be used to estimate these parameters: Machine Learning and the established Δ-Variance procedure. We show that for $2 \leq \beta \leq 4$ and $0 \leq \mathcal{S} \leq 3$, a suitably trained Convolutional Neural Network is able to estimate objectively both β (with root-mean-square error $\epsilon_{\beta} \sim 0.12$) and $\mathcal{S}$ (with $\epsilon_{\mathcal{S}} \sim 0.29$). Δ-variance is also able to estimate β, albeit with a somewhat larger error ($\epsilon_{\beta} \sim 0.17$) and with some human intervention, but is not able to estimate $\mathcal{S}$.

Accepted by Monthly Notices of the Royal Astronomical Society

https://arxiv.org/pdf/2002.05506

A kinematically hot population of young stars in the solar neighbourhood

A.S. Binks[1], R.D. Jeffries[1] and N.J. Wright[1]

[1] Astrophysics Group, School of Chemistry and Physics, Keele University, UK

E-mail contact: a.s.binks1 *at* keele.ac.uk

In the last three decades several hundred nearby members of young stellar moving groups (MGs) have been identified, but there has been less systematic effort to quantify or characterise young stars that do not belong to previously identified MGs. Using a kinematically unbiased sample of 225 lithium-rich stars within 100 pc, we find that only 50±10 per cent of young ($\lesssim$125 Myr), low-mass ($0.5 < M/M_{\odot} < 1.0$) stars, are kinematically associated with known MGs. Whilst we find some evidence that six of the non-MG stars may be connected with the Lower Centaurus-Crux association, the rest form a kinematically "hotter" population, much more broadly dispersed in velocity, and with no obvious concentrations in space. The mass distributions of the MG members and non-MG stars is similar, but the non-MG stars may be older on average. We briefly discuss several explanations for the origin of the non-MG population.

Accepted by MNRAS

http://arxiv.org/pdf/2003.13369

Probing the magnetospheric accretion region of the young pre-transitional disk system DoAr 44 using VLTI/GRAVITY

J. Bouvier[1], K. Perraut[1], J.-B. Le Bouquin[1], G. Duvert[1], C. Dougados[1], W. Brandner[2], M. Benisty[1,3], J.-P. Berger[1] and E. Alécian[1]

[1] Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France; [2] Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany; [3] Unidad Mixta Internacional Franco-Chilena de Astronomía (CNRS, UMI 3386), Univ. Chile, Chile

E-mail contact: jerome.bouvier *at* univ-grenoble-alpes.fr

Young stellar objects are thought to accrete material from their circumstellar disks through their strong stellar magnetospheres. We aim to directly probe the magnetospheric accretion region on a scale of a few 0.01 au in a young stellar system using long-baseline optical interferometry. We observed the pre-transitional disk system DoAr 44 with VLTI/GRAVITY on two consecutive nights in the K-band. We computed interferometric visibilities and phases in the continuum and in the BrG line in order to constrain the extent and geometry of the emitting regions. We resolve the continuum emission of the inner dusty disk and measure a half-flux radius of 0.14 au. We derive the inclination and position angle of the inner disk, which provides direct evidence that the inner and outer disks are misaligned in this pre-transitional system. This may account for the shadows previously detected in the outer disk. We show that BrG emission arises from an even more compact region than the inner disk, with an upper limit of 0.047 au (5 Rstar). Differential phase measurements between the BrG line and the continuum allow us to measure the astrometric displacement of the BrG line-emitting region relative to the continuum on a scale of a few tens of microarcsec, corresponding to a fraction of the stellar radius. Our results can be accounted for by a simple geometric model where the BrG line emission arises from a compact region interior to the inner disk edge, on a scale of a few stellar radii, fully consistent with the concept of magnetospheric accretion process in low-mass young stellar systems.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/2004.00848

Hunting for hot corinos and WCCC sources in the OMC-2/3 filament

M. Bouvier[1], A. López-Sepulcre[1,2], C. Ceccarelli[1,3], C. Kahane[1], M. Imai[4] et al.

[1] Univ. Grenoble Alpes, CNRS, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), 38000 Grenoble, France; [2] Institut de Radioastronomie Millimétrique (IRAM), 300 rue de la Piscine, 38406 Saint-Martin-D'Hères, France; [3] CNRS, IPAG, F-38000 Grenoble, France; [4] Department of Physics, The University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

E-mail contact: mathilde.bouvier *at* univ-grenoble-alpes.fr

Context. Solar-like protostars are known to be chemically rich, but it is not yet clear how much their chemical composition can vary and why. So far, two chemically distinct types of Solar-like protostars have been identified: hot corinos, which are enriched in interstellar Complex Organic Molecules (iCOMs), such as methanol (CH_3OH) or dimethyl ether (CH_3OCH_3), and Warm Carbon Chain Chemistry (WCCC) objects, which are enriched in carbon chain molecules, such as butadiynyl (C_4H) or ethynyl radical (CCH). However, none of these have been studied so far in environments similar to that in which our Sun was born, that is, one that is close to massive stars.
Aims. In this work, we search for hot corinos and WCCC objects in the closest analogue to the Sun's birth environment, the Orion Molecular Cloud 2/3 (OMC-2/3) filament located in the Orion A molecular cloud.
Methods. We obtained single-dish observations of CCH and CH_3OH line emission towards nine Solar-like protostars in this region. As in other, similar studies of late, we used the [CCH]/[CH_3OH] abundance ratio in order to determine the chemical nature of our protostar sample.
Results. Unexpectedly, we found that the observed methanol and ethynyl radical emission (over a few thousands au scale) does not seem to originate from the protostars but rather from the parental cloud and its photo-dissociation region, illuminated by the OB stars of the region.
Conclusions. Our results strongly suggest that caution should be taken before using [CCH]/[CH_3OH] from single-dish observations as an indicator of the protostellar chemical nature and that there is a need for other tracers or high angular resolution observations for probing the inner protostellar layers.

Accepted by A&A

http://arxiv.org/pdf/2003.06198

A new proxy to estimate the cosmic-ray ionisation rate in dense cores

S. Bovino[1], S. Ferrada-Chamorro[1], A. Lupi[2], D.R.G. Schleicher[1], and P. Caselli[3]

[1] Departamento de Astronomía, Facultad Ciencias Físicas y Matemáticas, Universidad de Concepción, Av. Esteban Iturra s/n Barrio Universitario, Casilla 160, Concepción, Chile; [2] Scuola Normale Superiore, Piazza dei Cavalieri 7, Pisa, IT-56126 Italy; [3] Centre for Astrochemical Studies, Max-Planck-Institute for Extraterrestrial Physics, Giessenbachstrasse 1, 85748, Garching, Germany

E-mail contact: stefanobovino *at* udec.cl

Cosmic rays are a global source of ionisation, and the ionisation fraction represents a fundamental parameter in the interstellar medium. Ions couple to magnetic fields, affect the chemistry, and the dynamics of star-forming regions as well as planetary atmospheres. However, the cosmic-ray ionisation rate represents one of the bottlenecks for astrochemical models, and its determination is one of the most puzzling problems in astrophysics. While for diffuse clouds reasonable values have been provided from $H_3{}^+$ observations, for dense clouds, due to the lack of rotational transitions, this is not possible, and estimates are strongly biased by the employed model. We present here an analytical expression, obtained from first principles, to estimate the cosmic-ray ionisation rate from observational quantities. The theoretical predictions are validated with high-resolution three-dimensional numerical simulations and applied to the well known core L1544; we obtained an estimate of $\zeta_2 \sim 2\text{–}3 \times 10^{-17}$ s^{-1}. Our results and the analytical formulae provided represent the first model-independent, robust tool to probe the cosmic-ray ionisation rate in the densest part of star-forming regions (on spatial scales of $R \leq 0.05$ pc). An error analysis is presented to give statistical relevance to our study.

Accepted by MNRAS Letters

http://arxiv.org/pdf/2003.05416

An imaging line survey of OMC-1 to OMC-3

N. Brinkmann[1], F. Wyrowski[1], J. Kauffmann[2], D. Colombo[1], K.M. Menten[1] et al.

[1] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany; [2] Haystack Observatory, Massachusetts Institute of Technology, Westford, MA 01886, USA

E-mail contact: brinkmann *at* mpifr-bonn.mpg.de

Aims. Our aim is to identify the dominant molecular cooling lines and characteristic emission features in the 1.3 mm window of distinct regions in the northern part of the Orion A molecular cloud. By defining and analysing template regions, we also intend to help with the interpretation of observations from more distant sources which cannot be easily spatially resolved.
Methods. We analyse an imaging line survey covering the area of OMC-1 to OMC-3 from 200.2 to 281.8 GHz obtained with the PI230 receiver at the APEX telescope. Masks are used to define regions with distinct properties (e.g. column density or temperature ranges) from which we obtain averaged spectra. Lines of 29 molecular species (55 isotopologues) are fitted for each region to obtain the respective total intensity.
Results. We find that strong sources like Orion KL have a clear impact on the emission on larger scales. Although not spatially extended, their line emission contributes substantially to spectra averaged over large regions. Conversely, the emission signatures of dense, cold regions like OMC-2 and OMC-3 (e.g. enhanced N_2H^+ emission and low HCN/HNC ratio) seem to be difficult to pick up on larger scales, where they are eclipsed by signatures of stronger sources. In all regions, HCO^+ appears to contribute between 3% and 6% to the total intensity, the most stable value for all bright species. N_2H^+ shows the strongest correlation with column density, but not with typical high-density tracers like HCN, HCO+, H_2CO, or HNC. Common line ratios associated with UV illumination, CN/HNC and CN/HCO^+, show ambiguous results on larger scales, suggesting that the identification of UV illuminated material may be more challenging. The HCN/HNC ratio may be related to temperature over varying scales.

Accepted by A&A

http://arxiv.org/pdf/2003.06842

The Planetary Luminosity Problem: "Missing Planets" and the Observational Consequences of Episodic Accretion

Sean Brittain[1], Joan R. Najita[2], Ruobing Dong[3] and Zhaohuan Zhu[4]

[1] Clemson University, 118 Kinard Laboratory, Clemson, SC 29634, USA; [2] National Optical Astronomical Observatory, 950 North Cherry Avenue, Tucson, AZ 85719, USA; [3] Department of Physics and Astronomy, University of Victoria, Victoria BC V8P 1A1, Canada; [4] Department of Physics and Astronomy, University of Nevada, Las Vegas, 4505 S. Maryland Pkwy, Las Vegas, NV 89154, USA

E-mail contact: sbritt *at* clemson.edu

The high occurrence rates of spiral arms and large central clearings in protoplanetary disks, if interpreted as signposts of giant planets, indicate that gas giants form commonly as companions to young stars (< few Myr) at orbital separations of 10–300 au. However, attempts to directly image this giant planet population as companions to more mature stars (> 10 Myr) have yielded few successes. This discrepancy could be explained if most giant planets form "cold start," i.e., by radiating away much of their formation energy as they assemble their mass, rendering them faint enough to elude detection at later times. In that case, giant planets should be bright at early times, during their accretion phase, and yet forming planets are detected only rarely through direct imaging techniques. Here we explore the possibility that the low detection rate of accreting planets is the result of episodic accretion through a circumplanetary disk. We also explore the possibility that the companion orbiting the Herbig Ae star HD 142527 may be a giant planet undergoing such an accretion outburst.

Accepted by ApJ

https://arxiv.org/pdf/2003.11980

The GRAVITY young stellar object survey. II. First spatially resolved observations of the CO bandhead emission in a high-mass YSO

A. Caratti o Garatti[1,2,3], R. Fedriani[1,3,4], R. Garcia Lopez[1,2,3], M. Koutoulaki[1,3,5], K. Perraut[6], H. Linz[2], W. Brandner[2], P. Garcia[7,8,9] and L. Klarmann et al.[2]

[1] Dublin Institute for Advanced Studies, 31 Fitzwilliam Place, D02 XF86 Dublin, Ireland; [2] MPIA, Königstuhl 17, Heidelberg, Germany, D-69117; [3] University College Dublin, School of Physics, Belfield, Dublin 4, Ireland; [4] Dept of Space, Earth & Environment, Chalmers Univ. of Technology, SE-412 93 Gothenburg, Sweden; [5] ESO, Karl-Schwarzschild-Str. 2, D-85748, Garching, Germany; [6] Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France; [7] Universidade do Porto - Faculdade de Engenharia, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal; [8] CENTRA, Instituto Superior Tecnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal; [9] ESO, Casilla 19001, Santiago 19, Chile

E-mail contact: alessio *at* cp.dias.ie

The inner regions of the discs of high-mass young stellar objects (HMYSOs) are still poorly known due to the small angular scales and the high visual extinction involved. We deploy near-infrared (NIR) spectro-interferometry to probe the inner gaseous disc in HMYSOs and investigate the origin and physical characteristics of the CO bandhead emission (2.3–2.4 μm). We present the first GRAVITY/VLTI observations at high spectral ($\mathcal{R}$=4000) and spatial (mas) resolution of the CO overtone transitions in NGC 2024 IRS 2. The continuum emission is resolved in all baselines and is slightly asymmetric, displaying small closure phases ($\leq$8°). Our best ellipsoid model provides a disc inclination of 34°±1°, a disc major axis position angle (PA) of 166°±1°, and a disc diameter of 3.99±0.09 mas (or 1.69±0.04 au, at a distance of 423 pc). The small closure phase signals in the continuum are modelled with a skewed rim, originating from a pure inclination effect. For the first time, our observations spatially and spectrally resolve the first four CO bandheads. Changes in visibility, as well as differential and closure phases across the bandheads are detected. Both the size and geometry of the CO-emitting region are determined by fitting a bidimensional Gaussian to the continuum-compensated CO bandhead visibilities. The CO-emitting region has a diameter of $2.74\pm^{0.08}_{0.07}$ mas (1.16±0.03 au), and is located in the inner gaseous disc, well within the dusty rim, with inclination and PA matching the dusty disc geometry, which indicates that both dusty and gaseous discs are coplanar. Physical and dynamical gas conditions are inferred by modelling the CO spectrum. Finally, we derive a direct measurement of the stellar mass of $M_* \sim 14.7^{+2}_{-3.6}\,M_\odot$ by combining our interferometric and spectral modelling results.

Accepted by A&A (635, L12)

https://arxiv.org/pdf/2003.05404

Relative Alignment between Dense Molecular Cores and Ambient Magnetic Field: The Synergy of Numerical Models and Observations

Che-Yu Chen[1], Erica A. Behrens[2], Jasmin E. Washington[1], Laura M. Fissel[3,4], Rachel K. Friesen[3,5] et al.

[1] Department of Astronomy, University of Virginia, Charlottesville, VA 22904, USA; [2] Department of Astronomy, Ohio State University, Columbus, OH 43210, USA; [3] National Radio Astronomy Observatory, Charlottesville, VA 22904, USA; [4] Department of Physics, Engineering Physics and Astronomy, Queen's University, Kingston, ON K7L 3N6, Canada

E-mail contact: cc6pg *at* virginia.edu

The role played by magnetic field during star formation is an important topic in astrophysics. We investigate the correlation between the orientation of star-forming cores (as defined by the core major axes) and ambient magnetic field directions in 1) a 3D MHD simulation, 2) synthetic observations generated from the simulation at different viewing angles, and 3) observations of nearby molecular clouds. We find that the results on relative alignment between cores and background magnetic field in synthetic observations slightly disagree with those measured in fully 3D simulation data, which is partly because cores identified in projected 2D maps tend to coexist within filamentary structures, while 3D cores are generally more rounded. In addition, we examine the progression of magnetic field from pc- to core-scale in the simulation, which is consistent with the anisotropic core formation model that gas preferably flow along the magnetic field toward dense cores. When comparing the observed cores identified from the GBT Ammonia Survey (GAS) and Planck polarization-inferred magnetic field orientations, we find that the relative core-field alignment has a regional dependence among different clouds. More specifically, we find that dense cores in the Taurus molecular cloud tend to align perpendicular to the background magnetic field, while those in Perseus and Ophiuchus tend to have random (Perseus) or slightly parallel (Ophiuchus) orientations with respect to the field. We argue that this feature of relative core-field orientation could be used to probe the relative significance of the magnetic field within the cloud.

Accepted by MNRAS

http://arxiv.org/pdf/2003.11033

Accretion in low-mass members of the Orion Nebula Cluster with young transition disks

R. M. G. de Albuquerque[1,2,3], J. F. Gameiro[1,2], S. H. P. Alencar[4], J. J. G. Lima[1,2], C. Sauty[3,5] and C. Melo[6]

[1] Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP, Rua das Estrelas, PT4150-762 Porto, Portugal; [2] Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre 687, PT4169-007 Porto, Portugal; [3] Laboratoire Univers et Théories, Observatoire de Paris, Université PSL, CNRS, Université de Paris, 92190 Meudon, France; [4] Departamento de Física - ICEx-UFMG, Av. Antônio Carlos, 6627, 30270-901 Belo Horizonte, MG, Brazil; [5] LUPM, Université de Montpellier, UMR 5299 CNRS/IN2P3, cc072, place Eugène Bataillon, 34090 Montpellier, France; [6] European Southern Observatory, Alonso de Córdova 3107, Vitacura, Región Metropolitana, Chile

E-mail contact: Raquel.Albuquerque *at* astro.up.pt

Although the Orion Nebula Cluster is one of the most studied clusters in the solar neighborhood, the evolution of the very low-mass members ($M_* < 0.25\,M_\odot$) has not been fully addressed due to their faintness. Our goal is to verify if some young and very low-mass objects in the Orion Nebula Cluster show evidence of ongoing accretion using broadband VLT/X-Shooter spectra. For each target, we determined the corresponding stellar parameters, veiling, observed Balmer jump, and accretion rates. Additionally, we searched for the existence of circumstellar disks through available on-line photometry. We detected accretion activity in three young stellar objects in the Orion Nebula Cluster, two of them being in the very low-mass range. We also detected the presence of young transition disks with ages between 1 and 3.5 Myr.

Accepted by A&A

https://arxiv.org/pdf/2003.09511

An ALMA/NOEMA study of gas dissipation and dust evolution in the 5 Myr-old HD141569A hybrid disc

E. Di Folco[1], J. Péricaud[1], A. Dutrey[1], J.-C. Augereau[2], E. Chapillon[3], S. Guilloteau[1], V. Piétu[3] and A. Boccaletti[4]

[1] Laboratoire d'Astrophysique de Bordeaux, Université de Bordeaux, CNRS, B18N, Allée Geoffroy Saint-Hilaire, 33615, Pessac, France; [2] Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France; [3] IRAM, 300 rue de la piscine, F-38406 Saint Martin d'Hères, France; [4] LESIA, Observatoire de Paris, PSL Research Univ., CNRS, Univ. Paris Diderot, Sorbonne Paris Cité, UPMC Paris 6, Sorbonne Univ., 5 place Jules Janssen, 92195 Meudon CEDEX, France

E-mail contact: emmanuel.di-folco *at* u-bordeaux.fr

Context. The study of gas-rich debris discs is fundamental to characterising the transition between protoplanetary discs and debris discs.
Aims. We determine the physical parameters of the brightest gas-rich debris disc orbiting HD 141569A. Methods. We analyse images from the NOrthern Extended Millimeter Array (NOEMA) and the Atacama Large Millimeter/submillimeter Array (ALMA) in ^{12}CO , ^{13}CO J=2→1, and ^{13}CO J=1→0 transitions. We incorporate ALMA archival data of the ^{12}CO J=3→2 transition and present continuum maps at 0.87 mm, 1.3 mm, and 2.8 mm. We use simple parametric laws with the Diskfit code and MCMC exploration to characterise the gas disc parameters and report a first attempt to characterise its chemical content with IRAM-30m.
Results. The continuum emission is equally shared between a compact ($\lesssim$50 au) and a smooth, extended dust component ($\sim 350\,au$). Large millimetre grains seem to dominate the inner regions, while the dust spectral index is marginally larger in the outer region. The ^{12}CO is optically thick, while ^{13}CO is optically thin with $\tau_{^{13}CO} \sim 0.15$ (C^{18}O is not detected). The ^{13}CO surface density is constrained to be one order of magnitude smaller than around younger Herbig Ae stars, and we derive a gas mass $M_{^{12}\mathrm{CO}} = 10^{-1} M_{\oplus}$. We confirm the presence of a small CO cavity ($R_{\mathrm{CO}} = 17 \pm 3$ au), and find a possibly larger radius for the optically thin ^{13}CO J=2→1 transition (35 ± 5 au). We show that the observed CO brightness asymmetry is coincident with the complex ring structures discovered with VLT/SPHERE in the inner 90 au. The ^{12}CO temperature $T_0(100\,au) \sim 30$ K is lower than expected for a Herbig A0 star, and could be indicative of subthermal excitation.
Conclusions. With the largest amount of dust and gas among hybrid discs, HD 141569A shows coincident characteristics of both protoplanetary discs (central regions), and debris discs at large distance. Together with its morphological characteristics and young age, it appears to be a good candidate to witness the transient phase of gas dissipation, with an apparently large gas-to-dust ratio ($G/D > 100$) favouring a faster evolution of dust grains.

Accepted by Astronmy & Astrophysics

https://www.aanda.org/articles/aa/full_html/2020/03/aa32243-17/aa32243-17.html

A Multiple Power Law Distribution for Initial Mass Functions

Christopher Essex[1], Shantanu Basu[1], Janett Prehl[2] and Karl Heinz Hoffmann[2]

[1] The University of Western Ontario, London, Canada.; [2] Technische Universitat Chemnitz, Chemnitz, Germany.

E-mail contact: basu *at* uwo.ca

We introduce a new multi-power-law distribution for the Initial Mass Function (IMF) to explore its potential properties. It follows on prior work that introduced mechanisms accounting for mass accretion in star formation, developed within the framework of general evolution equations for the mass distribution of accreting and non-accreting (proto)stars. This paper uses the same fundamental framework to demonstrate that the interplay between a mass-dependent and a time-dependent step-like dropout rate from accretion leads to IMFs that exhibit multiple power laws for an exponential mass growth. While the mass-dependent accretion and its dropout is intrinsic to each star, the time-dependent dropout might be tied to a specific history such as the rapid consumption of nebular material by nearby stars or the sweeping away of some material by shock waves. The time-dependent dropout folded into the mass-dependent process of star formation is shown to have a significant influence on the IMFs.

Accepted by MNRAS

http://www.astro.uwo.ca/~basu/

A ringed pole-on outflow from DO Tauri revealed by ALMA

Manuel Fernández López[1], Luis A. Zapata[2], Luis F. Rodríguez[2], María M. Vazzano[1], Andrés E. Guzmán[3] and Rosario López[4]

[1] Instituto Argentino de Radioastronomía, CONICET, 1894, Villa Elisa, Buenos Aires, Argentina; [2] Instituto de Radioastronomía y Astrofísica, UNAM, P.O. Box 3-72, 58090, Morelia, Michoacán, México; [3] National Astronomical Observatory of Japan, NINS, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan; [4] Departament d'Astronomia i Meteorologia (IEEC-UB), ICC, U. de Barcelona, Martí i Franquès 1, E-08028 Barcelona, Spain

E-mail contact: manferna *at* gmail.com

We present new ALMA Band 6 observations including the CO (2-1) line and 1.3 mm continuum emission from the surroundings of the young stellar object DO Tauri. The ALMA CO molecular data show three different series of rings at different radial velocities. These rings have radii around 220 au and 800 au. We make individual fits to the rings and note that their centers are aligned with DO Tauri and its optical high-velocity jet. In addition, we notice that the velocity of these structures increases with the separation from the young star. We discuss the data under the hypothesis that the rings represent velocity cuts through three outflowing shells that are possibly driven by a wide-angle wind, dragging the environment material along a direction close to the line of sight (i= 19°). We estimate the dynamical ages, the mass, the momentum and the energy of each individual outflow shell and those of the whole outflow. The results are in agreement with those found in outflows from Class II sources. We make a rough estimate for the size of the jet/wind launching region, which needs to be of ≤ 15 au. We report the physical characteristics of DO Tauri's disk continuum emission (almost face-on and with a projected major axis in the north-south direction) and its velocity gradient orientation (north-south), indicative of disk rotation for a 1-2 $M_\odot$ central star. Finally we show an HST [SII] image of the optical jet and report a measurement of its orientation in the plane of the sky.

Accepted by ApJ

https://arxiv.org/pdf/2003.01148

Dust depleted inner disks in a large sample of transition disks through long-baseline ALMA observations

Logan Francis[1] and Nienke van der Marel[1]

[1] University of Victoria, Department of Physics and Astronomy, 3800 Finnerty Road, Victoria, Canada

E-mail contact: loganfrancis3 *at* uvic.ca

Transition disks with large inner dust cavities are thought to host massive companions. However, the disk structure inside the companion orbit and how material flows toward an actively accreting star remain unclear. We present a high resolution continuum study of inner disks in the cavities of 38 transition disks. Measurements of the dust mass from archival Atacama Large Millimeter/Submillimeter Array observations are combined with stellar properties and spectral energy distributions to assemble a detailed picture of the inner disk. An inner dust disk is detected in 18 of 38 disks in our sample. Of the 14 resolved disks, 9 are significantly misaligned with the outer disk. The near-infrared excess is uncorrelated with the mm dust mass of the inner disk. The size-luminosity correlation known for protoplanetary disks is recovered for the inner disks as well, consistent with radial drift. The inner disks are depleted in dust relative to the outer disk and their dust mass is uncorrelated with the accretion rates. This is interpreted as the result of radial drift and trapping by planets in a low α ($\sim 10^{-3}$) disk, or a failure of the α-disk model to describe angular momentum transport and accretion. The only disk in our sample with confirmed planets in the gap, PDS 70, has an inner disk with a significantly larger radius and lower inferred gas-to-dust ratio than other disks in the sample. We hypothesize that these inner disk properties and the detection of planets are due to the gap having only been opened recently by young, actively accreting planets.

Accepted by ApJ

https://arxiv.org/pdf/2003.00079

Formation of single-moon systems around gas giants

Yuri I. Fujii[1,2] and Masahiro Ogihara[3]

[1] Institute for Advanced Research, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan; [2]

Department of Physics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8602, Japan; [3] Division of Science, National Astronomical Observatory of Japan, 2-21-1, Osawa, Mitaka, 181-8588 Tokyo, Japan

E-mail contact: yuri.f *at* nagoya-u.jp

Several mechanisms have been proposed to explain the formation process of satellite systems, and relatively large moons are thought to be born in circumplanetary disks. Making a single-moon system is known to be more difficult than multiple-moon or moonless systems. We aim to find a way to form a system with a single large moon, such as Titan around Saturn. We examine the orbital migration of moons, which change their direction and speed depending on the properties of circumplanetary disks. We modeled dissipating circumplanetary disks with taking the effect of temperature structures into account and calculated the orbital evolution of Titan-mass satellites in the final evolution stage of various circumplanetary disks. We also performed *N*-body simulations of systems that initially had multiple satellites to see whether single-moon systems remained at the end. The radial slope of the disk-temperature structure characterized by the dust opacity produces a patch of orbits in which the Titan-mass moons cease inward migration and even migrate outward in a certain range of the disk viscosity. The patch assists moons initially located in the outer orbits to remain in the disk, while those in the inner orbits fall onto the planet. We demonstrate for the first time that systems can form that have only one large moon around giant planet. Our *N*-body simulations suggest satellite formation was not efficient in the outer radii of circumplanetary disks.

Accepted by A&A Letters

http://arxiv.org/pdf/2003.05052

Do subsequent outbursts of the same EXor source present similar features?

Teresa Giannini[1], Alessio Giunta[2], Dario Lorenzetti[1], Giuseppe Altavilla[1,2], Simone Antoniucci[1], Francesco Strafella[3] and Vincenzo Testa[1]

[1] INAF-Osservatorio Astronomico di Roma, via Frascati 33, I-00078 Monte Porzio Catone, Italy; [2] ASI - Agenzia Spaziale Italiana - Via del Politecnico, 00133 Roma, Italy; [3] Dipartimento di Matematica e Fisica, Universitá del Salento, 73100 Lecce, Italy

E-mail contact: teresa.giannini *at* inaf.it

V1118 Ori is a classical EXor source whose light curve has been monitored over the past thirty years (although not continuously). It underwent a powerful outburst in 2005, followed by ten years of quiescence and a less intense outburst in 2015. In 2019, a new intense brightness increase was observed ($\Delta g \sim 3$ mag). This new accretion episode offers the opportunity to compare the photometric and spectroscopic properties of different outbursts of the same source. This allows one to highlight differences and similarities among different events by removing any possible bias related to the intrinsic properties of the star-disk system. We discovered the 2019 V1118 Ori outburst by examining the g-band light curve acquired by the *Zwicky Transient Facility* and followed the decreasing phase with the *Rapid Eye Mount* telescope in the *griz* bands. Two near-infrared spectra were also acquired at different brightness stages with the *Large Binocular Telescope*. The last event shows the following characteristics: 1) amplitude similar than in 2015 and lower than in 2005; 2) duration less than one year as in previous events; 3) rise (decline) speed of 0.018 (0.031) mag/day, which is different from previous cases; 4) a gradual blueing of the $[g-r]$ color is observed over time, while the $[r-i]$ color remains roughly unchanged; 5) with few exceptions, the near-infrared lines (mainly H I recombination) are the same observed in 2015; 6) the mass accretion rate peaks at $\dot{M}_{acc} \sim 10^{-7}$ $M_\odot\,yr^{-1}$ and decreases in about a month down to a few 10^{-8} $M_\odot\,yr^{-1}$. Our analysis shows that the comparison of data from different outbursts of the same source is a non-trivial exercise, which allows obtaining important clues useful to drive theoretical efforts towards a better understanding of the EXor phenomenon.

Accepted by A&A

http://arxiv.org/pdf/2003.13383

Giant star-forming clumps?

R.J. Ivison[1], J. Richard[2], A.D. Biggs[1], M.A. Zwaan[1], E. Falgarone[3] et al.

[1] European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching, Germany; [2] Univ Lyon, Univ Lyon1, Ens de Lyon, CNRS, Centre de Recherche Astrophysique de Lyon UMR5574, F-69230, Saint-Genis-Laval, France; [3] Laboratoire de Physique de l'ENS, ENS, Université PSL, CNRS, Sorbonne Université, Université Paris-

Diderot, Paris, France

E-mail contact: rji *at* roe.ac.uk

With the spatial resolution of the Atacama Large Millimetre Array (ALMA), dusty galaxies in the distant Universe typically appear as single, compact blobs of dust emission, with a median half-light radius, ≈1 kpc. Occasionally, strong gravitational lensing by foreground galaxies or galaxy clusters has probed spatial scales 1–2 orders of magnitude smaller, often revealing late-stage mergers, sometimes with tantalising hints of sub-structure. One lensed galaxy in particular, the Cosmic Eyelash at $z = 2.3$, has been cited extensively as an example of where the interstellar medium exhibits obvious, pronounced clumps, on a spatial scale of ≈100 pc. Seven orders of magnitude more luminous than giant molecular clouds in the local Universe, these features are presented as circumstantial evidence that the blue clumps observed in many $z \sim 2$–3 galaxies are important sites of ongoing star formation, with significant masses of gas and stars. Here, we present data from ALMA which reveal that the dust continuum of the Cosmic Eyelash is in fact smooth and can be reproduced using two Sérsic profiles with effective radii, 1.2 and 4.4 kpc, with no evidence of significant star-forming clumps down to a spatial scale of ≈80 pc and a star-formation rate of $<3\ M_\odot\ \mathrm{yr}^{-1}$.

Accepted by MNRAS

http://arxiv.org/pdf/2003.07863

Discovery of new members of the nearby young stellar association in Cepheus

A. Klutsch[1,2,4], A. Frasca[2], P. Guillout[3], D. Montes[4], F.-X. Pineau[3] et al.

[1] Institut für Astronomie und Astrophysik, Eberhard Karls Universität, Sand 1, D-72076 Tübingen, Germany; [2] INAF-Osservatorio Astrofisico di Catania, via S. Sofia 78, I-95123 Catania, Italy; [3] Observatoire Astronomique, Université de Strasbourg & CNRS, UMR 7550, 11 rue de l'Université, F-67000 Strasbourg, France; [4] Departamento de Física de la Tierra y Astrofísica and IPARCOS-UCM (Instituto de Física de Partículas y del Cosmos de la UCM), Facultad de Ciencias Físicas, Universidad Complutense de Madrid, E-28040 Madrid, Spain

E-mail contact: klutsch *at* astro.uni-tuebingen.de

Young field stars are hardly distinguishable from older ones because their space motion rapidly mixes them with the stellar population of the Galactic plane. Nevertheless, a careful target selection allows for young stars to be spotted throughout the sky.
We aim to identify additional sources associated with the four young comoving stars that we discovered towards the CO Cepheus void and to provide a comprehensive view of the Cepheus association.
Based on multivariate analysis methods, we have built an extended sample of 193 young star candidates, which are the optical and infrared counterparts of ROSAT All-Sky Survey and XMM-Newton X-ray sources. From optical spectroscopic observations, we measured their radial velocity with the cross-correlation technique. We derived their atmospheric parameters and projected rotational velocity with the code ROTFIT. We applied the subtraction of inactive templates to measure the lithium equivalent width, from which we infer their lithium abundance and age. Finally, we studied their kinematics using the second Gaia data release.
Our sample is mainly composed of young or active stars and multiple systems. We identify two distinct populations of young stars that are spatially and kinematically separated. Those with an age between 100 and 300 Myr are mostly projected towards the Galactic plane. In contrast, 23 of the 37 sources younger than 30 Myr are located in the CO Cepheus void, and 21 of them belong to the stellar kinematic group that we previously reported in this sky area. We report a total of 32 bona fide members and nine candidates for this nearby (distance = 157±10 pc) young (age = 10–20 Myr) stellar association. According to the spatial distribution of its members, the original cluster is already dispersed and partially mixed with the local population of the Galactic plane.

Accepted by A&A

http://arxiv.org/pdf/2003.12155

Unbiased Monte Carlo continuum radiative transfer in optically thick regions

Anton Krieger[1] and Sebastian Wolf[1]

[1] University of Kiel, Institute of Theoretical Physics and Astrophysics, Leibnizstrasse 15, 24118 Kiel, Germany

E-mail contact: akrieger *at* astrophysik.uni-kiel.de

Radiative transfer describes the propagation of electromagnetic radiation through an interacting medium. This process is often simulated by the use of the Monte Carlo method, which involves the probabilistic determination and tracking of simulated photon packages. In the regime of high optical depths, this approach encounters difficulties since a proper representation of the various physical processes can only be achieved by considering high numbers of simulated photon packages. As a consequence, the demand for computation time rises accordingly and thus practically puts a limit on the optical depth of models that can be simulated. Here we present a method that aims to solve the problem of high optical depths in dusty media, which relies solely on the use of unbiased Monte Carlo radiative transfer. For that end, we identified and precalculated repeatedly occuring and simulated processes, stored their outcome in a multidimensional cumulative distribution function, and immediately replaced the basic Monte Carlo transfer during a simulation by that outcome. During the precalculation, we generated emission spectra as well as deposited energy distributions of photon packages traveling from the center of a sphere to its rim. We carried out a performance test of the method to confirm its validity and gain a boost in computation speed by up to three orders of magnitude. We then applied the method to a simple model of a viscously heated circumstellar disk, and we discuss the necessity of finding a solution for the optical depth problem with regard to a proper temperature calculation. We find that the impact of an incorrect treatment of photon packages in highly optically thick regions extents even to optically thin regions, thus, changing the overall observational appearance of the disk.

Accepted by A&A

https://www.aanda.org/articles/aa/pdf/2020/03/aa37355-19/aa37355-19.html

Angular Momenta, Magnetization, and Accretion of Protostellar Cores

Aleksandra Kuznetsova[1], Lee Hartmann[1], and Fabian Heitsch[2]

[1] Department of Astronomy, University of Michigan, 1085 S. University Ave., Ann Arbor, MI 48109; [2] Department of Physics and Astronomy, University of North Carolina - Chapel Hill

E-mail contact: kuza *at* umich.edu

Building on our previous hydrodynamic study of the angular momenta of cloud cores formed during gravitational collapse of star-forming molecular gas in our previous work, we now examine core properties assuming ideal magnetohydrodynamics (MHD). Using the same sink-patch implementation for the *Athena* MHD code, we characterize the statistical properties of cores, including the mass accretion rates, specific angular momenta, and alignments between the magnetic field and the spin axis of the core on the 0.1 pc scale. Our simulations, which reproduce the observed relation between magnetic field strength and gas density, show that magnetic fields can help collimate low density flows and help seed the locations of filamentary structures. Consistent with our previous purely hydrodynamic simulations, stars (sinks) form within the heterogeneous environments of filaments, such that accretion onto cores is highly episodic leading to short-term variability but no long-term monotonic growth of the specific angular momenta. With statistical characterization of protostellar cores properties and behaviors, we aim to provide a starting point for building more realistic and self-consistent disk formation models, helping to address whether magnetic fields can prevent the development of (large) circumstellar disks in the ideal MHD limit.

Accepted by ApJ

http://arxiv.org/pdf/2003.13697

The disk of 2MASS 15491331−3539118 = GQ Lup C as seen by HST and WISE

C. Lazzoni[1,2], R. Gratton[1], J.M. Alcalá[3], S. Desidera[1], A. Frasca[4] et al.

[1] INAF — Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, I-35122, Padova, Italy; [2] Dipartimento di Fisica a Astronomia "G. Galilei", Universita' di Padova, Via Marzolo, 8, 35121 Padova, Italy; [3] INAF — Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, 80131 Napoli, Italy; [4] INAF — Osservatorio Astronomico di Catania, Via Santa Sofia, 78, Catania, Italy

E-mail contact: cecilia.lazzoni *at* inaf.it

Very recently, a second companion on wider orbit has been discovered around GQ Lup. This is a low-mass accreting star partially obscured by a disk seen at high inclination. If detected, this disk may be compared to the known disk around the primary. We detected this disk on archive HST and WISE data. The extended spectral energy distribution provided by these data confirms the presence of accretion from Hα emission and UV excess, and shows an IR excess

attributable to a warm disk. In addition, we resolved the disk on the HST images. This is found to be roughly aligned with the disk of the primary. Both of them are roughly aligned with the Lupus I dust filament containing GQ Lup.

Accepted by A&A

http://arxiv.org/pdf/2003.00743

Most Stars (and Planets?) Are Born in Intense Radiation Fields

Eve J. Lee[1,2] & Philip F. Hopkins[1]

[1] TAPIR, Mailcode 350-17, California Institute of Technology, Pasadena, CA 91125, USA; [2] Department of Physics and McGill Space Institute, McGill University, 3550 rue University, Montreal, QC, H3A 2T8, Canada

E-mail contact: evelee *at* physics.mcgill.ca

Protostars and young stars are strongly spatially "clustered" or "correlated" within their natal giant molecular clouds (GMCs). We demonstrate that such clustering leads to the conclusion that the incident bolometric radiative flux upon a random young star/disc is enhanced (relative to volume-averaged fluxes) by a factor which increases with the total stellar mass of the complex. Because the Galactic cloud mass function is top-heavy, the typical star in our Galaxy experienced a much stronger radiative environment than those forming in well-observed nearby (but relatively small) clouds, exceeding fluxes in the Orion Nebular Cluster by factors of $\gtrsim$30. Heating of the circumstellar disc around a median young star is dominated by this external radiation beyond $\sim$50AU. And if discs are not well-shielded by ambient dust, external UV irradiation can dominate over the host star down to sub-AU scales. Another consequence of stellar clustering is an extremely broad Galaxy-wide distribution of incident flux (spanning >10 decades), with half the Galactic star formation in a substantial "tail" towards even more intense background radiation. We also show that the strength of external irradiation is amplified super-linearly in high-density environments such as the Galactic centre, starbursts, or high-redshift galaxies.

Accepted by MNRAS Letters

http://arxiv.org/pdf/2003.03390

ALMA observations of NGC 6334S – I: Forming massive stars and cluster in subsonic and transonic filamentary clouds

Shanghuo Li[1,2,3], Qizhou Zhang[2], Hauyu Baobab Liu[4], Henrik Beuther[5], Aina Palau[6], Josep Miquel. Girart[7], Howard Smith[2], Joseph L. Hora[2], Yuxing Lin[8], Keping Qiu[9], Shaye Strom[2], Junzhi Wang[1], Fei Li[1,3] and Nannan Yue[3,10]

[1] Shanghai Astronomical Observatory, Chinese Academy of Sciences, 80 Nandan Road, Shanghai 200030, China; [2] Center for Astrophysics, Harvard & Smithsonian , 60 Garden Street, Cambridge, MA 02138, USA; [3] University of Chinese Academy of Sciences, 19A Yuquanlu, Beijing 100049, China; [4] Academia Sinica Institute of Astronomy and Astrophysics, P.O. Box 23-141, Taipei 106, Taiwan; [5] Max Planck Institute for Astronomy, Konigstuhl 17, 69117 Heidelberg, Germany; [6] Instituto de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, P.O. Box 3-72, 58090, Morelia, Michoacán, México; [7] Institut de Ciències de l'Espai (IEEC-CSIC), Campus UAB, Carrer de Can Magrans s/n, 08193 Cerdanyola del Vallès, Catalonia, Spain; [8] Max-Planck Institute für Radio Astronomy, Auf dem Hügel 69, 53121, Bonn, Germany; [9] School of Astronomy and Space Science, Nanjing University, 163 Xianlin Avenue, Nanjing 210023, China; [10] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012

E-mail contact: shanghuo.li *at* gmail.com

We present Atacama Large Millimeter/submillimeter Array (ALMA) and Karl G. Jansky Very Large Array (JVLA) observations of the massive infrared dark cloud NGC 6334S (also known as IRDC G350.56+0.44), located at the southwestern end of the NGC 6334 molecular cloud complex. The $H^{13}CO^+$ and the NH_2D lines covered by the ALMA observations at a $\sim$3 arcsec angular resolution ($\sim$0.02 pc) reveal that the spatially unresolved non-thermal motions are predominantly subsonic and transonic, a condition analogous to that found in low-mass star-forming molecular clouds. The observed supersonic non-thermal velocity dispersions in massive star forming regions, often reported in the literature, might be significantly biased by poor spatial resolutions that broaden the observed line widths due to unresolved motions within the telescope beam. Our 3 mm continuum image resolves 49 dense cores, whose masses range from 0.17 to 14 $M_\odot$. The majority of them are resolved with multiple velocity components. Our analyses of these gas velocity components find an anti-correlation between the gas mass and the virial parameter. This implies

that the more massive structures tend to be more gravitationally unstable. Finally, we find that the external pressure in the NGC 6334S cloud is important in confining these dense structures, and may play a role in the formation of dense cores, and subsequently, the embedded young stars.

Accepted by ApJ

https://arxiv.org/pdf/2003.13534

Planet-induced Vortices with Dust Coagulation in Protoplanetary Disks

Ya-Ping Li[1], Hui Li[1], Shengtai Li[1], Tilman Birnstiel[2,3], Joanna Drążkowska[2] and Sebastian Stammler[2]

[1] Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545, USA; [2] University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität München, Scheinerstr. 1, 81679 Munich, Germany; [3] Exzellenzcluster ORIGINS, Boltzmannstr. 2, D-85748 Garching, Germany

E-mail contact: leeyp2009 *at* gmail.com

In this work, we study how the dust coagulation/fragmentation will influence the evolution and observational appearances of vortices induced by a massive planet embedded in a low viscosity disk by performing global 2D high-resolution hydrodynamical simulations. Within the vortex, due to its higher gas surface density and steeper pressure gradients, dust coagulation, fragmentation and drift (to the vortex center) are all quite efficient, producing dust particles ranging from micron to ∼1.0 cm, as well as overall high dust-to-gas ratio (above unity). In addition, the dust size distribution is quite non-uniform inside the vortex, with the mass weighted average dust size at the vortex center (∼4.0 mm) being a factor of ∼10 larger than other vortex regions. Both large (∼mm) and small (tens of micron) particles contribute strongly to affect the gas motion within the vortex. As such, we find that the inclusion of dust coagulation has a significant impact on the vortex lifetime and the typical vortex lifetime is about 1000 orbits. After the initial gaseous vortex is destroyed, the dust spreads into a ring with a few remaining smaller gaseous vortices with a high dust concentration and a large maximum size (∼mm). At late time, the synthetic dust continuum images for the coagulation case show as a ring inlaid with several hot spots at 1.33 mm band, while only distinct hot spots remain at 7.0 mm.

Accepted by ApJL

http://arxiv.org/pdf/2003.06522

Discovery of two nearby post-T Tauri stellar associations

Jiaming Liu[1], Min Fang[2], and Chao Liu[3,4]

[1] Key Lab of Optical Astronomy, National Astronomical Observatories, CAS, Beijing 100101, China; [2] Department of Astronomy, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA; [3] Key Lab of Space Astronomy and Technology, National Astronomical Observatories, CAS, Beijing, 100101, China; [4] University of Chinese Academy of Sciences, Beijing 100049, China

E-mail contact: liuchao *at* nao.cas.cn

In this work we report the discovery of 2 new stellar associations in close vicinity of the Sun at roughly 180 and 150 pc. These two associations, named as u Tau assoc and e Tau assoc, were detected based on their clustering in a multi-dimensional parameter space including α, δ, μ_α, μ_δ and ϖ of Gaia. The fitting of pre-main-sequence model isochrones in their color-magnitude diagrams suggests that the two associations are of about 50 Myr old and the group members lower than $\sim$0.8 $M_\odot$ are at the stage of post-T Tauri.

Accepted by AJ

http://arxiv.org/pdf/2003.11725

The nature of a primary jet within a circumbinary disc outflow in a young stellar system

Chris Lynch[1] and Michael D. Smith[1]

[1] Centre for Astrophysics & Planetary Science, The University of Kent, Canterbury, Kent CT2 7NH, U.K

E-mail contact: m.d.smith *at* kent.ac.uk

Most stars form in binaries, and both stars may grow by accreting material from a circumbinary disc onto their own discs. We suspect that in many cases a wide molecular wind will envelope a collimated atomic jet emanating from close to an orbiting young star. This so-called Circumbinary Scenario is explored here in order to find common identifiable properties. The dynamical set up is studied with three dimensional simulations with chemistry and cooling included. We extract the properties on scales of order 100 AU and compare to the Co-Orbital Scenario in which the wind and jet sources are in orbit. We find that the rapid orbital motion generates a wide ionised sheath around the jet core with a large opening angle at the base. This is independent of the presence of the surrounding molecular outflow. However, the atomic jet is recollimated beyond ~ 55 AU when the molecular outflow restricts the motion of the ambient medium which, in turn, confines the jet. These physical properties are related to the optical Hα imaging, providing a means of distinguishing between models. The high excitation sheath and recollimation region can be explored on these scales through the next generation of instruments. However, in general, the amount and location of the ionised material, whether in the knots or the sheath, will depend on several parameters including the orbital period, axis alignment and pulse amplitude.

Accepted by Monthly Notices of the Royal Astronomical Society

http://arxiv.org/pdf/2003.01806

Different Modes of Star Formation II: Gas Accretion Phase of Initially Subcritical Star-Forming Clouds

Masahiro N. Machida[1,2] and Shantanu Basu[2]

[1] Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, Fukuoka, Fukuoka 819-0395, Japan; [2] Department of Physics and Astronomy, The University of Western Ontario, London, ON N6A 3K7, Canada

E-mail contact: machida.masahiro.018 *at* m.kyushu-u.ac.jp

The accretion phase of star formation is investigated in magnetically-dominated clouds that have an initial subcritical mass-to-flux ratio. We employ nonideal magnetohydrodynamic simulations that include ambipolar diffusion and ohmic dissipation. During the early prestellar phase the mass-to-flux ratio rises toward the critical value for collapse, and during this time the angular momentum of the cloud core is reduced significantly by magnetic braking. Once a protostar is formed in the core, the accretion phase is characterized by the presence of a small amount of angular momentum but a large amount of magnetic flux in the near-protostellar environment. The low angular momentum leads to a very small (or even nonexistent) disk and weak outflow, while the large magnetic flux can lead to an interchange instability that rapidly removes flux from the central region. The effective magnetic braking in the early collapse phase can even lead to a counter-rotating disk and outflow, in which the rotation direction of the disk and outflow is opposite to that of the infalling envelope. The solutions with a counter-rotating disk, tiny disk, or nonexistent disk (direct collapse) are unique outcomes that are realized in collapse from magnetically-dominated clouds with an initial subcritical mass-to-flux ratio.

Accepted by MNRAS

https://arxiv.org/pdf/2003.03078

Distribution of Water Vapor in Molecular Clouds. II

Gary J. Melnick[1], Volker Tolls[1], Ronald L. Snell[2], Michael J. Kaufman[3], Edwin A. Bergin[4] et al.

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS 66, Cambridge, MA 02138, USA; [2] Dept of Astronomy, University of Massachusetts, Amherst, MA 01003, USA; [3] Dept of Physics and Astronomy, San José State University, San Jose, CA 95192, USA; [4] Dept of Astronomy, The University of Michigan, 500 Church Street, Ann Arbor, MI 48109, USA

E-mail contact: vtolls *at* cfa.harvard.edu

The depth-dependent abundance of both gas-phase and solid-state water within dense, quiescent, molecular clouds is important to both the cloud chemistry and gas cooling. Where water is in the gas phase, it's free to participate in the network of ion-neutral reactions that lead to a host of oxygen-bearing molecules, and its many ortho and para energy levels make it an effective coolant for gas temperatures greater than 20 K. Where water is abundant as ice on grain surfaces, and unavailable to cool the gas, significant amounts of oxygen are removed from the gas phase, suppressing the gas-phase chemical reactions that lead to a number of oxygen-bearing species, including O_2. Models of FUV-illuminated clouds predict that the gas-phase water abundance peaks in the range $A_V \sim 3$ and 8 mag of the cloud surface, depending on the gas density and FUV field strength. Deeper within such clouds, water is predicted to exist mainly as ice on grain surfaces. More broadly, these models are used to analyze a variety of other regions, including outflow cavities associated with young stellar objects and the surface layers of protoplanetary disks. In this paper, we report the results of observational tests of FUV-illuminated cloud models toward the Orion Molecular Ridge and Cepheus B using data obtained from the Herschel Space Observatory and the Five College Radio Astronomy Observatory. Toward Orion, 2220 spatial positions were observed along the face-on Orion Ridge in the H_2O 1_{10}–1_{01} 557 GHz and NH_3 $J, K = 1, 0$–$0, 0$ 572 GHz lines. Toward Cepheus B, two strip scans were made in the same lines across the edge-on ionization front. These new observations demonstrate that gas-phase water exists primarily within a few magnitudes of dense cloud surfaces, strengthening the conclusions of an earlier study based on a much smaller data set, and indirectly supports the prediction that water ice is quite abundant in dense clouds.

Accepted by ApJ

http://arxiv.org/pdf/2003.04897

A Random Forest Approach to Identifying Young Stellar Object Candidates in the Lupus Star-Forming Region

Elizabeth Melton[1]

[1] Pennsylvania State University, Davey Laboratory, University Park, PA

E-mail contact: efm5151 *at* psu.edu

The identification and characterization of stellar members within a star-forming region are critical to many aspects of star formation, including formalization of the initial mass function, circumstellar disk evolution and star-formation history. Previous surveys of the Lupus star-forming region have identified members through infrared excess and accretion signatures. We use machine learning to identify new candidate members of Lupus based on surveys from two space-based observatories: ESA's *Gaia* and NASA's *Spitzer*. Astrometric measurements from *Gaia*'s Data Release 2 and astrometric and photometric data from the Infrared Array Camera (IRAC) on the *Spitzer* Space Telescope, as well as from other surveys, are compiled into a catalog for the Random Forest (RF) classifier. The RF classifiers are tested to find the best features, membership list, non-membership identification scheme, imputation method, training set class weighting and method of dealing with class imbalance within the data. We list 27 candidate members of the Lupus star-forming region for spectroscopic follow-up. Most of the candidates lie in Clouds V and VI, where only one confirmed member of Lupus was previously known. These clouds likely represent a slightly older population of star-formation.

Accepted by The Astronomical Journal

https://arxiv.org/pdf/2003.10575

Strong surface outflows on accretion discs

C.J. Nixon[1] **and J.E. Pringle**[1,2]

[1] Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH, UK; [2] Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, UK

E-mail contact: cjn *at* leicester.ac.uk

In order to provide an explanation for the unexpected radial brightness distribution of the steady accretion discs seen in nova-like variables, Nixon & Pringle (2019) proposed that the accretion energy is redistributed outwards by means of strong, magnetically driven, surface flows. In this paper we note that the "powerful, rotating disc winds" observed in the soft states of black hole X-ray binaries, and also in the disc around a magnetized neutron star in Her X-1, have the properties of the outflows postulated by Nixon & Pringle to exist in the nova-like variable accretion discs around white dwarfs. The relevant properties are that the flows are not winds, but are, instead, bound flows (traveling at less than the escape velocity) and that the mass fluxes in the flows are a substantial fraction of the accretion rate in the disc.

Accepted by A&A

http://arxiv.org/pdf/2003.01726

Deciphering the 3-D Orion Nebula-I: Expanding Shells in the Huygens Region

C. R. O'Dell[1] and N. P. Abel[2]

[1] Vanderbilt University; [2] Clermont College, University of Cincinnati; [3] University of Kentucky

E-mail contact: N71932 *at* comcast.net

Based on imaging and spectroscopic data, we develop a 3-D model for the Huygens Region of the Orion Nebula. θ^1 Ori C, the hottest star in the Trapezium, is surrounded by a wind-blown Central Bubble that opens SW into the Extended Orion Nebula. Outside of this feature lies a layer of ionized gas at about 0.4 pc from θ^1 Ori C. Both of these features are moving rapidly away from θ^1 Ori C with an expansion age for the Central Bubble of only 15,000 yrs.

Accepted by Astrophysical Journal

http://arxiv.org/pdf/2003.01840

Census of young stellar population in the Galactic H II region Sh2-242

Alik Panja[1], Soumen Mondal[1], Somnath Dutta[2], Santosh Joshi[3], Sneh Lata[3] et al.

[1] S.N. Bose National Centre for Basic Sciences, Kolkata 700106, India; [2] Institute of Astronomy and Astrophysics, Academia Sinica, Taipei 10617, Taiwan; [3] Aryabhatta Research Institute of Observational Sciences, Nainital 263002, India

E-mail contact: alik.panja *at* gmail.com

We present here identification and characterization of the young stellar population associated with an active star-forming site Sh2-242. We used our own new optical imaging and spectroscopic observational data, as well as several archival catalogs, e.g., Pan-STARRS 1, Gaia DR2, IPHAS, WIRCam, 2MASS, and Spitzer. Slit spectroscopic results confirm the classification of the main ionizing source BD+26 980 as an early-type star of spectral type B0.5 V. The spectrophotometric distance of the star is estimated as 2.08 ± 0.24 kpc, which confirms the source as a member of the cluster. An extinction map covering a large area (diameter $\sim 50'$) is generated with H and K photometry toward the region. From the map, three distinct locations of peak extinction complexes ($A_V \approx 7$–17 mag) are identified for the very first time. Using the infrared color excess, a total of 33 Class I and 137 Class II young objects are classified within the region. The IPHAS photometry reveals classification of 36 Hα emitting sources, which might be class II objects. Among 36 Hα emitting sources, 5 are already identified using infrared excess emission. In total, 201 young objects are classified toward S242 from this study. The membership status of the young sources is further windowed with the inclusion of parallax from the Gaia DR2 catalog. Using the optical and infrared color-magnitude diagrams, the young stellar objects are characterized with an average age of $\sim$1 Myr and the masses in the range 0.1–3.0 $M_\odot$. The census of the stellar content within the region is discussed using combined photometric and spectroscopic data.

Accepted by AJ

http://arxiv.org/pdf/2003.09581

A Semi-Automated Computational Approach for Infrared Dark Cloud Localization: A Catalog of Infrared Dark Clouds

Jyothish Pari[1] and Joseph L. Hora[1]

[1] Center for Astrophysics | Harvard & Smithsonian, 60 Garden St, MS-65, Cambridge, MA 02138-1516 USA

E-mail contact: jhora *at* cfa.harvard.edu

The field of computer vision has greatly matured in the past decade, and many of the methods and techniques can be useful for astronomical applications. One example is in searching large imaging surveys for objects of interest, especially when it is difficult to specify the characteristics of the objects being searched for. We have developed a method using contour finding and convolution neural networks (CNNs) to search for Infrared Dark Clouds (IRDCs) in the *Spitzer* Galactic plane survey data. IRDCs can vary in size, shape, orientation, and optical depth, and are often located near regions with complex emission from molecular clouds and star formation, which can make the IRDCs difficult to reliably identify. False positives can occur in regions where emission is absent, rather than from a foreground IRDC. The contour finding algorithm we implemented found most closed figures in the mosaic and we

developed rules to filter out some of the false positive before allowing the CNNs to analyze them. The method was applied to the *Spitzer* data in the Galactic plane surveys, and we have constructed a catalog of IRDCs which includes additional parts of the Galactic plane that were not included in earlier surveys.

Accepted by PASP

https://arxiv.org/pdf/2003.01122

Molecular clumps disguising their star formation efficiency per freefall time: What we can do not to be fooled

Geneviêve Parmentier[1]

[1] Astronomisches Rechen-Institut, Zentrum für Astronomie Heidelberg, Germany

E-mail contact: gparm *at* ari.uni-heidelberg.de

The presence of a volume density gradient in molecular clumps allow them to raise their star formation rate compared to what they would experience were their gas uniform in density. This higher star formation rate yields in turn a higher value for the star formation efficiency per freefall time that we measure. The measured star formation efficiency per freefall time $\epsilon_{\rm ff,meas}$ of clumps is therefore plagued by a degeneracy, as two factors contribute to it: one is the density gradient of the clump gas, the other is the intrinsic star formation efficiency per freefall time $\epsilon_{\rm ff,int}$ with which the clump would form stars should there be no gas density gradient. This paper presents a method allowing one to recover the intrinsic efficiency of a centrally-concentrated clump. It hinges on the relation between the surface densities in stars and gas measured locally from clump center to clump edge. Knowledge of the initial density profile of the clump gas is not required. A step-by-step description of the method is provided as a tool in hand for observers. Once $\epsilon_{\rm ff,int}$ has been estimated, it can be compared with its measured, clump-averaged, counterpart $\epsilon_{\rm ff,meas}$ to quantify the impact that the initial gas density profile of a clump has had on its star formation history.

Accepted by ApJ

https://arxiv.org/pdf/2003.01613

Do fragmentation and accretion affect the stellar Initial Mass Function?

R. Riaz[1]**, D.R.G. Schleicher**[1]**, S. Vanaverbeke**[2]**, Ralf S. Klessen**[3,4]

[1] Departamento de Astronomía, Facultad Ciencias Físicas y Matemáticas, Universidad de Concepción, Av. Esteban Iturra s/n Barrio Universitario, Casilla 160-C, Concepción, Chile; [2] Centre for mathematical Plasma-Astrophysics, Department of Mathematics, KU Leuven, Celestijnenlaan 200B, 3001 Heverlee, Belgium; [3] Universität Heidelberg, Zentrum für Astronomie, Institut für Theoretische Astrophysik, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany; [4] Universität Heidelberg, Interdisziplinäres Zentrum für Wissenschaftliches Rechnen, Im Neuenheimer Feld 205, 69120 Heidelberg, Germany

E-mail contact: rriaz *at* astro-udec.cl

While the stellar Initial Mass Function (IMF) appears to be close to universal within the Milky Way galaxy, it is strongly suspected to be different in the primordial Universe, where molecular hydrogen cooling is less efficient and the gas temperature can be higher by a factor of 30. In between these extreme cases, the gas temperature varies depending on the environment, metallicity and radiation background. In this paper we explore if changes of the gas temperature affect the IMF of the stars considering fragmentation and accretion. The fragmentation behavior depends mostly on the Jeans mass at the turning point in the equation of state where a transition occurs from an approximately isothermal to an adiabatic regime due to dust opacities. The Jeans mass at this transition in the equation of state is always very similar, independent of the initial temperature, and therefore the initial mass of the fragments is very similar. Accretion on the other hand is strongly temperature dependent. We argue that the latter becomes the dominant process for star formation efficiencies above 5–7%, increasing the average mass of the stars.

Accepted by MNRAS

http://arxiv.org/pdf/2003.07639

Dust dynamics and vertical settling in gravitoturbulent protoplanetary discs

A. Riols[1], B. Roux[1], H. Latter[2], G. Lesur[1]

[1] Univ. Grenoble Alpes, CNRS, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), F-38000, Grenoble, France; [2] DAMTP, University of Cambridge, Centre for Mathematical Sciences, Wilberforce Road, Cambridge CB3 0WA, UK

E-mail contact: antoine.riols *at* univ-grenoble-alpes.fr

Gravitational instability (GI) controls the dynamics of young massive protoplanetary discs. Apart from facilitating gas accretion on to the central protostar, it must also impact on the process of planet formation: directly through fragmentation, and indirectly through the turbulent concentration of small solids. To understand the latter process, it is essential to determine the dust dynamics in such a turbulent flow. For that purpose, we conduct a series of 3D shearing box simulations of coupled gas and dust, including the gas's self-gravity and scanning a range of Stokes numbers, from 0.001 to ∼0.2. First, we show that the vertical settling of dust in the midplane is significantly impeded by gravitoturbulence, with the dust scale-height roughly 0.6 times the gas scale height for centimetre grains. This is a result of the strong vertical diffusion issuing from (a) small-scale inertial-wave turbulence feeding off the GI spiral waves and (b) the larger-scale vertical circulations that naturally accompany the spirals. Second, we show that at $R = 50$ AU concentration events involving sub-metre particles and yielding order 1 dust to gas ratios are rare and last for less than an orbit. Moreover, dust concentration is less efficient in 3D than in 2D simulations. We conclude that GI is not especially prone to the turbulent accumulation of dust grains. Finally, the large dust scale-height measured in simulations could be, in the future, compared with that of edge-on discs seen by ALMA, thus aiding detection and characterisation of GI in real systems.

Accepted by MNRAS

http://arxiv.org/pdf/2003.01167

Disk structure around the Class I protostar L1489 IRS revealed by ALMA: a warped disk system

Jinshi Sai[1,2,3], Nagayoshi Ohashi[2,3], Kazuya Saigo[4], Tomoaki Matsumoto[5], Yusuke Aso[3,6], Shigehisa Takakuwa[3,7], Yuri Aikawa[1], Ippei Kurose[1], Hsi-Wei Yen[3], Kohji Tomisaka[8], Kengo Tomida[9] and Masahiro N. Machida[10]

[1] Department of Astronomy, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan; [2] Subaru Telescope, National Astronomical Observatory of Japan, 650 North A'ohoku Place, Hilo, HI 96720, USA; [3] Academia Sinica Institute of Astronomy and Astrophysics, 11F of Astro-Math Bldg, 1, Sec 4., Roosevelt Rd, Taipei 10617, Taiwan; [4] Chile Observatory, National Astronomical Observatory of Japan, Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan; [5] Faculty of Humanity and Environment, Hosei University, Fujimi, Chiyoda-ku, Tokyo 102-8160, Japan; [6] Korea Astronomy and Space Science Institute (KASI), 776 Daedeokdae-ro, Yuseong-gu, Daejeon 34055, Republic of Korea; [7] Department of Physics and Astronomy, Graduate School of Science and Engineering, Kagoshima University, 1-21-35 Korimoto, Kagoshima, Kagoshima 890-0065, Japan; [8] National Astronomical Observatory of Japan, Osawa, 2-21-1, Mitaka, Tokyo 181-8588, Japan; [9] Department of Earth and Space Science, Osaka University, Toyonaka, Osaka 560-0043, Japan; [10] Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, Fukuoka, Fukuoka 819-0395, Japan

E-mail contact: jsai *at* asiaa.sinica.edu.tw

We have observed the Class I protostar L1489 IRS with the Atacama Millimeter/submillimeter Array (ALMA) in Band 6. The $C^{18}O$ J =2–1 line emission shows flattened and non-axisymmetric structures in the same direction as its velocity gradient due to rotation. We discovered that the $C^{18}O$ emission shows dips at a radius of ∼200–300 au while the 1.3 mm continuum emission extends smoothly up to $r \sim 400$ au. At the radius of the $C^{18}O$ dips, the rotational axis of the outer portion appears to be tilted by ∼15° from that of the inner component. Both the inner and outer components with respect to the $C^{18}O$ dips exhibit the $r^{-0.5}$ Keplerian rotation profiles until $r \sim 600$ au. These results not only indicate that a Keplerian disk extends up to ∼600 au but also that the disk is warped. We constructed a three dimensional warped disk model rotating at the Keplerian velocity, and demonstrated that the warped disk model reproduces main observed features in the velocity channel maps and the PV diagrams. Such a warped disk system can form by mass accretion from a misaligned envelope. We also discuss a possible disk evolution scenario based on

comparisons of disk radii and masses between Class I and Class II sources.

Accepted by ApJ

https://arxiv.org/pdf/2003.07067.pdf

Tidal and general relativistic effects in rocky planet formation at the substellar mass limit using N-body simulations

Mariana B. Sánchez[1,2], Gonzalo C. de Elía[1,2] and Juan J. Downes[3]

[1] Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque S/N (1900), La Plata, Argentina; [2] Instituto de Astrofísica de La Plata, CCT La Plata-CONICET-UNLP, Paseo del Bosque S/N (1900), La Plata, Argentina; [3] Centro Universitario Regional del Este, Universidad de la República, AP 264, Rocha 27000, Uruguay

E-mail contact: msanchez *at* fcaglp.unlp.edu.ar

Recent observational results show that very low mass stars and brown dwarfs are able to host close-in rocky planets. Low-mass stars are the most abundant stars in the Galaxy and the formation efficiency of their planetary systems is relevant in the computation of a global probability of finding Earth-like planets inside habitable zones. Tidal forces and relativistic effects are relevant in the latest dynamical evolution of planets around low-mass stars and their effect on the planetary formation efficiency still needs to be addressed. Our goal is to evaluate the impact of tidal forces and relativistic effects on the formation of rocky planets around a star close to the substellar mass limit, in terms of the resulting planetary architectures and its distribution according to the corresponding evolving habitable zone. Thus, we performed a set of N-body simulations spanning the first 100 Myr of the evolution of two systems composed respectively by 224 embryos with a total mass 0.25 $M_\oplus$ and 74 embryos with a total mass 3 $M_\oplus$ around a central object of 0.08 $M_\odot$. For these two scenarios, we compared the planetary architectures that result from simulations that are purely gravitational with those from simulations that include the early contraction and spin-up of the central object, the distortions and dissipation tidal terms and general relativistic effects. We found that including these effects allows the formation and survival of a close-in population located in the habitable zone of the system. This means that both effects are relevant during the formation of rocky planets and their early evolution around stars close to the substellar mass limit, in particular when low-mass planetary embryos are involved.

Accepted by Astronomy and Astrophysics

https://arxiv.org/pdf/2003.07509

On the structure and mass delivery towards circumplanetary discs

Matthäus Schulik[1], Anders Johansen[1], Bertram Bitsch[2], Elena Lega[3], Michiel Lambrechts[1]

[1] Lund Observatory, Box 43, Sölvegatan 27, SE-22100 Lund, Sweden; [2] Max-Planck Institut für Astronomie, Königsstuhl 17, 69117 Heidelberg, Germany; [3] Laboratoire Lagrange, UMR7293, Université de la Côte d'Azur, Boulevard de la Observatoire, 06304 Nice Cedex 4, France

E-mail contact: schulik *at* astro.lu.se

Circumplanetary discs (CPDs) form around young gas giants and are thought to be the sites of moon formation as well as an intermediate reservoir of gas that feeds the growth of the gas giant. How the physical properties of such CPDs are affected by the planetary mass and the overall opacity is relatively poorly understood. In order to clarify this, we use the global radiation hydrodynamics code FARGOCA, with a grid structure that allows resolving the planetary gravitational potential sufficiently well for a CPD to form. We then study the gas flows and density/temperature structures that emerge as a function of planet mass, opacity and potential depth. Our results indicate interesting structure formation for Jupiter-mass planets at low opacities, which we subsequently analyse in detail. Using an opacity level that is 100 times lower than that of ISM dust, our Jupiter-mass protoplanet features an envelope that is sufficiently cold for a CPD to form, and a free-fall region separating the CPD and the circumstellar disc emerges. Interestingly, this free-fall region appears to be a result of supersonic erosion of outer envelope material, as opposed to the static structure formation that one would expect at low opacities. Our analysis reveals that the planetary spiral arms seem to pose a significant pressure barrier that needs to be overcome through radiative cooling in order for gas to free-fall onto the CPD. The circulation inside the CPD is near-keplerian and modified by the presence of CPD spiral

arms. For high opacities we recover results from the literature, finding an essentially featureless hot envelope. With this work, we demonstrate the first simulation and analysis of a complete detachment process of a protoplanet from its parent disc in a 3D radiation hydrodynamics setting.

Accepted by A&A

http://arxiv.org/pdf/2003.13398

Effects of scattering, temperature gradients, and settling on the derived dust properties of observed protoplanetary disks

Anibal Sierra[1] & Susana Lizano[1]

[1] Instituto de Radioastronomía y Astrofísica, UNAM, Apartado Postal 3-72, 58089 Morelia Michoacán, México

E-mail contact: a.sierra *at* irya.unam.mx

It is known that the millimeter dust thermal emission of protoplanetary disks is affected by scattering, such that for optically thick disks the emission decreases with respect to the pure absorption case and the spectral indices can reach values below 2. The latter can also be obtained with temperature gradients. Using simple analytical models of radiative transfer in thin slabs, we quantify the effect of scattering, vertical temperature gradients, and dust settling on the emission and spectral indices of geometrically thin face-on accretion disks around young stars. We find that in vertically isothermal disks with large albedo ($\omega_\nu \gtrsim 0.6$), the emergent intensity can increase at optical depths between 10^{-2} and 10^{-1}. We show that dust settling has important effects on the spectral indices in the optically thick regime, since the disk emission mainly traces small dust grains in the upper layers of the disk. The λ=870 μm emission of these small grains can hide large grains at the disk mid plane when the dust surface density is larger than $\sim$3.21 g cm^{-2}. Finally, because of the change of the shape of the spectral energy distribution, optically thick disks at 1.3 mm and grains with sizes between 300 μm $< a_{\rm max} <$ 1 mm have a 7 mm flux $\sim$60% higher than the extrapolation from higher millimeter frequencies, assumed when scattering is neglected. This effect could provide an explanation to the excess emission at λ=7 mm reported in several disks.

Accepted by ApJ

http://arxiv.org/pdf/2003.02982

Chandra Resolves the Double FU Orionis System RNO 1B/1C in X-rays

Stephen L. Skinner[1] and Manuel Güdel[2]

[1] Center for Astrophysics and Space Astronomy (CASA), Univ. of Colorado, Boulder, CO, USA 80309-0389; [2] Dept. of Astrophysics, Univ. of Vienna, Türkenschanzstr. 17, A-1180 Vienna, Austria

E-mail contact: stephen.skinner *at* colorado.edu

We present new Chandra X-ray observations of the close pair of young stars RNO 1B and 1C (6″ separation) located in the L1287 cloud. RNO 1B erupted in 1978–1990 and is classified as an FU Orionis star (FUor). RNO 1C also shows most of the properties of an FUor but no eruption has yet been seen. Only a few dozen FUors are known and the presence of two such objects with a small angular separation is rare, suggesting a common origin. Both stars were faintly detected by Chandra and we summarize their X-ray properties within the framework of other previously detected FUors. We also report other X-ray detections in L1287 including the deeply-embedded young star RNO 1G, the jet-like radio source VLA 3, and an enigmatic hard flaring source with no 2MASS counterpart that was only detected in the second of two Chandra exposures.

Accepted by AJ

http://arxiv.org/pdf/2003.07944

Local Molecular Gas toward the Aquila Rift Region

Yang Su[1], Ji Yang[1,2], Qing-zeng Yan[1], Yan Gong[1,3], Zhiwei Chen[1] et al.

[1] Purple Mountain Observatory and Key Laboratory of Radio Astronomy, Chinese Academy of Sciences, Nanjing

210034, China; [2] School of Astronomy and Space Science, University of Science and Technology of China, 96 Jinzhai Road, Hefei 230026, China

E-mail contact: yangsu *at* pmo.ac.cn

We present the results of a ∼250 square degrees CO mapping ($+26° < l < +50°$ and $-5° < b < +5°$) toward the Aquila Rift region at a spatial resolution of ∼50″ and a grid spacing of 30″. The high dynamic range CO maps with a spectral resolution of ∼0.2 km s^{-1} display highly structured molecular cloud (MC) morphologies with valuable velocity information, revealing complex spatial and dynamical features of the local molecular gas. In combination with the MWISP CO data and the Gaia DR2, distances of the main MC structures in the local ISM are well determined toward the Aquila Rift. We find that the total MC mass within 1 kpc is about $>4.1 \times 10^5\ M_\odot$ in the whole region. In fact, the mass of the molecular gas is dominated by the W40 giant molecular cloud (GMC) at ∼474 pc ($\sim 1.4 \times 10^5\ M_\odot$) and the GMC complex G036.0+01.0 at ∼560–670 pc ($\sim 2.0 \times 10^5\ M_\odot$), while the MCs at ∼220–260pc have gas mass of 10^2–$10^3\ M_\odot$. Interestingly, a ∼80 pc long filamentary MC G044.0−02.5 at a distance of ∼404 pc shows a systematic velocity gradient along and perpendicular to the major axis of the filament. The HI gas with the enhanced emission has the similar spatial morphologies and velocity features compared to the corresponding CO structure, indicating that the large-scale converging HI flows is probably responsible for the formation of the MC. Meanwhile, the long filamentary MC consists of many sub-filaments with the lengths ranging from ∼0.5 pc to several pc, as well as prevalent networks of filaments in other large-scale local MCs.

Accepted by ApJ

http://arxiv.org/pdf/2003.08587

Molecule formation in dust-poor irradiated jets I. Stationary disk winds

B. Tabone[1,2], B. Godard[2,3], G. Pineau des Forêts[2,4], S. Cabrit[4] and E. F. van Dishoeck[1,5]

[1] Leiden Observatory, Leiden University, PO Box 9513, 2300 RA Leiden, The Netherlands; [2] LERMA, Observatoire de Paris, PSL Research Univ., CNRS, Sorbonne Univ., 75014 Paris, France; [3] Laboratoire de Physique de l'École normale supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université Paris-Diderot, Sorbonne Paris Cité, 75005 Paris, France; [4] Université Paris-Saclay, CNRS, Institut d'Astrophysique Spatiale, 91405, Orsay, France; [5] Max-Planck-Institut für Extraterrestrische Physik, Giessenbachstrasse1, 85748 Garching, Germany

E-mail contact: tabone *at* strw.leidenuniv.nl

Context. Recent ALMA observations suggest that the highest velocity part of molecular protostellar jets are launched from the dust-sublimation regions of the accretion disks (< 0.3 au). However, formation and survival of molecules in inner protostellar disk winds, in the presence of a harsh FUV radiation field and the absence of dust, remain unexplored.
Aims. We aim at determining if simple molecules can be synthesized and spared in fast and collimated dust-free disk winds or if a fraction of dust is necessary to explain the observed molecular abundances.
Methods. This work is based on the Paris-Durham shock code designed to model irradiated environments. Fundamental properties of the dust-free chemistry are investigated from single point models. A laminar 1D disk wind model is then built using a parametric flow geometry. This model includes time-dependent chemistry and the attenuation of the radiation field by gas-phase photoprocesses.
Results. We show that a small fraction of H_2 ($\lesssim 10^{-2}$), primarily formed through the H^- route, can efficiently initiate molecule synthesis such as CO and SiO above $T_K \sim 800$ K. The attenuation of the radiation field by atomic species (eg. C, Si, S) proceeds through continuum self-shielding. This process ensures efficient formation of CO, OH, SiO, H_2O through neutral-neutral reactions, and the survival of these molecules. Class 0 dust-free winds with high mass-loss rates ($\dot{M}_w \geq 2 \times 10^{-6}$ Msun/yr) are predicted to be rich in molecules if warm ($T_K \geq 800$ K). The molecular content of disk winds is very sensitive to the presence of dust and a mass-fraction of surviving dust as small as 10^{-5} significantly increases the H_2O and SiO abundances.
Conclusions. Chemistry of high-velocity jets is a powerful tool to probe their content in dust and uncover their launching point. Models of internal shocks are required to fully exploit the current (sub-)millimeter observations and prepare future JWST observations.

Accepted by A&A

https://arxiv.org/pdf/2003.01845

Collision between Molecular Clouds I. The effect of the cloud virial ratio in head-on collisions

Tabassum S Tanvir[1,2], **James E Dale**[2]

[1] Research School of Astronomy and Astrophysics, The Australian National University, Cotter Rd, Weston Creek , ACT 2611, Australia; [2] Centre for Astrophysics Research, University of Hertfordshire, College Lane, AL10 9AB, Hatfield, UK

E-mail contact: tabassum.tanvir *at* anu.edu.au

In a series of papers we investigate the effect of collisions between turbulent molecular clouds on their structure, evolution and star formation activity. In this paper we look into the role of the clouds' initial virial ratios. Three different scenarios were examined: both clouds initially bound, one cloud bound and one unbound, and both clouds initially unbound. Models in which one or both clouds are bound generate filamentary structures aligned along the collision axis and discernible in position-position and position–velocity space. If neither cloud is bound, no filaments result. Unlike in previous simulations of collisions between smooth clouds, owing to the substructure created in the clouds by turbulence before the collisions, dissipation of kinetic energy by the collision is very inefficient and in none of our simulations is sufficient bulk kinetic energy lost to render the clouds bound. Simulations where both clouds are bound created twice as much stellar mass than the bound-unbound model, and both these scenarios produced much more stellar mass than the simulation in which both clouds are unbound. Each simulation was also compared with a control run in which the clouds do not collide. We find the bound-bound collision increases the overall star formation efficiency by a factor of approximately two relative to the control, but that the bound-unbound collision produces a much smaller increase, and the collision has very little effect on the unbound–unbound cloud collision.

Accepted by MNRAS

http://arxiv.org/pdf/2003.05010

Physical Conditions and Kinematics of the Filamentary Structure in Orion Molecular Cloud 1

Yu-Hsuan Teng[1,2,3] **and Naomi Hirano**[1]

[1] Institute of Astronomy and Astrophysics, Academia Sinica, 11F of Astronomy-Mathematics Building, National Taiwan University, No.1, Sec.4, Roosevelt Rd., Taipei 10617, Taiwan; [2] Department of Physics, National Taiwan University, No.1, Sec.4, Roosevelt Rd., Taipei 10617, Taiwan; [3] Center for Astrophysics and Space Sciences, Department of Physics, University of California San Diego, 9500 Gilman Drive, La Jolla, CA 92093, USA

E-mail contact: yuteng *at* ucsd.edu

We have studied the structure and kinematics of the dense molecular gas in the Orion Molecular Cloud 1 (OMC1) region with the N_2H^+ 3–2 line. The $6' \times 9'$ ($\sim 0.7 \times 1.1$ pc) region surrounding the Orion KL core has been mapped with the Submillimeter Array (SMA) and the Submillimeter Telescope (SMT). The combined SMA and SMT image having a resolution of $\sim 5.4'$ (~ 2300 au) reveals multiple filaments with a typical width of 0.02–0.03 pc. On the basis of the non-LTE analysis using the N_2H^+ 3–2 and 1–0 data, the density and temperature of the filaments are estimated to be $\sim 10^7$ cm^{-3} and $\sim$ 15–20 K, respectively. The core fragmentation is observed in three massive filaments, one of which shows the oscillations in the velocity and intensity that could be the signature of core-forming gas motions. The gas kinetic temperature is significantly enhanced in the eastern part of OMC1, likely due to the external heating from the high mass stars in M42 and M43. In addition, the filaments are colder than their surrounding regions, suggesting the shielding from the external heating due to the dense gas in the filaments. The OMC1 region consists of three sub-regions, i.e. north, west, and south of Orion KL, having different radial velocities with sharp velocity transitions. There is a north-to-south velocity gradient from the western to the southern regions. The observed velocity pattern suggests that dense gas in OMC1 is collapsing globally toward the high-mass star-forming region, Orion Nebula Cluster.

Accepted by ApJ

https://arxiv.org/pdf/2003.02459.pdf

Scattering-induced intensity reduction: large mass content with small grains in the inner region of the TW Hya disk

Takahiro Ueda[1], Akimasa Kataoka[1] and Takashi Tsukagoshi[1]

[1] National Astronomical Observatory of Japan, Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan

E-mail contact: takahiro.ueda *at* nao.ac.jp

Dust continuum observation is one of the best methods to constrain the properties of protoplanetary disks. Recent theoretical studies have suggested that the dust scattering at the millimeter wavelength potentially reduces the observed intensity, which results in an underestimate in the dust mass. We investigate whether the dust scattering indeed reduces the observed continuum intensity by comparing the ALMA archival data of the TW Hya disk at Band 3, 4, 6, 7 and 9 to models obtained by radiative transfer simulations. We find that the model with scattering by 300 μm-sized grains well reproduces the observed SED of the central part of the TW Hya disk while the model without scattering is also consistent within the errors of the absolute fluxes. To explain the intensity at Band 3, the dust surface density needs to be $\sim$10 g cm^{-2} at 10 au in the model with scattering, which is 26 times more massive than previously predicted. The model without scattering needs 2.3 times higher dust mass than the model with scattering because it needs lower temperature. At Band 7, scattering reduces the intensity by $\sim$35% which makes the disk looks optically thin even though it is optically thick. Our study suggests the TW Hya disk is still capable of forming cores of giant planets at where the current solar system planets exist.

Accepted by ApJ

http://arxiv.org/pdf/2003.09353

ALMA 0.88 mm Survey of Disks around Planetary-mass Companions

Ya-Lin Wu[1], Brendan P. Bowler[1], Patrick D. Sheehan[2], Sean M. Andrews[3], Gregory J. Herczeg[4] et al.

[1] McDonald Observatory and the Department of Astronomy, University of Texas at Austin, Austin, TX 78712, USA; [2] Center for Interdisciplinary Exploration and Research in Astrophysics and Department of Physics and Astronomy, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208-3112, USA; [3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA; [4] Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing 100871, People's Republic of China

E-mail contact: yalinwu *at* utexas.edu

Characterizing the physical properties and compositions of circumplanetary disks can provide important insights into the formation of giant planets and satellites. We report ALMA 0.88 mm (Band 7) continuum observations of six planetary-mass (10–20 $M_{\rm Jup}$) companions: CT Cha b, 1RXS 1609 b, ROXs 12 b, ROXs 42B b, DH Tau b, and FU Tau b. No continuum sources are detected at the locations of the companions down to 3σ limits of 120–210 μJy. Given these non-detections, it is not clear whether disks around planetary-mass companions indeed follow the disk flux-host mass trend in the stellar regime. The faint radio brightness of these companion disks may result from a combination of fast radial drift and a lack of dust traps. Alternatively, as disks in binary systems are known to have significantly lower millimeter fluxes due to tidal interactions, these companion disks may instead follow the relationship of moderate-separation binary stars. This scenario can be tested with sensitive continuum imaging at rms levels of $\lesssim$1 μJy.

Accepted by AJ

http://arxiv.org/pdf/2003.08658

Application of Convolutional Neural Networks to Identify Stellar Feedback Bubbles in CO Emission

Duo Xu[1], Stella S. R. Offner[1], Robert Gutermuth[2] and Colin Van Oort[3]

[1] Department of Astronomy, The University of Texas at Austin, Austin, TX 78712, USA;; [2] Department of Astronomy, University of Massachusetts, Amherst, MA 01003, USA; [3] University of Vermont, Burlington, VT 05405, USA

E-mail contact: xuduo117 *at* utexas.edu

We adopt a deep learning method CASI (Convolutional Approach to Shell Identification) and extend it to 3D (CASI-3D) to identify signatures of stellar feedback in molecular line spectra, such as ^{13}CO. We adopt magneto-hydrodynamics simulations that study the impact of stellar winds in a turbulent molecular cloud as an input to generate synthetic observations. We apply the 3D radiation transfer code RADMC-3D to model ^{13}CO (J=1-0) line emission from the simulated clouds. We train two CASI-3D models: ME1 is trained to predict only the position of feedback, while MF is trained to predict the fraction of the mass coming from feedback in each voxel. We adopt 75% of the synthetic observations as the training set and assess the accuracy of the two models with the remaining data. We demonstrate that model ME1 identifies bubbles in simulated data with 95% accuracy, and model MF predicts the bubble mass within 4% of the true value. We test the two models on bubbles that were previously visually identified in Taurus in ^{13}CO. We show our models perform well on the highest confidence bubbles that have a clear ring morphology and contain one or more sources. We apply our two models on the full 98 deg^2 FCRAO ^{13}CO survey of the Taurus cloud. Models ME1 and MF predict feedback gas mass of 2894 $M_{\odot}$ and 302 $M_{\odot}$, respectively. When including a correction factor for missing energy due to the limited velocity range of the ^{13}CO data cube, model ME1 predicts feedback kinetic energies of 4.0×10^{46} ergs and 1.5×10^{47} ergs with/without subtracting the cloud velocity gradient. Model MF predicts feedback kinetic energy of 9.6×10^{45} ergs and 2.8×10^{46} ergs with/without subtracting the cloud velocity gradient. Model ME1 predicts bubble locations and properties consistent with previous visually identified bubbles. However, model MF demonstrates that feedback properties computed based on visual identifications are significantly over-estimated due to line of sight confusion and contamination from background and foreground gas.

Accepted by ApJ

https://arxiv.org/pdf/2001.04506

First embedded cluster formation in California molecular cloud

Jin-Long Xu[1,2], Ye Xu[3], Peng Jiang[1,2], Ming Zhu[1,2], Xin Guan[1] et al.

[1] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China; [2] CAS Key Laboratory of FAST, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China; [3] Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210008, China

E-mail contact: xujl *at* bao.ac.cn

We performed a multi-wavelength observation toward LkHα 101 embedded cluster and its adjacent $85' \times 60'$ region. The LkHα 101 embedded cluster is the first and only one significant cluster in California molecular cloud (CMC). These observations have revealed that the LkHα 101 embedded cluster is just located at the projected intersectional region of two filaments. One filament is the highest-density section of the CMC, the other is a new identified filament with a low-density gas emission. Toward the projected intersection, we find the bridging features connecting the two filaments in velocity, and identify a V-shape gas structure. These agree with the scenario that the two filaments are colliding with each other. Using the Five-hundred-meter Aperture Spherical radio Telescope (FAST), we measured that the RRL velocity of the LkHα 101 H II region is 0.5 km s^{-1}, which is related to the velocity component of the CMC filament. Moreover, there are some YSOs distributed outside the intersectional region. We suggest that the cloud-cloud collision together with the fragmentation of the main filament may play an important role in the YSOs formation of the cluster.

Accepted by ApJL

http://arxiv.org/pdf/2003.09811

In Search for Infall Motion in molecular clumps II: HCO+ (1-0) and HCN (1-0) Observations toward a Sub-sample of Infall Candidates

Yang Yang[1,2], Zhibo Jiang[1,2,3], Zhiwei Chen[1], Shaobo Zhang[1], Shuling Yu[1,2] and Yiping Ao[1]

[1] Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing, Jiangsu 210008, People's Republic of China; [2] University of Science and Technology of China, Chinese Academy of Sciences, Hefei, Anhui 230026, People's Republic of China; [3] China Three Gorges University, Yichang, Hubei 443002, People's Republic of China

E-mail contact: zbjiang *at* pmo.ac.cn

Gravitational accretion accumulates the original mass, and this process is crucial for us to understand the initial phases of star formation. Using the specific infall profiles in optically thick and thin lines, we searched the clumps with infall motion from the Milky Way Imaging Scroll Painting (MWISP) CO data in previous work. In this study, we selected 133 sources of them as a sub-sample for further research and identification. The excitation temperatures of these sources are between 7.0 and 38.5 K, while the H_2 column densities are between 10^{21} and 10^{23} cm^{-2}. We have observed optically thick lines HCO^+ (1-0) and HCN (1-0) using the DLH 13.7-m telescope, and found 56 sources of them with blue profile and no red profile in these two lines, which are likely to have infall motions, with the detection rate of 42%. It suggests that using CO data to restrict sample can effectively improve the infall detection rate. Among these confirmed infall sources, there are 43 associated with Class 0/I young stellar objects (YSOs), and 13 are not. These 13 sources are probably associated with the sources in earlier evolutionary stage. By comparison, the confirmed sources which are associated with Class 0/I YSOs have higher excitation temperatures and column densities, while the other sources are colder and have lower column densities. Most infall velocities of the sources we confirmed are between 10^{-1} to 10^{0} km s^{-1}, which is consistent with previous studies.

Accepted by Research in Astronomy and Astrophysics

http://arxiv.org/pdf/2003.07136

Transition from ordered pinched to warped magnetic field on a 100 au scale in the Class 0 protostar B335

Hsi-Wei Yen[1], Bo Zhao[2], Patrick Koch[1], Ruben Krasnopolsky[1], Zhi-Yun Li[3], Nagayoshi Ohashi[1], Hsien Shang[1], Shigehisa Takakuwa[4,1] and Ya-Wen Tang[1]

[1] Academia Sinica Institute of Astronomy and Astrophysics, 11F of Astro-Math Bldg, 1, Sec. 4, Roosevelt Rd, Taipei 10617, Taiwan; [2] Max-Planck-Institut für extraterrestrische Physik (MPE), Garching, Germany, 85748; [3] Astronomy Department, University of Virginia, Charlottesville, VA 22904, USA; [4] Department of Physics and Astronomy, Graduate School of Science and Engineering, Kagoshima University, 1-21-35 Korimoto, Kagoshima, Kagoshima 890-0065, Japan

E-mail contact: hwyen *at* asiaa.sinica.edu.tw

We present our observational results of the 0.87 mm polarized dust emission in the Class 0 protostar B335 obtained with the Atacama Large Millimeter/submillimeter Array (ALMA) at a $0\farcs2$ (20 au) resolution. We compared our data at 0.87 mm with those at 1.3 mm from the ALMA archive. The observed polarization orientations at the two wavelengths are consistent within the uncertainty, and the polarization percentages are systematically higher at 1.3 mm than 0.87 mm by a factor of ∼1.7, suggesting that the polarized emission originates from magnetically aligned dust grains. We inferred the magnetic field orientations from the observed polarization orientations. We found that the magnetic field changes from ordered and highly pinched to more complicated and asymmetric structures within the inner 100 au scale of B335, and the magnetic field connects to the center along the equatorial plane as well as along the directions which are ∼40°–60° from the equatorial plane. We performed non-ideal MHD simulations of collapsing dense cores. We found that similar magnetic field structures appear in our simulations of dense cores with the magnetic field and rotational axis slightly misaligned by 15° but not in those with the aligned magnetic field and rotational axis. Our results suggest that the midplane of the inner envelope within the inner 100 au scale of B335 could be warped because of the misaligned magnetic field and rotational axis, and the magnetic field could be dragged by the warped accretion flows.

Accepted by ApJ

https://arxiv.org/pdf/2003.04502.pdf

HII regions and high-mass starless clump candidates I: Catalogs and properties

S. Zhang[1], A. Zavagno[1,2], J. Yuan[3], H. Liu[4,5], M. Figueira[6] et al.

[1] Aix Marseille Univ, CNRS, CNES, LAM, Marseille, France; [2] Institut Universitaire de France (IUF); [3] National Astronomical Observatories, Chinese Academy of Sciences, 20A Datun Road, Chaoyang District, Beijing 100012, China; [4] CASSACA, China-Chile Joint Center for Astronomy, Camino El Observatorio #1515, Las Condes, Santiago, Chile; [5] Departamento de Astronomía, Universidad de Concepción, Av. Esteban Iturra s/n, Distrito Universitario, 160-C, Chile; [6] National Centre for Nuclear Research, ul. Pasteura 7, 02-093, Warszawa

E-mail contact: siju.zhang *at* lam.fr

The role of ionization feedback on high-mass (>8 $M_\odot$) star formation (HMSF) is still highly debated. Questions remain concerning the presence of nearby HII regions changes the properties of early HMSF and whether HII regions promote or inhibit the formation of high-mass stars. To characterize the role of HII regions on the HMSF, we study the properties of a sample of candidates high-mass starless clumps (HMSCs), of which about 90% have masses larger than 100 $M_\odot$. These high-mass objects probably represent the earliest stages of HMSF; we search if (and how) their properties are modified by the presence of an HII region. We took advantage of the recently published catalog of HMSC candidates. By cross matching the HMSCs and HII regions, we classified HMSCs into three categories: 1) The HMSCs associated with HII regions both in the position in the projected plane of the sky and in velocity; 2) HMSCs associated in the plane of the sky, but not in velocity; and 3) HMSCs far away from any HII regions in the projected sky plane. We carried out comparisons between associated and nonassociated HMSCs based on statistical analyses of multiwavelength data from infrared to radio. Statistical analyses suggest that HMSCs associated with HII regions are warmer, more luminous, more centrally-peaked and turbulent. We also clearly show, for the first time, that the ratio of bolometric luminosity to envelope mass of HMSCs (L/M) could not be a reliable evolutionary probe for early HMSF due to the external heating effects of the HII regions. More centrally peaked and turbulent properties of HMSCs associated with HII regions may promote the formation of high-mass stars by limiting fragmentation. High resolution interferometric surveys toward HMSCs are crucial to reveal how HII regions impact the star formation process inside HMSCs.

Accepted by A&A

http://arxiv.org/pdf/2003.11433

Global 3-D Radiation Magnetohydrodynamic Simulations for FU Ori's Accretion Disk and Observational Signatures of Magnetic Fields

Zhaohuan Zhu[1], Yan-Fei Jiang[2] and James M. Stone[3]

[1] Department of Physics and Astronomy, University of Nevada, Las Vegas, 4505 S. Maryland Parkway, Las Vegas, NV 89154, USA; [2] Center for Computational Astrophysics, Flatiron Institute, New York, NY 10010, USA; [3] nstitute for Advance Study, 1 Einstein Drive, Princeton, NJ, 08540, USA

E-mail contact: zhaohuan.zhu *at* unlv.edu

22 pages, 20 figures

FU Ori is the prototype of FU Orionis systems which are outbursting protoplanetary disks. Magnetic fields in FU Ori's accretion disks have previously been detected using spectropolarimetry observations for Zeeman effects. We carry out global radiation ideal MHD simulations to study FU Ori's inner accretion disk. We find that (1) when the disk is threaded by vertical magnetic fields, most accretion occurs in the magnetically dominated atmosphere at z$\sim$R, similar to the "surface accretion" mechanism in previous locally-isothermal MHD simulations. (2) A moderate disk wind is launched in the vertical field simulations with a terminal speed of $\sim$300-500 km/s and a mass loss rate of 1-10% the disk accretion rate, which is consistent with observations. Disk wind fails to be launched in simulations with net toroidal magnetic fields. (3) The disk photosphere at the unit optical depth can be either in the wind launching region or the accreting surface region. Magnetic fields have drastically different directions and magnitudes between these two regions. Our fiducial model agrees with previous optical Zeeman observations regarding both the field directions and magnitudes. On the other hand, simulations indicate that future Zeeman observations at near-IR wavelengths or towards other FU Orionis systems may reveal very different magnetic field structures. (4) Due to energy loss by the disk wind, the disk photosphere temperature is lower than that predicted by the thin disk theory, and the previously inferred disk accretion rate may be lower than the real accretion rate by a factor of $\sim$2-3.

Accepted by MNRAS

https://arxiv.org/pdf/1912.01632

The resonant drag instability of dust streaming in turbulent protoplanetary disc

V.V. Zhuravlev[1]

[1] Sternberg Astronomical Institute, Lomonosov Moscow State University, Universitetskij pr., 13, Moscow 119234,

Russia

E-mail contact: zhuravlev *at* sai.msu.ru

Damping of the previously discovered resonant drag instability (RDI) of dust streaming in protoplanetary disc is studied using the local approach to dynamics of gas-dust perturbations in the limit of the small dust fraction. Turbulence in a disc is represented by the effective viscosity and diffusivity in equations of motion for gas and dust, respectively. In the standard case of the Schmidt number (ratio of the effective viscosity to diffusivity) $Sc = 1$, the reduced description of RDI in terms of the inertial wave (IW) and the streaming dust wave (SDW) falling in resonance with each other reveals that damping solution differs from the inviscid solution simply by adding the characteristic damping frequency to its growth rate. RDI is fully suppressed at the threshold viscosity, which is estimated analytically, first, for radial drift, next, for vertical settling of dust, and at last, in the case of settling combined with radial drift of the dust. In the last case, RDI survives up to the highest threshold viscosity, with a greater excess for smaller solids. Once $Sc \neq 1$, a new instability specific for dissipative perturbations on the dust settling background emerges. This instability of the quasi-resonant nature is referred to as settling viscous instability (SVI). The mode akin to SDW (IW) becomes growing in a region of long waves provided that $Sc > 1$ ($Sc < 1$). SVI leads to an additional increase of the threshold viscosity.

Accepted by MNRAS

http://arxiv.org/pdf/2003.09212

Importance of radiative effects in gap opening by planets in protoplanetary disks

Alexandros Ziampras[1], Wilhelm Kley[1], and Cornelis P. Dullemond[2]

[1] Institut für Astronomie und Astrophysik, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany;
[2] Institute for Theoretical Astrophysics, Heidelberg University, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

E-mail contact: alexandros.ziampras *at* uni-tuebingen.de

Recent ALMA observations revealed concentric annular structures in several young class-II objects. In an attempt to produce the rings and gaps in some of these systems, they have been modeled numerically with a single embedded planet assuming a locally isothermal equation of state. This is often justified by observations targeting the irradiation-dominated outer regions of disks (approximately 100 au). We test this assumption by conducting hydrodynamics simulations of embedded planets in thin locally isothermal and radiative disks that mimic the systems HD 163296 and AS 209 in order to examine the effect of including the energy equation in a seemingly locally isothermal environment as far as planet-disk interaction is concerned. We find that modeling such disks with an ideal equation of state makes a difference in terms of the number of produced rings and the spiral arm contrast in the disk. Locally isothermal disks produce sharper annular or azimuthal features and overestimate a single planet's gap-opening capabilities by producing multiple gaps. In contrast, planets in radiative disks carve a single gap for typical disk parameters. Consequently, for accurate modeling of planets with semimajor axes up to about 100 au, radiative effects should be taken into account even in seemingly locally isothermal disks. In addition, for the case of AS 209, we find that the primary gap is significantly different between locally isothermal and radiative models. Our results suggest that multiple planets are required to explain the ring-rich structures in such systems.

Accepted by A&A

http://arxiv.org/pdf/2003.02298

Abstracts of recently accepted major reviews

High-energy particles and radiation in star-forming regions

Andrei M. Bykov[1], Alexandre Marcowith[2], Elena Amato[3], Maria E. Kalyashova[1], J.M. Diederik Kruijssen[4], Eli Waxman[5]

[1] Ioffe Institute, 194021, St. Petersburg, Russia; [2] Laboratoire Univers et Particules de Montpellier CNRS/Université de Montpellier, Place E. Bataillon, 34095 Montpellier, France; [3] INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi, 5, 50125, Firenze, Italy; [4] Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Mönchhofstr. 12-14, 69120 Heidelberg, Germany; [5] Weizmann Institute of Science, 76100, Rehovot, Israel

E-mail contact: byk *at* astro.ioffe.ru

Non-thermal particles and high-energy radiation can play a role in the dynamical processes in star-forming regions and provide an important piece of the multiwavelength observational picture of their structure and components. Powerful stellar winds and supernovae in compact clusters of massive stars and OB associations are known to be favourable sites of high-energy particle acceleration and sources of non-thermal radiation and neutrinos. Namely, young massive stellar clusters are likely sources of the PeV (petaelectronvolt) regime cosmic rays (CRs). They can also be responsible for the cosmic ray composition, e.g., ^{22}Ne/^{20}Ne anomalous isotopic ratio in CRs. Efficient particle acceleration can be accompanied by super-adiabatic amplification of the fluctuating magnetic fields in the systems converting a part of kinetic power of the winds and supernovae into the magnetic energy through the CR-driven instabilities. The escape and CR propagation in the vicinity of the sources are affected by the non-linear CR feedback. These effects are expected to be important in starburst galaxies, which produce high-energy neutrinos and gamma-rays. We give a brief review of the theoretical models and observational data on high-energy particle acceleration and their radiation in star-forming regions with young stellar population.

Accepted by Space Science Reviews

http://arxiv.org/pdf/2003.11534

Accretion versus outflow regions around Young Stellar Objects

Raquel de Albuquerque

Departamento de Física e Astronomia, Faculdade de Ciências da Universidade do Porto, Portugal
Instituto de Astrofísica e Ciências do Espaco, CAUP, Portugal
Laboratoire Univers et Théories, Observatoire de Paris, France

Instituto de Astrofísica e Ciências do Espaco, CAUP, Rua das Estrelas, PT4150-762 Porto, Portugal

Electronic mail: Raquel.Albuquerque *at* astro.up.pt

Ph.D dissertation directed by: João J. G. Lima, Jorge F. Gameiro and Christophe Sauty

Ph.D degree awarded: February 2020

The interplay between accretion and outflow processes in young stellar objects (YSOs) constitutes one of the big challenges in the field of star formation. We can better understand their evolution not only by a proper derivation and analysis of stellar and activity parameters through spectra, but also by modelling and simulating accretion and outflow mechanisms. In order to take a step further towards a better understanding of these phenomena, we started by carrying out a detailed study of the spectra of some YSOs and explored different tools that can be used to better understand these stars. We then proceeded to perform detailed simulations of the environment around such a YSO, where both accretion and outflows are at play, using existing numerical tools and self-similar semi-analytical magnetohydrodynamic solutions as initial conditions. Thus, to accomplish the goals of this project, we first test available software for main-sequence stars that has the potential to characterize pre-main sequence stars through their main stellar parameters. Second, we characterize a sample of YSOs using ultraviolet to near-infrared spectra plus available photometry. Third, we explore a long-term monitoring of two variable classical T Tauri stars, through both spectroscopy and photometry, in order to characterize their circumstellar environment. Fourth, we actually simulate the circumstellar environment of one of these objects and evaluate if it is compatible with what is observationally expected. Our simulations are able to reproduce the general behaviour expected for the environment around such a YSO. Also, we can derive from those simulations mass accretion and mass loss rates that agree well with the ones we could obtain from the corresponding spectra and with those available in the literature. Furthermore, we have simulations that could not only represent the bimodal behaviour of RY Tau, characterized by active and quiescent periods, but also the ceasing of accretion activity in YSOs. The work presented in this thesis, shows how the synergy between an observational and a numerical approach can improve our knowledge towards the study of low-mass YSOs.

https://hdl.handle.net/10216/126546

Pre-main-sequence populations and young stellar variability in the Large Magellanic Cloud

Viktor Zivkov

Keele University, UK; European Southern Observatory, Germany

Lennard-Jones Laboratories, School of Chemical and Physical Sciences, Keele University, ST5 5BG, UK

Electronic mail: v.zivkov *at* keele.ac.uk

Ph.D dissertation directed by: Joana M. Oliveira and Monika G. Petr-Gotzens

Ph.D degree awarded: March 2020

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. This work presents a comprehensive analysis of the PMS population in a $\sim 1.5\,\mathrm{deg}^2$ area located in the gas-rich Large Magellanic Cloud (LMC). The identification and classification of the populations was achieved by statistical analysis of the $K_s/(Y-K_s)$ colour−magnitude distribution of stars using a PSF photometric source catalogue of the VISTA Survey of the Magellanic Clouds (VMC). The analysis reveals ~ 2260 PMS candidates with ages $\lesssim$10 Myr and masses $\lesssim 4\,\mathrm{M}_\odot$. The young populations exhibit non-uniform spatial distributions and appear to be hierarchically organized with large structures containing smaller and denser substructures. Regions containing only intermediate/low-mass PMS stars are more scattered and usually located in the outskirts of star forming complexes. The young populations are clustered along ridges and filaments where dust emission in the far-infrared (FIR) ($70\,\mu$m – $500\,\mu$m) is bright. At $70\,\mu$m and $100\,\mu$m we report a strong dust emission increase in regions hosting young massive stars, which is less pronounced in regions populated only by less massive ($\lesssim 4\,\mathrm{M}_\odot$) PMS stars.

In addition, this thesis presents the first systematic variability study of massive young stellar objects (YSOs) in the LMC. By using a χ^2-analysis on multi-epoch observations obtained by the VMC and my open time programme, stellar variability is identified. 173 high-reliability YSO candidates are selected based on several *Spitzer* studies, out of which 39 displayed variability. They have been classified into eruptive, fader, dipper, short-term variable and long period variable-YSO based on the appearance of their K_s-band lightcurves. The majority of YSO variables are aperiodic; for five YSOs the lightcurves indicate a possible periodicity, identified using a Lomb-Scargle periodogram analysis. The lightcurve shapes and colour shifts can be mostly associated with unsteady accretion or (grey) extinction. Overall, the observed amplitudes are moderate with only two YSOs exhibiting a $\Delta K_\mathrm{s} > 1$ mag. Eruptive variables tend to have the largest amplitudes amongst all classes. Compared with similar Galactic studies the amplitudes tend to be smaller, which could be attributed to smaller extinction variations due to the larger gas-to-dust ratio of the LMC.

New Jobs

Postdoctoral Position in Star Formation & Observational Astrophysics

Center for Astrophysics and Space Astronomy (CASA)
Astrophysical and Planetary Sciences Department (APS)
University of Colorado, Boulder
Boulder, Colorado, USA

Applications are invited for a two-year postdoctoral position at the University of Colorado Boulder starting in August 2020, to work with Prof. John Bally on observations and theory of star formation.

The successful applicant will contribute to a research program using multi-wavelength imaging and spectroscopy from Apache Point Observatory, Subaru, ALMA, the JVLA, and other facilities. Familiarity with data reduction methods and tools is essential. Candidates familiar with numerical simulations such as N-body, SPH, or other codes used to investigate the physics of outflows, their interactions with the surrounding ISM, protostellar dynamic interactions and mergers among protostars will also be considered.

The general goal is to investigate the feedback processes that operate in the self-regulation of star formation. Specific goals include: [1] Complete the analysis and publication of existing data on the Orion OMC1 outflow, ejected stars, and environment. [2] Observe other Galactic explosive outflow candidates to constrain their event rates, properties, and impacts. [3] Continue near-IR monitoring of nearby star-forming galaxies to probe the properties of extra-galactic IR transients detected by Spitzer. [4] Explore the use of 6.7 GHz (methanol) and 22 GHz (water) maser outbursts as alerts for protostellar mergers or major accretion-powered IR-transients. [5] Model circumstellar disk & envelope behavior in interactions using public-domain SPH and N-body codes.

Who We Are:

The Center for Astrophysics and Space Astronomy (CASA: https://www.colorado.edu/casa/) is dedicated to advancing our understanding of the Universe in which we live through observations, theory, and the development of ground-based and space-borne instrumentation. Founded in 1985, CASA is an affiliated unit within the structure of the Astrophysical and Planetary Sciences (APS) Department at the University of Colorado, Boulder (https://www.colorado.edu/aps/).

What Your Key Responsibilities Will Be:

The successful applicant will contribute to the research program by generating new observing proposals, reducing and analyzing data, and writing up results. Potential applicants are invited to contact John Bally (john.bally@colorado.edu) to discuss their potential fit to this position.

What We Offer:

The appointment will be for an initial period of two years, with renewal for a third year contingent upon satisfactory progress and availability of funds. The position includes a competitive salary, research/travel funds, and access to CU's computing resources and partnership in the Apache Point Observatory and Sloan Digital Sky Survey.

Benefits:

The University of Colorado offers excellent benefits, including medical, dental, retirement, paid time off, tuition benefit and ECO Pass. The University of Colorado Boulder is one of the largest employers in Boulder County and offers an inspiring higher education environment. Learn more about the University of Colorado Boulder (https://colorado.edu).

Be Adaptable. Be Imaginative. Be Boulder.

What We Require:

Applicants must have a PhD in astronomy and/or physics on arrival.

What We Would Like You To Have:

Experience with visual, infrared, and radio data reduction and analysis methods. Familiarity with numerical simulation of star-forming environments would be welcome.

Special Instructions:

To apply, please submit the following materials by May 15, 2020:

• Resume/CV (including a list of publications)

• Cover letter

• Transcripts/Proof of Degree

• Statement of research philosophy - Brief (up to 3 pages) research statement of your scientific interests and how you would specifically contribute to the research program described above.

• Three letters of recommendation to be emailed as PDFs

Application materials are accepted electronically via CU Boulder Jobs.

Please send copies of application material via e-mail to

john.bally@colorado.edu.

Full consideration will be given to applications that are completed by May 15, 2020 or until the position is filled.

Posting Contact Information:

https://jobs.colorado.edu/jobs/JobDetail/?jobId=23016

Posting Contact Name: Boulder Campus Human Resources

Posting Contact Email: Recruiting@colorado.edu

The University of Colorado Boulder is committed to building a culturally diverse community of faculty, staff, and students dedicated to contributing to an inclusive campus environment. We are an Equal Opportunity employer, including veterans and individuals with disabilities.

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.

Meetings

Cool Stars, Stellar Systems, and the Sun 21

Dear Colleagues,

We regret to announce that the Cool Stars, Stellar Systems, and the Sun 21st Conference, originally planned to be held on June 22-26, 2020, in Toulouse, France, has to be postponed due to the current Covid-19 pandemic. The decision was discussed within the SOC and LOC, and agreed by all members of the organizing committees. We plan to reschedule CS21 in Summer 2021.

Preliminary dates (tbc) for CS21 would be 5-9 July 2021, at the same location in Toulouse, France. We foresee that the program that was designed for CS21 this year, including the planned invited talks and the scheduled splinter sessions, will still be largely relevant next year, unless other hot topics emerge till then. We will continue to provide updated information on the current CS21 website.

As chairs of the SOC and LOC, we would like to express our gratitude to all the members of the organizing committees, especially to the members of the LOC for the efforts they deployed in this uncertain context. We extend our thanks to the chairs of the proposed Splinter sessions, to the speakers who accepted our invitation for the plenary sessions, and to all of you who had registered for the conference.

Take care, and we hope to see you next year!

S. Brun, J. Bouvier, P. Petit

Cloudy Workshop Athens Greece

Registration is now open for the Cloudy workshop to be held 2020 June 15 to 19 at the Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing (IAASARS) in Athens Greece. https://www.astro.noa.gr/en/main/. The science part of the workshop is described at https://cloud9.pa.uky.edu/~gary/cloudy/CloudySummerSchool/ while instructions for registering and local information will be posted on the forum https://groups.io/g/CloudyAthens2020. Please join it to get updates on the workshop.

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 first-principles prediction of the conditions in the material and its observed spectrum.

The workshop will cover observation, 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.

ACO Torino-2021 Conference:
Chemical Processes in Solar-type Star Forming Regions

Dear Colleagues,

This is the first announcement of the Conference:

CHEMICAL PROCESSES IN SOLAR-TYPE STAR FORMING REGIONS

jointly organized by the Department of Chemistry of the University of Torino and INAF Astrophysical Observatory of Arcetri in the context of the EU 2020 ITN project AstroChemical Origins (ACO).

The meeting will consist of invited reviews, invited and contributed talks, and posters. Support for PhD and young students is also planned.

Conference site: Department of Chemistry, University of Torino, Italy Conference dates: 13^{th} – 17^{th} September 2021 Registration deadline: 20^{th} May 2021 Abstract submission deadline: 1^{st} May 2021

The announcement of the conference is available on the web at: https://sites.google.com/inaf.it/aco-conference/

Please circulate this notice among your colleagues, especially young PhD and PostDoc students.

Rationale:

How the chemical complexity evolves during the process leading to the formation of a Sun and its planetary system? Is the chemical richness of a Solar-like planetary system, at least partially, inherited from the earliest stages or is there a complete chemical reset? A powerful way to answering these questions is by comparing the chemical content in young protostars and primitive bodies of the Solar System, using astrochemistry as a tool. Yet, to do so, we need to fully understand the processes that govern the chemical evolution of a molecular cloud into a young planetary system.

The goal of the conference is to gather together the actors of this intrinsically interdisciplinary endeavor: astronomers, chemists and modelers. The recent huge progresses in the three areas make the time ripe for these communities to join and ride this scientific wave.

We invite all of you to join the Conference.

The Scientific Organizing Committee P. Ugliengo, C. Codella, A. Barucci, C. Ceccarelli, L. Piccirillo, A. Rimola, C. Vastel, S. Viti, S. Yamamoto

Summary of Upcoming Meetings

AIP Thinkshop on Protoplanetary Disk Chemodynamics
11 - 15 May 2020, Leibnitz Institute for Astrophysics Potsdam, Germany
https://meetings.aip.de/event/1

Planet Formation: From Dust Coagulation to Final Orbital Assembly
1 - 26 June 2020, Munich, Germany
http://www.munich-iapp.de/planetformation

The Physics of Star Formation: From Stellar Cores to Galactic Scales; 29 June - 3 July 2020, Lyon, France
http:/staratlyon.univ-lyon1.fr/en

Illuminating the Dusty Universe: A Tribute to the Work of Bruce Draine
6 - 10 July 2020, Florence, Italy
https://web.astro.princeton.edu/IlluminatingTheDusty Universe

The Early Phase of Star Formation
12 - 17 July 2020, Ringberg, Germany
http://www.mpia.de/homes/stein/EPoS/2020/2020.php

Star Formation: From Clouds to Discs - A Tribute to the Career of Lee Hartmann
17 - 20 August 2020, Malahide, Ireland
https://www.dias.ie/cloudstodiscs/

Star Formation in Different Environments 2020
24 - 28 August 2020, Quy Nhon, Vietnam
http://icisequynhon.com/conferences/sfde/

Planetary Science: The Young Solar System
6 - 12 September 2020, Quy Nhon, Vietnam
http://www.icisequynhon.com/conferences/planetary_science/

Wheel of Star Formation: A conference dedicated to Prof. Jan Palouš
14 - 18 September 2020, Prague, Czech Republic
https://janfest2020.asu.cas.cz

Conditions and Impact of Star Formation - Across Times and Scales
28 September - 2 October 2020, Chile
https://astro.uni-koeln.de/symposium-star-formation-2020.html

From Clouds to Planets II: The Astrochemical Link
28 September - 2 October 2020, Berlin, Germany
https://events.mpe.mpg.de/event/12/

The Aftermath of a Revolution: Planet Formation Five Years after HL Tau
7 - 11 December 2020, Chile
https://www.eso.org/sci/meetings/2020/hltau2020.html

Protostars & Planets VII
1 - 7 April 2021, Kyoto, Japan
http://www.ppvii.org

Cool Stars, Stellar Systems, and the Sun 21
postponed to summer 2021, Toulouse, France
https://coolstars21.github.io/

Chemical Processes in Solar-type Star Forming Regions
13 - 17 September 2021, Torino, Italy
https://sites.google.com/inaf.it/aco-conference

Short Announcements

Fizeau exchange visitors program - call for applications

Dear colleagues!

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff), with priority given to PhD students and young postdocs. non-EU based missions will only be funded if considered essential by the Fizeau Committee. Applicants are strongly encouraged to seek also partial support from their home or host institutions.

The deadline for applications is May 15 for visits to be carried out between mid July 2020 and December 2020!.

Note: the next call will be issued in November 2020!

Note: requests for support for the Fizeau VLTI school in September are NOT part of this call. Such requests will be handled by the school organizers.

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

The program is funded by OPTICON/H2020.

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

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

Electronic mail: fizeau@european-interferometry.eu

Abstract submission deadline

The deadline for submitting abstracts and other submissions is the first day of the month. Abstracts submitted after the deadline will appear in the following month's issue.