The Star Formation Newsletter

Editor: Bo Reipurth
reipurth@ifa.hawaii.edu

Associate Editor: Anna McLeod
anna.mcleod@berkeley.edu

Technical Editor: Hsi-Wei Yen
hwyen@asiaa.sinica.edu.tw

Editorial Board
Joao Alves
Alan Boss
Jerome Bouvier
Lee Hartmann
Thomas Henning
Paul Ho
Jes Jorgensen
Charles J. Lada
Thijs Kouwenhoven
Michael R. Meyer
Ralph Pudritz
Luis Felipe Rodríguez
Ewine van Dishoeck
Hans Zinnecker

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
Interview ............................................ 3
Abstracts of Newly Accepted Papers .......... 5
Abstracts of Newly Accepted Major Reviews . 35
Dissertation Abstracts ............................. 36
New Jobs .......................................... 39
Meetings ......................................... 40
Summary of Upcoming Meetings ............... 42
New Books ....................................... 44

Cover Picture
The ρ Ophiuchi clouds are among the nearest star forming regions. While it has been observed in great detail at almost all wavelengths, only wide-field astrophotography can capture its magnificent appearance.

Image courtesy Adam Block
http://www.adamblockphotos.com
http://caelumobservatory.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/starformation/index.cfm
Stéphane Guilloteau  
in conversation with Bo Reipurth

Q: You originally started studying mathematics and physics. What motivated a change to astronomy and what were your early interests?

A: Astronomy has long been a passion for me. This dates back from the clear summer skies on the Noirmoutier island along the Atlantic coast in France in my childhood. I was admitted at the Ecole Normale Supérieure in Paris through the Mathematics section, but followed lectures in Physics (mostly quantum mechanics and atomic physics) once there. I jumped on the opportunity to make a thesis in astronomy with Alain Omont: this was about OH masers, and made a good transition between molecular physics and astronomy.

Q: You have a long-standing interest in circumstellar disks of young stars, and have published numerous papers on the subject. Please discuss some of your results.

A: The IRAM array was the first one with enough spectral line sensitivity to be able to observe these disks. This was a practically unexplored territory in 1991. I had the luck to be able to offer Anne Dutrey a post-doc position, and many things started then under her initiative. A second chance occurred nearly simultaneously when I was doing my turn as “Astronomer on Duty” at the IRAM array, in January 1992. Among the scheduled projects was one by Michal Simon on UZ Tau and GG Tau. The two dust disks of UZ Tau came along well as expected, but nothing could be seen on GG Tau, although it should have been much brighter. I realized the only reasonable explanation was that this source was resolved, and added in the schedule a complementary observation with short baselines. This was my first paper on disks, and the start of an enjoyable long term collaboration.

Among the results, I like citing the 1998 work on DM Tau (the first quantitative analysis of disk parameters), and the 2012 one on using the CS molecule as a tracer of turbulence. Obtaining the first evidence for a radial gradient in dust properties in 2011 was a very difficult project, although it is now a fairly obvious property with ALMA observations.

Q: I especially recall your 1999 paper on the quadruple system GG Tau. What are the characteristics of that system?

A: Until 2014, GG Tau was a hierarchical quadruple system, with a large (1000 au) massive, circum-binary disk that makes it a unique laboratory to test our understanding of the impact of tidal forces on disks. Then, using the VLT/I, Emmanuel DiFolco found that Ab is itself a close (3-5 au separation) binary star, finally explaining why no “mm” disk was detected around Ab: tidal truncation precludes any cold extended disk. Despite 25 years of studies, we still do not understand why the circum-tertiary cavity is so large. The most common theoretical explanation requires the Aa/Ab orbit to be misaligned with the outer disk. However, our recent study of the shadows cast by the inner circumstellar disks on the outer disk show that two of these are in the outer disk plane. Strange.... Incidentally, the GG Tau image of 1999 played a significant role to convince people that ALMA ought to be big.

Q: You have also studied dynamical masses of young stars.

A: This has been a more than 20 years long story, with a close collaboration with Michal Simon from Stony Brook. Dynamical masses are only one step: the real goal is to test the validity of theoretical tracks in early stellar evolution to derive ages for stars, and establish a clock for the formation of stars and planets. It has been challenging, requiring substantial amounts of data from the only telescopes able to contribute in this domain, the IRAM array before 2012, and also ALMA later. Furthermore, it is not a fancy topic, so getting the observations was not easy (I would even say often unsuccessful). We had to rely partially on archival data, but these were not tailored to our purpose, making them more difficult to use, and even useless in many cases. But the results were worth the efforts. Our latest paper this year shows that only models involving the magnetic pressure support for the young stars agree with the measured star properties. Since these models lead to longer contraction times, it makes young stars about 3 times older than more commonly believed before (and protostars too). This has a significant impact on the lifetime of protoplanetary disks, and on their ability to form planets, as well as on the accretion history during the protostellar and early stellar phase.

This work illustrates the importance of pursuing fundamental, long term projects, rather than having to show immediate spectacular results for further fundings.

Q: During your years in Grenoble, you were heavily involved with the IRAM interferometer at Plateau de Bure, which you and your team described in a large paper from...
1992. What were the challenges then, and what is the status today?

**A:** The technical challenges were enormous, as this was the very beginning of millimeter radio-astronomy in France and Germany. Building receivers was a wizardry issue at that time (it was the epoch of the very first SIS receivers). I joined IRAM in 1987 as interferometer project scientist after the death of Nicolas Weliachev, who had lead the design. The IRAM array came after BIMA, OVRO and Nobeyama, so the pressure to get it complete was high. We got fringes in Dec 1988, but had to re-design the whole control software in 1989. Once in operation, the IRAM array underwent significant upgrades almost continuously (receivers, new correlators, additional antennas, longer baselines). It was a period for pioneers. I remember long week-ends on Plateau de Bure with only 3 people on-site (the two operators and myself), ensuring 24 hours observations, antenna configuration change (one antenna for each of us), as well as cooking. There was also a very active scientific environment at IRAM headquarters in Grenoble, thanks to the visitors coming to analyze their (sparse and precious) data.

Now NOEMA (the NOrthern Extended Millimeter Array), a major upgrade of the IRAM array to 12 antennas, wide bandwidths and 150 000 spectral channels, is nearly complete. 10 antennas are operational, the 11th in a few months, and a dual-frequency system is foreseen in a few years. This is a major facility for the next decades, bringing high angular resolution to frequency surveys.

I worry however that the close contact between observers and the array staff is no longer maintained, as all observations are performed remotely. This is a danger, and a real difficulty in maintaining a joint scientific and technical expertise and in training new generations of researchers and engineers. This unfortunately applies even more to ALMA.

**Q:** Subsequently you were for many years project scientist for the development of the ALMA interferometer. What are your recollections from that period?

**A:** Lots of travel (among which a memorable private visit of Basilica San Marco in Venice, and a round-trip from Europe to Hawaii for a 2 hours meeting)!

More seriously, the biggest challenge was here more political than technical. ALMA is the first world-wide scientific collaboration ever, and we had to bring 3 partners with different cultures and experiences together. On one side, NRAO had a “ready-to-go” project (the MMA), but this was felt as being too small for a major step forward. ESO had considerable experience in managing large scale, multi-national projects, but no hands-on expertise at all in mm interferometry. Japan could not join on the same timescale as the two others.

Despite that, the project started very quickly: the first MoU for a joint study was signed in 1997, and the official acceptance of the project took place in Feb 2003. Overall, this has been a very fast project, especially considering that the mm radio community had to transition from almost craft work to semi-industrial series production.

**Q:** You have also invested a lot of time in developing tools for the analysis of millimeter observations.

**A:** Indeed. All this started in 1983 because I was working on NH$_3$ data from Effelsberg, and needed some software to analyze spectra with hyperfine structure. The IRAM 30-m in Spain was foreseen for 1985, and the University of Grenoble had a project for a small (2.5 m) telescope operating at 230 GHz, POM-2. Thus, rather than building a small tool just for NH$_3$, I decided to write, with the help of Robert Lucas, a spectral line analysis package that could suit all single-dish telescopes. The first version of CLASS was working on 16-bit computers with 128 kB of memory (and 10 MB removable hard disks). CLASS became the de-facto data analysis software for the 30-m, and has been used by many other single-dish telescopes. A general graphic package was later developed with Pierre Valiron.

These were relatively simple to use, so for the IRAM array, it was decided to use the same framework for the array control, the calibration program, and a simple interferometric imaging and display tool optimized for its purpose: small images with a significant amount of spectral channels (AIPS, the interferometer package of those days, was only able to process 8 channels at once).

We are about to release an upgraded version of that package, now named IMAGER, that can handle ALMA data sets, as well as the 150 000 channels of NOEMA correlator, while still running on a laptop. Honestly, I would have never been able to predict such a long lifetime for these tools, but they served me well (and I hope others too).

**Q:** What are your current interests?

**A:** Proto-planetary disks are still on top of my list. They are the starting place of planet formation. Despite the progress made in the last 10 years, one major characteristic is still poorly known: their mass. Also, studies have focussed on the “monsters”, the big and bright ones, but the more representative smaller ones (less than 100 au size) remain a relatively uncharted territory. Both topics are challenging, because of the high sensitivity required for the related observations. They require hours long integration even with ALMA, but one should remember that most images made with the IRAM array before 2006 required more than 24 hours of telescope time.

I also invest some efforts in improving our understanding of chemistry in disks, as molecules remain our main probes for their physical conditions (I often joke about chemistry being an unavoidable pain).
Abstracts of recently accepted papers

Spectral evolution and radial dust transport in the prototype young eruptive system EX Lup

Péter Ábraháım, Lei Chen, Ágnes Kóspál, Jeroen Bouwman, Andrés Carmona, Martin Haas, Aurora Sicila-Aguilar, Catalina Sobrino Figuredo, Roy van Boekel and József Varga

1 Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, Konkoly-Thege Miklós út 15-17, 1121 Budapest, Hungary; 2 Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany; 3 Université de Toulouse, UPS-OMP, IRAP, Toulouse F-31400, France 4 Astronomisches Institut, Ruhr-Universität Bochum, Universitätsstrasse 150, 44801, Bochum, Germany 5 SUPA, School of Science and Engineering, University of Dundee, Nethergate, Dundee, DD1 4HN, UK 6 Leiden Observatory, Leiden University, PO Box 9513, NL2300, RA Leiden, The Netherlands

E-mail contact: abraham at konkoly.hu

EX Lup is the prototype of a class of pre-main sequence eruptive stars defined by their repetitive outbursts lasting several months. In 2008 January-September EX Lup underwent its historically largest outburst, brightening by about 4 magnitudes in visual light. In previous studies we discovered on-going silicate crystal formation in the inner disk during the outburst, but also noticed that the measured crystallinity fraction started decreasing after the source returned to the quiescent phase. Here we present new observations of the 10 μm silicate feature, obtained with the MIDI and VISIR instruments at Paranal Observatory. The observations demonstrate that within five years practically all crystalline forsterite disappeared from the surface of the inner disk. We reconstruct this process by presenting a series of parametric axisymmetric radiative transfer models of an expanding dust cloud that transports the crystals from the terrestrial zone to outer disk regions where comets are supposed to form. Possibly the early Sun also experienced similar flare-ups, and the forming planetesimals might have incorporated crystalline silicate material produced by such outbursts. Finally, we discuss how far the location of the dust cloud could be constrained by future JWST observations.

Accepted by Astrophys. J.


Protostellar Evolution in Serpens Main: Possible Origin of Disk-Size Diversity

Yusuke Aso, Hirano Naomi, Yuri Aikawa, Masahiro M. Machida, Nagayoshi Ohashi, Masao Siato, Shigehisa Takakuwa, Hsi-Wei Yen and Jonathan P. Williams

1 Academia Sinica Institute of Astronomy and Astrophysics, 11F of ASMA Building, No.1, Sec. 4, Roosevelt Rd, Taipei 10617, Taiwan; 2 Department of Astronomy, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan; 3 Department of Earth and Planetary Sciences, Faculty of Sciences Kyushu University, Fukuoka 812-8581, Japan; 4 Nobeyama Radio Observatory, Nobeyama, Minamimaki, Minamisaku, Nagano 384-1305, Japan; 5 SOKENDAI, Department of Astronomical Science, Graduate University for Advanced Studies, Japan; 6 Department of Physics and Astronomy, Graduate School of Science and Engineering, Kagoshima University, 1-21-35 Korimoto,Kagoshima, Kagoshima 890-0065, Japan; 7 Institute for Astronomy, University of Hawaii at Manoa, Honolulu, Hawaii, USA

E-mail contact: yaso at asiaa.sinica.edu.tw

We have observed the submillimeter continuum condensations SMM2, SMM4, SMM9, and SMM11 in the star forming cluster Serpens Main using the Atacama Large Millimeter/submillimeter Array during Cycle 3 in the 1.3 mm continuum, 12CO J=2-1, SO J,N=6,5-5,4, and C18O J=2-1 lines at an angular resolution of ~0.55” (240 au). Sixteen sources have been detected in the 1.3 mm continuum, which can be classified into three groups. Group 1 consists of six sources showing extended continuum emission and bipolar/monopolar 12CO outflows. Although all the Group
1 members are classified as Class 0 protostars, our observations suggest evolutionary trends among them in terms of 12CO outflow dynamical time, SO emission distribution, C18O fractional abundance, and continuum morphology. Group 2 consists of four sources associated with a continuum filamentary structure and no 12CO outflows. Central densities estimated from the 1.3 mm continuum intensity suggest that they are prestellar sources in a marginally Jeans unstable state. Group 3 consists of six Spitzer sources showing point-like 1.3 mm continuum emission and clumpy 12CO outflows. These features of Group 3 suggest envelope dissipation, preventing disk growth from the present size, \( r < \sim 60 \) au. The Group 3 members are protostars that may be precursors to the T Tauri stars associated with small disks at tens-au radii identified in recent surveys.

Accepted by The Astrophysical Journal


Detection of H\(\alpha\) emission from PZ Tel B using SPHERE/ZIMPOL

Arianna Musso Barcucci\(^1\), Gabriele Cugno\(^2\), Ralf Launhardt\(^1\), André Müller\(^1\), Judit Szulagyi\(^3\), Roy van Boekel\(^1\), Thomas Henning\(^1\), Mickael Bonnefoy\(^4\), Sascha P. Quanz\(^2\), and Faustine Cantalloube\(^1\)

\(^1\) Max Planck Institute for Astronomy (MPIA), Königstuhl 17, 69117 Heidelberg, Germany; \(^2\) ETH Zürich, Institute for Particle Physics and Astrophysics, Wolfgang-Pauli-Str. 27, 8093 Zürich, Switzerland; \(^3\) Center for Theoretical Astrophysics and Cosmology, Institute for Computational Science, University of Zürich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland; \(^4\) Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France

E-mail contact: musso at mpia.de

H\(\alpha\) is a powerful tracer of accretion and chromospheric activity, which has been detected in the case of young brown dwarfs and even recently in planetary mass companions (e.g. PDS70 b and c). H\(\alpha\) detections and characterisation of brown dwarf and planet companions can further our knowledge of their formation and evolution, and expanding such a sample is therefore our primary goal. We used the Zurich IMaging POLarimeter (ZIMPOL) of the SPHERE instrument at the Very Large Telescope (VLT) to observe the known 38–72 M\(_J\) companion orbiting PZ Tel, obtaining simultaneous angular differential imaging observations in both continuum and narrow H\(\alpha\) band. We detect H\(\alpha\) emission from the companion, making this only the second H\(\alpha\) detection of a companion using the SPHERE instrument. We used our newly added astrometric measurements to update the orbital analysis of PZ Tel B, and we used our photometric measurements to evaluate the H\(\alpha\) line flux. Given the estimated bolometric luminosity, we obtained an H\(\alpha\) activity (\(\log(L_{H\alpha}/L_{bol})\)) between −4.16 and −4.31. The H\(\alpha\) activity of PZ Tel B is consistent with known average activity levels for M dwarf of the same spectral type. Given the absence of a known gaseous disk and the relatively old age of the system (24 Myr), we conclude that the H\(\alpha\) emission around PZ Tel B is likely due to chromospheric activity.

Accepted by A&A


A kinematically unbiased, all-sky search for nearby, young, low-mass stars

Alexander S. Binks\(^1,2\), Matthieu Chalifour\(^3,4\), Joel H. Kastner\(^3\), David Rodriguez\(^5\), Simon J. Murphy\(^6\), David A. Principe\(^7\), Kristina Punzi\(^8\), Germano G. Sacco\(^9\) and Jesús Hernández\(^10\)

\(^1\) Astrophysics Group, School of Chemistry and Physics, Keele University, UK; \(^2\) Instituto de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México (UNAM), Morelia, México; \(^3\) Center for Imaging Science and Laboratory for Multiwavelength Astrophysics, Rochester Institute of Technology, Rochester, NY, USA; \(^4\) Department of Physics \& Astronomy, Swarthmore College, Swarthmore, PA, USA; \(^5\) Space Telescope Science Institute, Baltimore, MD, USA; \(^6\) School of Science, The University of New South Wales, Canberra, ACT 2600, Australia; \(^7\) MIT Kavli Institute for Astrophysics and Space Research, 70 Vassar St, Cambridge, MA 02109, USA; \(^8\) Astronomy Department, Wellesley College, Wellesley, MA, USA; \(^9\) Arcetri Observatory, Florence, Italy; \(^10\) Instituto de Astronomía, UNAM, Unidad Académica en Ensenada, Ensenada 22860, México

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

The past two decades have seen dramatic progress in our knowledge of the population of young stars of age <200 Myr that lie within 150 pc of the Sun. These nearby, young stars, most of which are found in loose, comoving groups, provide the opportunity to explore (among many other things) the dissolution of stellar clusters and their diffusion
into the field star population. Here, we exploit the combination of astrometric and photometric data from Gaia and photometric data from GALEX (UV) and 2MASS (near-IR) in an attempt to identify additional nearby, young, late-type stars. Specifically, we present a sample of 146 GALEX UV-selected late-type (predominantly K-type) field stars with Gaia-based distances <125 pc (based on Gaia Data Release 1) that have isochronal ages <80 Myr even if equal-components binaries. We investigate the spectroscopic and kinematic properties of this sample. Despite their young isochronal ages, only ∼10 per cent) of stars among this sample can be confidently associated with established nearby, young moving groups (MGs). These candidate MG members include 5 stars newly identified in this study. The vast majority of our sample of 146 nearby young star candidates have anomalous kinematics relative to the known MGs. These stars may hence represent a previously unrecognised population of young stars that has recently mixed into the older field star population. We discuss the implications and caveats of such a hypothesis—including the intriguing fact that, in addition to their non-young-star-like kinematics, the majority of the UV-selected, isochronally young field stars within 50 pc appear surprisingly X-ray faint.

Accepted by MNRAS


The 3D structure of CO depletion in high-mass prestellar regions
S. Bovino¹, S. Ferrada-Chamorro¹, A. Lupi², G. Sabatini¹,³,⁴, A. Giannetti⁴, and D.R.G. Schleicher¹

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 Dipartimento di Fisica e Astronomia, Università degli Studi di Bologna, via Gobetti 93/2, I-40129 Bologna, Italy; ⁴ INAF - Istituto di Radioastronomia - Italian node of the ALMA Regional Centre (ARC), via Gobetti 101, I-40129 Bologna, Italy

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

Disentangling the different stages of the star-formation process, in particular in the high-mass regime, is a challenge in astrophysics. Chemical clocks could help alleviating this problem, but their evolution strongly depends on many parameters, leading to degeneracy in the interpretation of the observational data. One of these uncertainties is the degree of CO depletion. We present here the first self-consistent magneto-hydrodynamic simulations of high-mass star-forming regions at different scales, fully coupled with a non-equilibrium chemical network, which includes C-N-O bearing molecules. Depletion and desorption processes are treated time-dependently. The results show that full CO-depletion (i.e. all gas-phase CO frozen-out on the surface of dust grains), can be reached very quickly, in one third or even smaller fractions of the free-fall time, whether the collapse proceeds on slow or fast timescales. This leads to a high level of deuteration in a short time both for typical tracers like N₂H⁺, as well as for the main ion H₃⁺, the latter being in general larger and more extended. N₂ depletion is slightly less efficient, and no direct effects on N-bearing molecules and deuterium fractionation are observed. We show that CO depletion is not the only driver of deuteration, and that there is a strong impact on $D_{frac}$ when changing the grain-size. We finally apply a two-dimensional gaussian Point Spread Function to our results to mimic observations with single-dish and interferometers. Our findings suggest that the low-values observed in high-mass star-forming clumps are in reality masking a full-depletion stage in the inner 0.1 pc region.

Accepted by ApJ


The Radial Distribution of Dust Particles in the HL Tau Disk from ALMA and VLA Observations
Carlos Carrasco-Gonzalez¹, Anibal Sierra¹, Mario Flock², Zhaohuan Zhu³, Thomas Henning², Claire Chandler⁴, Roberto Galvan-Madrid¹, Enrique Macias⁵, Guillem Anglada⁶, Hendrik Linz², Mayra Osorio⁶, Luis F. Rodriguez¹, Leonardo Testi⁷, Jose M. Torrelles⁸, Laura Perez⁹ and Yao Liu¹⁰

¹ Instituto de Radioastronomía y Astrofísica (IRyA-UNAM); ² Max-Planck-Institut fuer Astronomie (MPIA); ³ Department of Physics and Astronomy, University of Nevada, Las Vegas; ⁴ National Radio Astronomy Observatory (NRAO); ⁵ Department of Astronomy, Boston University; ⁶ Instituto de Astrofísica de Andalucía (IAA-CSIC); ⁷ Euro-
Understanding planet formation requires one to discern how dust grows in protoplanetary disks. An important parameter to measure in disks is the maximum dust grain size present. This is usually estimated through measurements of the dust opacity at different millimeter wavelengths assuming optically thin emission and dust opacity dominated by absorption. However, Atacama Large Millimeter/submillimeter Array (ALMA) observations have shown that these assumptions might not be correct in the case of protoplanetary disks, leading to overestimation of particle sizes and to underestimation of the disks mass. Here, we present an analysis of high-quality ALMA and Very Large Array images of the HL Tau protoplanetary disk, covering a wide range of wavelengths, from 0.8 mm to 1 cm, and with a physical resolution of 7.35 au. We describe a procedure to analyze a set of millimeter images without any assumption about the optical depth of the emission, and including the effects of absorption and scattering in the dust opacity. This procedure allows us to obtain the dust temperature, the dust surface density, and the maximum particle size at each radius. In the HL Tau disk, we found that particles have already grown to a few millimeters in size. We detect differences in the dust properties between dark and bright rings, with dark rings containing low dust density and small dust particles. Different features in the HL Tau disk seem to have different origins. Planet-disk interactions can explain substructure in the external half of the disk, but the internal rings seem to be associated with the presence of snow lines of several molecules.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1908.07140

The chemical composition of the Herbig Ae SB2 system AK Sco (HD 152404)

F. Castelli1, S. Hubrig2, S.P. Jarvinen2 and M. Schöller3

1 Istituto Nazionale di Astrofisica – Osservatorio Astronomico di Trieste; 2 Leibniz-Institut für Astrophysik Potsdam (AIP); 3 European Southern Observatory

E-mail contact: shubrig@aip.de

We investigate the stellar atmospheres of the two components of the Herbig Ae SB2 system AK Sco to determine the elements present in the stars and their abundance. Equal stellar parameters $T_{\text{eff}} = 6500 \text{K}$ and $\log g = 4.5$ were used for both stars. We studied HARPSpol spectra (resolution 110 000) that were previously used to state the presence of a weak magnetic field in the secondary. A composite synthetic spectrum was compared in the whole observed region $\lambda \lambda 3900–6912 \text{Å}$ with the observed spectrum. The abundances were derived mostly from unblended profiles, in spite of their sparsity, owing to the complexity of the system and to the not negligible $v \sin i$ of 18 km s$^{-1}$ and 21 km s$^{-1}$ adopted for the two components, respectively. The identified elements are those typical of stars with spectral type F5 IV-V, except for Li i at 6707 Å and He i at 5875.61 Å, whose presence is related with the Herbig nature of the two stars. Furthermore, overabundances were determined in both stars for Y, Ba, and La. Zirconium is overabundant only in the primary, while sulfur is overabundant outside the adopted error limits only in the secondary. In contrast to previous results showing a high occurrence rate of λ Boo peculiarities or normal chemical composition among the Herbig Ae/Be stars, the abundance pattern of AK Sco is similar to that of only few other Herbig stars displaying weak Ap/Bp peculiarities. A few accretion diagnostic lines are discussed.

Accepted by MNRAS


The first steps of interstellar phosphorus chemistry

Johanna Chantzos1, Victor M. Rivilla2, Anton Vasyunin3,4, Elena Redaelli1, Luca Bizzocchi1, Francesco Fontani2 and Paola Caselli1

1 Max-Planck-Institute for extraterrestrial Physics, Giessenbachstrasse 1, 85748 Garching, Germany; 2 INAF-Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, I-50125, Firenze, Italy; 3 Ural Federal University, Ekaterinburg, Russia; 4 Visiting Leading Researcher, Engineering Research Institute ‘Ventspils International Radio Astronomy Centre’ of Ventspils University of Applied Sciences, Inzenieru 101, Ventspils LV-3601, Latvia
Phosphorus-bearing species are essential to the formation of life on Earth, however they have barely been detected in the interstellar medium. In particular, towards star-forming regions only PN and PO have been identified so far. Since only a small number of detections of P-bearing molecules are available, their chemical formation pathways are not easy to constrain and are thus highly debatable. An important factor still missing in the chemical models is the initial elemental abundance of phosphorus, that is, the depletion level of P at the start of chemical models of dense clouds. In order to overcome this problem, we study P-bearing species in diffuse and translucent clouds. In these objects phosphorus is expected to be mainly in the gas phase and therefore the elemental initial abundance needed in our chemical simulations corresponds to the cosmic one and is well constrained. For the study of P-bearing chemistry we used an advanced chemical model. We updated and significantly extended the P-chemistry network based on chemical databases and previous literature. We performed single-pointing observations with the IRAM 30m telescope in the 3 mm range towards the line of sight to the strong continuum source B0355+508 aiming for the (2-1) transitions of PN, PO, HCP, and CP. This line of sight incorporates five diffuse and/or translucent clouds. The (2-1) transitions of the PN, PO, HCP, and CP were not detected. We report high signal-to-noise-ratio detections of the (1-0) lines of $^{13}$CO, HNC, and CN along with a first detection of C$^{34}$S towards this line of sight. We have attempted to reproduce the observations of HNC, CN, CS, and CO in every cloud with our model by applying typical physical conditions for diffuse or translucent clouds. We find that towards the densest clouds with $V_{LSR} = -10, -17 \text{ km s}^{-1}$ the best-fit model is given by the parameters $(n(H), A_V, T_{gas}) = (300 \text{ cm}^{-3}, 3 \text{ mag}, 40 \text{ K})$. According to our best-fit model, the most abundant P-bearing species are HCP and CP ($\sim 10^{-10}$). The molecules PN, PO, and PH$_3$ also show relatively high predicted abundances of $\sim 10^{-11}$. We show that the abundances of these species are sensitive to visual extinction, cosmic-ray ionization rate, and the diffusion-to-desorption energy ratio on dust grains. The production of P-bearing species is favored towards translucent rather than diffuse clouds, where the environment provides a stronger shielding from the interstellar radiation. Based on our improved model, we show that the (1-0) transitions of HCP, CP, PN, and PO are expected to be detectable with estimated intensities of up to $\sim 200 \text{ mK}$.

Accepted by A&A


The HH 212 interstellar laboratory: astrochemistry as a tool to reveal protostellar disks on Solar System scales around a rising Sun

C. Codella$^{1,2}$, C. Ceccarelli$^{2,1}$, C.-F. Lee$^{3,4}$, E. Bianchi$^2$, N. Balucani$^{5,2,1}$, L. Podio$^1$, S. Cabrit$^{6,7}$, F. Gueth$^8$, A. Gusdorf$^{6,7}$, B. Lefloch$^2$ and B. Tabone$^{9,6}$

1 INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy; 2 Univ. Grenoble Alpes, Institut de Planétologie et d’Astrophysique de Grenoble (IPAG), 38401 Grenoble, France; 3 Academia Sinica Institute of Astronomy and Astrophysics, P.O. Box 23-141, Taipei 106, Taiwan; 4 Graduate Institute of Astronomy and Astrophysics, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 10617, Taiwan; 5 Dipartimento di Chimica, Biologia e Biotecnologie, Università degli Studi di Perugia, Perugia 06123, Italy; 6 LERMA, Observatoire de Paris, École Normale Supérieure, PSL University, CNRS, Sorbonne Université, Paris, France; 7 Laboratoire de Physique de l’École Normale Supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université Paris-Diderot, Sorbonne Paris Cité, Paris, France; 8 IRAM, 300 rue de la Piscine, 38406 Saint-Martin-d’Hères, France; 9 Leiden Observatory, Leiden University, P.O. Box 9513, NL-2300 RA Leiden, the Netherlands

E-mail contact: codella at arctetri.astro.it

The investigation of star forming regions have enormously benefited from the recent advent of the ALMA interferometer working in the mm- and submm-wavelength spectral windows. More specifically, the unprecedented combination of high-sensitivity and high-angular resolution provided by ALMA allows one to shed light on the jet/disk systems associated with a Sun-like mass protostar. In this context, also astrochemistry enjoyed the possibility to analyze complex spectra obtained using large bandwidths: several interstellar Complex Organic Molecules (iCOMs; C-bearing species with at least 6 atoms) have been detected and imaged around protostars, often thanks to a large number of rotational-vibrational lines. This in turn boosted the study of the astrochemistry at work during the earliest phases of star formation paving the way to the chemical complexity in planetary systems where Life could emerge. There is mounting evidence that the observations of iCOMs (e.g. CH$_3$CHO or NH$_2$CHO) can be used as unique tool to shed light, on Solar System scales (less than 50 au), on the molecular content of protostellar disk. The increase of
iCOMs abundances occur only under very selective physical conditions, such as those associated low-velocity shocks found where the infalling envelope is impacting the rotating accretion disk. The imaging of these regions with simpler molecules such as CO or CS is indeed paradoxically hampered by their high abundances and consequently high line opacities which do not allow the observers to disentangle all the emitting components at these small scales. In this respect, we review the state-of-the-art of the ALMA analysis about the standard Sun-like star forming region in Orion named HH 212, associated with a pristine jet-disk protostellar system. We enrich the discussion with unpublished ALMA datasets, showing (i) how all the physical components involved in the formation of a Sun-like star can be revealed only by observing different molecular tracers, and (ii) how the observation of iCOMs emission, observed to infer the chemical composition of star forming regions, can be used also as unique tracer to image protostellar disks on Solar System scales, i.e. where planets will eventually form.

Accepted by ACS Earth and Space Chemistry


Flybys in protoplanetary discs: II. Observational signatures

Nicolás Cuello1,2,6, Fabien Louvet1, Daniel Mentiplay4, Christophe Pinte4,5, Daniel J. Price4, Andrew J. Winter6, Rebecca Nealon6, François Ménard5, Giuseppe Lodato7, Valentin Christiaens4, Matías Montesinos8,2,9, Jorge Cuadra1,2, Guillaume Laibe10, Lucas Cieza11, Ruobing Dong12, Richard Alexander6

1 Instituto de Astrofísica, Pontificia Universidad Católica de Chile, Santiago, Chile; 2 Núcleo Milenio de Formación Planetaria (NPF), Chile; 3 Departamento de Astronomía de Chile, Universidad de Chile, Santiago, Chile; 4 Monash Centre for Astrophysics (MoCA) and School of Physics and Astronomy, Monash University, Clayton VIC 3800, Australia; 5 Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France; 6 School of Physics and Astronomy, University of Leicester, University Road, Leicester, LE1 7RH, United Kingdom; 7 Dipartimento di Fisica, Università Degli Studi di Milano, Via Celoria, 16, Milano, 20133, Italy; 8 Universidad de Valparaíso, Chile; 9 Chinese Academy of Sciences South America Center for Astronomy, National Astronomical Observatories, CAS, Beijing 100012, China; 10 Univ Lyon, Univ Lyon1, Ens de Lyon, CNRS, Centre de Recherche Astrophysique de Lyon UMR5574, F-69230, Saint-Genis-Laval, France; 11 Facultad de Ingeniería y Ciencias, Nucleo de Astronomía, Universidad Diego Portales, Av. Ejército 441, Santiago, Chile; 12 Department of Physics & Astronomy, University of Victoria, Victoria, BC, V8P 1A1, Canada

E-mail contact: cuellonicolas at gmail.com

Tidal encounters in star clusters perturb discs around young protostars. In Cuello et al. (2019a, Paper I) we detailed the dynamical signatures of a stellar flyby in both gas and dust. Flybys produce warped discs, spirals with evolving pitch angles, increasing accretion rates, and disc truncation. Here we present the corresponding observational signatures of these features in optical/near-infrared scattered light and (sub-) millimeter continuum and CO line emission. Using representative prograde and retrograde encounters for direct comparison, we post-process hydrodynamical simulations with radiative transfer methods to generate a catalogue of multi-wavelength observations. This provides a reference to identify flybys in recent near-infrared and sub-millimetre observations (e.g., RW Aur, AS 205, HV Tau & DO Tau, FU Ori, V2775 Ori, and Z CMa).

Accepted by MNRAS


Four newborn planets transiting the young solar analog V1298 Tau

Trevor J. David1, Erik A. Petigura2, Rodrigo Luger3, Daniel Foreman-Mackey3, John H. Livingston4, Eric E. Mamajek1,5 and Lynne A. Hillenbrand6

1 Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA; 2 Department of Physics and Astronomy, University of California, Los Angeles, CA 90095, USA; 3 Center for Computational Astrophysics, Flatiron Institute, New York, NY 10010, USA; 4 Department of Astronomy, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan; 5 Department of Physics & Astronomy, University of Rochester, Rochester, NY 14627, USA; 6 Department of Astronomy, California Institute of Technology, Pasadena, CA 91125,
Exoplanets orbiting pre-main sequence stars are laboratories for studying planet evolution processes, including atmospheric loss, orbital migration, and radiative cooling. V1298 Tau, a young solar analog with an age of 23±4 Myr, is one such laboratory. The star is already known to host a Jupiter-sized planet on a 24 day orbit. Here, we report the discovery of three additional planets — all between the size of Neptune and Saturn — based on our analysis of K2 Campaign 4 photometry. Planets c and d have sizes of 5.6 and 6.4 $R_{\oplus}$, respectively and with orbital periods of 8.25 and 12.40 days reside 0.25% outside of the nominal 3:2 mean-motion resonance. Planet e is 8.7 $R_{\oplus}$ in size but only transited once in the K2 time series and thus has a period longer than 36 days, but likely shorter than 223 days. The V1298 Tau system may be a precursor to the compact multiplanet systems found to be common by the Kepler mission. However, the large planet sizes stand in sharp contrast to the vast majority of Kepler multis which have planets smaller than 3 $R_{\oplus}$. Simple dynamical arguments suggest total masses of <28 $M_{\oplus}$ and <120 $M_{\oplus}$ for the c-d and d-b planet pairs, respectively. The implied low masses suggest that the planets may still be radiatively cooling and contracting, and perhaps losing atmosphere. The V1298 Tau system offers rich prospects for further follow-up including atmospheric characterization by transmission or eclipse spectroscopy, dynamical characterization through transit-timing variations, and measurements of planet masses and obliquities by radial velocities.

Accepted by ApJL


Adapting a solid accretion scenario for migrating planets in FARGO3D

L.A. DePaula¹, T.A. Michtchenko¹, P.A. Sousa-Silva²

¹ Instituto Astronômico, Geofísico e Ciência Atmosféricas, Universidade de São Paulo, Rua do Matão 1226, 05508-900 São Paulo, Brazil; ² São Paulo State University - UNESP, Av. Prof. Issete Fontaõ, 505, 13876-750 - São João da Boa Vista, SP - Brazil

E-mail contact: luiz.paula at usp.br

In this work, we adapt a module for planetary formation within the hydrodynamic code FARGO3D. Planetary formation is modeled by a solid core accretion scenario, with the core growing in oligarchic regime. The initial superficial density of planetesimals is proportional to the initial superficial density of gas in the disc. We include a numerical approach to describe the evolution of the eccentricity and the inclination of planetesimals during the formation. This approach impacts directly on the accretion rate of solids. When the core reaches a critical mass, gas accretion begins, following the original FARGO scheme adapted to the FARGO3D code. To exemplify how the module for planetary formation can be used, we investigate the migration of a planet in a two-dimensional, locally isothermal gas disc with a prescribed accretion rate, analyzing the timescale involved in the planetary migration process along with the timescale for planetary formation. The analysis reveals that the mass of the nucleus must be close to its critical value when crossing the ice line to avoid the planet’s fall into the stellar envelope. This will allow enough time for the planet to initiate runaway gas accretion, leading to a rapid mass increase and entering type II planetary migration.

Accepted by MNRAS


Physical properties of terrestrial planets and water delivery in the habitable zone using N-body simulations with fragmentation

Agustín Dugaro¹,², Gonzalo C. de Elía¹,² and Luciano A. Darriba¹,²

¹ Instituto de Astrofísica de La Plata; ² Facultad de Ciencias Astronómicas y Geofísicas - Universidad Nacional de La Plata

E-mail contact: adugaro at fcaglp.unlp.edu.ar

The goal of this research is to study how the fragmentation of planetary embryos can affect the physical and dynamical properties of terrestrial planets around solar-type stars. Our study focuses on the formation and evolution of planets and water delivery in the habitable zone (HZ). We distinguish class A and class B HZ planets, which have an
accretion seed initially located inside and beyond the snow line, respectively. We developed an N-body integrator that incorporates fragmentation and hit-and-run collisions, which is called D3 N-body code. From this, we performed 46 numerical simulations of planetary accretion in systems that host two gaseous giants similar to Jupiter and Saturn. We compared two sets of 23 N-body simulations, one of which includes a realistic collisional treatment and the other one models all impacts as perfect mergers. The final masses of the HZ planets formed in runs with fragmentation are about 15% to 20% lower than those obtained without fragmentation. As for the class A HZ planets, those formed in simulations without fragmentation experience very significant increases in mass with respect to their initial values, while the growth of those produced in runs with fragmentation is less relevant. We remark that the fragments play a secondary role in the masses of the class A HZ planets, providing less than 30% of their final values. In runs without fragmentation, the final fraction of water of the class A HZ planets keeps the initial value since they do not accrete water-rich embryos. In runs with fragmentation, the final fraction of water of such planets strongly depends on the model used to distribute the water after each collision. The class B HZ planets do not show significant differences concerning their final water contents in runs with and without fragmentation. From this, we find that the collisional fragmentation is not a barrier to the survival of water worlds in the HZ.


The first detection of a low-frequency turnover in nonthermal emission from the jet of a young star

Anton Feeney-Johansson$^{1,2}$, Simon J. D. Purser$^1$, Tom P. Ray$^{1,2}$, Jochen Eisloffel$^3$, Matthias Hoeft$^3$, Alexander Drabent$^3$ and Rachael E. Ainsworth$^4$

1 Dublin Institute for Advanced Studies, Astronomy & Astrophysics Section, 31 Fitzwilliam Place, Dublin 2, D02 XF86, Ireland; 2 School of Physics, Trinity College, Dublin 2, Ireland; 3 Thüringer Landessternwarte Tautenburg, Sternwarte 5, D-07778, Tautenburg, Germany; 4 Jodrell Bank Centre for Astrophysics, Alan Turing Building, School of Physics and Astronomy, The University of Manchester, Oxford Road, Manchester M13 9PL, UK

E-mail contact: antonfj at cp.dias.ie

Radio emission in jets from young stellar objects (YSOs) in the form of nonthermal emission has been seen toward several YSOs. Thought to be synchrotron emission from strong shocks in the jet, it could provide valuable information about the magnetic field in the jet. Here we report on the detection of synchrotron emission in two emission knots in the jet of the low-mass YSO DG Tau A at 152 MHz using the Low-Frequency Array (LOFAR), the first time nonthermal emission has been observed in a YSO jet at such low frequencies. In one of the knots, a low-frequency turnover in its spectrum is clearly seen compared to higher frequencies. This is the first time such a turnover has been seen in nonthermal emission in a YSO jet. We consider several possible mechanisms for the turnover and fit models for each of these to the spectrum. Based on the physical parameters predicted by each model, the Razin effect appears to be the most likely explanation for the turnover. From the Razin effect fit, we can obtain an estimate for the magnetic field strength within the emission knot of $\sim 20 \mu G$. If the Razin effect is the correct mechanism, this is the first time the magnetic field strength along a YSO jet has been measured based on a low-frequency turnover in nonthermal emission.

Accepted by The Astrophysical Journal Letters


Planet formation and migration near the silicate sublimation front in protoplanetary disks

Mario Flock$^{1,2}$, Neal J. Turner$^2$, Gijs D. Mulders$^3$, Yasuhiro Hasegawa$^2$, Richard P. Nelson$^4$ and Bertram Bitsch$^1$

1 Max-Planck Institute for Astronomy (MPIA), K"onigstuhl 17, 69117 Heidelberg, Germany; 2 Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109, USA; 3 Department of the Geophysical Sciences, The University of Chicago, Chicago, IL 60637, USA; 4 Astronomy Unit, Queen Mary University of London, Mile End Road, London E1 4NS, UK
Context. The increasing number of newly detected exoplanets at short orbital periods raises questions about their formation and migration histories. Planet formation and migration depend heavily on the structure and dynamics of protoplanetary disks. A particular puzzle that requires explanation arises from one of the key results of the Kepler mission, namely the increase in the planetary occurrence rate with orbital period up to 10 days for F, G, K and M stars.

Aims. We investigate the conditions for planet formation and migration near the dust sublimation front in protostellar disks around young Sun-like stars. We are especially interested in determining the positions where the drift of pebbles would be stopped, and where the migration of Earth-like planets and super-Earths would be halted.

Methods. For this analysis we use iterative 2D radiation hydrostatic disk models which include irradiation by the star, and dust sublimation and deposition depending on the local temperature and vapor pressure.

Results. Our results show the temperature and density structure of a gas and dust disk around a young Sun-like star. We perform a parameter study by varying the magnetized turbulence onset temperature, the accretion stress, the dust mass fraction, and the mass accretion rate. Our models feature a gas-only inner disk, a silicate sublimation front and dust rim starting at around 0.08 au, an ionization transition zone with a corresponding density jump, and a pressure maximum which acts as a pebble trap at around 0.12 au. Migration torque maps show Earth- and super-Earth-mass planets halt in our model disks at orbital periods ranging from 10 to 22 days.

Conclusions. Such periods are in good agreement with both the inferred location of the innermost planets in multi-planetary systems, and the break in planet occurrence rates from the Kepler sample at 10 days. In particular, models with small grains depleted produce a trap located at a 10-day orbital period, while models with a higher abundance of small grains present a trap at around a 17-day orbital period. The snow line lies at 1.6 au, near where the occurrence rate of the giant planets peaks. We conclude that the dust sublimation zone is crucial for forming close-in planets, especially when considering tightly packed super-Earth systems.

Accepted by A&A (630, A147, 2019)

Rotational evolution of solar-type protostars during the star-disk interaction phase

F. Gallet, C. Zanni, and L. Amard

1 Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France; 2 INAF - Osservatorio Astrofisico di Torino, Strada Osservatorio 20, 10025, Pino Torinese, Italy; 3 University of Exeter, Department of Physics & Astronomy, Stoker Road, Devon, Exeter, EX4 4QL, UK

E-mail contact: florian.gallet1 at univ-grenoble-alpes.fr

The early pre-main sequence phase during which they are still likely surrounded by an accretion disk represents a puzzling stage of the rotational evolution of solar-mass stars. While they are still accreting and contracting they do not seem to spin-up substantially. It is usually assumed that the magnetospheric star-disk interaction tends to maintain the stellar rotation period constant (disk-locking), but this hypothesis has never been thoroughly verified. Our aim is to investigate the impact of the star-disk interaction mechanism on the stellar spin evolution during the accreting pre-main sequence phases. We devise a model for the torques acting onto the stellar envelope based on studies of stellar winds and develop a new prescription for the star-disk coupling grounded on numerical simulations of star-disk interaction and magnetospheric ejections. We then use this torque model to follow the long-term evolution of the stellar rotation. Magnetospheric ejections and accretion powered stellar winds play an important role in the spin evolution of solar-type stars. However, kG dipolar magnetic fields are not uncommon but not ubiquitous. Besides, it is unclear how massive stellar winds can be powered, while numerical models of the propeller regime display a strong variability that has no observational confirmation. Better observational statistics and more realistic models could contribute to soften our calculations’ requirements.

Accepted by A&A
IRAS 09002-4732: A Laboratory for the Formation of Rich Stellar Clusters
Konstantin V. Getman$^1$, Eric D. Feigelson$^1$, Michael A. Kuhn$^2$, Patrick S. Broos$^1$ and Gordon P. Garmire$^1$

1 Department of Astronomy & Astrophysics, Pennsylvania State University, 525 Davey Lab, University Park, PA 16802; 2 Department of Astronomy, California Institute of Technology, Pasadena CA 91125

E-mail contact: gkosta at astro.psu.edu

IRAS 09002-4732 is a poorly studied embedded cluster of stars in the Vela Molecular Ridge at a distance of 1.7 kpc. Deep observations with the Chandra X-ray Observatory, combined with existing optical and infrared surveys, produce a catalog of 441 probable pre-main sequence members of the region. The stellar spatial distribution has two components: most stars reside in a rich, compact, elliptical cluster, but a minority reside within a molecular filament several parsecs long that straddles the cluster. The filament has active distributed star formation with dozens of unclustered protostars. The cluster pre-main sequence population is $\lesssim$ 0.8 Myr old and deeply embedded; its most massive member is extremely young producing an ultracompact H II region. The cluster total population deduced from the X-ray luminosity function is surprisingly rich, twice that of the Orion Nebula Cluster. The cluster core is remarkably dense where strong N-body interactions should be occurring; its Initial Mass Function may be deficient in massive stars. We infer that IRAS 09002-4732 is a rare case where a rich cluster is forming today in a molecular filament, consistent with astrophysical models of cluster formation in clouds that involve the hierarchical formation and merging of groups in molecular filaments.

Accepted by The Astronomical Journal


Chemical complexity in high-mass star formation: An observational and modeling case study of the AFGL 2591 VLA 3 hot core
C. Gieser$^{1,2}$, D. Semenov$^{1,3}$, H. Beuther$^1$, A. Ahmad$^{1,2}$, J.C. Mottram$^1$, Th. Henning$^1$, M. Beltran$^4$, L.T. Maud$^5$, F. Bosco$^{1,2}$, S. Leurini$^6$, T. Peters$^7$, P. Klaassen$^8$, R. Kuiper$^9$, S. Feng$^{10,11}$, J.S. Urquhart$^{12}$, L. Moscadelli$^4$, T. Csengeri$^{13}$, S. Lumsden$^{14}$, J.M. Winters$^{15}$, S. Suri$^1$, Q. Zhang$^{16}$, R. Pudritz$^{17}$, A. Palau$^{18}$, K.M. Menten$^{19}$, R. Galvan-Madrid$^{18}$, F. Wyrowski$^{19}$, P. Schilke$^{19}$, Á. Sánchez-Monge$^{19}$, H. Linz$^1$, K.G. Johnston$^{14}$, I. Jiménez-Serra$^{20}$, S. Longmore$^{21}$ and T. Möller$^{19}$

1 Max Planck Institute for Astronomy, Königstuhl 17,69117 Heidelberg, Germany; 2 Fellow of the International Max Planck Research School for Astronomy and Cosmic Physics at the University of Heidelberg (IMPRS-HD); 3 Department of Chemistry, Ludwig Maximilian University, Butenandtstr. 5-13, 81377 Munich, Germany; 4 INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy; 5 European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching, Germany; 6 INAF, Osservatorio Astronomico di Cagliari, Via della Scienza 5, I-09047, Selargius (CA), Italy; 7 Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Str. 1, D-85748 Garching, Germany; 8 UK Astronomy Technology Centre, Royal Observatory Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, UK; 9 Institute of Astronomy and Astrophysics, University of Tübingen, Auf der Morgenstelle 10, 72076, Tübingen, Germany; 10 National Astronomical Observatory of China, Datum Road 20, Chaoyang, Beijing, 100012, P. R. China; 11 CAS Key Laboratory of FAST, NAOC, Chinese Academy of Sciences; 12 Centre for Astrophysics and Planetary Science, University of Kent, Canterbury, CT2 7NH, UK; 13 Max Planck Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany; 14 School of Physics and Astronomy, University of Leeds, Leeds LS29JT, United Kingdom; 15 IRAM, 300 rue de la Piscine, Domaine Universitaire de Grenoble, 38406 St.-Martin-d’Hères, France; 16 Center for Astrophysics Harvard & Smithsonian, 60 Garden Street, Cambridge, MA 02138, USA; 17 Department of Physics and Astronomy, McMaster University, 1280 Main St. W, Hamilton, ON L8S 4M1, Canada; 18 Instituto de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, 58090 Morelia, Michoacán, México; 19 I. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, D-50937, Köln, Germany; 20 Centro de Astrobiología (CSIC, INTA), Ctra. de Ajalvir, km. 4, Torrejón de Ardoz, 28850 Madrid, Spain; 21 Astrophysics Research Institute, Liverpool John Moores University, Liverpool, L3 5RF, UK

E-mail contact: gieser at mpia.de

Aims. In order to understand the observed molecular diversity in high-mass star-forming regions, we have to determine the underlying physical and chemical structure of those regions at high angular resolution and over a range of
evolutionary stages.

Methods. We present a detailed observational and modeling study of the hot core VLA 3 in the high-mass star-forming region AFGL 2591, which is a target region of the NOrthern Extended Millimeter Array (NOEMA) large program CORE. Using NOEMA observations at 1.37 mm with an angular resolution of \( \sim 0.42 \text{''} (1400 \text{ au at 3.33 kpc}) \), we derived the physical and chemical structure of the source. We modeled the observed molecular abundances with the chemical evolution code MUSCLE (MUlti Stage Chemical codE).

Results. With the kinetic temperature tracers CH$_3$CN and H$_2$CO we observe a temperature distribution with a power-law index of \( q = 0.41 \pm 0.08 \). Using the visibilities of the continuum emission we derive a density structure with a power-law index of \( p = 1.7 \pm 0.1 \). The hot core spectra reveal high molecular abundances and a rich diversity in complex molecules. The majority of the molecules have an asymmetric spatial distribution around the forming protostar(s), which indicates a complex physical structure on scales \(< 1400 \text{ au} \). In contrast to the observational analysis, our chemical modeling predicts a lower density power-law index of \( p < 1.4 \). Reasons for this discrepancy are discussed.

Conclusions. Combining high spatial resolution observations with detailed chemical modeling allows us to derive a concise picture of the physical and chemical structure of the famous AFGL 2591 hot core. The next steps are to conduct a similar analysis for the whole CORE sample, and then use this analysis to constrain the chemical diversity in high-mass star formation to a much greater depth.

Accepted by Astronomy & Astrophysics


Dark Collapse or Supermassive Star: a fundamental limit imposed by hydrostatic equilibrium

L. Haemmerlé$^1$, G. Meynet$^1$, L. Mayer$^2$, R. S. Klessen$^3$, T. E. Woods$^4$ and A. Heger$^5$

$^1$ Département d’Astronomie, Université de Genève, chemin des Maillettes 51, CH-1290 Versoix, Switzerland; $^2$ Center for Theoretical Astrophysics and Cosmology, Institute for Computational Science, University of Zurich, Wintersubstrasse 190, CH-8057 Zurich, Switzerland; $^3$ Universität Heidelberg, Zentrum für Astronomie, Institut für Theoretische Astrophysik, Albert-Ueberle-Str. 2, D-69120 Heidelberg, Germany; $^4$ National Research Council, Herzberg Astronomy & Astrophysics, 5071 West Saanich Road, Victoria, BC V9E 2E7, Canada; $^5$ School of Physics and Astronomy, Monash University, VIC 3800, Australia

E-mail contact: lionel.haemmerle at unige.ch

Major mergers of gas-rich galaxies provide promising conditions for the formation of supermassive black holes (SMBHs; \( \gtrsim 10^5 \text{ M}_\odot \)) by direct collapse, since they can trigger mass inflows as high as \( 10^4 – 10^5 \text{ M}_\odot \text{ yr}^{-1} \) on sub-parsec scales. However, the channel of SMBH formation in this case, either dark collapse (direct collapse without prior stellar phase) or supermassive star (SMS; \( \gtrsim 10^4 \text{ M}_\odot \)), remains unknown. Here, we derive a criterion on mass and accretion rate for SMS formation by testing the consistency of hydrostatic equilibrium in case of rapid accretion. We compute hydrostatic models of SMSs accreting at \( 1 – 1000 \text{ M}_\odot \text{ yr}^{-1} \), and estimate the departures from equilibrium a posteriori by taking into account the finite speed of sound. We find that stars accreting above the atomic cooling limit (\( \gtrsim 10 \text{ M}_\odot \text{ yr}^{-1} \)) can maintain hydrostatic equilibrium only once they are supermassive. In this case, they evolve adiabatically with a hylotropic structure, i.e. entropy is locally conserved and scales with the square-root of the mass coordinate. Our results imply that stars can become supermassive by accretion only at the rates of atomically cooled haloes (\( \sim 0.1 – 10 \text{ M}_\odot \text{ yr}^{-1} \)). Once they are supermassive, larger rates are possible. Dark collapse occurs if the accretion rate exceeds the atomic cooling limit before a SMS already formed.

Accepted by A&A


Characterization of mid-infrared polarization due to scattering in protoplanetary disks

Stefan Heese$^1$ and Sebastian Wolf$^1$

$^1$ University of Kiel, Institute of Theoretical Physics and Astrophysics, Leibnizstrasse 15, 24118 Kiel, Germany

E-mail contact: sheese at astrophysik.uni-kiel.de
It is generally assumed that magnetic fields play an important role in the formation and evolution of protoplanetary disks. One way of observationally constraining magnetic fields is to measure polarized emission and absorption produced by magnetically aligned elongated dust grains. The fact that radiation also becomes linearly polarized by light scattering at optical to millimeter wavelengths complicates magnetic field studies. We characterize the linear polarization of mid-infrared radiation due to scattering of the stellar radiation and dust thermal re-emission radiation (self-scattering). We find that the thermal re-emission radiation is stronger than the scattered stellar radiation for disks with inner holes smaller than 10 au within the considered parameter range. The mid-infrared polarization due to scattering shows several clear trends: For scattered stellar radiation only, the linear polarization degree decreases slightly with increasing radial distance, while it increases with radial distance for thermal re-emission radiation only and for a combination of scattered stellar radiation and thermal re-emission radiation. The linear polarization degree decreases with increasing disk flaring and luminosity of the central star. An increasing inner radius shifts the increase of the linear polarization degree further outside, while a larger scale height increases the linear polarization degree for small radial distances and decreases this degree further outside. For longer wavelengths, the linear polarization degree converges more slowly.

Accepted by Astronomy & Astrophysics


First detection of submillimeter-wave $^{13}$C I $^3P_1 - ^3P_0$ emission in a gaseous debris disk of 49 Ceti with ALMA

Aya E. Higuchi¹, Yoko Oya² and Satoshi Yamamoto²

¹ National Astronomical Observatory of Japan, Osawa, Mitaka, Tokyo 181-8588, Japan; ² Department of Physics, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

E-mail contact: aya.higuchi at nao.ac.jp

We have detected the submillimeter-wave fine-structure transition $^3P_1 - ^3P_0$ of $^{13}$C, [C I], in the gaseous debris disk of 49 Ceti with the Atacama Large Millimeter/submillimeter Array (ALMA). Recently, the [C I] $^3P_1 - ^3P_0$ emission has been spatially resolved in this source with ALMA. In this dataset, the $F=3/2 - 1/2$ hyperfine component of [C I], which is blue-shifted by 2.2 km s$^{-1}$ from the normal species line, [C I], has been identified in the outer part of the 49 Ceti disk, thanks to the narrow velocity widths of the gas components. The [C I]/[$^{13}$C I] line intensity ratio is found to be 12±3, which is significantly lower than the $^{12}$C/$^{13}$C abundance ratio of 77 in the interstellar medium. This result clearly reveals that the [C I] emission is optically thick in 49 Ceti at least partly, as speculated by the previous work. As far as we know, this is the first detection of [$^{13}$C I] $^3P_1 - ^3P_0$ emission at 492 GHz not only in debris disks but also in the interstellar medium.

Accepted by ApJL


Nonideal MHD Simulation of HL Tau Disk: Formation of Rings

Xiao Hu¹, Zhaohuan Zhu¹, Satoshi Okuzumi², Xue-Ning Bai³,⁴, Lile Wang⁵, Kengo Tomida⁶ and and James M. Stone⁷

¹ Department of Physics and Astronomy, University of Nevada, Las Vegas, 4505 South Maryland Parkway, Las Vegas, NV 89154, USA; ² Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Meguro, Tokyo, 152-8551, Japan; ³ Institute for Advanced Study, Tsinghua University, Beijing 100084, China; ⁴ Department of Astronomy, Tsinghua University, Beijing 100084, China; ⁵ Center for Computational Astrophysics, Flatiron Institute, New York, NY 10010, USA; ⁶ Department of Earth and Space Science, Osaka University, Toyonaka, Osaka, 560-0043, Japan; ⁷ Department of Astrophysical Sciences, 4 Ivy Lane, Peyton Hall, Princeton University, Princeton, NJ 08544, USA

E-mail contact: xiao.hu.astro at gmail.com

Recent high-resolution observations unveil ring structures in circumstellar disks. The origin of these rings has been widely investigated under various theoretical scenarios. In this work we perform global 3D nonideal MHD simulations including effects from both ohmic resistivity and ambipolar diffusion (AD) to model the HL Tau disk. The nonideal MHD diffusion profiles are calculated based on the global dust evolution calculation including sintering effects. Disk
ionization structure changes dramatically across the snow line due to the change of dust size distribution close to the snow line of major volatiles. We find that accretion is mainly driven by disk wind. Gaps and rings can be quickly produced from different accretion rates across the snow line. Furthermore, AD leads to highly preferential accretion at the midplane, followed by magnetic reconnection. This results in a local zone of decretion that drains the mass in the field reconnection area, which leaves a gap and an adjacent ring just outside of it. Overall, under favorable conditions, both snow lines and nonideal MHD effects can lead to gaseous gaps and rings in protoplanetary disks.

Accepted by ApJ

An unusually large gaseous transit in a debris disc
Daniela P. Iglesias1,2, Johan Olofsson1,2, Amelia Bayo1,2, Sebastian Zieba3, Matas Montesinos1,2,4, Jonathan Smoker5, Grant M. Kennedy6, Nicolas Godoy1,2, Blake Pantoja7, Geert Jan Talens8, Zahed Wahhaj5 and Catalina Zamora1,2

1 Instituto de Fisica y Astronomia, Facultad de Ciencias, Universidad de Valparaiso, Av. Gran Bretana 1111, 5030 Casilla, Valparaiso, Chile; 2 Nucleo Milenio de Formacion Planetaria - NPF, Universidad de Valparaiso, Av. Gran Bretana 1111, Valparaiso, Chile; 3 Universitat Innsbruck, Institut fur Astro- und Teilchenphysik, Technikerstrasse 25, 6020 Innsbruck, Austria; 4 Chinese Academy of Sciences South America Center for Astronomy, National Astronomical Observatories, CAS, Beijing 100012, China; 5 European Southern Observatory, Alonso de Cordova 3107, Vitacura, Santiago, Chile; 6 Department of Physics, University of Warwick, Gibbet Hill Road, Coventry CV4 7AL, UK; 7 Departamento de Astronomia, Universidad de Chile, Camino el Observatorio 1515, Las Condes, Santiago, Chile, Casilla 36-D; 8 Institut de Recherche sur les Exoplanetes, Departement de Physique, Universite de Montreal, Montral, QC H3C 3J7, Canada

E-mail contact: dpiglesi@uc.cl

We present the detection of an unusually large transient gas absorption in several ionized species in the debris disc star HD 37306 using high-resolution optical spectra. We have been analysing a large sample of debris discs searching for circumstellar gas absorptions aiming to determine the frequency of gas in debris discs. HD 37306 stood out showing remarkably broad absorptions superimposed onto several photospheric Ca II, Fe II and Ti II lines. The observed absorptions, unlike typical exocometary transits, lasted for at least eight days. Here we analyse simultaneous spectroscopic and photometric data of the event and evaluate different scenarios that might explain the observed features. We conclude that the most likely scenario might be an exocometary break-up releasing a significant amount of gas close to the star, producing an occulting ring/torus shape.

Accepted by MNRAS

Fingerprints of the protosolar cloud collapse in the Solar System II: Nucleosynthetic anomalies in meteorites
Emmanuel Jacquet1, Francesco C. Pignatale1,2, Marc Chaussidon2 and Sébastien Charnoz2

1 Muséum national d’Histoire naturelle, UMR 7590, CP52, 57 rue Cuvier, 75005, Paris, France; 2 Institut de Physique du Globe de Paris (IPGP), 1 rue Jussieu, 75005, Paris, France

E-mail contact: emanuel.jacquet at mmhm.fr

The isotopic heterogeneity of the Solar System shown by meteorite analyses is more pronounced for its earliest objects, the Calcium-Aluminum-rich Inclusions (CAIs). This suggests that it was inherited from spatial variations in different Stardust populations in the protosolar cloud. We model the formation of the solar protoplanetary disk following its collapse and find that the solid-weighted standard deviation of different nucleosynthetic contributions in the disk is reduced by one order of magnitude compared to the protosolar cloud, whose successive isotopic signatures are fossilized by CAIs. The enrichment of carbonaceous chondrites in r-process components, whose proportions are inferred to have diminished near the end of infall, is consistent with their formation at large heliocentric distances, where the early signatures would have been preferentially preserved after outward advection. We also argue that thermal processing had little effect on the (mass-independent) isotopic composition of bulk meteorites for refractory elements.
Distortion of Magnetic Fields in Barnard 68
Ryo Kandori1, Motohide Tamura1,2,3, Masao Saito1, Kohji Tomisaka2, Tomoaki Matsumoto4, Nobuhiko Kusakabe1, Jungmi Kwon3, Takahiro Nagayama5, Tetsuya Nagata6, Ryo Tazaki7 and Ken’ichi Tatematsu2

1 Astrobiology Center of NINS, 2-21-1, Osawa, Mitaka, Tokyo 181-8588, Japan; 2 National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan; 3 Department of Astronomy, The University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan; 4 Faculty of Sustainability Studies, Hosei University, Fujimi, Chiyoda-ku, Tokyo 102-8160; 5 Kagoshima University, 1-21-35 Korimoto, Kagoshima 890-0065, Japan; 6 Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan; 7 Astronomical Institute, Graduate School of Science Tohoku University, 6-3 Aramaki, Aoba-ku, Sendai 980-8578, Japan

E-mail contact: r.kandori at nao.ac.jp

The magnetic field structure, kinematical stability, and evolutionary status of the starless dense core Barnard 68 (B68) are revealed based on the near-infrared polarimetric observations of background stars, measuring the dichroically polarized light produced by aligned dust grains in the core. After subtracting unrelated ambient polarization components, the magnetic fields pervading B68 are mapped using 38 stars and axisymmetrically distorted hourglass-like magnetic fields are obtained, although the evidence for the hourglass field is not very strong. On the basis of simple 2D and 3D magnetic field modeling, the magnetic inclination angles on the plane-of-sky and in the line-of-sight direction are determined to be $47^\circ \pm 5^\circ$ and $20^\circ \pm 10^\circ$, respectively. The total magnetic field strength of B68 is obtained to be $26.1 \pm 0.8 \mu G$. The critical mass of B68, evaluated using both magnetic and thermal/turbulent support, is $M_{cr} = 2.30 \pm 0.20 \, M_\odot$, which is consistent with the observed core mass of $M_{core} = 2.1 \, M_\odot$, suggesting nearly critical state. We found a relatively linear relationship between polarization and extinction up to $A_V \sim 30$ mag toward the stars with deepest obscuration. Further theoretical and observational studies are required to explain the dust alignment in cold and dense regions in the core.

Effect of wind-driven accretion on planetary migration
C.N. Kimmig1, C.P. Dullemond1, W. Kley2

1 Zentrum für Astronomie, Heidelberg University, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany; 2 Institut für Astronomie und Astrophysik, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany

E-mail contact: mail at carolin.kim

Planetary migration is a key link between planet formation models and observed exoplanet statistics. So far the theory of migration has focused on the interaction of planets with an inviscid or viscously evolving disk. Turbulent viscosity is thought to be the main driver of disk evolution and is known to affect the migration process. Recently, the topic of wind-driven accretion is experiencing a renaissance, as evidence is mounting that PPDs may be less turbulent than previously thought, and 3-D non-ideal MHD modeling of the wind-launching process is maturing.

Aim. We wish to investigate how wind-driven accretion may affect migration. We aim for a qualitative exploration of the main effects, rather than a quantitative prediction.

Methods. We perform 2-D hydrodynamic simulations with the FARGO3D code in the $(r, \phi)$-plane. The vertical coordinate and the launching of the wind are not treated explicitly. Instead, the torque of the wind onto the disk is treated using a simple 2-parameter formula treating the wind mass loss rate and the lever arm.

Results. We find that the wind-driven accretion process has a different way of replenishing the co-orbital region than the viscous accretion. The former always injects mass from the outer edge of the co-orbital region and removes mass from the inner edge, while the latter injects or removes mass from the co-orbital region depending on the radial density gradients in the disk. The migration behavior can differ very much and under certain conditions it can drive rapid type-III-like outward migration. We derive an analytic expression for the parameters under which this outward migration occurs.
Conclusion. If wind-driven accretion plays a role in the secular evolution of PPDs, migration studies have to include this process as well, because it can strongly affect the resulting migration rate and direction.

Accepted by A&A


Carina’s Pillars of Destruction: the view from ALMA

P.D. Klaassen¹, M.R. Reiter¹, A.F. McLeod²-³, J.C. Mottram⁴, J.E. Dale⁵ and M. Gritschneder⁶

¹ UK Astronomy Technology Centre; ² UC Berkeley; ³ Texas Tech; ⁴ Max Planck Institute for Astronomy; ⁵ U. Hertfordshire; ⁶ Ludwig-Maximilians-Universität

E-mail contact: pamela.klaassen at stfc.ac.uk

Forming high-mass stars have a significant effect on their natal environment. Their feedback pathways, including winds, outflows, and ionising radiation, shape the evolution of their surroundings which impacts the formation of the next generation of stars. They create or reveal dense pillars of gas and dust towards the edges of the cavities they clear. They are modelled in feedback simulations, and the sizes and shapes of the pillars produced are consistent with those observed. However, these models predict measurably different kinematics which provides testable discriminants.

Here we present the first ALMA Compact Array (ACA) survey of 13 pillars in Carina, observed in $^{12}\text{CO}$, $^{13}\text{CO}$ and $^{18}\text{O}$ J=2-1, and the 230 GHz continuum. The pillars in this survey were chosen to cover a wide range in properties relating to the amount and direction of incident radiation, proximity to nearby irradiating clusters and cloud rims, and whether they are detached from the cloud. With these data, we are able to discriminate between models. We generally find pillar velocity dispersions of $<1\text{ km s}^{-1}$ and that the outer few layers of molecular emission in these pillars show no significant offsets from each other, suggesting little bulk internal motions within the pillars. There are instances where the pillars are offset in velocity from their parental cloud rim, and some with no offset, hinting at a stochastic development of these motions.

Accepted by MNRAS


Properties of the dense core population in Orion B as seen by the Herschel Gould Belt survey

V. Könyves¹-², Ph. André², D. Arzoumanian³, N. Schneider⁴, A. Men’shchikov², S. Bontemps⁵, B. Ladjelate⁶, P. Didelon², S. Pezzuto⁷, M. Benedettini⁷, A. Bracco⁸, J. Di Francesco⁹,¹⁰, S. Goodwin¹¹, K. L. J. Rygl¹², Y. Shimajiri², L. Spinočlio⁷, D. Ward-Thompson¹ and G. J. White¹³,¹⁴

¹ Jeremiah Horrocks Institute, University of Central Lancashire, Preston PR1 2HE, UK; ² Laboratoire d’Astrophysique (AIM), CEA/DRF, CNRS, Université Paris-Saclay, Université Paris Diderot, Sorbonne Paris Cité, 91191 Gif-sur-Yvette, France; ³ Department of Physics, Graduate School of Science, Nagoya University, Nagoya 464-8602, Japan; ⁴ I. Physik. Institut, University of Cologne, Cologne, Germany; ⁵ Laboratoire d’Astrophysique de Bordeaux - UMR 5804, CNRS - Université Bordeaux 1, BP 89, 33270 Floirac, France; ⁶ Instituto de Radioastronomía Milimétrica (IRAM), Av. Divina Pastora 7, Núcleo Central, 18012 Granada, Spain; ⁷ Istituto di Astrofisica e Planetologia Spaziali-INAF, Via Fosso del Cavaliere 100, I-00133 Roma, Italy; ⁸ Laboratoire de Physique de l’École Normale Supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université de Paris, Paris, France; ⁹ Department of Physics and Astronomy, University of Victoria, P.O. Box 355, STN CSC, Victoria, BC, V8W 3P6, Canada; ¹⁰ National Research Council Canada, 5071 West Saanich Road, Victoria, BC, V9E 2E7, Canada; ¹¹ Department of Physics and Astronomy, University of Sheffield, Hounsfield Road, Sheffield S3 7RH, UK; ¹² INAF–Istituto di Radioastronomia, and Italian ALMA Regional Centre, Via Gobetti 101, I-40129 Bologna, Italy; ¹³ Department of Physics and Astronomy, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK; ¹⁴ RAL Space, STFC Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire,OXI 1QX, UK

E-mail contact: vera.konyves at gmail.com

We present a detailed study of the Orion B molecular cloud complex ($d \sim 400\text{ pc}$), which was imaged with the PACS and SPIRE photometric cameras at wavelengths from 70 $\mu\text{m}$ to 500 $\mu\text{m}$ as part of the Herschel Gould Belt survey (HGBS). We release new high-resolution maps of column density and dust temperature for the whole complex, derived in the
same consistent manner as for other HGBS regions. In the filamentary sub-regions NGC 2023/2024, NGC 2068/2071, and L1622, a total of 1768 starless dense cores were identified based on Herschel data, 490–804 (∼ 28 – 45%) of which are self-gravitating prestellar cores that will likely form stars in the future. A total of 76 protostellar dense cores were also found. The typical lifetime of the prestellar cores was estimated to be $t_{\text{pre, Orion B}} = 1.7_{-0.6}^{+0.8}$ Myr. The prestellar core mass function (CMF) derived for the whole sample of prestellar cores peaks at $A_V^\text{bg} \sim 0.5 M_\odot$ (in $dN/d\log M$ format) and is consistent with a power law with logarithmic slope $-1.27 \pm 0.24$ at the high-mass end, compared to the Salpeter slope of $-1.35$. In the Orion B region, we confirm the existence of a transition in prestellar core formation efficiency (CFE) around a fiducial value $A_V^\text{bg} \sim 7$ mag in background visual extinction, similar to the trend observed with Herschel in other regions, such as the Aquila cloud. This is not a sharp threshold, however, but a smooth transition between a regime with very low prestellar CFE at $A_V^\text{bg} < 5$ and a regime with higher, roughly constant CFE at $A_V^\text{bg} \gtrsim 10$. The total mass in the form of prestellar cores represents only a modest fraction (∼ 20%) of the dense molecular cloud gas above $A_V^\text{bg} \gtrsim 7$ mag. About 60–80% of the prestellar cores are closely associated with filaments, and this fraction increases up to > 90% when a more complete sample of filamentary structures is considered. Interestingly, the median separation observed between nearest core neighbors corresponds to the typical inner filament width of ∼ 0.1 pc, which is commonly observed in nearby molecular clouds. Analysis of the CMF observed as a function of background cloud column density shows that the most massive prestellar cores are spatially segregated in the highest column density areas, and suggests that both higher- and lower-mass prestellar cores may form in denser filaments.

Accepted by A&A


The role of C/O in nitrile astrochemistry in PDRs and planet-forming disks

Romane Le Gal$^1$, Madison T. Brady$^2$, Karin I. Öberg$^1$, Evelyne Roueff$^3$, and Franck Le Petit$^3$

$^1$ Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA; $^2$ California Institute of Technology, Pasadena, CA 91125, USA; $^3$ Sorbonne Université, Observatoire de Paris, Université PSL, CNRS, LERMA, F-92190, Meudon, France

E-mail contact: romane.le_gal at cfa.harvard.edu

Complex nitriles, such as HC$_3$N, and CH$_3$CN, are observed in a wide variety of astrophysical environments, including at relatively high abundances in photon-dominated regions (PDR) and the UV exposed atmospheres of planet-forming disks. The latter have been inferred to be oxygen-poor, suggesting that these observations may be explained by organic chemistry in C-rich environments. In this study we first explore if the PDR complex nitrile observations can be explained by gas-phase PDR chemistry alone if the elemental C/O ratio is elevated. In the case of the Horsehead PDR, we find that gas-phase chemistry with C/O $\gtrsim 0.9$ can indeed explain the observed nitrile abundances, increasing predicted abundances by several orders of magnitude compared to standard C/O assumptions. We also find that the nitrile abundances are sensitive to the cosmic ray ionization treatment, and provide constraints on the branching ratios between CH$_3$CN and CH$_3$NC productions. In a fiducial disk model, an elevated C/O ratio increases the CH$_3$CN and HC$_3$N productions by more than an order of magnitude, bringing abundance predictions within an order of magnitude to what has been inferred from observations. The C/O ratio appears to be a key variable in predicting and interpreting complex organic molecule abundances in photon-dominated regions across a range of scales.

Accepted by ApJ


Assessing the Performance of Molecular Gas Clump Identification Algorithms

Chong Li$^{1,2}$, Hongchi Wang$^1$, Yuanwei Wu$^3$, Yuehui Ma$^{1,2}$ and Lianghao Lin$^{1,4}$

$^1$ Purple Mountain Observatory and Key Laboratory of Radio Astronomy, Chinese Academy of Sciences, 10 Yuanhua Road, Nanjing 210033, China; $^2$ University of Chinese Academy of Sciences, 19A Yuquan Road, Shijingshan District, Beijing 100049, China; $^3$ National Time Service Center, Key Laboratory of Precise Positioning and Timing Technology, Chinese Academy of Sciences, Xi’an 710600, China; $^4$ School of Astronomy and Space Science, University of Science and Technology of China, 96 jinzhai Road, Hefei 230026, China

E-mail contact: chongli at pmo.ac.cn
The detection of clumps (cores) in molecular clouds is an important issue in sub-millimetre astronomy. However, the completeness of the identification and the accuracy of the returned parameters of the automated clump identification algorithms are still not clear by now. In this work, we test the performance and bias of the GaussClumps, ClumpFind, Fellwalker, Reinhold, and Dendrograms algorithms in identifying simulated clumps. By designing the simulated clumps with various sizes, peak brightness, and crowdedness, we investigate the characteristics of the algorithms and their performance. In the aspect of detection completeness, Fellwalker, Dendrograms, and Gaussclumps are the first, second, and third best algorithms, respectively. The numbers of correct identifications of the six algorithms gradually increase as the size and SNR of the simulated clumps increase and they decrease as the crowdedness increases. In the aspect of the accuracy of retrieved parameters, Fellwalker and Dendrograms exhibit better performance than the other algorithms. The average deviations in clump parameters for all algorithms gradually increase as the size and SNR of clumps increase. Most of the algorithms except Fellwalker exhibit significant deviation in extracting the total flux of clumps. Taken altogether, Fellwalker, Gaussclumps, and Dendrograms exhibit the best performance in detection completeness and extracting parameters. The deviation in virial parameter for the six algorithms is relatively low. When applying the six algorithms to the clump identification for the Rosette molecular cloud, ClumpFind1994, ClumpFind2006, Gaussclumps, Fellwalker, and Reinhold exhibit performance that is consistent with the results from the simulated test.

Accepted by RAA


Binary outflows from young stars: interaction of co-orbital jet and wind

Chris J.R. Lynch¹, Michael D. Smith¹ and Simon C.O. Glover²

¹ Centre for Astrophysics & Planetary Science, The University of Kent, Canterbury, Kent CT2 7NH, U.K.; ² Universität Heidelberg, Zentrum für Astronomie, Institut für theoretische Astrophysik, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

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

Jets from young stellar objects provide insight into the workings of the beating heart at the centre of star forming cores. In some cases, multiple pulsed outflows are detected such as the atomic and molecular jets from a proposed binary system in the T Tauri star HH 30. We investigate here the development and propagation of duelling atomic and molecular outflows stemming from the two stars in co-orbit. We perform a series of numerical experiments with the ZEUS-MP code with enhanced cooling and chemistry modules. The aim of this work is to identify signatures on scales of order 100 AU. The jet sources are off the grid domain and so it is the propagation and interaction from ~ 20 AU out to 100 AU simulated here. We find that the molecular flow from the orbiting source significantly disturbs the atomic jet, deflecting and twisting the jet and disrupting the jet knots. Regions of high ionisation are generated as the atomic jet rams through the dense molecular outflow. Synthetic images in atomic and molecular lines are presented which demonstrate identifying signatures. In particular, the structure within the atomic jet is lost and Hα may trace the walls of the present CO cavity or where the walls have been recently. These results provide a framework for the interpretation of upcoming high resolution observations.

Accepted by MNRAS


Low dust emissivities and radial variations in the envelopes of Class 0 protostars: a signature of early grain growth?

Galametz Maud¹, Maury Analle¹,₂, Valdivia Valeska¹, Testi Leonardo³,⁴, Belloche Arnaud⁵ and Andr Philippe¹

¹ AIM, CEA, CNRS, Université Paris-Saclay, Université Paris Diderot, Sorbonne Paris Cit, F-91191 Gif-sur-Yvette, France; ² Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA; ³ ESO, Karl Schwarzschild Strasse 2, 85748 Garching bei München, Germany; ⁴ INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy; ⁵ Max-Planck-Institut für Radioastronomie, Auf dem Hgel 69, 53121 Bonn, Germany

E-mail contact: maud.galametz at cca.fr
Analyzing the properties of dust and its evolution in the early phases of star formation is crucial to put constraints on the collapse and accretion processes as well as on the pristine properties of planet-forming seeds. We analyze PdBI observations at 1.3 and 3.2 mm for 12 Class 0 protostars obtained as part of the CALYPSO survey and derive dust emissivity index (beta) profiles as a function of the envelope radius at 200-2000 au scales. Most of the protostellar envelopes show low dust emissivity indices decreasing toward the central regions. The decreasing trend remains after correction of the (potentially optically-thick) central region emission, with surprisingly low beta (lower than 1) values across most of the envelope radii of NGC1333-IRAS4A, NGC1333-IRAS4B, SVS13B, and Serpens-SMM4. We discuss the various processes that could explain such low and varying dust emissivity indices at envelope radii 200-2000 au. Our observations of extremely low dust emissivity indices could trace the presence of large (mm-size) grains in Class 0 envelopes and a radial increase of the dust grain size toward the inner envelope regions. While it is expected that large grains in young protostellar envelopes could be built via grain growth and coagulation, we stress that the typical timescales required to build mm grains in current coagulation models are at odds with the youth of our Class 0 protostars. Additional variations in the dust composition could also partly contribute to the low beta we observe. The steepness of the beta radial gradient depends strongly on the envelope mass, which might favor a scenario where large grains are built in high density protostellar disks and transported to the intermediate envelope radii, for example with the help of outflows and winds.

Accepted by A&A


Carbon depletion observed inside T Tauri inner rims: Formation of icy, kilometer size planetesimals by 1 Myr
M.K. McClure

1 Marie Curie Postdoctoral Fellow, Anton Pannekoek Institute for Astronomy, Universiteit van Amsterdam, Science Park 904, 1098 XH Amsterdam, Netherlands
E-mail contact: m.k.mcclure at uva.nl

The carbon content of protoplanetary disks is an important parameter to characterize planets formed at different disk radii. There is some evidence from far-infrared and submillimeter observations that gas in the outer disk is depleted in carbon, with a corresponding enhancement of carbon-rich ices at the disk midplane. Observations of the carbon content inside of the inner sublimation rim could confirm how much carbon remains locked in kilometer size bodies in the disk. Using near-infrared spectra, I self-consistently determine the stellar, extinction, veiling, and accretion properties of the 26 stars in my sample. From these values, I extract the inner disk excess of the target stars and identify a series of C\(^0\) recombination lines in 18 of these disks and use the CHIANTI atomic line database with an optically thin slab model to constrain the average \(n_e\), \(T_e\), and \(n_C\) for these lines in the five disks with a complete set of lines. By comparing these values with other slab models of the inner disk using the Cloudy photoionization code, I also constrain \(n_{H}\) and the carbon abundance, \(X_C\), and hence the amount of carbon ‘missing’ from the slab. The inner disks are extremely dense (\(n_{H} \sim 10^{16} \text{ cm}^{-3}\)), warm (\(T_e \sim 4500 \text{ K}\)), and moderately ionized (\(\log X_e \sim 3.3\)). Three of the five modeled disks show robust carbon depletion \(\leq 42\) relative to the solar value. I discuss multiple ways in which the ‘missing’ carbon could be locked out of the accreting gas. Given the high-density inner disk gas, evidence for radial drift, and lack of obvious gaps in these three systems, their carbon depletion is most consistent with the ‘missing’ carbon being sequestered in kilometer size bodies. For DR Tau, nitrogen and silicon are also depleted by factors of 45 and 4, respectively, suggesting that the kilometer size bodies into which the grains are locked were formed beyond the \(N_2\) snowline.

Accepted by A&A


Tracking Dust Grains During Transport and Growth in Protoplanetary Disks
William Misener\(^1,2\), Sebastiaan Krijt\(^3,4,5\) and Fred J. Ciesla\(^2,4\)

1 Department of Earth, Planetary, and Space Sciences, The University of California, Los Angeles, 595 Charles E. Young Drive East, Los Angeles, CA 90095, USA; 2 Department of the Geophysical Sciences, The University of Chicago, 5734
Protoplanetary disks are dynamic objects, within which dust grains and gas are expected to be redistributed over large distances. Evidence for this redistribution is seen both in other protoplanetary disks and in our own Solar System, with high-temperature materials thought to originate close to the central star found in the cold, outer regions of the disks. While models have shown this redistribution is possible through a variety of mechanisms, these models have generally ignored the possible growth of solids via grain-grain collisions that would occur during transit. Here we investigate the interplay of coagulation and radial and vertical transport of solids in protoplanetary disks, considering cases where growth is limited by bouncing or by fragmentation. We find that in all cases, growth effectively limits the ability for materials to be carried outward or preserved at large distances from the star. This is due to solids being incorporated into large aggregates which drift inwards rapidly under the effects of gas drag. We discuss the implications for mixing in protoplanetary disks, and how the preservation of high temperature materials in outer disks may require structures or outward flow patterns to avoid them being lost via radial drift.

Accepted by The Astrophysical Journal


Radial variations in grain sizes and dust scale heights in the protoplanetary disk around HD 163296 revealed by ALMA polarization observation

Satoshi Ohashi¹ and Akimasa Kataoka²

¹ RIKEN Cluster for Pioneering Research, 2-1, Hirosawa, Wako-shi, Saitama 351-0198, Japan; ² National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

E-mail contact: satoshi.ohashi at riken.jp

The HD 163296 disk shows ring and gap substructures with ALMA observations. In addition, this is the only disk where the rings and gaps are spatially resolved in millimeter-wave polarization measurements. In this paper, we conduct radiative transfer modeling that includes self-scattering polarization to constrain the grain size and its distribution. We found that the grain size and dust scale height are the key parameters for reproducing the radial and azimuthal distributions of the observed polarization signature. Radial variation is mainly determined by grain size. The polarization fraction is high if the particle size is \( \sim \lambda/2\pi \); it is low if the particle size is larger or smaller than this. In contrast, azimuthal variation in polarization is enhanced if the dust scale height is increased. Based on detailed modeling of the HD 163296 polarization, we found the following radial variations in the grain size and dust scale height. The maximum grain size was 140 microns in the gaps and significantly larger or smaller in the rings. The dust scale height is less than one-third the gas scale height inside the 70 au ring, and two-thirds the gas scale height outside the 70 au ring. Furthermore, we constrained the gas turbulence to be \( \alpha \lesssim 1.5 \times 10^{-3} \) in the 50 au gap and \( \alpha \sim 0.015 - 0.3 \) in the 90 au gap. The transition of the turbulence strength at the boundary of the 70 au ring indicates the existence of a dead zone.

Accepted by ApJ


Herschel spectroscopy of Massive Young Stellar Objects in the Magellanic Clouds

J.M. Oliveira¹, J. Th. van Loon¹, M. Sewilo²,³, M.Y. Lee⁴,⁵, V. Lebouteiller⁶, C.-H.R. Chen⁵, D. Cormier⁸, M.D. Filipovic⁷, L.R. Carlon⁸, R. Indebetouw⁹,¹⁰, S. Madden⁶, M. Meixner¹¹,¹², B. Sargent¹² and Y. Fukui¹³

¹ Lennard Jones Laboratories, School of Chemical & Physical Sciences, Keele University, Staffordshire ST5 5BG, UK; ² CRESST II and Exoplanets and Stellar Astrophysics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA; ³ Department of Astronomy, University of Maryland, College Park, MD 20742, USA; ⁴ Korea Astronomy and Space Science Institute, 776 Daedeokdae-ro, 34055 Daejeon, Republic of Korea; ⁵ Max-Planck-Institut fur Radioastronomie, Auf dem Hugel 69, 53121 Bonn, Germany; ⁶ Laboratoire AIM, CEA/Service d’Astrophysique,
The formation and the evolution of protoplanetary disks are important stages in the lifetime of stars. Terrestrial planets form or migrate within the innermost regions of these protoplanetary disks and so, the processes of disk evolution and planet formation are intrinsically linked. Studies of the dust distribution, composition, and evolution of these regions are crucial to understanding planet formation. We built a homogeneous observational dataset of Herbig Ae/Be disks with the aim of spatially resolving the sub au-scale region to gain a statistical understanding of their morphological and compositional properties, in addition to looking for correlations with stellar parameters.
such as luminosity, mass, and age. We observed 27 Herbig Ae/Be stars with the GRAVITY instrument installed at the combined focus of the Very Large Telescope Interferometer (VLTI) and operating in the near-infrared K-band, focused on the K-band thermal continuum, which corresponds to stellar flux reprocessed by the dust grains. Our sample covers a large range of effective temperatures, luminosities, masses, and ages for the intermediate- mass star population. The circumstellar disks in our sample also cover a range of various properties in terms of reprocessed flux, flared or flat morphology, and gaps. We developed semi-physical geometrical models to fit our interferometric data. Our best-fit models correspond to smooth and wide rings that support previous findings in the H-band, implying that wedge-shaped rims at the dust sublimation edge are favored. The measured closure phases are generally non-null with a median value of $10^\circ$, indicating spatial asymmetries of the intensity distributions. Multi-size grain populations could explain the closure phase ranges below 20-25$^\circ$ but other scenarios should be invoked to explain the largest ones. Our measurements extend the Radius-Luminosity relation to $10^{-4} L_\odot$ luminosity values and confirm the significant spread around the mean relation observed by PIONIER in the H-band. Gapped sources exhibit a large N-to-K band size ratio and large values of this ratio are only observed for the members of our sample that would be older than 1 Ma, less massive, and with lower luminosity. In the mass range of $2 M_\odot$, we do observe a correlation in the increase of the relative age with the transition from group II to group I, and an increase of the N-to-K size ratio. However, the size of the current sample does not yet permit us to invoke a clear, universal evolution mechanism across the Herbig Ae/Be mass range. The measured locations of the K-band emission in our sample suggest that these disks might be structured by forming young planets, rather than by depletion due to EUV, FUV, and X-ray photo-evaporation.

Accepted by A&A

https://doi.org/10.1051/0004-6361/201936403

A new take on the low-mass brown dwarf companions on wide-orbits in Upper-Scorpius

S. Petrus$^1$, M. Bonnefoy$^3$, G. Chauvin$^{2,4}$, C. Babusiaux$^1$, P. Delorme$^1$, A.-M. Lagrange$^1$, N. Florent$^1$, A. Bayo$^{1,4}$, M. Janson$^5$, B. Biller$^6$, E. Manjavacas$^7$, G.-D. Marleau$^8$, T. Kopytova$^{9,10}$

$^1$ Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France; $^2$ Unidad Mixta Internacional Franco-Chilena de Astronomía, CNRS/INSU UMI 3386 and Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile; $^3$ Instituto de Física y Astronomía, Universidad de Valparaíso, Chile; $^4$ Núcleo Milenio de Formación Planetaria (NPF), Chile; $^5$ Stockholm University Department of Astronomy AlbaNova University Center 10691 Stockholm Sweden; $^6$ Institute for Astronomy The University of Edinburgh Royal Observatory Blackford Hill Edinburgh EH9 3HJ U.K.; $^7$ W.M. Keck Observatory 65-1120 Mamalahoa Hwy. Kāne‘ohe, HI 96743 USA; $^8$ Institut für Astronomie und Astrophysik, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany $^9$ School of Earth & Space Exploration, Arizona State University, Tempe AZ 85287, USA; $^{10}$ Ural Federal University, Yekaterinburg 620002, Russia

E-mail contact: simon.petrus at univ-grenoble-alpes.fr

The Upper-Scorpius association (5–11 Myr) contains a unique population of low-mass ($M < 30 M_{\text{Jup}}$) brown-dwarfs. The detailed relative characterization of their physical properties (mass, radius, temperature, composition, ongoing accretion) offers the opportunity to potentially explore their origin and their mechanisms of formation. We aim at characterizing the chemical and physical properties of three young, late-M brown-dwarfs claimed to be companions of the Upper-Scorpius stars USc0161031.9–16191305, HIP77900, and HIP78530 using medium resolution spectroscopy at UV ($R \sim 3300$), optical ($R \sim 5400$), and near-infrared ($R \sim 4300$) wavelengths. The spectra of six free-floating analogues from the same association are analyzed for comparison and to explore the potential physical differences between these substellar objects. We also aim at analyzing emission lines at UV and optical wavelengths to investigate the presence of ongoing accretion processes. The X-Shooter spectrograph at VLT was used to obtain the spectra of our targets over the 0.3–2.5 μm range simultaneously. Performing a forward modelling of the observed spectra with the ForMoSA code (Nested Sampling Bayesian inference method in using BT-SETTL15 models), we infer the $T_{\text{eff}}$, log($g$), and radius of our objects. Our results are compatible with physical parameters found for free floating analogues of the association and with evolutionary-model predictions. However the final accuracy on the $T_{\text{eff}}$ estimates is strongly limited by non-reproducibilities of the BT-SETTL15 models for late-M brown-dwarfs. We identified emission lines in the spectrum of several objects attributed to chromospheric activity except for USc01608–2315 for which they are indicative of active accretion. We confirm the ×4 over-luminosity of USc0161031.9–16191305B. It could be explained by the object activity and if the companion is an unresolved multiple system.
The magnetic properties of the protostellar core IRAS 15398-3359
E. Redaelli¹, F. O. Alves¹, F. P. Santos² and P. Caselli¹

¹ Centre for Astrochemical Studies, Max-Planck-Institut fuer extraterrestrische Physik, Giessenbachstrasse 1, D-85749 Garching bei Muenchen (Germany); ² Max-Planck-Institute for Astronomy, Koenigstuhl 17, 69117 Heidelberg, Germany

E-mail contact: eredaelli at mpe.mpg.de

Context. Magnetic fields can affect significantly the star formation process. The theory of the magnetically-driven collapse in a uniform field predicts that initially the contraction happens along the field lines. When the gravitational pull grows strong enough, the magnetic field lines pinch inwards, giving rise to a characteristic hourglass shape.

Aims. We investigate the magnetic field structure of a young Class 0 object, IRAS 15398-3359, embedded in the Lupus I cloud. Previous observations at large scales suggest that this source evolved in an highly magnetised environment. This object thus appears an ideal candidate to study the magnetically driven core collapse in the low-mass regime.

Methods. We have performed polarisation observations of IRAS 15398-3359 at 214 µm using the SOFIA/HAWC+ instrument, thus tracing the linearly polarised thermal emission of cold dust.

Results. Our data unveil a significant bend of the magnetic field lines due to the gravitational pull. The magnetic field appears ordered and aligned with the large-scale B-field of the cloud and with the outflow direction. We estimate a magnetic field strength of $B = 78\,\mu G$, expected to be accurate within a factor of two. The measured mass-to-flux parameter is $\lambda = 0.95$, indicating that the core is in a transcritical regime.

The Giant Herbig-Haro Flow HH 212 and Associated Star Formation
Bo Reipurth¹, C.J. Davis², John Bally³, A.C. Raga⁴, B.P. Bowler⁵, T.R. Geballe⁶, Colin Aspin⁷, and Hsin-Fang Chiang⁸

¹ Institute for Astronomy, University of Hawaii at Manoa, 640 N. Aohoku Place, Hilo, HI 96720, USA; ² National Science Foundation, 2415 Eisenhower Ave, Alexandria, VA 22314, USA; ³ CASA, University of Colorado, Boulder, CO, USA; ⁴ Instituto de Ciencias Nucleares, UNAM, Mexico; ⁵ McDonald Observatory and the Department of Astronomy, University of Texas at Austin, Austin, TX 78712, USA; ⁶ Gemini Observatory, 670 North Aohoku Place, Hilo HI 96720, USA; ⁷ Institute for Astronomy, University of Hawaii at Manoa, 640 N. Aohoku Place, Hilo, HI 96720, USA; ⁸ National Center for Supercomputing Applications, Urbana, IL 61801, USA

E-mail contact: astronomer@star.institute.edu

The bipolar jet HH 212, among the finest collimated jets known, has so far been detected only in near-infrared H₂ emission. Here we present deep optical images that show two of the major bow shocks weakly detected in optical [SII] emission, as expected for a bona fide Herbig-Haro jet. We present widefield H₂ images which reveal two more bow shocks located symmetrically around the source and along the main jet axis. Additionally, examination of Spitzer 4.5 µm images reveals yet another bright bow shock further to the north along the jet axis; no corresponding bow shock is seen to the south. In total, the HH 212 flow has an extent of 1050 arcsec, corresponding to a projected dimension of 2.0 pc. HH 212 thus joins the growing group of parsec-scale Herbig-Haro jets. Proper motion measurements indicate a velocity of about 170 km/sec, highly symmetric around the source, with an uncertainty of ≈ 30 km/sec, suggesting a probable age of the giant HH 212 flow of about 7000 yr. The jet is driven by a deeply embedded source, known as IRAS 05413-0104. We draw attention to a Spitzer near- and mid-infrared source, which we call IRS-B, located only 7 arcsec from the driving source, towards the outskirts of the dense cloud core. Infrared photometry and spectroscopy suggests that IRS-B is a K-type star with a substantial infrared excess, except that for an extinction of $A_V = 44$ the star would have only a weak infrared excess, and so in principle it could be a K-giant at a distance of about 2 kpc.

Accepted by Astron. J. (AJ, 158:107, 2019)
On the size of the CO-depletion radius in the IRDC G351.77-0.51

G. Sabatini\textsuperscript{1,2,3}, A. Giannetti\textsuperscript{2}, S. Bovino\textsuperscript{3}, J. Brand\textsuperscript{2}, S. Leurini\textsuperscript{1}, E. Schisano\textsuperscript{3,5}, T. Pillai\textsuperscript{6,7}, and K. M. Menten\textsuperscript{6}

\textsuperscript{1}Dipartimento di Fisica e Astronomia, Università degli Studi di Bologna, via Gabetti 93/2, I-40129 Bologna, Italy
\textsuperscript{2}INAF - Istituto di Radioastronomia - Italian node of the ALMA Regional Centre (ARC), via Gabetti 101, I-40129 Bologna, Italy
\textsuperscript{3}Departamento de Astronomía, Universidad de Concepción, Barrio Universitario, Concepción, Chile
\textsuperscript{4}INAF - Osservatorio Astronomico di Cagliari, via della Scienzia 5, 09047 Selargius (CA), Italy
\textsuperscript{5}Istituto di Astrofisica e Planetologia Spaziali - INAF, Via Fosso del Cavaliere 100, I-00133 Roma, Italy
\textsuperscript{6}Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
\textsuperscript{7}Institute for Astrophysical Research, 725 Commonwealth Ave, Boston University Boston, MA 02215, USA

E-mail contact: sabatini@ira.inaf.it; giovanni.sabatini4@unibo.it

An estimate of the degree of CO-depletion ($f_D$) provides information on the physical conditions occurring in the innermost and densest regions of molecular clouds. A key parameter in these studies is the size of the depletion radius, i.e. the radius within which the C-bearing species, and in particular CO, are largely frozen onto dust grains.

In this work, we estimate the size of the depleted region by studying the Infrared Dark Cloud (IRDC) G351.77-0.51. Continuum observations performed with the Herschel Space Observatory and the Large APEX Bolometer Camera, together with APEX C$^{18}$O and C$^{17}$O $J=2\rightarrow 1$ line observations, allowed us to recover the large-scale beam- and line-of-sight-averaged depletion map of the cloud. We built a simple model to investigate the depletion in the inner regions of the clumps in the filament and the filament itself. The model suggests that the depletion radius ranges from 0.02 to 0.15 pc, comparable with the typical filament width (i.e. $\sim$0.1 pc). At these radii, the number density of H$_2$ reaches values between 0.2 and 5.5\times10^{5} \text{ cm}^{-3}$. These results provide information on the approximate spatial scales on which different chemical processes operate in high-mass star forming regions and also suggest caution when using CO for kinematical studies in IRDCs.

Accepted by Monthly Notices of the Royal Astronomical Society


Probing fragmentation and velocity sub-structure in the massive NGC 6334 filament with ALMA

Yoshito Shimajiri\textsuperscript{1,2,3}, Philippe André\textsuperscript{1}, Eva Ntormousi\textsuperscript{1,5}, Alexander Men’shchikov\textsuperscript{1}, Doris Arzoumanian\textsuperscript{6,7} and Pedro Palmeirim\textsuperscript{7}

\textsuperscript{1} Laboratoire d’Astrophysique (AIM), CEA, CNRS, Université Paris-Saclay, Université Paris Diderot, Sorbonne Paris Cité, 91191 Gif-sur-Yvette, France; \textsuperscript{2} Department of Physics and Astronomy, Graduate School of Science and Engineering, Kagoshima University, 1-21-35 Korimoto, Kagoshima, Kagoshima 890-0065, Japan; \textsuperscript{3} National Astronomical Observatory of Japan, Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan; \textsuperscript{4} Foundation for Research and Technology (FORTH), Nikolaou Plastira 100, Vassilikou Vouton GR - 711 10, Heraklion, Greece; \textsuperscript{5} Department of Physics and ITCP, University of Crete, 71003 Heraklion, Greece; \textsuperscript{6} Department of Physics, Graduate School of Science, Nagoya University, Nagoya 464-8602, Japan; \textsuperscript{7} Instituto de Astrofísica e Ciencias do Espaco, Universidade do Porto, CAUP, Rua das Estrelas, PT4150-762 Porto, Portugal

E-mail contact: yoshito.shimajiri at nao.ac.jp

Herschel surveys of Galactic clouds support a paradigm for low-mass star formation in which dense filaments play a crucial role. The detailed fragmentation properties of star-forming filaments remain poorly understood, however, and the validity of the filament paradigm in the high-mass regime is still unclear. Following up on an earlier 350 $\mu$m dust continuum study with the ArTMiS camera on the APEX telescope, we conducted ALMA observations of the main filament in the high-mass star-forming region NGC6334 in the 3mm continuum and the N2H+(1-0) line at 3 arcsec resolution to investigate its detailed density and velocity structure. The filament was detected in both tracers. We identified 26 cores at 3mm and 5 velocity-coherent fiber-like features in N2H+ within the filament. The typical length of, and velocity difference between, the fiber-like features of the NGC6334 filament are reminiscent of
the properties for the fibers of the low-mass star-forming filament B211/B213. Only 2 or 3 of the 5 velocity-coherent features are well aligned with the filament and may represent genuine, fiber sub-structures. The core mass distribution has a peak at 10M\(\text{sun}\), which is an order of magnitude higher than the peak of the prestellar core mass function in nearby, low-mass star-forming clouds. The cores can be divided into 7 groups, closely associated with ArTMiS clumps. The projected separation between cores and the projected spacing between clumps are roughly consistent with the effective Jeans length in the filament and a physical scale of about 4 times the filament width, respectively, suggesting a bimodal fragmentation process in the filament. Despite being one order of magnitude denser and more massive than the B211/B213 filament, the NGC6334 filament has a very similar density/velocity structure. The main difference is that the cores in NGC6334 appear to be an order of magnitude denser and more massive than the cores in Taurus. This suggests that dense filaments may evolve and fragment in a similar manner in low- and high-mass star-forming regions, and that the filament paradigm may hold in the intermediate-mass (if not high-mass) star formation regime. Accepted by Astronomy and Astrophysics


Modeling deuterium chemistry in starless cores: full scrambling versus proton hop
O. Sipilä\(^1\), P. Caselli\(^1\) and J. Harju\(^2,1\)
\(^1\) Max-Planck-Institute for Extraterrestrial Physics (MPE), Giessenbachstr. 1, 85748 Garching, Germany; \(^2\) Department of Physics, P.O. Box 64, 00014 University of Helsinki, Finland
E-mail contact: osipila at mpe.mpg.de

We constructed two new models for deuterium and spin-state chemistry for the purpose of modeling the low-temperature environment prevailing in starless and pre-stellar cores. The fundamental difference between the two models is in the treatment of ion-molecule proton-donation reactions of the form \(XH^+ + Y \rightarrow X + YH^+\), which are allowed to proceed either via full scrambling or via direct proton hop, that is, disregarding proton exchange. The choice of the reaction mechanism affects both deuterium and spin-state chemistry, and in this work our main interest is on the effect on deuterated ammonia. We applied the new models to the starless core H-MM1, where several deuterated forms of ammonia have been observed. Our investigation slightly favors the proton hop mechanism over full scrambling because the ammonia D/H ratios are better fit by the former model, although neither model can reproduce the observed NH\(_2\)D ortho-to-para ratio of 3 (the models predict a value of \(\sim 2\)). Extending the proton hop scenario to hydrogen atom abstraction reactions yields a good agreement for the spin-state abundance ratios, but greatly overestimates the deuterium fractions of ammonia. However, one can find a reasonably good agreement with the observations with this model by increasing the cosmic-ray ionization rate over the commonly adopted value of \(\sim 10^{-17} \text{s}^{-1}\). We also find that the deuterium fractions of several other species, such as H\(_2\)CO, H\(_2\)O, and CH\(_3\), are sensitive to the adopted proton-donation reaction mechanism. Whether the full scrambling or proton hop mechanism dominates may be dependent on the reacting system, and new laboratory and theoretical studies for various reacting systems are needed to constrain chemical models. Accepted by Astronomy & Astrophysics


Bow Magnetic Morphology Surrounding Filamentary Molecular Clouds? 3D Magnetic Field Structure of Orion-A
M. Tahani\(^1,2\), R. Plume\(^2\), J.C. Brown\(^2\), J.D. Soler\(^3\), and J. Kainulainen\(^3,4\)
\(^1\) Dominion Radio Astrophysical Observatory, Herzberg Astronomy and Astrophysics Research Centre, National Research Council Canada, P. O. Box 248, Penticton, BC V2A 6J9 Canada; \(^2\) Physics & Astronomy, University of Calgary, Calgary, Alberta, Canada; \(^3\) Max-Planck-Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany; \(^4\) Chalmers University of Technology, Department of Space, Earth and Environment, SE-41293 Gothenburg, Sweden
E-mail contact: mehrnoosh.tahani at nrc.ca

Using a method based on Faraday rotation measurements, Tahani et al. 2018 find the line-of-sight component of magnetic fields in Orion-A and show that their direction changes from the eastern side of this filamentary structure to
its western side. Three possible magnetic field morphologies that can explain this reversal across the Orion-A region are toroidal, helical, and bow-shaped morphologies. In this paper we construct simple models to represent these three morphologies and compare them with the available observational data to find the most probable morphology(ies). To compare the observations with the models, we use probability values and a Monte-Carlo analysis to determine the most likely magnetic field morphology among these three morphologies. We find that the bow morphology has the highest probability values and that our Monte-Carlo analysis suggests that the bow morphology is more likely. We suggest that the bow morphology is the most likely and the most natural of the three morphologies that could explain a magnetic field reversal across the Orion-A filamentary structure (i.e., bow, helical and toroidal morphologies).

Accepted by A&A


Spiral Structure in the Gas Disk of TW Hya
Richard Teague, Jaehan Bae, Jane Huang, Edwin Bergin

1 Department of Astronomy, University of Michigan, 311 West Hall, 1085 S. University Ave, Ann Arbor, MI 48109, USA; 2 Department of Terrestrial Magnetism, Carnegie Institution for Science, 5241 Broad Branch Road NW, Washington, DC 20015, USA; 3 Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: rteague at umich.edu

We report the detection of spiral substructure in both the gas velocity and temperature structure of the disk around TW Hya, suggestive of planet-disk interactions with an unseen planet. Perturbations from Keplerian rotation tracing out a spiral pattern are observed in the SE of the disk, while significant azimuthal perturbations in the gas temperature are seen in the outer disk, outside 90 au, extending the full azimuth of the disk. The deviation in velocity is either \( \Delta v_\phi/v_{\text{kep}} \sim 0.1 \) or \( \Delta v_z/v_{\text{kep}} \sim 0.01 \) depending on whether the perturbation is in the rotational or vertical direction, while radial perturbations can be ruled out. Deviations in the gas temperature are \( \pm 4 \) K about the azimuthally averaged profile, equivalent to deviations of \( \Delta T_{\text{gas}}/T_{\text{gas}} \sim 0.05 \). Assuming all three structures can be described by an Archimedean spiral, measurements of the pitch angles of both velocity and temperature spirals show a radially decreasing trend for all three, ranging from 9° at 70 au, dropping to 3° at 200 au. Such low pitch-angled spirals are not readily explained through the wake of an embedded planet in the location of previously reported at 94 au, but rather require a launching mechanism which results in much more tightly wound spirals. Molecular emission tracing distinct heights in the disk is required to accurately distinguish between spiral launching mechanisms.

Accepted by ApJL


Meridional flows in the disk around a young star
Richard Teague, Jaehan Bae, Edwin A. Bergin

1 Department of Astronomy, University of Michigan, 311 West Hall, 1085 S. University Ave, Ann Arbor, MI 48109, USA; 2 Department of Terrestrial Magnetism, Carnegie Institution for Science, 5241 Broad Branch Road NW, Washington, DC 20015, USA

E-mail contact: rteague at umich.edu

Protoplanetary disks are known to possess a stunning variety of substructure in the distribution of their mm sized grains, predominantly seen as rings and gaps (Andrews et al. 2018), which are frequently interpreted as due to the shepherding of large grains by either hidden, still-forming planets within the disk (Zhang et al. 2018) or (magneto-)hydrodynamic instabilities (Flock et al. 2015). The velocity structure of the gas offers a unique probe of both the underlying mechanisms driving the evolution of the disk, the presence of embedded planets and characterising the transportation of material within the disk, such as following planet-building material from volatile-rich regions to the chemically-inert midplane, or detailing the required removal of angular momentum. Here we present the radial profiles of the three velocity components of gas in upper disk layers in the disk of HD 163296 as traced by \(^{12}\)CO molecular emission. These velocities reveal significant flows from the disk surface towards the midplane of disk at the radial locations of gaps argued to be opened by embedded planets (Isella et al. 2016, 2018, Teague et al. 2018,
Pinte et al. 2018), bearing striking resemblance to meridional flows, long predicted to occur during the early stages of planet formation (Szulagyi et al. 2014, Morbidelli et al. 2014, Fung & Chiang 2016, Dong et al. 2019). In addition, a persistent radial outflow is seen at the outer edge of the disk, potentially the base of a wind associated with previously detected extended emission (Klaassen et al. 2013).

Accepted by Nature


Accretion Kinematics in the T Tauri Binary TWA 3A: Evidence for Preferential Accretion onto the TWA 3A Primary

Benjamin M. Tofflemire¹, Robert D. Mathieu² and Christopher M. Johns-Krull³

¹ University of Texas at Austin; ² University of Wisconsin - Madison; ³ Rice University

E-mail contact: tofflemire at utexas.edu

We present time-series, high-resolution optical spectroscopy of the eccentric T Tauri binary TWA 3A. Our analysis focuses on variability in the strength and structure of the accretion tracing emission lines H alpha and He I 5876A. We find emission line strengths to display the same orbital-phase dependent behavior found with time-series photometry, namely, bursts of accretion near periastron passages. Such bursts are in good agreement with numerical simulations of young eccentric binaries. During accretion bursts, the emission of He I 5876A consistently traces the velocity of the primary star. After removing a model for the system’s chromospheric emission, we find the primary star typically emits 70% of the He I accretion flux. We interpret this result as evidence for circumbinary accretion streams that preferentially feed the TWA 3A primary. This finding is in contrast to most numerical simulations, which predict the secondary should be the dominant accretor in a binary system. Our results may be consistent with a model in which the precession of an eccentric circumbinary disk gap alternates between preferentially supplying mass to the primary and secondary.

Accepted by AJ


Near-infrared Monitoring of the Accretion Outburst in the MYSO S255-NIRS3

Mizuho Uchiyama¹, Takuya Yamashita¹, Koichiro Sugiyama¹,², Tatsuya Nakaoka³, Miho Kawabata¹,³,⁴,⁵,⁶, Ryosuke Itoh³,⁴,⁵, Masayuki Yamanaka¹,³,⁴, Hiroshi Akitaya³, Koji Kawabata³, Yoshinori Yonekura⁷, Yu Saito⁵, Kazuhiito Motogi⁴ and Kenta Fujisawa⁸

¹ National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan; ² National Astronomical Research Institute of Thailand, 260 Moo 4, T.Donkaew, A. Maerim, Chiang Mai, 50180, Thailand; ³ Hiroshima Astrophysical Science Center, Hiroshima University, 1-3-1 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8526, Japan; ⁴ Department of Astronomy, Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan; ⁵ Okayama Observatory, Kyoto University, 3037-5 Honjo, Kamogata, Asakuchi, Okayama 719-0232, Japan; ⁶ Bisei Astronomical Observatory, 1723-70 Okura, Bisei, Ibaraki, Okayama 714-1411, Japan; ⁷ Center for Astronomy, Ibaraki University, 2-1-1 Bunkyo, Mito, Ibaraki 310-8512, Japan; ⁸ Graduate School of Sciences and Technology for Innovation, Yamaguchi University, 1677-1 Yoshida, Yamaguchi, Yamaguchi 753-8512, Japan; ⁹ The Research Institute for Time Studies, Yamaguchi University, 1677-1 Yoshida, Yamaguchi, Yamaguchi 753-8511, Japan

E-mail contact: mizuho.uchiyama at nao.ac.jp

We followed-up the massive young stellar object (MYSO) S255-NIRS3 (=S255-IRS1b) during its recent accretion outburst event in the Ks band with Kanata/HONIR for four years after its burst and obtained a long-term light curve. This is the most complete NIR light-curve of the S255-NIRS3 burst event that has ever been presented. The light curve showed a steep increase reaching a peak flux that was 3.4 mag brighter than the quiescent phase and then a relatively moderate year-scale fading until the last observation, similar to that of the accretion burst events such as EXors found in lower-mass young stellar objects. The behavior of the Ks band light curve is similar to that observed in 6.7 GHz class II methanol maser emission, with a sudden increase followed by moderate year-scale fading. However, the maser emission peaks appear 30-50 days earlier than that of the Ks band emission. The similarities confirmed that the origins of the maser emission and the Ks band continuum emission is common as previously shown from another
The possible role of stellar mergers for the formation of multiple stellar populations in globular clusters

Long Wang¹, Pavel Kroupa¹, Koh Takahashi² and Tereza Jerabkova³

¹ Helmholtz-Institut für Strahlen- und Kernphysik, University of Bonn, Nussallee 14-16, D-53115 Bonn, Germany; ² Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institute), Am Mühlenberg 1, D-14476, Potsdam-Golm, Germany; ³ European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748 Garching, Germany

E-mail contact: longwang.astro at live.com

Many possible scenarios for the formation of multiple stellar populations (MSP) in globular clusters (GCs) have been discussed so far, including the involvement of asymptotic giant branch stars, fast rotating main sequence stars, very massive main sequence stars and mass-transferring massive binaries based on stellar evolution modelling. But self-consistent, dynamical simulations of very young GCs are usually not considered. In this work, we perform direct N-body modelling such systems with total masses up to \(3.2 \times 10^5 M_\odot\), taking into account the observationally constrained primordial binary properties, and discuss the stellar-mergers driven both by binary stellar evolution and dynamical evolution of GCs. The occurrence of stellar mergers is enhanced significantly in binary-rich clusters of such that stars forming from the gas polluted by merger-driven ejection/winds would appear as MSPs. We thus emphasize that stellar mergers can be an important process that connects MSP formation with star cluster dynamics, and that multiple MSP formation channels can naturally work together. The scenario studied here, also in view of a possible top-heavy IMF, may be particularly relevant for explaining the high mass fraction of MSPs (the mass budget problem) and the absence of MSPs in young and low-mass star clusters.

Accepted by MNRAS

Predicting the Observational Signature of Migrating Neptune-sized Planets in Low-viscosity Disks

Philipp Weber¹, Sebastin Prez²,³, Pablo Bentez-Llambay¹, Oliver Gressel¹,⁴, Simon Casassus⁵ and Leonardo Krapp¹

¹ Niels Bohr International Academy, The Niels Bohr Institute, University of Copenhagen, Blegdamsvej 17, DK-2100 Copenhagen, Denmark; ² Universidad de Santiago de Chile, Av. Libertador Bernardo OHiggins 3363, Estación Central, Santiago, Chile; ³ Departamento de Física, Universidad de Santiago de Chile, Av. Ecuador 3493, Estación Central, Santiago, Chile; ⁴ Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16, D-14482, Potsdam, Germany; ⁵ Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile

E-mail contact: Philipp.Weber at nbi.ku.dk

The migration of planetary cores embedded in a protoplanetary disk is an important mechanism within planet-formation theory, relevant for the architecture of planetary systems. Consequently, planet migration is actively discussed, yet often results of independent theoretical or numerical studies are unconstrained due to the lack of observational diagnostics designed in light of planet migration. In this work we follow the idea of inferring the migration behavior of embedded planets by means of the characteristic radial structures that they imprint in the disks dust density distribution. We run hydrodynamical multifluid simulations of gas and several dust species in a locally isothermal \(\alpha\)-disk in the low-viscosity regime \((\alpha = 10^{-5})\) and investigate the obtained dust structures. In this framework, a planet of roughly Neptune mass can create three (or more) rings in which dust accumulates. We find that the relative spacing of these rings depends on the planets migration speed and direction. By performing subsequent radiative transfer calculations and image synthesis we show that – always under the condition of a near-inviscid disk – different migration scenarios are, in principle, distinguishable by long-baseline, state-of-the-art Atacama Large
Millimeter/submillimeter Array observations. Accepted by The Astrophysical Journal


Susceptibility of planetary atmospheres to mass loss and growth by planetesimal impacts: the impact shoreline
M. C. Wyatt¹, Q. Kral² and C. A. Sinclair¹

¹ Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK; ² LESIA, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Univ. Paris Diderot, Sorbonne Paris Cité, 5 place Jules Janssen, 92195 Meudon, France

E-mail contact: wyatt at ast.cam.ac.uk

This paper considers how planetesimal impacts affect planetary atmospheres. Atmosphere evolution depends on the ratio of gain from volatiles to loss from atmosphere stripping \( f_v \); for constant bombardment, atmospheres with \( f_v < 1 \) are destroyed in finite time, but grow linearly with time for \( f_v > 1 \). An impact outcome prescription is used to characterise how \( f_v \) depends on planetesimal impact velocities, size distribution and composition. Planets that are low mass and/or close to the star have atmospheres that deplete in impacts, while high mass and/or distant planets grow secondary atmospheres. Dividing these outcomes is an \( f_v = 1 \) impact shoreline analogous to Zahnle & Catling’s cosmic shoreline. The impact shoreline’s location depends on assumed impacting planetesimal properties, so conclusions for the atmospheric evolution of a planet like Earth with \( f_v \approx 1 \) are only as strong as those assumptions. Application to the exoplanet population shows the gap in the planet radius distribution at \( \sim 1.3R_\oplus \) is coincident with the impact shoreline, which has a similar dependence on orbital period and stellar mass to the observed gap. Given sufficient bombardment, planets below the gap would be expected to lose their atmospheres, while those above could have atmospheres enhanced in volatiles. The level of atmosphere alteration depends on the total bombardment a planet experiences, and so on the system’s (usually unknown) other planets and planetesimals, though massive distant planets would have low accretion efficiency. Habitable zone planets around lower luminosity stars are more susceptible to atmosphere stripping, disfavouring M stars as hosts of life-bearing planets if Earth-like bombardment is conducive to the development of life.

Accepted by MNRAS


Chemical Evolution of HC3N in Dense Molecular Clouds
Naiping Yu¹², Jun-Jie Wang¹², Jin-Long Xu¹

¹ National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China; ² NAOC-TU Joint Center for Astrophysics, Lhasa 850000, China

E-mail contact: npyu at bao.ac.cn

We investigated the chemical evolution of HC3N in six dense molecular clouds, using archival available data from the Herschel infrared Galactic Plane Survey (Hi-GAL) and the Millimeter Astronomy Legacy Team Survey at 90 GHz (MALT90). Radio sky surveys of the Multi-Array Galactic Plane Imaging Survey (MAGPIS) and the Sydney University Molonglo Sky Survey (SUMSS) indicate these dense molecular clouds are associated with ultracompact HII (UCHII) regions and/or classical HII regions. We find that in dense molecular clouds associated with normal classical HII regions, the abundance of HC3N begins to decrease or reaches a plateau when the dust temperature gets hot. This implies UV photons could destroy the molecule of HC3N. On the other hand, in the other dense molecular clouds associated with UCHII regions, we find the abundance of HC3N increases with dust temperature monotonously, implying HC3N prefers to be formed in warm gas. We also find that the spectra of HC3N (10–9) in G12.804–0.199 and RCW 97 show wing emissions, and the abundance of HC3N in these two regions increases with its nonthermal velocity width, indicating HC3N might be a shock origin species. We further investigated the evolutionary trend of \( N(N_2H^+)/N(HC_3N) \) column density ratio, and found this ratio could be used as a chemical evolutionary indicator of cloud evolution after the massive star formation is started.
Discovery of a Photoionized Bipolar Outflow towards the Massive Protostar G45.47+0.05

Yichen Zhang1, Kei E. I. Tanaka2,3, Viviana Rosero4, Jonathan C. Tan5,6, Joshua Marvil4, Yu Cheng6, Mengyao Liu6, Maria T. Beltrán7 and Guido Garay8

1 Star and Planet Formation Laboratory, RIKEN Cluster for Pioneering Research, Wako, Saitama 351-0198, Japan; 2 Department of Earth and Space Science, Osaka University, Toyonaka, Osaka 560-0043, Japan; 3 ALMA Project, National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan; 4 National Radio Astronomy Observatory, 1003 Lopezville Rd., Socorro, NM 87801, USA; 5 Department of Space, Earth & Environment, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden; 6 Department of Astronomy, University of Virginia, Charlottesville, VA 22904–4325, USA; 7 INAF – Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy; 8 Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile

E-mail contact: yczhang.astro at gmail.com

Massive protostars generate strong radiation feedback, which may help set the mass they achieve by the end of the accretion process. Studying such feedback is therefore crucial for understanding the formation of massive stars. We report the discovery of a photoionized bipolar outflow towards the massive protostar G45.47+0.05 using high-resolution observations at 1.3 mm with the Atacama Large Millimeter/Submillimeter Array (ALMA) and at 7 mm with the Karl G. Jansky Very Large Array (VLA). By modeling the free-free continuum, the ionized outflow is found to be a photoevaporation flow with an electron temperature of $10,000$ K and an electron number density of $\sim 1.5 \times 10^7$ cm$^{-3}$ at the center, launched from a disk of radius of 110 au. H30α hydrogen recombination line emission shows strong maser amplification, with G45 being one of very few sources to show such millimeter recombination line masers. The mass of the driving source is estimated to be $30 \pm 50 M_\odot$ based on the derived ionizing photon rate, or $30 \pm 40 M_\odot$ based on the H30α kinematics. The kinematics of the photoevaporated material is dominated by rotation close to the disk plane, while accelerated to outflowing motion above the disk plane. The mass loss rate of the photoevaporation outflow is estimated to be $\sim (2 - 3.5) \times 10^{-5} M_\odot$ yr$^{-1}$. We also found hints of a possible jet embedded inside the wide-angle ionized outflow with non-thermal emissions. The possible co-existence of a jet and a massive photoevaporation outflow suggests that, in spite of the strong photoionization feedback, accretion is still on-going.

The impact of planet wakes on the location and shape of the water ice line in a protoplanetary disk

Alexandros Ziampras1, Sareh Ataiee1, Wilhelm Kley1, Cornelis P. Dullemond2, and Clément Baruteau3

1 Institut für Astronomie und Astrophysik, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany; 2 Institute for Theoretical Astrophysics, Zentrum für Astronomie, Heidelberg University, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany; 3 Research Institute in Astrophysics and Planetology, University of Toulouse, 14 Avenue Edouard Belin, 31400 Toulouse, France

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

Context. Planets in accretion disks can excite spiral shocks, and — if massive enough — open gaps in their vicinity. Both of these effects can influence the overall disk thermal structure.

Aims. We model planets of different masses and semimajor axes in disks of various viscosities and accretion rates to examine their impact on disk thermodynamics and highlight the mutable, non-axisymmetric nature of icelines in systems with massive planets.

Methods. We conduct a parameter study using numerical hydrodynamics simulations where we treat viscous heating, thermal cooling and stellar irradiation as additional source terms in the energy equation, with some runs including radiative diffusion. Our parameter space consists of a grid containing different combinations of planet and disk parameters.

Results. Both gap opening and shock heating can displace the iceline, with the effects being amplified for massive
planets in optically thick disks. The gap region can split an initially hot ($T > 170$ K) disk into a hot inner disk and a hot ring just outside of the planet’s location, while shock heating can reshape the originally axisymmetric iceline into water-poor islands along spirals. We also find that radiative diffusion does not alter the picture significantly in this context.

**Conclusions.** Shock heating and gap opening by a planet can effectively heat up optically thick disks and in general move and/or reshape the water iceline. This can affect the gap structure and migration torques. It can also produce azimuthal features that follow the trajectory of spiral arms, creating hot zones, “islands” of vapor and ice around spirals which could affect the accretion or growth of icy aggregates.

Accepted by A&A


**Synthetic Large-Scale Galactic Filaments – on their Formation, Physical Properties, and Resemblance to Observations**

Catherine Zucker$^1$, Rowan Smith$^2$ and Alyssa Goodman$^1$

$^1$ Harvard Astronomy, Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA; $^2$ Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, Oxford Road, Manchester, M13 9PL, UK

E-mail contact: catherine.zucker at cfa.harvard.edu

Using a population of large-scale filaments extracted from an AREPO simulation of a Milky Way-like galaxy, we seek to understand the extent to which observed large-scale filament properties (with lengths $\approx 100$ pc) can be explained by galactic dynamics alone. From an observer’s perspective in the disk of the galaxy, we identify filaments forming purely due to galactic dynamics, without the effects of feedback or local self-gravity. We find that large-scale Galactic filaments are intrinsically rare, and we estimate that at maximum approximately one filament per kpc$^2$ should be identified in projection, when viewed from the direction of our Sun in the Milky Way. In this idealized scenario, we find filaments in both the arm and interarm regions, and hypothesize that the former may be due to gas compression in the spiral-potential wells, with the latter due to differential rotation. Using the same analysis pipeline applied previously to observations, we analyze the physical properties of large-scale Galactic filaments, and quantify their sensitivity to projection effects and galactic environment (i.e. whether they lie in the arm or interarm regions). We find that observed “Giant Molecular Filaments” are consistent with being non-self-gravitating structures dominated by galactic dynamics. Straighter, narrower, and denser “Bone-like” filaments, like the paradigmatic Nessie filament, have similar column densities, velocity gradients, and Galactic plane heights ($z \approx 0$ pc) to those in our simple model, but additional physical effects (such as feedback and self-gravity) must be invoked to explain their lengths and widths.

Accepted by ApJ

Review of Zeeman Effect Observations of Regions of Star Formation
Richard M. Crutcher¹ and Athol J. Kemball¹

¹ Department of Astronomy, University of Illinois, 1002 W. Green St., Urbana, IL, USA
E-mail contact: crutcher at illinois.edu

The Zeeman effect is the only observational technique available to measure directly the strength of magnetic fields in regions of star formation. This chapter reviews the physics of the Zeeman effect and its practical use in both extended gas and in masers. We discuss observational results for the five species for which the Zeeman effect has been detected in the interstellar medium – H I, OH, and CN in extended gas and OH, CH₃OH, and H₂O in masers. These species cover a wide range in density, from ~ 10 cm⁻³ to ~ 10¹⁰ cm⁻³, which allows magnetic fields to be measured over the full range of cloud densities. However, there are significant limitations, including that only the line-of-sight component of the magnetic field strength can usually be measured and that there are often significant uncertainties about the physical conditions being sampled, particularly for masers. We discuss statistical methods to partially overcome these limitations. The results of Zeeman observations are that the mass to magnetic flux ratio, which measures the relative importance of gravity to magnetic support, is subcritical (gravity dominates magnetic support) at lower densities but supercritical for \( N_H \gtrsim 10^{22} \text{ cm}^{-2} \). Above \( n_H \sim 300 \text{ cm}^{-3} \), which is roughly the density at which clouds typically become self-gravitating, the strength of magnetic fields increases approximately as \( B \propto n^{2/3} \), which suggest that magnetic fields do not provide significant support at high densities. This is consistent with high-density clouds being supercritical. However, magnetic fields have a large range in strengths at any given density, so the role of magnetic fields should differ significantly from one cloud to another. And for maser regions the dependence of field strength on density may have a slightly lower slope. Turbulent reconnection theory seems to best match the Zeeman observational results.

Accepted by Frontiers in Astronomy and Space Sciences

http://doi.org/10.3389/fspas.2019.00066
The origins of the ingredients necessary for life on Earth – such as water, carbon, and nitrogen – are unknown, with nitrogen’s origins proving to be particularly elusive. By far the most abundant carrier of nitrogen in star-forming regions and protoplanetary disks is molecular nitrogen (N2), which is too volatile to contribute directly to planetesimal formation in any solid form, is not disposed to chemical processing into more refractory forms, and is essentially invisible to astronomical observation. In this dissertation, I investigate the disposition of other nitrogen carriers, especially nitrogen-bearing organics, in a variety of protostellar environments to constrain how nitrogen makes its way into the building blocks of the Earth. In Chapter 2, I use Herschel observations to compare the abundance of nitrogen-bearing organics in a high-mass and a low-mass protostellar hot core, finding that HCN is the dominant carrier of nitrogen in organics. Its abundance relative to water (HCN/H2O) can be compared to N/H2O ratios in comets. Through this comparison, I rule out organic molecular ices as the primary contributor to cometary nitrogen, but identify that they are a likely important donor of the 15N isotopic enrichment which is seen in the Earth, comets, and other Solar System terrestrial bodies. I find that refractory forms of nitrogen are the likely source of the majority of cometary nitrogen, but their abundance is difficult to directly constrain or characterize. In Chapter 3, I describe an observational survey using the IRAM 30m and NOEMA observatories to measure HCN towards five additional low-mass protostars, to explore possible variations in the results described in Chapter 2. Here, I use models of the physical and chemical structure of the protostellar envelopes to jointly interpret the single-dish and interferometric observations. I find that on small scales, the brightness of HCN strongly depends on the bolometric luminosity of each protostar, leading to a strong detection of HCN on small scales in only one of the five protostars. Its abundance is close to the value measured for the low-mass protostar in Chapter 2, but the non-detections towards the other four protostars prevent a broader exploration of variation in HCN abundances in low-mass protostellar hot cores. In Chapter 4, I use high-resolution ALMA observations to better-characterize the physical and chemical properties of one protostar studied in Chapter 3. By comparing high-resolution CS, CH3OH, and H13CN emission, I observe a velocity gradient that I identify as associated with a tentative protostellar disk. NOEMA measurements of the sensitive temperature probe CH3CN indicate hot gas (T \sim 170 \, K) coincident with this disk, supporting a scenario of active disk accretion. In Chapter 5, I summarize the conclusions of each chapter, and outline several important paths forward for the study of the elusive nitrogen carriers that were the original source of the Earth’s nitrogen. Overall, I find evidence supporting a common refractory-centric inheritance of nitrogen among the Galaxy’s terrestrial worlds, and I advance the observational study of nitrogen carriers in the planet-forming zones of young protostellar systems.
One of the governing questions driving my current research is to understand how stellar clusters and OB associations are formed and how they evolve. The Orion star-forming region (SFR) is an ideal laboratory to investigate the connection between clusters and OB association – i.e., how their star formation histories (SFH) and dynamical evolution compare. The proximity of the region, also known as the Orion OB 1 association, makes it one of the most significant stars formation laboratories in astronomy since it harbors a half dozen subgroups containing well-known OB stars and giant molecular clouds and has generated about $10^4$ low- and high-mass stars for at least the last $\sim 12$ Myr. To explain the complexity of the Orion region, Blaauw proposed a sequential star formation scenario, where a previous generation of stars is responsible for the formation of a new one via positive feedback.

The goal of this dissertation is to characterize the poorly studied population of stars in the vicinity of the supergiant $\epsilon$ Orionis (Orion Belt sub-region, Blaauw’s OB 1b population) and put them in the context of the Orion star-forming region. The $\epsilon$ Orionis region was first mentioned in 1931 by the Per Collinder in his catalog of open clusters, which is today known as the Collinder catalog. He distinguished the Orion Belt asterism (Alnitak, Alnilam, Mintaka) as Collinder 70. Notation commonly used for this particular region was introduced by Blaauw. He sliced Orion into the divisions according to the differences in age and content of gas and dust.

My goal was to disentangle the different populations and construct a consistent catalog of positions and photometry measurements for objects in the region. I identified members of the population and specified the most important observables and the contextual relation with the whole Orion star-forming region.

My work has identified a rich and well-defined stellar population north of NGC 1981, the Orion Belt Population – OBP. The newly discovered population is likely the low-mass counterpart to the Ori OB 1b subgroup. I present the results of Gaia DR2 data application in the attempt to resolve the 3D structure of the Orion Belt Population. To obtain more quantitative results I extended my research by complementing previously obtained data with other bands and by modeling the spectral energy distributions (SED) of the infrared counterparts of young stellar objects (YSO). The colors and spectral index analysis revealed the general nature of the point sources. By constructing and analyzing a wide SED, it is possible to quantify several physical parameters and also constrain the evolutionary stage of the YSOs.

Such an analysis, however, requires not only a good coverage of the wavelength range but also high spatial resolution data to ensure that the fluxes we are studying arise mainly from the star-disk system and are not contaminated by their surroundings. For this purpose, using infrared surveys such as 2MASS, All-WISE, IRAS and several optical surveys from the literature, I assembled the best data available for a sample of bonafide IR counterparts of OBP candidates and constructed their SED to the best possible extent.
In parallel to that analysis I investigated the variability of members in OBP. The primary motivation was to inspect YSO variability amongst OBP members with a statistical approach. I highlight my analysis and attempt to guide other researchers in their use of AllWISE multi-epoch photometry for thermal infrared variability studies. Multi-epoch photometry from AllWISE makes a useful resource in cases where mid-infrared variability is expected to be present with large amplitudes, or for YSOs where it can be connected to the presence of disks. I identified variables using the Stetson index, which quantifies the correlation of variability in two (or more) bands.

Many of the stars display unique variability characteristics that can only be appreciated from inspection of light curves. I also investigate the influence of mid-IR variability on the spectral index, which is a classical metric to identify YSO.

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.
New Jobs

Two PhD positions at Lund Observatory on Planet Formation and Exoplanets

Lund Observatory announces two PhD positions within astronomy and astrophysics. The PhD students will work within the subjects:

(1) The PhD student will work on models of the formation of giant planets. The student will use the code PLANETESYS, developed in the research team of Anders Johansen, to consider the destruction, growth and sedimentation of dust in the gas envelope of a growing protoplanet. The goal of the thesis project is to understand how the evolution of dust affects the opacity and convective dynamics in the gas envelopes of growing planets. The PhD supervisor will be Professor Anders Johansen.

(2) The PhD student will work on the analysis and interpretation of observations of exoplanets using high resolution ground-based spectroscopy. The student will work with data obtained from state-of-the-art spectrographs such as HARPS, ESPRESSO and others, and use models to constrain the physical, chemical and thermal structure characteristics of exoplanet atmospheres. This project will be focussed on short period giant and sub-giant exoplanets, while preparing for observations of smaller rocky planets in the era of the ELT. The PhD supervisor will be Jens Hoeijmakers who will join Lund Observatory as an Assistant Professor in 2020.

In addition to working on the topics listed above, the students will work within the inspiring environment at Lund Observatory, which currently hosts 45 scientific staff, including postdocs and 15 PhD students.

Deadline for applications: 1 December 2019

Apply here: [http://www.astro.lu.se/vacancies](http://www.astro.lu.se/vacancies)
Meetings

From Clouds to Planets II: The Astrochemical Link
28 September - 2 October 2020, Berlin, Germany

Dear colleagues,

we would like to announce the 2nd conference “From Clouds to Planets II: The Astrochemical Link” to be held in Harnack Haus, Berlin, from 28 September to 2 October 2020. The meeting is meant to bring together about 150 experts in star and planet formation and astrochemistry to discuss the enormous progress since the first meeting in 2015. Please see below for more details:

https://events.mpe.mpg.de/event/12/

Paola Caselli and Dmitry Semenov

Cool Stars, Stellar Systems, and the Sun 21: call for splinter sessions

The CS21 SOC invites the community to propose splinter sessions on current hot topics. Proposals for splinter sessions can be made by individuals or groups of individuals. At this time, we are planning on 9 splinter sessions of 180 minutes each to be accommodated in our schedule. The splinter organizers will have access to abstracts of potential contributions submitted on the abstract form.

Splinter organizers should be prepared to produce and maintain a website that includes the schedule and speakers, and describes opportunities for people to participate in the session. The splinter websites will be linked from the main CS21 website, so all meeting participants are aware of the splinter sessions and can make informed choices about which sessions they wish to attend. A complete program for each splinter should be online six weeks prior to the meeting, that is by May 8th, 2020 - and hopefully earlier.

Any splinter session proposal should include the following:

Title  Names of the session organizers with primary contact information; names of co-organizers if appropriate  Two page summary of the goal of the session, including discussion on why this is a timely and relevant topic for CS21  List of potential speakers, and a plan for how additional speakers will be solicited (Note that CS21 follows a “one person - one talk” rule. Plenary speakers cannot give a talk in a splinter session, nor can one person talk in more than one splinters session.)  Proposed Splinter format that includes a description on how the audience will be involved  Commitment to set up a website in support of the splinter, with a complete program online by May 8th, 2020  Commitment to contribute a summary of the session for the proceedings Deadline for splinter session proposals is December 9, 2019. Please submit proposals by mailing a plain text file to cs21@irap.omp.eu with the subject line 'Splinter Session Proposal'.

We plan to announce accepted splinter sessions by January, 10th 2020, and will provide links to your splinter session website for attendees to submit contributions to your splinter as soon as possible.

Please do not propose splinters that are too similar to the 5 main morning sessions (see CS21 conference program) if you wish to maximize your chances of success.

Best regards,

The SOC of CS21

https://coolstars21.github.io/
COSPAR2020-B0.1:
Unifying planetary system formation out of elementary building blocks: from dust, gas and ice to our Solar System and exoplanets

Dear Colleagues,

we wish to invite you to attend the event B0.1: "Unifying planetary system formation out of elementary building blocks: from dust, gas and ice to our Solar System and exoplanets". at the 43rd COSPAR Scientific Assembly that will be held in Sydney, Australia, 15-22 August, 2020.

https://www.cospar2020.org/
https://www.cospar-assembly.org/

**************************IMPORTANT DATE**************************
ABSTRACT SUBMISSION DEADLINE is 14 FEBRUARY 2020

Scientific Rationale:
The assembly of planetary systems can no longer be considered a process exclusive to mature circumstellar (i.e., protoplanetary) disks, as strings of evidence are pushing its onset to the earliest phases of star formation. These findings require previously separate communities to come together and to exchange expertise. This event offers the venue for such exchange in the form of a unique interdisciplinary platform for discussing the full evolutionary sequence of our Solar System and of exoplanetary systems that may be analogous and different from our own. The event is open to experts on the Solar System, its small and large bodies; exoplanets; protoplanetary disks, embedded and prestellar phases of star formation. It will cover studies of gas, ice, dust and larger bodies from theoretical, observational and experimental perspectives. This science is stimulated by the increasing amount of in-situ measurements from past missions such as Cassini and Rosetta, present missions like New Horizons, and upcoming missions such as JUICE and Europa Clipper. Simultaneously, the field is being revolutionized with interferometric observations from powerful facilities such as ALMA, exoplanet demographics from transits and radial velocities (e.g., TESS, ESPRESSO) and with experimental studies in state-of-the-art laboratories simulating the various space environments. This event is sponsored by and coordinated with Commissions B1, E4 and F3.

Main Scientific Organizers:
Maria Drozdovskaya (CSH; Switzerland) & Diego Turrini (INAF-IAPS; Italy)

Scientific Organizing Committee:
Michael Ireland, ANU, Australia; Stavro Ivanovski, INAF-OATS, Italy; Niels Ligterink, CSH, Switzerland; Gian-franco Vidalì, Syracuse, U.S.A.; Eric Herbst, UVA, U.S.A.; Martin Rubin, UniBe, Switzerland; Trevor Ireland, ANU, Australia; Raphael Marschall, SwRi, U.S.A.; Sho Sasaki, Osaka, Japan; Sean Andrews, CfA, U.S.A.

Confirmed Invited Speakers:
Fred Ciesla (University of Chicago, U.S.A.) Joanna Dr??kowska (University Observatory of the Ludwig Maximilian University of Munich, Germany) Davide Fedele (INAF/Osservatorio Astrofisico di Arcetri, Italy) Mark Krumholz (ANU, Australia) Jeong-Eun Lee (Kyung Hee University, South Korea) Yamila Miguel (Leiden University, The Netherlands) Paola Pinilla (Max Planck Institute for Astronomy in Heidelberg, Germany) Alessandro Sozzetti (INAF/Osservatorio Astronomico di Torino, Italy) Frances Westall (CNRS in Orleans, France) Makoto Yoshikawa (JAXA, Japan)
Summary of Upcoming Meetings

Planet Formation Workshop 2019
25 - 28 November 2019, Tokyo, Japan
http://th.nao.ac.jp/meeting/planet-formation-workshop2019/

First Stars VI
1 - 6 March 2020 Concepcion, Chile
http://www.astro.udec.cl/FirstStarsVI/

Linking Dust, Ice, and Gas in Space
19 - 24 April 2020, Capri, Italy
http://frcongressi.net/ecla2020.meet/

COOL STARS 21: Cambridge Workshop on Cool Stars, Stellar Systems and the Sun
22 - 26 June 2020, Toulouse, France
https://coolstars21.github.io/

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

Interstellar Shocks School
22 - 27 March 2020, Les Houches, France
https://www.sciencesconf.org/browse/conference/?confid=8899

Linking Dust, Ice, and Gas in Space; 19 - 24 April 2020, Capri Islands, Italy
http://www.frcongressi.it/ecla2020/

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

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

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/IlluminatingTheDustyUniverse

The Early Phase of Star Formation
12 - 17 July 2020, Ringberg, Germany

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/

Conditions and Impact of Star Formation - Across Times and Scales
21 September - 2 October 2020, Chile
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.
Fundamentals of Radio Astronomy: Observational Methods
Jonathan M. Marr, Ronald L. Snell, Stanley E. Kurtz

Fundamentals of Radio Astronomy: Astrophysics
Ronald L. Snell, Stanley E. Kurtz, Jonathan M. Marr

Since the detection of HI at 21 cm wavelength and the discovery of CO in dark clouds, radio astronomy has been a central tool in studies of the interstellar medium and star forming clouds. This has been even more true with the advent of cm and mm interferometers, and the more recent availability of the EVLA and ALMA has transformed the study of circumstellar disks and of outflows. This two-volume set of introductory textbooks provide the essential foundation for students who plan to use radio observations in the study of molecular clouds, HII regions, and star formation. While one volume focuses on the instrumentation, telescopes, and observing methods of radio astronomy, the other deals with the astrophysical processes that give rise to radio emission. All three authors have taught radio astronomy courses, and the books are organized with questions and problems after each chapter. The books are also equipped with extensive appendices with supporting material that focus on background and technical information.

The following lists the chapters and subsections of the book:

Volume on Observational Methods:

1  Introductory Material
   1.1 Brief History of Radio Astronomy
   1.2 Some Fundamentals of Radio Waves
   1.3 Finding Our Way in the Sky
   1.4 Basic Structure of a Traditional Radio Telescope
   1.5 Radio Maps

2  Introduction to Radiation Physics
   2.1 Measures of the Amount of Radiation
2.2 Blackbody Radiation
2.3 Rayleigh-Jeans Approximation
2.4 Brightness Temperature
2.5 Coherent Radiation
2.6 Interference of Light
2.7 Polarization of Radiation

3 Radio Telescopes
3.1 Radio Telescope Reflectors, Antennas, and Feeds
3.2 Heterodyne Receivers
3.3 Noise, Noise Temperature, and Antenna Temperature
3.4 Bolometer Detectors
3.5 Spectrometers
3.6 Very Low-Frequency Radio Astronomy

4 Single-Dish Radio Telescope Observations
4.1 Basic Measurements with a Single-Dish Telescope
4.2 Antenna Beam
4.3 Observing Resolved versus Unresolved Sources
4.4 Spectral-Line Observations
4.5 Obtaining Radio Images
4.6 Calibration of a Radio Telescope
4.7 Telescope Sensitivity Considerations in Planning an Observation
4.8 Polarization Calibration

5 Aperture Synthesis Basics: Two-Element Interferometers
5.1 Why Aperture Synthesis?
5.2 Two-Element Interferometer
5.3 Observations of a Single-Point Source
5.4 Fringe Function
5.5 Visibility Function
5.6 Observations of a Pair of Unresolved Sources
5.7 Observations of a Single Extended Source
5.8 Coherence and the Effects of Finite Bandwidth and Integration Time
5.9 Basic Principles of Interferometry

6 Aperture Synthesis: Advanced Discussion
6.1 Cross-Correlation of Received Signals
6.2 Complex-Valued Cross-Correlation
6.3 Complex Correlation of a Point Source at a Single Frequency
6.4 Extended Sources and the Fourier Transform
6.5 Fourier Transforms for Some Common Source Shapes
6.6 Three Dimensions, the Earth’s Rotation, and the Complex Fringe Function
6.7 Nonzero Bandwidth and Finite Integration Time
6.8 Source Structure and the Visibility Function
6.9 The Earth’s Rotation and UV Tracks
6.10 Interferometers as Spatial Filters
6.11 Sensitivity and Detection Limits
6.12 Calibration
6.13 Image Formation
6.14 Very Long Baseline Interferometry

Volume on Astrophysics:

1 Introductory Material
1.1 Units and Nomenclature
1.2 Radiation Measures
1.3 Sky Coordinates
1.4 Doppler Effect
1.5 Cosmological Redshift and the Expanding Universe
1.6 Distance and Age Calculations

2 Propagation of Radiation
2.1 Radiative Transfer
2.2 Propagation in an Ionized Medium

3 Continuum Emission Processes
3.1 Radiation from Accelerated Charges
3.2 Thermal Radiation
3.3 Non-Thermal Radiation

4 Spectral Lines
4.1 Emission and Absorption Lines
4.2 Radio Spectral Lines

5 The Cold Interstellar Medium
5.1 21-cm Spectral Line of Atomic Hydrogen
5.2 Observations of the Rotational Lines of Molecules
5.3 Observations of the Thermal Emission from Dust

6 HII Regions and Planetary Nebulae at Radio Wavelengths
6.1 HII Regions
6.2 Radio Emission from HII Regions
6.3 The Classification and Evolution of HII Regions
6.4 Planetary Nebulae

7 Radio Emission from Stellar Objects
7.1 Solar Radio Emission
7.2 Radio Emission from Stars
7.3 Young Stars
7.4 Radio Pulsars

8 Galaxies at Radio Wavelengths
8.1 21-cm HI Observations
8.2 Molecular Gas in Galaxies
8.3 Radio Continuum Emission from Galaxies
8.4 Distant Galaxies

9 Radio Galaxies and Quasars
9.1 Brief Overview of Active Galaxies
9.2 AGN Model
9.3 Morphologies, Sizes, and Spectra of Radio Galaxies and Quasars
9.4 Inferring Physical Conditions in AGN

10 Cosmic Microwave Background
10.1 Cosmological Models
10.2 Blackbody Nature of the CMB
10.3 Anisotropies in the CMB
10.4 Cosmological Parameters
10.5 CMB Polarization

CRC Press 2019
ISBN 9781498725774, 346 pages, hardcover US$129.95
ISBN 9781420076769, 332 pages, hardcover US$105.00
Available from http://crcpress.com