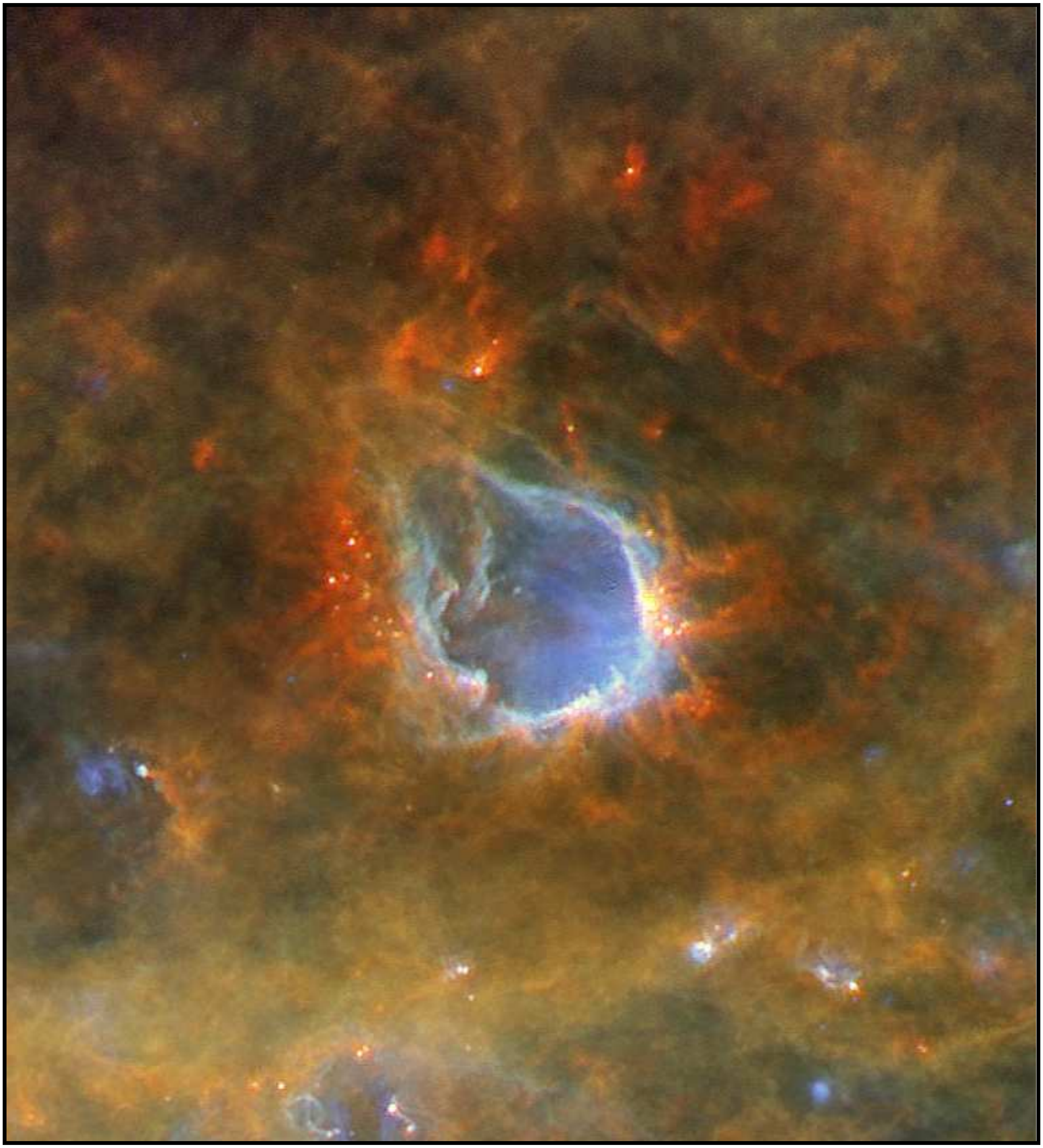
THE STAR FORMATION NEWSLETTER

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

No. 294 — 15 June 2017 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)



The Star Formation Newsletter

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

Newsletter Archive

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

List of Contents

Cover Picture

Herschel's view of RCW 120. The image is a composite of the wavelengths of 70 microns (blue), 160 microns (green) and 350 microns (red). A massive star at the centre, not visible at these infrared wavelengths, has blown a bubble with radiation pressure. This has compressed the material at the edge of the bubble, causing it to collapse and triggering the birth of new stars. RCW 120 is located at a distance of about 1400 pc.

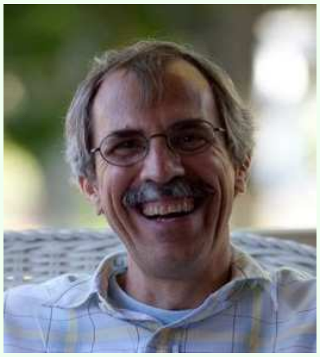
Image courtesy G. Li Causi, IAPS/INAF, Italy and ESA/NASA.

Submitting your abstracts

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

Scott Kenyon

in conversation with Bo Reipurth



Q: *What was your 1983 thesis about and who was your adviser?*

A: When I went to Illinois, I planned to work with Sumner Starrfield and Jim Truran on numerical simulations of classical novae. At my first AAS meeting, I shared a hotel room with Ron Webbink. He told me that every Ph.D. student should become 'the master of their domain'. With others already studying novae, he suggested I could make a larger impact on another topic. He thought symbiotic stars were ready for a new synthesis. I read a few reviews and then every paper in the library. For several months, I spent a few hours a day in the stacks looking at light curves and photographic spectra in old journals. They had not been touched in decades. While organizing my notes on individual systems and their common properties, I had a great introduction to the ebb and flow of scientific ideas. I saw how good ideas can lose favor and then return to prominence with new data or with a better theory.

As my advisor, Ron helped me chart the projects that became my thesis. I also worked with Jay Gallagher on observational programs and with Jim Truran on symbiotic nova eruptions. In addition to giving me excellent training in the tools of the trade, they gave me a firm grounding in the synergy between theory and observations.

Q: *Your thesis turned into a book about symbiotic stars. How did that happen?*

A: Although there are few symbiotics, there is an amazingly diverse literature. After I published my compendium of individual systems as a companion volume to my thesis, Jim Pringle suggested that some revised version of the compendium would make a good addition to the Astrophysics Series of Cambridge University Press and asked whether he could mention it to Simon Mitton, the editor of the Series. Certain that Simon would pass on this opportunity, I said 'Sure'. Some time later, Simon wrote that he agreed with Jim!

As a CfA Fellow, I could pursue any topic. This freedom allowed me to take time off from writing journal papers. I drafted a historical introduction, chapters on the theory and observations for quiescent and outburst phases, and a final chapter on formation and evolution. I reorganized the compendium into various tables and a detailed appendix. The book gave me an opportunity to look at the big picture and arrange my ideas more completely.

Q: *How did you switch your interest to star formation?*

A: After I gave a talk at the CfA about symbiotics and novae, Lee Hartmann showed me light curves of several FUors. Once we had discussed their spectroscopic evolution, Lee agreed they were good candidates for accretion events similar to those in dwarf novae and in some symbiotic stars. As we worked on the FUors, I developed an interest in the UV and IR excesses of T Tauri stars. Disk accretion matched data for the UV excesses. Radiation from a flat disk did not produce a large enough IR excess, but we realized that a disk in hydrostatic equilibrium should flare at large radii and intercept more radiation from the central star. This model matched the IR excesses fairly well and is still a central component in theories for protoplanetary disks. Over the next several years, we just kept finding interesting projects to collaborate on.

The CfA had a very strong group on star formation but few people working on interacting binary stars. When Charlie Lada arrived, he organized a popular internal symposium and then persuaded Frank Shu, Dave Hollenbach, and others from the Center for Star Formation Studies at Ames, UC Berkeley, and UC Santa Cruz to collaborate on workshops at Wellesley College. With substantial free time for discussion, these meetings generated a lot of excitement. As Charlie spent more time on the workshops, I organized several of the internal symposia, which broadened my interest to protostars and planet formation.

Q: *Lee and you worked extensively on models of FUors. What were the main challenges?*

A: The first challenge was convincing skeptics that our ideas were plausible! At the Santa Cruz workshop where we first described our FUor model, people questioned the fits to the spectral energy distributions (SEDs) and the comparisons of the light curves with dwarf novae and some symbiotic stars. The high accretion rates were also novel and scary. Lee and Peter Petrov described other issues in previous interviews (*Star Formation Newsletter* #260 and #267). Fortunately, the model made clear predictions. The inner disk region emitting the optical light should rotate more rapidly than an outer disk region producing the IR light. Lee had good optical line profiles from the MMT; we used the Kitt Peak Fourier Transform Spectrometer for the IR line profiles. It was tedious getting a full FTS scan and reducing the data, but eventually we had line profiles confirming a much smaller rotation rate than in the optical, just as the model predicts. The strong IR absorption lines in FUors are much different from the IR line profiles observed in T Tauri stars. Thus, we could distinguish the active accretion disks of FUors from the reprocessing disks in T Tauri stars.

Analyzing the line profiles and the SEDs in detail was a major challenge. Together with Nuria Calvet, we isolated lines produced in the disk 'photosphere' from those in the outflowing wind. And we also separated the IR emission from the disk and infalling envelope. Over time, our picture of these systems has held up rather well.

Q: *In your 1990 paper with Lee and with Karen and Steve Strom you recognized the luminosity problem for embedded protostars. How have your conclusions held up with time and the extensive recent studies of that issue?*

A: In 1990, we had two ideas to resolve the luminosity problem, (i) a longer-lived accretion phase for class I protostars (which now includes the class 0 sources) or (ii) a relatively short-lived phase (or phases) of high accretion that escaped identification in our sample of Taurus-Auriga protostars. Later, Mike Dunham and collaborators noted that converting some of the kinetic energy of infall into outflows would reduce the luminosity problem.

It has been fun to watch this issue develop. Our ideas more or less languished until Spitzer, which opened up routine detection of protostars in many more molecular clouds. With larger samples in nearby clouds like Taurus-Auriga and Perseus and still-growing samples in more distant clouds, the luminosity problem remains an interesting issue. Stella Offner and Chris McKee used better source statistics and an improved analytical model to show that some combination of our two solutions and Mike Dunham's idea can resolve the problem. Although our original sample was fairly small, it was large enough to capture the essence of the problem. Today, there are many numerical calculations of protostellar collapse which try to infer the balance between longer lifetimes and intermittent episodes of high accretion. I suspect it will take awhile to find the right balance, but it seems we are all on the right track. As in the symbiotics, we see the ebb and flow of ideas over the course of 25 years.

Q: *In 1995, you published a paper with Lee on the 'Pre-Main-Sequence Evolution in the Taurus-Auriga Molecular Cloud' which has amassed well over a thousand citations and remains highly cited. What accounts for the success and longevity of this paper?*

A: I think the paper has several strengths. Aside from including a comprehensive summary for all of the pre-main sequence stars known at the time, we finally had enough data in one star forming region to measure the frequency of IR excess emission and to learn how IR excesses correlate with the UV excesses, mm continuum emission, and the frequency of jets and molecular outflows. The good statistics (for the time) allowed us to consider different models for the luminosity function and strengthened our identification of the luminosity problem. Coupled with the recent progress in models for the SEDs of protostars and disks, we also showed how the IR colors and SEDs changed during the evolution from protostar to a T Tauri star with a disk to a T Tauri star without a disk. Finally, we set up some of the framework for testing the basic theory for single star formation developed by Frank Shu, Pat Cassen, Steve Stahler, Fred Adams, Sue Terebey, and many others.

Q: *You have had a long lasting interest in the Kuiper Belt.*

A: In 1994, Jane Luu and I started wondering how small solids in the flared disks of T Tauri stars grew into Kuiper Belt Objects (KBOs) so close to Neptune's orbit. Jane knew of George Wetherill and Glen Stewart's papers on the growth of terrestrial planets and I had experience in numerical methods from projects with Sumner Starrfield. We decided to build a code to follow the collisional evolution of large KBOs at 40 AU. It was much harder than we expected! Eventually, we matched published results on the growth of planetary embryos at 1 AU and developed predictions for the size distribution of KBOs that roughly agreed with Jane's data. Later, I worked with Ben Bromley to make the single annulus code into a multiannulus code and then into a hybrid code with an n-body component for planets. Our calculations showed why KBOs are not much more massive than Pluto and why the classical KBOs on roughly circular orbits have a different size distribution than the 'Plutinos' on more elliptical orbits in the 3:2 resonance with Neptune. Aside from our work, it has been fascinating to watch the development of grander connections between the flared disk model and the properties of planetary systems.

Q: *These projects led to work on Sedna?*

A: Exactly. Mike Brown's discovery of Sedna and its very eccentric orbit spurred a lot of theoretical interest in the evolution of the outer solar system. Ben & I realized that our collisional code could make objects like Sedna out at 100 AU, but we needed another mechanism for the eccentric orbit. From discussions with Elizabeth and Charlie Lada, we knew that most stars form in clusters. We had the idea that a close encounter between a very young Sun and another star in the cluster might perturb the orbit enough to produce the large eccentricity. Or maybe the Sun could capture a KBO from the other star. It turned out that the captured KBOs had orbits more similar to Sedna's than those from indigenous stars. If the model is correct, then Sedna might be the nearest exoplanet!

Q: *This capture idea has also been applied to Planet Nine.*

A: Yes. In 2014, Scott Sheppard and Chad Trujillo discovered another distant 'Sedna' on an eccentric orbit. With nearly a dozen objects beyond 50 AU, Sheppard & Trujillo noted that their space distribution is much less random than expected and showed that another more massive planet can organize the orbits into the observed pattern. We looked into ways for growing the planet *in situ* and for scattering an ice giant from 10–15 AU out to 100–250 AU.

Later, Batygin & Brown re-analyzed Sheppard & Trujillo's data, confirmed the idea of a Planet Nine, and predicted where it might be found. Their best semimajor axis, 500–750 AU, is well-beyond the original prediction of Sheppard & Trujillo. We also re-considered our proposals and identified ways *in situ* growth and scattering might place an Earth-mass planet so far from the Sun. One of our scattering scenarios requires a long-lived disk with roughly 1-2 Jupiter masses of gas at 100–200 AU. This disk mass is just below Herschel's detection limit. If low mass disks exist around nearby 10–100 Myr, ALMA could detect them.

Several groups have re-visited the capture idea. If Planet Nine is ever detected, the distinctive predictions for a, e, and $\imath$ of these models might help us to constrain the formation of the outer solar system.

Q: *You have paid much attention to debris disks as keys to understand the formation of terrestrial planets.*

A: Like the KBOs and Sedna, debris disks provide an interesting window into the last stages in the growth of icy and rocky planets. Close to the central star, high velocity collisions of lunar mass and larger objects should generate copious amounts of small dust grains. I think we were the first to predict detectable warm dust as 50–100 lunar mass objects gradually collide and merge into a single Earth. Farther out in the disk, our calculations predict that collisions of 1-10 km icy planetesimals left over from the production of icy dwarf planets produce an IR excess which gradually decays as the star ages. The data agree roughly with some of our predictions.

If the *in situ* formation model for Planet Nine is generally valid, debris disks at large distances from their host stars might have a dark lane where a massive planet has scoured out the dust from its orbit. Some systems appear to have dark lanes; ALMA should be able to test whether the structure of the dark lane and surrounding debris is consistent with a massive embedded planet.

Aside from our so-called self-stirring model (where Pluto or larger mass planets within the debris stir up the leftover planetesimals to high velocity), other groups suggest that a more massive planet orbiting inside (sometimes outside) the debris belt stirs up the small planetesimals. If these massive planets exist, then current or next generation of adaptive optics imagers should detect the Saturn to Jupiter mass planets required in this model.

Q: *In recent years Ben and you have written papers on rocky planet formation. What are your new insights?*

A: After Joan Najita and I tried to reconcile populations of known exoplanets with the masses of protoplanetary disks in Taurus-Auriga, we wondered whether the predictions of planet formation theories for solar-type stars are consistent with observations of debris disks at ages of 10–100 Myr and the observed fraction of Earth-mass planets orbiting at 1–2 AU around older stars. We learned that the fraction of young stars with warm dust from rocky planet formation is at least 10 times smaller than the fraction of older (Kepler) stars with rocky planets. They should be equal! After going through the Spitzer and Kepler statistics and various models for making rocky planets, we concluded that the simplest solution is a residual gas disk in the terrestrial zones of most 10–100 Myr old stars. If the gas surface density inside 2 AU is only 0.001% of the mass of a T Tauri disk, the gas rapidly drags the debris from planet formation into the central star. Observations with JWST can test this possibility.

Q: *What is next?*

A: My big goal is to model the complete formation of an entire solar system! Between ALMA, JWST, TESS, and the next generation of large ground-based telescopes, and the Lucy and Psyche asteroid missions, there will be a wealth of new data. These observations will let us make better connections between what we see in the solar system and what we detect in the disks and planetary systems of other stars. As we incorporate new ideas into our calculations, faster computers can get us to this goal.

As steps along the way to a complete model, Joan and I are looking at how various aspects of disk evolution, such as photoevaporation, impact the architecture of planetary systems. We are also considering how to generate the residual gas disk around 10–100 Myr old stars and to predict observational consequences of the disk.

Mike Brown keeps challenging us to build a better model explaining why Pluto and other similar dwarf planets beyond 35–40 AU are so infrequent compared to much less massive KBOS. I am hopeful we can find a solution!

A few years ago, Ben & I explored the formation of the small satellites of Pluto-Charon. Our model worked pretty well for the four known satellites, but it predicted some smaller satellites outside the orbit of Hydra that New Horizons did not detect. We plan to try some new ideas about the evolution of solids orbiting the binary to see whether we can match the orbits of the known satellites and to generate better limits on somewhat smaller satellites outside Hydra's orbit. After New Horizons visits a KBO in January 2019, I am sure we will have more data to confuse and to constrain our models!

Abstracts of recently accepted papers

Chemical segregation in hot cores with disk candidates: An investigation with ALMA

V. Allen[1,2], F. F. S. van der Tak[1,2], A. Sanchez-Monge[3], R. Cesaroni[4] and M. T. Beltran[4]

[1] Kapteyn Astronomical Institute, University of Groningen, the Netherlands
[2] SRON, Groningen, the Netherlands
[3] I. Physikalisches Institut, Cologne, Germany
[4] INAF, Osservatorio Astrofisico di Arcetri, Florence, Italy

E-mail contact: allen *at* astro.rug.nl

In the study of high-mass star formation, hot cores are empirically defined stages where chemically rich emission is detected toward a massive YSO. It is unknown whether the physical origin of this emission is a disk, inner envelope, or outflow cavity wall and whether the hot core stage is common to all massive stars. We investigate the chemical makeup of several hot molecular cores to determine physical and chemical structure. We use high spectral and spatial resolution submillimeter observations to determine how this stage fits into the formation sequence of a high-mass star. The submillimeter interferometer ALMA (Atacama Large Millimeter Array) was used to observe the G35.20-0.74N and G35.03+0.35 hot cores at 350 GHz in Cycle 0. We analyzed spectra and maps from four continuum peaks (A, B1, B2 and B3) in G35.20-0.74N, separated by 1000-2000 AU, and one continuum peak in G35.03+0.35. We made all possible line identifications across 8 GHz of spectral windows of molecular emission lines down to a 3? line flux of 0.5 K and determined column densities and temperatures for as many as 35 species assuming local thermodynamic equilibrium (LTE). In comparing the spectra of the four continuum peaks, we find each has a distinct chemical composition expressed in over 400 different transitions. In G35.20, B1 and B2 contain oxygen- and sulfur-bearing organic and inorganic species but few nitrogen-bearing species whereas A and B3 are strong sources of O-, S-, and N-bearing organic and inorganic species (especially those with the CN bond). Column densities of vibrationally excited states are observed to be equal to or greater than the ground state for a number of species. Deuterated methyl cyanide is clearly detected in A and B3 with D/H ratios of 8 and 13%, respectively, but is much weaker at B1 and undetected at B2. No deuterated species are detected in G35.03, but similar molecular abundances to G35.20 were found in other species. We also find co-spatial emission of isocyanic acid (HNCO) and formamide (NH 2 CHO) in both sources indicating a strong chemical link between the two species. The chemical segregation between N-bearing organic species and others in G35.20 suggests the presence of multiple protostars surrounded by a disk or torus.

Accepted by Astronomy and Astrophysics

https://arxiv.org/pdf/1705.06346

High-Mass Star Formation in the Outer Scutum-Centaurus Arm

W. P. Armentrout[1,2], L. D. Anderson[1,2,3], Dana S. Balser[4], T. M. Bania[5], T. M. Dame[6] and Trey V. Wenger[4,7]

[1] Department of Physics and Astronomy, West Virginia University, Morgantown, West Virginia 26505, USA
[2] Center for Gravitational Waves and Cosmology, West Virginia University, Chestnut Ridge Research Building, Morgantown, WV 26505, USA
[3] Adjunct Astronomer at the Green Bank Observatory, PO Box 2, Green Bank, WV 24944, USA
[4] National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903-2475, USA
[5] Institute for Astrophysical Research, Department of Astronomy, Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA
[6] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[7] Astronomy Department, University of Virginia, P.O. Box 400325, Charlottesville, VA 22904-4325, USA

E-mail contact: wparmentrout *at* mix.wvu.edu

The Outer Scutum-Centaurus (OSC) spiral arm is the most distant molecular spiral arm in the Milky Way, but until recently little was known about this structure. Discovered by Dame and Thaddeus (2011), the OSC lies ∼15 kpc from the Galactic Center. Due to the Galactic warp, it rises to nearly 4° above the Galactic Plane in the first Galactic quadrant, leaving it unsampled by most Galactic plane surveys. Here we observe H IIregion candidates spatially coincident with the OSC using the Very Large Array to image radio continuum emission from 65 targets and the Green Bank Telescope to search for ammonia and water maser emission from 75 targets. This sample, drawn from the WISE Catalog of Galactic H IIRegions, represents every H IIregion candidate near the longitude-latitude (l,v) locus of the OSC. Coupled with their characteristic mid-infrared morphologies, detection of radio continuum emission strongly suggests that a target is a bona fide H IIregion. Detections of associated ammonia or water maser emission allow us to derive a kinematic distance and determine if the velocity of the region is consistent with that of the OSC. Nearly 60% of the observed sources were detected in radio continuum, and over 20% have ammonia or water maser detections. The velocities of these sources mainly place them beyond the Solar orbit. These very distant high-mass stars have stellar spectral types as early as O4. We associate high-mass star formation at 2 new locations with the OSC, increasing the total number of detected H IIregions in the OSC to 12.

Accepted by Astrophysical Journal

https://arxiv.org/pdf/1705.02795

First Millimeter Detection of the Disk around a Young, Isolated, Planetary-mass Object

Amelia Bayo[1], Viki Joergens[2], Yao Liu[2,3], Robert Brauer[4], Johan Olofsson[1,2], Javier Arancibia[1], Paola Pinilla[5], Sebastian Wolf[4], Jan Philipp Ruge[4], Thomas Henning[2], Antonella Natta[6,7], Katharine G. Johnston[8], Mickael Bonnefoy[9], Henrik Beuther[2] and Gael Chauvin[9,10]

[1] Instituto de Fisica y Astronomia, Facultad de Ciencias, Universidad de Valparaiso, Av. Gran Bretana 1111, Valparaiso, Chile

[2] Max Planck Institut fr Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

[3] Purple Mountain Observatory, and Key Laboratory for Radio Astronomy, Chinese Academy of Sciences, 2 West Beijing Road, Nanjing 210008, China

[4] Institute of Theoretical Physics and Astrophysics, University of Kiel, Leibnizstr. 15, D-24118 Kiel, Germany

[5] Department of Astronomy/Steward Observatory, The University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA

[6] School of Cosmic Physics, Dublin Institute for Advanced Studies, 31 Fitzwilliams Place, Dublin 2, Ireland

[7] INAF-Osservatorio Astrofisico di Arcetri, L.go E. Fermi 5, I-50125 Firenze, Italy

[8] School of Physics and Astronomy, E.C. Stoner Building, The University of Leeds, Leeds LS2 9JT, UK

[9] Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France

[10] Unidad Mixta Internacional Franco-Chilena de Astronomia, CNRS/INSU UMI 3386 and Departamento de Astronomia, Universidad de Chile, Casilla 36-D, Santiago, Chile

E-mail contact: amelia.bayo *at* uv.cl

OTS44 is one of only four free-floating planets known to have a disk. We have previously shown that it is the coolest and least massive known free-floating planet (?12 M_{Jup}) with a substantial disk that is actively accreting. We have obtained Band 6 (233 GHz) ALMA continuum data of this very young disk-bearing object. The data show a clear unresolved detection of the source. We obtained disk-mass estimates via empirical correlations derived for young, higher-mass, central (substellar) objects. The range of values obtained are between 0.07 and 0.63 $M_{\oplus}$ (dust masses). We compare the properties of this unique disk with those recently reported around higher- mass (brown dwarfs) young objects in order to infer constraints on its mechanism of formation. While extreme assumptions on dust temperature yield disk-mass values that could slightly diverge from the general trends found for more massive brown dwarfs, a range of sensible values provide disk masses compatible with a unique scaling relation between M_{dust} and M_* through the substellar domain down to planetary masses.

Accepted by The Astrophysical Journal Letters

https://arxiv.org/pdf/1705.06378

A Tale of Three Cities: OmegaCAM discovers multiple sequences in the color-magnitude diagram of the Orion Nebula Cluster

G. Beccari[1], M.G. Petr-Gotzens[1], H.M.J. Boffin[1], M. Romaniello[1,12], D. Fedele[2], G. Carraro[3], G. De Marchi[4], W.-J. de Wit[5], J.E. Drew[6], V.M. Kalari[7], C.F. Manara[4], E.L. Martin[8], S. Mieske[5], N. Panagia[9], L. Testi[1], J.S. Vink[10], J.R. Walsh[1] and N.J. Wright[6,11]

[1] European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748 Garching bei Munchen, Germany
[2] INAF-Osservatorio Astrofisico di Arcetri, L.go E. Fermi 5, 50125, Firenze, Italy
[3] Dipartimento di Fisica e Astronomia Galileo Galilei, Vicolo Osservatorio 3, I-35122, Padova, Italy
[4] Science Support Office, Directorate of Science, European Space Research and Technology Centre (ESA/ESTEC), Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands
[5] European Southern Observatory, Alonso de Crdova 3107, Casilla 19001, Santiago, Chile
[6] School of Physics, Astronomy and Mathematics, University of Hertfordshire, College Lane Campus, Hatfield, AL10 9AB, UK
[7] Departamento de Astronoma, Universidad de Chile, Casilla 36-D, Correo Central, Santiago, Chile
[8] CSIC-INTA Centro de Astrobiologia Carretera Ajalvir km 4 28550 Madrid, Spain
[9] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[10] Armagh Observatory, College Hill, Armagh BT61 9DG, United Kingdom
[11] Astrophysics Group, Keele University, Keele ST5 5BG, UK
[12] Excellence Cluster Universe, Garching bei Munchen, Germany

E-mail contact: gbeccari *at* eso.org

As part of the Accretion Discs in H-alpha with OmegaCAM (ADHOC) survey, we imaged in r, i and H-alpha a region of 12x8 square degrees around the Orion Nebula Cluster. Thanks to the high-quality photometry obtained, we discovered three well-separated pre-main sequences in the color-magnitude diagram. The populations are all concentrated towards the cluster's center. Although several explanations can be invoked to explain these sequences we are left with two competitive, but intriguing, scenarios: a population of unresolved binaries with an exotic mass ratio distribution or three populations with different ages. Independent high-resolution spectroscopy supports the presence of discrete episodes of star formation, each separated by about a million years. The stars from the two putative youngest populations rotate faster than the older ones, in agreement with the evolution of stellar rotation observed in pre-main sequence stars younger than 4 Myr in several star forming regions. Whatever the final explanation, our results prompt for a revised look at the formation mode and early evolution of stars in clusters.

Accepted by A&A

https://arxiv.org/pdf/1705.09496

Complex Organic Molecules Towards Embedded Low-Mass Protostars

Jennifer B. Bergner[1], Karin I. Oberg[2], Robin T. Garrod[3] and Dawn M. Graninger[2]

[1] Harvard University Department of Chemistry and Chemical Biology, Cambridge, MA 02138, USA
[2] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA
[3] University of Virginia Departments of Chemistry and Astronomy, Charlottesville, VA 22904, USA

E-mail contact: jennifer.bergner *at* cfa.harvard.edu

Complex organic molecules (COMs) have been observed towards several low-mass young stellar objects (LYSOs). Small and heterogeneous samples have so far precluded conclusions on typical COM abundances, as well as the origin(s) of abundance variations between sources. We present observations towards 16 deeply embedded (Class 0/I) low-mass protostars using the IRAM 30m telescope. We detect CH_2CO, CH_3CHO, CH_3OCH_3, CH_3OCHO, CH_3CN, HNCO, and HC_3N towards 67%, 37%, 13%, 13%, 44%, 81%, and 75% of sources respectively. Median column densities derived using survival analysis range between 6.0x10^{10} cm^{-2} (CH_3CN) and 2.4x10^{12} cm^{-2} (CH_3OCH_3) and median abundances range between 0.48% (CH_3CN) and 16% (HNCO) with respect to CH_3OH. Column densities for each molecule vary by about one order of magnitude across the sample. Abundances with respect to CH_3OH are more narrowly distributed, especially for oxygen-bearing species. We compare observed median abundances with a chemical model for low-mass protostars and find fair agreement, although some modeling work remains to bring abundances higher with respect to CH_3OH. Median abundances with respect to CH_3OH in LYSOs are also found to be generally comparable to observed abundances in hot cores, hot corinos, and massive young stellar objects. Compared with comets, our sample is comparable for all molecules except HC_3N and CH_2CO, which likely become depleted at later evolutionary stages.

Accepted by ApJ

https://arxiv.org/pdf/1705.05338

Multiplicity and disks within the high-mass core NGC7538IRS1: Resolving cm line and continuum emission at $\sim 0.06'' \times 0.05''$ resolution

H. Beuther[1], H. Linz[1], Th. Henning[1], S. Feng[2] and R. Teague[1]

[1] Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany

[2] Max Planck Institute for Extraterrestrial Physics, Giessenbachstrasse 1, 85748 Garching, Germany

E-mail contact: beuther *at* mpia.de

Context: High-mass stars have a high degree of multiplicity and most likely form via disk accretion processes. The detailed physics of the binary and disk formation are still poorly constrained.
Aims: We seek to resolve the central substructures of the prototypical high-mass star-forming region NGC7538IRS1 at the highest possible spatial resolution line and continuum emission to investigate the protostellar environment and kinematics.
Methods: Using the Karl G. Jansky Very Large Array (VLA) in its most extended configuration at ∼24 GHz has allowed us to study the NH_3 and thermal CH_3OH emission and absorption as well as the cm continuum emission at an unprecedented spatial resolution of $0.06'' \times 0.05''$, corresponding to a linear resolution of ∼150 AU at a distance of 2.7 kpc.
Results: A comparison of these new cm continuum data with previous VLA observations from 23 yrs ago reveals no recognizable proper motions. If the emission were caused by a protostellar jet, proper motion signatures should have been easily identified. In combination with the high spectral indices $S \propto \nu^{\alpha}$ (α between 1 and 2), this allows us to conclude that the continuum emission is from two hypercompact HII regions separated in projection by about 430 AU. The NH_3 spectral line data reveal a common rotating envelope indicating a bound high-mass binary system. In addition to this, the thermal CH_3OH data show two separate velocity gradients across the two hypercompact HII regions. This indicates two disk-like structures within the same rotating circumbinary envelope. Disk and envelope structures are inclined by $\sim 33^{\circ}$, which can be explained by initially varying angular momentum distributions within the natal, turbulent cloud.
Conclusions: Studying high-mass star formation at sub-$0.1''$ resolution allows us to isolate multiple sources as well as to separate circumbinary from disk-like rotating structures. These data show also the limitations in molecular line studies in investigating the disk kinematics when the central source is already ionizing a hypercompact HII region. Recombination line studies will be required for sources such as NGC7538IRS1 to investigate the gas kinematics even closer to the protostars.

Accepted by Astronomy & Astrophysics

http://www.mpia.de/homes/beuther/papers.html

Tidal dissipation in rotating low-mass stars and implications for the orbital evolution of close-in massive planets. II. Effect of stellar metallicity

E. Bolmont[1,2], F. Gallet[3], S. Mathis[1], C. Charbonnel[3,4], L. Amard[3,5] and Y. Alibert[6]

[1] Laboratoire AIM Paris-Saclay, CEA / DRF - CNRS - Univ. Paris Diderot - IRFU / SAp, Centre de Saclay, F-91191 Gif-sur-Yvette Cedex, France

[2] NaXys, Department of Mathematics, University of Namur, 8 Rempart de la Vierge, 5000 Namur, Belgium

[3] Department of Astronomy, University of Geneva, Chemin des Maillettes 51, 1290 Versoix, Switzerland

[4] IRAP, UMR 5277, CNRS and Universit de Toulouse, 14, av. E.Belin, F-31400 Toulouse, France

[5] LUPM UMR 5299 CNRS / UM, Universit de Montpellier, CC 72, F-34095 Montpellier Cedex 05, France

[6] Physikalisches Institut & Center for Space and Habitability, Universitaet Bern, 3012 Bern, Switzerland

E-mail contact: emeline.bolmont *at* cea.fr

Observations of hot Jupiter type exoplanets suggest that their orbital period distribution depends on the metallicity of their host star. We investigate here whether the impact of the stellar metallicity on the evolution of the tidal dissipation inside the convective envelope of rotating stars and its resulting effect on the planetary migration might be a possible explanation for this observed statistical trend. We use a frequency-averaged tidal dissipation formalism coupled to an orbital evolution code and to rotating stellar evolution models in order to estimate the effect of a change of stellar metallicity on the evolution of close-in planets. We consider here two different stellar masses: 0.4 and 1.0 $M_\odot$ evolving from the early pre-main sequence phase up to the red giant branch. We show that the metallicity of a star has a strong effect on the stellar parameters which in turn strongly influence the tidal dissipation in the convective region. While on the pre-main sequence the dissipation of a metal poor Sun-like star is higher than the dissipation of a metal rich Sun-like star, on the main sequence it is the opposite. However, for the 0.4 $M_\odot$ star, the dependence of the dissipation with metallicity is much less visible. Using an orbital evolution model, we show that changing the metallicity leads to different orbital evolutions (e.g., planets migrate farther out from an initially fast rotating metal rich star). By using this model, we qualitatively reproduced the observational trends of the population of hot Jupiters with the metallicity of their host stars. However, more steps are needed to improve our model to try to quantitatively fit our results to the observations. Namely, we need to improve the treatment of the rotation evolution in the orbital evolution model and ultimately we need to consistently couple of the orbital model to the stellar evolution model.

Accepted by A&A

https://arxiv.org/pdf/1705.10167.pdf

In situ accretion of gaseous envelopes on to planetary cores embedded in evolving protoplanetary discs

Gavin A.L. Coleman[1], John C.B. Papaloizou[2], Richard P. Nelson[1,3]

[1] Astronomy Unit, Queen Mary University of London, Mile End Road, London, E1 4NS, U.K

[2] DAMTP, University of Cambridge, Wilberforce Road, Cambridge, CB3 0WA, U.K

[3] Kavli Institute for Theoretical Physics, University of California, Santa Barbara, CA 93106, USA

E-mail contact: g.coleman *at* qmul.ac.uk

The core accretion hypothesis posits that planets with significant gaseous envelopes accreted them from their protoplanetary discs after the formation of rocky/icy cores. Observations indicate that such exoplanets exist at a broad range of orbital radii, but it is not known whether they accreted their envelopes in situ, or originated elsewhere and migrated to their current locations. We consider the evolution of solid cores embedded in evolving viscous discs that undergo gaseous envelope accretion in situ with orbital radii in the range 0.1–10 au. Additionally, we determine the long-term evolution of the planets that had no runaway gas accretion phase after disc dispersal. We find: (i) Planets with 5 $M_\oplus$ cores never undergo runaway accretion. The most massive envelope contained 2.8 $M_\oplus$ with the planet orbiting at 10 au. (ii) Accretion is more efficient onto 10 $M_\oplus$ and 15 $M_\oplus$ cores. For orbital radii $a_p \geq 0.5$ au, 15 $M_\oplus$ cores always experienced runaway gas accretion. For $a_p \geq 5$ au, all but one of the 10 $M_\oplus$ cores experienced runaway gas accretion. No planets experienced runaway growth at $a_p = 0.1$ au. (iii) We find that, after disc dispersal, planets with significant gaseous envelopes cool and contract on Gyr time-scales, the contraction time being sensitive to the opacity assumed. Our results indicate that Hot Jupiters with core masses $\lesssim$15 $M_\oplus$ at $\lesssim$0.1 au likely accreted their gaseous envelopes at larger distances and migrated inwards. Consistently with the known exoplanet population, Super-Earths and mini-Neptunes at small radii during the disc lifetime, accrete only modest gaseous envelopes.

Accepted by MNRAS

http://arxiv.org/pdf/1705.08147

Multiple kinematical populations in Vela OB2 from Gaia DR1 data

F. Damiani[1], L. Prisinzano[1], R.D. Jeffries[2], G.G. Sacco[3], S. Randich[3], and G. Micela[1]

[1] INAF - Osservatorio Astronomico di Palermo G.S.Vaiana, Piazza del Parlamento 1, I-90134 Palermo, Italy

[2] Astrophysics Group, Keele University, Keele, Staffordshire ST5 5BG, United Kingdom

[3] INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125, Firenze, Italy

E-mail contact: damiani *at* astropa.inaf.it

Recent results using radial-velocity measurements from the Gaia-ESO Survey have led to the discovery of multiple kinematic populations across the Vela OB2 association. We present here a proper-motion study of the same region. Our aim is to test whether the radial-velocity populations have a counterpart in proper-motion space, and if so, how the two sets of kinematical data complement each other. This work is based on parallaxes and proper motions from the TGAS catalog, as part of Gaia DR1. Two distinct proper-motion populations are found dispersed across ∼5 degrees (or ∼30 pc at their likely distances). Their detailed correspondence to the radial-velocity populations could not be tested, because of the paucity of common objects. However, compelling indications are found that one of the new proper-motion populations consists mostly of members of the young cluster NGC 2547, and the other is related to the gamma Vel cluster. Constraints on the age of the two populations, both of which appear to be only 10–35 Myr old, and their possible mutual interactions within the last 1.5 Myrs, are discussed.

Accepted by A&A Letters

http://arxiv.org/pdf/1705.03816

The Gaia-ESO Survey: dynamics of ionized and neutral gas in the Lagoon nebula (M8)

F. Damiani[1], R. Bonito[1,2], L. Prisinzano[1], T. Zwitter[3], A. Bayo[4], V. Kalari[5], F.M. Jiménez-Esteban[6], M.T. Costado[7], P. Jofré[8,9], S. Randich[10], E. Flaccomio[1], A.C. Lanzafame[11], C. Lardo[12], L. Morbidelli[10], and S. Zaggia[13]

[1] INAF - Osservatorio Astronomico di Palermo G.S.Vaiana, Piazza del Parlamento 1, I-90134 Palermo, Italy
[2] Dipartimento di Fisica e Chimica, Università di Palermo, Piazza del Parlamento 1, 90134, Palermo, Italy
[3] Faculty of Mathematics and Physics, University of Ljubljana, Jadranska 19, 1000, Ljubljana, Slovenia
[4] Instituto de Fsica y Astronomía, Universidad de Valparaiso, Chile
[5] Departamento de Astronomía, Universidad de Chile, Casilla 36-D Santiago, Chile
[6] Departmento de Astrofísica, Centro de Astrobiologa (INTA-CSIC), ESAC Campus, Camino Bajo del Castillo s/n, E-28692 Villanueva de la Cañada, Madrid, Spain
[7] Instituto de Astrofsica de Andaluca-CSIC, Apdo. 3004, 18080 Granada, Spain
[8] Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, United Kingdom
[9] Núcleo de Astronomía, Facultad de Ingeniería, Universidad Diego Portales, Av. Ejrcito 441, Santiago, Chile
[10] INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125, Florence, Italy
[11] Dipartimento di Fisica e Astronomia, Sezione Astrofisica, Università di Catania, via S. Sofia 78, 95123, Catania, Italy
[12] Laboratoire d'astrophysique, Ecole Polytechnique Fédérale de Lausanne (EPFL), Observatoire de Sauverny, CH-1290 Versoix, Switzerland
[13] INAF - Padova Observatory, Vicolo dell'Osservatorio 5, 35122 Padova, Italy

E-mail contact: damiani *at* astropa.inaf.it

We present a spectroscopic study of the dynamics of the ionized and neutral gas throughout the Lagoon nebula (M8), using VLT/FLAMES data from the Gaia-ESO Survey. We explore the connections between the nebular gas and the stellar population of the associated star cluster NGC6530. We characterize through spectral fitting emission lines of Hα, [N II] and [S II] doublets, [O III], and absorption lines of sodium D doublet, using data from the FLAMES/Giraffe and UVES spectrographs, on more than 1000 sightlines towards the entire face of the Lagoon nebula. Gas temperatures are derived from line-width comparisons, densities from the [S II] doublet ratio, and ionization parameter from Hα/[N II] ratio. Although doubly-peaked emission profiles are rarely found, line asymmetries often imply multiple velocity components along the line of sight. This is especially true for the sodium absorption, and for the [O III] lines. Spatial maps for density and ionization are derived, and compared to other known properties of the nebula and of its massive stars 9 Sgr, Herschel 36 and HD 165052 which are confirmed to provide most of the ionizing flux. The detailed velocity fields across the nebula show several expanding shells, related to the cluster NGC6530, the O stars 9 Sgr and Herschel 36, and the massive protostar M8East-IR. The origins of kinematical expansion and ionization of the NGC6530 shell appear to be different. We are able to put constrains on the line-of-sight (relative or absolute) distances between some of these objects and the molecular cloud. The large obscuring band running through the middle of the nebula is being compressed by both sides, which might explain its enhanced density. We also find an unexplained large-scale velocity gradient across the entire nebula. At larger distances, the transition from ionized to neutral gas is studied using the sodium lines.

Accepted by A&A

http://arxiv.org/pdf/1705.08194

Different dust and gas radial extents in protoplanetary disks: consistent models of grain growth and CO emission

Stefano Facchini[1], Til Birnstiel[2,3], Simon Bruderer[1] and Ewine F. van Dishoeck[1,4]

[1] Max-Planck-Institut für Extraterrestrische Physik, Giessenbachstrasse 1, 85748 Garching, Germany

[2] Max-Planck-Institut für Astronomie, Königstuhl, D-69117 Heidelberg, Germany

[3] University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität München, Scheinerstr. 1, 81679 Munich, Germany

[4] Leiden Observatory, Leiden University, P.O. Box 9513, NL-2300 RA Leiden, The Netherlands

E-mail contact: facchini *at* mpe.mpg.de

ALMA observations of protoplanetary disks confirm earlier indications that there is a clear difference between the dust and gas radial extents. The origin of this difference is still debated, with both radial drift of the dust and optical depth effects suggested in the literature. In thermo-chemical models, the dust properties are usually prescribed by simple parametrisations. In this work, the feedback of more realistic dust particle distributions onto the gas chemistry and molecular emissivity is investigated, with a particular focus on CO isotopologues. The radial dust grain size distribution is determined using dust evolution models that include growth, fragmentation and radial drift for a given static gas density structure. The vertical settling of dust particles is computed in steady-state. A new version of the code DALI is used to take into account how dust surface area and density influence the disk thermal structure, molecular abundances and excitation. Synthetic images of both continuum thermal emission and low J CO isotopologues lines are produced. The difference of dust and gas radial sizes is largely due to differences in the optical depth of CO lines and millimeter continuum, without the need to invoke radial drift. The effect of radial drift is primarily visible in the sharp outer edge of the continuum intensity profile. The gas outer radius probed by ^{12}CO emission can easily differ by a factor of ~ 2 between the models for a turbulent α ranging between 10^{-4} and 10^{-2}, with the ratio of the CO and mm radius $R^{\rm out}_{\rm CO}/R^{\rm out}_{\rm mm}$ increasing with turbulence. Grain growth and settling concur in thermally decoupling the gas and dust components, due to the low collision rate with large grains. As a result, the gas can be much colder than the dust at intermediate heights, reducing the CO excitation and emission, especially for low turbulence values. Also, due to disk mid-plane shadowing, a second CO thermal desorption (rather than photodesorption) front can occur in the warmer outer mid-plane disk. The models are compared to ALMA observations of HD 163296 as a test case. In order to reproduce the observed CO snowline of the system, a binding energy for CO typical of ice mixtures, with $E_{\rm b} \geq 1100\,$K, needs to be used rather than the lower pure CO value. The difference between observed gas and dust extent is largely due to optical depth effects, but radial drift and grain size evolution also affect the gas and dust emission in subtle ways. In order to properly infer fundamental quantities of the gaseous component of disks, such as disk outer radii and gas surface density profiles, simultaneous modelling of both dust and gas observations including dust evolution is needed.

Accepted by A&A

https://arxiv.org/pdf/1705.06235

Millimeter Observations of the disk around GW Ori

M. Fang[1,2], A. Sicilia-Aguilar[3,1], D. Wilner[4], Y. Wang[5,6], V. Roccatagliata[7], D. Fedele[8], and J.Z. Wang[9]

[1] Departamento de Fsica Teórica, Universidad Autnoma de Madrid, Cantoblanco 28049, Madrid, Spain

[2] Department of Astronomy, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA

[3] SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews KY16 9SS, UK

[4] Harvard–Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

[5] Max Planck Institute for Astronomy, Königstuhl 17, 69117, Heidelberg, Germany

[6] Purple Mountain Observatory and Key Laboratory of Radio Astronomy, Chinese Academy of Sciences, 2 West Beijing Road, 210008 Nanjing, China

[7] Universitäts-Sternwarte München, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81679, München, Germany

[8] Max Planck Institut für Extraterrestrische Physik, Giessenbachstrasse 1, 85748, Garching, Germany

[9] Shanghai Astronomical Observatory, Chinese Academy of Sciences, 80 Nandan Road, 200030, Shanghai, China

E-mail contact: mfang.cn *at* gmail.com

The GW Ori system is a pre-main sequence triple system (GW Ori A/B/C) with companions (GW Ori B/C) at ∼1 AU and ∼8 AU, respectively, from the primary (GW Ori A). The primary of the system has a mass of 3.9 $M_\odot$, but shows a spectral type of G8. Thus, GW Ori A could be a precursor of a B star, but it is still at an earlier evolutionary stage than Herbig Be stars. GW Ori provides us an ideal target for experiments and observations (being a "blown-up" upscaled Solar System with a very massive "sun" and at least two "upscaled planets"). We present the first spatially-resolved millimeter interferometric observations of the disk around the triple pre-main-sequence system GW Ori, obtained with the the Submillimeter Array, both in continuum and in the ^{12}CO $J = 2$–1, ^{13}CO $J = 2$–1, and C^{18}O $J = 2$–1 lines. These new data reveal a huge, massive, and bright disk in the GW Ori system. The dust continuum emission suggests a disk radius around 400 AU. But, the ^{12}CO $J = 2$–1 emission shows much more extended disk with a size around 1300 AU. Due to the spatial resolution (∼1″), we cannot detect the gap in the disk which is inferred from spectral energy distribution (SED) modeling. We characterize the dust and gas properties in the disk by comparing the observations with the predictions from the disk models with various parameters calculated with a Monte Carlo radiative transfer code RADMC-3D. The disk mass is around 0.12 $M_\odot$, and the disk inclination with respect to the line of sight is around ∼35°. The kinematics in the disk traced by the CO line emission strongly suggest that the circumstellar material in the disk is in Keplerian rotation around GW Ori. Tentatively substantial C^{18}O depletion in gas phase is required to explain the characteristics of the line emission from the disk.

Accepted by A&A

http://arxiv.org/pdf/1705.01917

Age spreads and the temperature dependence of age estimates in Upper Sco

Qiliang Fang[1,2], Gregory Herczeg[1] and Aaron Rizzuto[3]

[1] Kavli Institute for Astronomy and Astrophysics, Peking University, 100871 Beijing, China
[2] Department of Astronomy, School of Physics, Peking University, 100871 Beijing, China
[3] Department of Astronomy, University of Texas, Texas, USA

E-mail contact: gherczeg1 *at* gmail.com

Past estimates for the age of the Upper Sco Association are typically 11–13 Myr for intermediate-mass stars and 4–5 Myr for low-mass stars. In this study, we simulate populations of young stars to investigate whether this apparent dependence of estimated age on spectral type may be explained by the star formation history of the association. Solar and intermediate mass stars begin their pre-main sequence evolution on the Hayashi track, with fully convective interiors and cool photospheres. Intermediate mass stars quickly heat up and transition onto the radiative Henyey track. As a consequence, for clusters in which star formation occurs on a similar timescale as the transition from a convective to a radiative interior, discrepancies in ages will arise when ages are calculated as a function of temperature instead of mass. Simple simulations of a cluster with constant star formation over several Myr may explain about half of the difference in inferred ages versus photospheric temperature; speculative constructions that consist of a constant star formation followed by a large supernova-driven burst could fully explain the differences, including those between F and G stars where evolutionary tracks may be more accurate. The age spreads of low-mass stars predicted from these prescriptions for star formation are consistent with the observed luminosity spread of Upper Sco. The conclusion that a lengthy star formation history will yield a temperature dependence in ages is expected from the basic physics of pre-main sequence evolution and is qualitatively robust to the large uncertainties in pre-main sequence evolutionary models.

Accepted by ApJ

http://arxiv.org/pdf/1705.08612

Tidal dissipation in rotating low-mass stars and implications for the orbital evolution of close-in planets. I. From the PMS to the RGB at solar metallicity

F. Gallet[1], E. Bolmont[2,3], S. Mathis[2], C. Charbonnel[1,4] and L. Amard[1,5]

[1] Department of Astronomy, University of Geneva, Chemin des Maillettes 51, 1290 Versoix, Switzerland
[2] Laboratoire AIM Paris-Saclay, CEA / DRF - CNRS - Univ. Paris Diderot - IRFU / SAp, Centre de Saclay, F-91191

Gif-sur-Yvette Cedex, France
[3] NaXys, Department of Mathematics, University of Namur, 8 Rempart de la Vierge, 5000 Namur, Belgium
[4] IRAP, UMR 5277, CNRS and Université de Toulouse, 14, av. E. Belin, F-31400 Toulouse, France
[5] LUPM UMR 5299 CNRS / UM, Université de Montpellier, CC 72, F-34095 Montpellier Cedex 05, France

E-mail contact: florian.gallet *at* unige.ch

Star-planet interactions must be taken into account in stellar models to understand the dynamical evolution of close-in planets. The dependence of the tidal interactions on the structural and rotational evolution of the star is of peculiar importance and should be correctly treated. We quantify how tidal dissipation in the convective envelope of rotating low-mass stars evolves from the pre-main sequence up to the red-giant branch depending on the initial stellar mass. We investigate the consequences of this evolution on planetary orbital evolution. We couple the tidal dissipation formalism described in Mathis (2015) to the stellar evolution code STAREVOL and apply it to rotating stars with masses between 0.3 and 1.4 $M_{\odot}$. As a first step, this formalism assumes a simplified bi-layer stellar structure with corresponding averaged densities for the radiative core and the convective envelope. We use a frequency-averaged treatment of the dissipation of tidal inertial waves in the convection zone (we neglect the dissipation of tidal gravity waves in the radiation zone). In addition, we generalize the work of Bolmont & Mathis (2016) by following the orbital evolution of close-in planets using the new tidal dissipation predictions for advanced phases of stellar evolution. On the pre-main sequence the evolution of tidal dissipation is controlled by the evolution of the internal structure of the contracting star. On the main-sequence it is strongly driven by the variation of surface rotation that is impacted by magnetized stellar winds braking. The main effect of taking into account the rotational evolution of the stars is to lower the tidal dissipation strength by about four orders of magnitude on the main-sequence, compared to a normalized dissipation rate that only takes into account structural changes. The evolution of the dissipation strongly depends on the evolution of the internal structure and rotation of the star. From the pre-main sequence up to the tip of the red-giant branch, it varies by several orders of magnitude, with strong consequences for the orbital evolution of close-in massive planets. These effects are the strongest during the pre-main sequence, implying that the planets are mainly sensitive to the star's early history.

Accepted by A&A

https://arxiv.org/pdf/1705.10164.pdf

Variable protostellar mass accretion rates in cloud cores

Yang Gao[1] and Yu-Qing Lou[2,3]

[1] Centre for Combustion Energy and Department of Thermal Engineering, Tsinghua University, Beijing 100084, China
[2] Department of Physics and Tsinghua Centre for Astrophysics (THCA), Tsinghua University, Beijing 100084, China
[3] Tsinghua-NAOC joint Research Center for Astrophysics, Tsinghua University, Beijing 100084, China

E-mail contact: gaoyang-00 *at* mail.tsinghua.edu.cn

Spherical hydrodynamic models with a polytropic equation of state (EoS) for forming protostars are revisited in order to investigate the so-called luminosity conundrum highlighted by observations. For a molecular cloud (MC) core with such an EoS with polytropic index $\gamma > 1$, the central mass accretion rate (MAR) decreases with increasing time as a protostar emerges, offering a sensible solution to this luminosity problem. As the MAR decreases, the protostellar luminosity also decreases, meaning that it is invalid to infer the star formation time from the currently observed luminosity using an isothermal model. Furthermore, observations of radial density profiles and the radio continua of numerous MC cores evolving towards protostars also suggest that polytropic dynamic spheres of $\gamma > 1$ should be used in physical models.

Accepted by MNRAS

http://arxiv.org/pdf/1705.09012

Identifying and Analysing Protostellar Disc Fragments in Smoothed Particle Hydrodynamics Simulations

Cassandra Hall[1,2], Duncan Forgan[3,4], Ken Rice[1,5]

[1] SUPA, Institute for Astronomy, University of Edinburgh, Blackford Hill, Edinburgh, EH9 3HJ, UK
[2] Department of Physics & Astronomy, University of Leicester, Leicester, LE1 7RH, UK

[3] SUPA, School of Physics & Astronomy, University of St Andrews, North Haugh, St Andrews, KY16 9SS, UK
[4] St Andrews Centre for Exoplanet Science
[5] Centre for Exoplanet Science, University of Edinburgh, Edinburgh, UK

E-mail contact: cassandra.hall *at* le.ac.uk

We present a new method of identifying protostellar disc fragments in a simulation based on density derivatives, and analyse our data using this and the existing CLUMPFIND method, which is based on an ordered search over all particles in gravitational potential energy. Using smoothed particle hydrodynamics, we carry out 9 simulations of a 0.25 $M_\odot$ disc around a 1 $M_\odot$ star, all of which fragment to form at least 2 bound objects. We find that when using all particles ordered in gravitational potential space, only fragments that survive the duration of the simulation are detected. When we use the density derivative method, all fragments are detected, so the two methods are complementary, as using the two methods together allows us to identify all fragments, and to then determine those that are likely to be destroyed. We find a tentative empirical relationship between the dominant azimuthal wavenumber in the disc m and the maximum semi-major axis a fragment may achieve in a simulation, such that $\alpha_{\max} \propto 1/m$. We find the fragment destruction rate to be around half that predicted from population synthesis models. This is due to fragment-fragment interactions in the early gas phase of the disc, which can cause scattering and eccentricity pumping on short timescales, and affects the fragment's internal structure. We therefore caution that measurements of eccentricity as a function of semi-major axis may not necessarily constrain the formation mechanism of giant planets and brown dwarfs.

Accepted by MNRAS

http://arxiv.org/pdf/1705.06690

Hints for Small Disks around Very Low-Mass Stars and Brown Dwarfs

Nathanial P. Hendler[1], Gijs D. Mulders[1], Ilaria Pascucci[1], Aaron Greenwood[2], Inga Kamp[2], Thomas Henning[3], François Ménard[4], William R.F. Dent[5], Neal J. Evans II[6]

[1] Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721, USA
[2] Kapteyn Astronomical Institute, University of Groningen, Postbus 800, 9700 AV Groningen, The Netherlands
[3] Max Planck Institute for Astronomy, Konigstuhl 17, D-69117 Heidelberg, Germany
[4] Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France
[5] Atacama Large Millimeter/submillimeter Array (ALMA) Santiago Central Offices, Alonso de Cordova 3107, Vitacura, Casilla 763 0355, Santiago, Chile Department of Engineering
[6] Department of Astronomy, The University of Texas at Austin, Austin, TX 78712, USA

E-mail contact: equant *at* lpl.arizona.edu

The properties of disks around brown dwarfs and very-low mass stars (hereafter VLMOs) provide important boundary conditions on the process of planet formation and inform us about the numbers and masses of planets than can form in this regime. We use the Herschel Space Observatory PACS spectrometer to measure the continuum and [OI] 63 μm line emission towards 11 VLMOs with known disks in the Taurus and Chamaeleon I star-forming regions. We fit radiative transfer models to the spectral energy distributions of these sources. Additionally, we carry out a grid of radiative transfer models run in a regime that connects the luminosity of our sources with brighter T Tauri stars. We find VLMO disks with sizes [1.3–78] au, smaller than typical T Tauri disks, fit well the spectral energy distributions assuming disk geometry and dust properties are stellar-mass independent. Reducing the disk size increases the disk temperature and we show that VLMOs do not follow previously derived disk temperature-stellar luminosity relationships if the disk outer radius scales with stellar mass. Only 2 out of 11 sources are detected in [OI] despite a better sensitivity than was achieved for T Tauri stars, suggesting that VLMO disks are underluminous. Using thermochemical models we show that smaller disks can lead to the unexpected [OI] non-detections in our sample. The disk outer radius is an important factor in determining the gas and dust observables. Hence, spatially resolved observations with ALMA – to establish if and how disk radii scale with stellar mass – should be pursued further.

Accepted by ApJ

http://arxiv.org/pdf/1705.01952

Herschel observations of the circumstellar environment of the two Herbig Be stars R Mon and PDS27

M. J. Jiménez-Donaire[1,2], G. Meeus[2,3], A. Karska[4], B. Montesinos[5,3], J. Bouwman[6], C. Eiroa[2,3] and T. Henning[6]

[1] Zentrum für Astronomie der Universität Heidelberg, Inst. für Theor. Astrophysik, Albert-Ueberle Str. 2, 69120 Heidelberg, Germany.
[2] Universidad Autónoma de Madrid, Dpto. Física Teórica, Facultad de Ciencias, Campus Cantoblanco, 28049 Madrid, Spain
[3] Unidad Asociada CAB-UAM, Madrid, Spain.
[4] Centre for Astronomy, Nicolaus Copernicus University, Faculty of Physics, Astronomy and Informatics, Grudziadzka 5, PL-87100 Torun, Poland.
[5] Departamento de Astrofísica, Centro de Astrobiología (CAB, CSIC-INTA), ESAC Campus, Camino Bajo del Castillo s/n, E-28692 Villanueva de la Cañada, Madrid, Spain.
[6] Max Planck Institut für Astronomie, Konigstühl 17, 69117 Heidelberg, Germany.

E-mail contact: m.jimenez *at* zah.uni-heidelberg.de

Context. The circumstellar environment of Herbig Be stars in the far-infrared is poorly characterised, mainly because they are often embedded and rather distant. The analysis of far-infrared spectroscopy allows us to make a major step forward by covering multiple rotational lines of molecules, e.g. CO, that are useful probes of physical conditions of the gas.
Aims. To characterise the gas and dust in the disc and environment of Herbig Be stars, and to compare the results with those of their lower-mass counterparts, the Herbig Ae stars.
Methods. We report and analyse far-infrared observations of two Herbig Be stars, R Mon and PDS 27, obtained with Herschels instruments PACS and SPIRE. We construct spectral energy distributions and derive the infrared excess. We extract line fluxes from the PACS and SPIRE spectra and construct rotational diagrams in order to estimate the excitation temperature of the gas. We derive CO, [O I] and [C I] luminosities to determine physical conditions of the gas, as well as the dominant cooling mechanism.
Results. We confirm that the Herbig Be stars are surrounded by remnants from their parental clouds, with an IR excess that mainly originates in a disc. In R Mon we detect [O I], [C I], [C II], CO (26 transitions), water and OH, while in PDS 27 we only detect [C I] and CO (8 transitions). We attribute the absence of OH and water in PDS 27 to UV photo-dissociation and photo-evaporation. From the rotational diagrams, we find several components for CO: we derive $T_{\rm rot}$ 949±90 K, 358±20 K & 77±12 K for R Mon, 96±12 K & 31±4 K for PDS 27 and 25±8 K & 27±6 K for their respective compact neighbours. The forsterite feature at 69 μm was not detected in either of the sources, probably due to the lack of (warm) crystalline dust in a flat disc. We find that cooling by molecules is dominant in the Herbig Be stars, while this is not the case in Herbig Ae stars where cooling by [O I] dominates. Moreover, we show that in the Herbig Be star R Mon, outflow shocks are the dominant gas heating mechanism, while in Herbig Ae stars this is stellar.
Conclusions. The outflow of R Mon contributes to the observed line emission by heating the gas, both in the central spaxel/beam covering the disc and the immediate surroundings, as well as in those spaxels/beams covering the parabolic shell around it. PDS 27, a B2 star, has dispersed a large part of its gas content and/or destroyed molecules; this is likely given its intense UV field.

Accepted by A&A

https://arxiv.org/pdf/1705.05860.pdf

An analytical model for the evolution of the protoplanetary discs

Fazeleh Khajenabi[1], Kimia Kazrani[1], Mohsen Shadmehri[1]

[1] Department of Physics, Faculty of Sciences, Golestan University, Gorgan 49138-15739, Iran

E-mail contact: f.khajenabi *at* gu.ac.ir

We obtain a new set of analytical solutions for the evolution of a self-gravitating accretion disc by holding the Toomre parameter close to its threshold, and obtaining the stress parameter from the cooling rate. In agreement with the previous numerical solutions, furthermore, the accretion rate is assumed to be independent of the disc radius. Extreme

situations where the entire disc is either optically thick or optically thin are studied independently and the obtained solutions can be used for exploring the early or the final phases of a protoplanetary disc evolution. Our solutions exhibit decay of the accretion rate as a power-law function of the age of the system with the exponent -0.75 and -1.04 for optically thick and thin cases, respectively. Our calculations permit us to explore evolution of the snow line analytically. Location of the snow line in the optically thick regime evolves as a power-law function of time with the exponent -0.16, however, when the disc is optically thin, location of the snow line as a function of time with the exponent -0.7 has a stronger dependence on time. It means that in an optically thin disc inward migration of the snow line is faster than an optically thick disc.

Accepted by ApJ

http://arxiv.org/pdf/1705.00288

Gas kinematics in massive star-forming regions from the Perseus spiral arm

M. S. Kirsanova[1], A. M. Sobolev[2] and M. Thomasson[3]

[1] Institute of Astronomy, Russian Academy of Sciences, Moscow, Russia

[2] Ural Federal University, Ekaterinburg, Russia

[3] Onsala Space Observatory, Onsala, Sweden

E-mail contact: kirsanova *at* inasan.ru

We present results of a survey of 14 star-forming regions from the Perseus spiral arm in CS(2-1) and 13CO(1-0) lines with the Onsala Space Observatory 20 m telescope. Maps of 10 sources in both lines were obtained. For the remaining sources a map in just one line or a single-point spectrum were obtained. On the basis of newly obtained and published observational data we consider the relation between velocities of the "quasi-thermal" CS(2-1) line and 6.7 GHz methanol maser line in 24 high-mass star-forming regions in the Perseus arm. We show that, surprisingly, velocity ranges of 6.7 GHz methanol maser emission are predominantly red-shifted with respect to corresponding CS(2-1) line velocity ranges in the Perseus arm. We suggest that the predominance of the "red-shifted masers" in the Perseus arm could be related to the alignment of gas flows caused by the large-scale motions in the Galaxy. Large-scale galactic shock related to the spiral structure is supposed to affect the local kinematics of the star-forming regions. Part of the Perseus arm, between galactic longitudes from 85deg to 124deg, does not contain blue-shifted masers at all. Radial velocities of the sources are the greatest in this particular part of the arm, so the velocity difference is clearly pronounced. 13CO(1-0) and CS(2-1) velocity maps of G183.35-0.58 show gas velocity difference between the center and the periphery of the molecular clump up to 1.2 km/s. Similar situation is likely to occur in G85.40-0.00. This can correspond to the case when the large-scale shock wave entrains the outer parts of a molecular clump in motion while the dense central clump is less affected by the shock.

Accepted by Astronomy Reports

https://arxiv.org/pdf/1705.02197

Mass transport from the envelope to the disk of V346 Nor: a case study for the luminosity problem in an FUor-type young eruptive star

Á. Kóspál[1,2], P. Ábrahám[1], T. Csengeri[3], O. Fehér[1], M. Hogerheijde[4], Ch. Brinch[5], M. M. Dunham[6,7], E. Vorobyov[8,9], D. Salter[10], and Th. Henning[2]

[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] Max Planck Institute for Radioastronomy, Auf dem Hügel 69, 53121 Bonn, Germany

[4] Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA Leiden, The Netherlands

[5] Niels Bohr International Academy, The Niels Bohr Institute, University of Copenhagen, Blegdamsvej 17, 2100 Copenhagen Ø, Denmark

[6] Department of Physics, State University of New York at Fredonia, Fredonia, NY 14063, USA

[7] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS 78, Cambridge, MA 02138, USA

[8] Department of Astrophysics, The University of Vienna, Vienna, A-1180, Austria

[9] Research Institute of Physics, Southern Federal University, Stachki 194, Rostov-on-Don, 344090, Russia
[10] Department of Astronomy and Laboratory for Millimeter-Wave Astronomy, University of Maryland, College Park, MD 20742, USA

E-mail contact: kospal *at* konkoly.hu

A long-standing open issue of the paradigm of low-mass star formation is the luminosity problem: most protostars are less luminous than theoretically predicted. One possible solution is that the accretion process is episodic. FU Ori-type stars (FUors) are thought to be the visible examples for objects in the high accretion state. FUors are often surrounded by massive envelopes, which replenish the disk material and enable the disk to produce accretion outbursts. However, we have insufficient information on the envelope dynamics in FUors, about where and how mass transfer from the envelope to the disk happens. Here we present ALMA observations of the FUor-type star V346 Nor at 1.3 mm continuum and in different CO rotational lines. We mapped the density and velocity structure of its envelope and analyze the results using channel maps, position-velocity diagrams, and spectro-astrometric methods. We found that V346 Nor is surrounded by gaseous material on 10 000 au scale in which a prominent outflow cavity is carved. Within the central ∼700 au, the circumstellar matter forms a flattened pseudo-disk where material is infalling with conserved angular momentum. Within ∼350 au, the velocity profile is more consistent with a disk in Keplerian rotation around a central star of $0.1\,M_\odot$. We determined an infall rate from the envelope onto the disk of $6{\times}10^{-6}\,M_\odot\,\mathrm{yr}^{-1}$, a factor of few higher than the quiescent accretion rate from the disk onto the star, hinting for a mismatch between the infall and accretion rates as the cause of the eruption.

Accepted by Astrophysical Journal

The chemical structure of the Class 0 protostellar envelope NGC 1333 IRAS 4A

E. Koumpia[1,2,7], D.A. Semenov[3], F.F.S. van der Tak[1,2], A.C.A. Boogert[4], E. Caux[5,6]

[1] SRON Netherlands Institute for Space Research, Landleven 12, 9747 AD Groningen, The Netherlands
[2] Kapteyn Institute, University of Groningen, Landleven 12, 9747 AD Groningen, The Netherlands
[3] Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany [4] Universities Space Research Association, Stratospheric Observatory for Infrared Astronomy, NASA Ames Research Center, MS 232-11, Moffett Field, CA 94035, USA
[5] Université de Toulouse, UPS-OMP, IRAP, Toulouse, France
[6] CNRS, IRAP, 9 Av. Colonel Roche, BP 44346, F-31028 Toulouse Cedex 4, France

E-mail contact: ev.koumpia *at* gmail.com

It is not well known what drives the chemistry of a protostellar envelope, in particular the role of the stellar mass and the outflows on its chemical enrichment. We study the chemical structure of NGC 1333 IRAS 4A in order to (i) investigate the influence of the outflows on the chemistry, (ii) constrain the age of our object, (iii) compare it with a typical high-mass protostellar envelope. In our analysis we use JCMT line mapping and HIFI pointed spectra. To study the influence of the outflow on the degree of deuteration, we compare JCMT maps of HCO^+ and DCO^+ with non-LTE (RADEX) models in a region that spatially covers the outflow activity of IRAS 4A. To study the envelope chemistry, we derive empirical molecular abundance profiles for the observed species using the radiative transfer code (RATRAN) and adopting a 1D dust density/temperature profile from the literature. We compare our best-fit observed abundance profiles with the predictions from the time dependent gas grain chemical code (ALCHEMIC). The CO, HCN, HNC and CN abundance require an enhanced UV field which points towards an outflow cavity. The abundances (wrt H_2) are 1 to 2 orders of magnitude lower than those observed in the high mass protostellar envelope (AFGL 2591), while they are found to be similar within factors of a few with respect to CO. Differences in UV radiation may be responsible for such chemical differentiation, but temperature differences seem a more plausible explanation. The CH_3OH modeled abundance profile points towards an age of $>4{\times}10^4$ yrs for IRAS 4A. The spatial distribution of H_2D^+ differs from that of other deuterated species, indicating an origin from a foreground colder layer (<20 K). The observed abundances can be explained by passive heating towards the high mass protostellar envelope, while the presence of UV cavity channels become more important toward the low mass protostellar envelope.

Accepted by A&A

http://arxiv.org/pdf/1705.00908

Characterizing the stellar population of NGC 1980

Marina Kounkel[1], Lee Hartmann[1], Nuria Calvet[1] and Tom Megeath[2]

[1] Department of Astronomy, University of Michigan, 1085 S. University st., Ann Arbor, MI 48109, USA
[2] Ritter Astrophsical Research Center, Department of Physics and Astronomy, University of Toledo, Toledo, OH 43606, USA

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

NGC 1980 is a young cluster that is located about 0.5 degrees south of the Orion Nebula Cluster (ONC). Recent studies by Bouy et al. and Pillitteri et al. have suggested that NGC 1980 contains an older population of stars compared to a much younger ONC, and that it belongs to a foreground population that may be located in front of the Orion A molecular gas by as much as 40 pc. In this work we present low-resolution spectra towards 148 young stars found towards the NGC 1980 region. We determine the spectral types of these stars, examine accretion signatures and measure the extinction towards them. We determine that based on these observations, the age of the population of NGC 1980 is indistinguishable from L1641, estimated to be 3 Myr, comparable with the study by Fang et al.

Accepted by AJ

https://arxiv.org/pdf/1705.07922

Origin of warm and hot gas emission from low-mass protostars: *Herschel*-HIFI observations of CO J=16–15. I. Line profiles, physical conditions, and H_2O abundance

L.E. Kristensen[1,2], E.F. van Dishoeck[2,3], J.C. Mottram[4], A. Karska[5], U.A. Yıldız[6], E.A. Bergin[7], P. Bjerkeli[1], S. Cabrit[8], S. Doty[9], N.J. Evans II[10], A. Gusdorf[11], D. Harsono[12], G.J. Herczeg[13], D. Johnstone[14,15], J.K. Jørgensen[1], T.A. van Kempen[16,2], J.-E. Lee[17,18], S. Maret[19,20], M. Tafalla[21], R. Visser[22], and S.F. Wampfler[23]

[1] Centre for Star and Planet Formation, Niels Bohr Institute and Natural History Museum of Denmark, University of Copenhagen, Øster Voldgade 5-7, DK-1350 Copenhagen K, Denmark, [2] Leiden Observatory, Leiden University, PO Box 9513, 2300 RA Leiden, the Netherlands, [3] Max Planck Institut für Extraterrestrische Physik, Giessenbachstrasse 1, 85748 Garching, Germany, [4] Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany, [5] Centre for Astronomy, Nicolaus Copernicus University, Faculty of Physics, Astronomy and Informatics, Grudziadzka 5, PL-87100 Torun, Poland, [6] Jet Propulsion Laboratory, 4800 Oak Groave Drive, Pasadena, CA 91109, USa, [7] Department of Astronomy, The University of Michigan, 500 Church Street, Ann Arbor, MI 48109-1042, USA, [8] LERMA, UMR 8112 du CNRS, Observatoire de Paris, 61 Av. de l'Observatoire, 75014 Paris, France, [9] Department of Physics and Astronomy, Denison University, Granville, OH, 43023, USA, [10] Department of Astronomy, The University of Texas at Austin, Austin, TX 78712, USA, [11] LERMA, UMR 8112 du CNRS, Observatoire de Paris, École Normale Supérieure, 61 Av. de l'Observatoire, 75014, Paris, France, [12] Heidelberg University, Center for Astronomy, Institute for Theoretical Astrophysics, Albert-Ueberle-Strasse 2, 69120 Heidelberg, Germany, [13] Kavli Institute for Astronomy and Astrophysics, Peking University, Yi He Yuan Lu 5, Haidian Qu, 100871 Beijing, China, [14] National Research Council Canada, Herzberg Institute of Astrophysics, 5071 West Saanich Road, Victoria, BC V9E 2E7, Canada, [15] Department of Physics and Astronomy, University of Victoria, Victoria, BC V8P 1A1, Canada, [16] SRON Netherlands Institute for Space Research, Location Utrecht, Sorbonnelaan 2, 3584 CA, Utrecht, [17] Department of Astronomy & Space Science, Kyung Hee University, Gyeonggi 446-701, [18] Korea School of Space Research, Kyung Hee University, Yongin-shi, Kyungki-do 449-701, Korea, [19] Univ. Grenoble Alpes, IPAG, 38000 Grenoble, France, [20] CNRS, IPAG, 38000 Grenoble, France, [21] Observatorio Astronómico Nacional (IGN), Calle Alfonso XII,3. 28014, Madrid, Spain, [22] European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748 Garching, Germany, [23] Center for Space and Habitability, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland

E-mail contact: lars.kristensen *at* nbi.ku.dk

Context. Through spectrally unresolved observations of high-J CO transitions, *Herschel* Photodetector Array Camera and Spectrometer (PACS) has revealed large reservoirs of warm (300 K) and hot (700 K) molecular gas around low-mass protostars. The excitation and physical origin of this gas is still not understood.
Aims. We aim to shed light on the excitation and origin of the CO ladder observed toward protostars, and on the water abundance in different physical components within protostellar systems using spectrally resolved *Herschel*-HIFI data.

Methods. Observations are presented of the highly excited CO line $J = 16–15$ ($E_{\rm up}/k_{\rm B} = 750$ K) with the *Herschel* Heterodyne Instrument for the Far Infrared (HIFI) toward a sample of 24 low-mass protostellar objects. The sources were selected from the *Herschel* "Water in Star-forming regions with *Herschel*" (WISH) and "Dust, Ice, and Gas in Time" (DIGIT) key programs.
Results. The spectrally resolved line profiles typically show two distinct velocity components: a broad Gaussian component with an average $FWHM$ of 20 km s^{-1} containing the bulk of the flux, and a narrower Gaussian component with a $FWHM$ of 5 km s^{-1} that is often offset from the source velocity. Some sources show other velocity components such as extremely-high-velocity features or "bullets". All these velocity components were first detected in H_2O line profiles. The average rotational temperature over the entire profile, as measured from comparison between CO J=16–15 and 10–9 emission, is $\sim$ 300 K. A radiative-transfer analysis shows that the average H_2O/CO column-density ratio is $\sim$0.02, suggesting a total H_2O abundance of $\sim 2\times10^{-6}$, independent of velocity.
Conclusions. Two distinct velocity profiles observed in the HIFI line profiles suggest that the high-J CO ladder observed with PACS consists of two excitation components. The warm PACS component (300 K) is associated with the broad HIFI component, and the hot PACS component (700 K) is associated with the offset HIFI component. The former originates in either outflow cavity shocks or the disk wind, and the latter in irradiated shocks. The low water abundance can be explained by photodissociation. The ubiquity of the warm and hot CO components suggest that fundamental mechanisms govern the excitation of these components; we hypothesize that the warm component arises when H_2 stops being the dominant coolant. In this scenario, the hot component arises in cooling molecular H_2-poor gas just prior to the onset of H_2 formation. High spectral resolution observations of highly excited CO transitions uniquely shed light on the origin of warm and hot gas in low-mass protostellar objects.

Accepted by A&A

https://arxiv.org/pdf/1705.10269

The Structure of the Young Star Cluster NGC 6231. I. Stellar Population

Michael A. Kuhn[1,2], Nicolás Medina[1,2], Konstantin V. Getman[3], Eric D. Feigelson[3,1], Mariusz Gromadzki[4], Jordanka Borissova[1,2] and Radostin Kurtev[1,2]

[1] Millennium Institute of Astrophysics, Vicuña Mackenna 4860, 7820436 Macul, Santiago, Chile
[2] Instituto de Fisica y Astronomía, Universidad de Valparaíso, Gran Bretaña 1111, Playa Ancha, Valparaíso, Chile
[3] Department of Astronomy & Astrophysics, 525 Davey Laboratory, Pennsylvania State University, University Park, PA 16802, USA
[4] Warsaw University Astronomical Observatory, Al. Ujazdowskie 4, 00-478 Warszawa, Poland

E-mail contact: mkuhn1 *at* gmail.com

NGC 6231 is a young cluster (age ∼2–7 Myr) dominating the Sco OB1 association (distance ∼1.59 kpc) with ∼100 O and B stars and a large pre–main-sequence stellar population. We combine a reanalysis of archival *Chandra* X-ray data with multi-epoch NIR photometry from the VVV survey and published optical catalogs to obtain a catalog of 2148 probable cluster members. This catalog is 70% larger than previous censuses of probable cluster members in NGC 6231, and it includes many low-mass stars detected in the NIR but not in the optical and some B-stars without previously noted X-ray counterparts. In addition, we identify 295 NIR variables, about half of which are expected to be pre–main-sequence stars. With the more-complete sample, we estimate a total population in the *Chandra* field of 5700–7500 cluster members down to 0.08 $M_\odot$ (assuming a universal initial mass function) with a completeness limit at 0.5 $M_\odot$. A decrease in stellar X-ray luminosities is noted relative to other younger clusters. However, within the cluster, there is little variation in the distribution of X-ray luminosities for ages less than 5 Myr. X-ray spectral hardness for B stars may be useful for distinguishing between early-B stars with X-rays generated in stellar winds and B-star systems with X-rays from a pre–main-sequence companions (>35% of B stars). A small fraction of catalog members have unusually high X-ray median energies or reddened near-infrared colors, which might be explained by absorption from thick or edge-on disks or being background field stars.

Accepted by AJ

https://arxiv.org/pdf/1706.00017

Binary Star Formation and the Outflows from their Discs

Rajika Kuruwita[1], Christoph Federrath[1] and Michael Ireland[1]

[1] Australian National University

E-mail contact: rajika.kuruwita *at* anu.edu.au

We carry out magnetohydrodynamical simulations with FLASH of the formation of a single, a tight binary (a ∼2.5 AU) and a wide binary star (a ∼45 AU). We study the outflows and jets from these systems to understand the contributions the circumstellar and circumbinary discs have on the efficiency and morphology of the outflow. In the single star and tight binary case we obtain a single pair of jets launched from the system, while in the wide binary case two pairs of jets are observed. This implies that in the tight binary case the contribution of the circumbinary disc on the outflow is greater than that in the wide binary case. We also find that the single star case is the most efficient at transporting mass, linear and angular momentum from the system, while the wide binary case is less efficient (∼50%, ∼33%, ∼42% of the respective quantities in the single star case). The tight binary's efficiency falls between the other two cases (∼71%, ∼66%, ∼87% of the respective quantities in the single star case). By studying the magnetic field structure we deduce that the outflows in the single star and tight binary star case are magnetocentrifugally driven, whereas in the wide binary star case the outflows are driven by a magnetic pressure gradient.

Accepted by MNRAS

http://arxiv.org/pdf/1705.08152

An extensive VLT/X-Shooter library of photospheric templates of pre-main sequence stars

C. F. Manara[1], A. Frasca[2], J. M. Alcala[3], A. Natta[4,5], B. Stelzer[6,7] and L. Testi[8,5,9]

[1] Scientific Support Office, Directorate of Science, European Space Research and Technology Centre (ESA/ESTEC), Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands
[2] INAF - Osservatorio Astrofisico di Catania, via S. Sofia, 78, 95123 Catania, Italy
[3] INAF-Osservatorio Astronomico di Capodimonte, via Moiariello 16, 80131 Napoli, Italy
[4] School of Cosmic Physics, Dublin Institute for Advanced Studies, 31 Fitzwilliams Place, Dublin 2, Ireland
[5] INAF-Osservatorio Astrofisico di Arcetri, L.go E. Fermi 5, 50125 Firenze, Italy
[6] Eberhard Karls Universität, Kepler Center for Astro and Particle Physics, Institut fr Astronomie und Astrophysik, Sand 1, 72076 Tübingen, Germany
[7] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy
[8] European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748 Garching bei München, Germany
[9] Excellence Cluster Universe, Boltzmannstr. 2, 85748 Garching, Germany

E-mail contact: cmanara *at* cosmos.esa.int

Context: Studies of the formation and evolution of young stars and their disks rely on the knowledge of the stellar parameters of the young stars. The derivation of these parameters is commonly based on comparison with photospheric template spectra. Furthermore, chromospheric emission in young active stars impacts the measurement of mass accretion rates, a key quantity to study disk evolution.
Aims: Here we derive stellar properties of low-mass ($M_\star < 2\ M_\odot$) pre-main sequence stars without disks, which represent ideal photospheric templates for studies of young stars. We also use these spectra to constrain the impact of chromospheric emission on the measurements of mass accretion rates. The spectra in reduced, flux-calibrated, and corrected for telluric absorption form are made available to the community.
Methods: We derive the spectral type for our targets by analyzing the photospheric molecular features present in their VLT/X-Shooter spectra by means of spectral indices and comparison of the relative strength of photospheric absorption features. We also measure effective temperature, gravity, projected rotational velocity, and radial velocity from our spectra by fitting them with synthetic spectra with the ROTFIT tool. The targets have negligible extinction ($A_V < 0.5$ mag) and spectral type from G5 to K6, and from M6.5 to M8. They thus complement the library of photospheric templates presented by Manara et al. (2013). We perform synthetic photometry on the spectra to derive the typical colors of young stars in different filters. We measure the luminosity of the emission lines present in the spectra and estimate the noise due to chromospheric emission in the measurements of accretion luminosity in accreting stars.

Results: We provide a calibration of the photospheric colors of young pre-main sequence stars as a function of their spectral type in a set of standard broad-band optical and near-infrared filters. The logarithm of the noise on the accretion luminosity normalized to the stellar luminosity is roughly constant and equal to ~ -2.3 for targets with masses larger than 1 solar mass, and decreases with decreasing temperatures for lower mass stars. For stars with masses of $\sim 1.5 M_\odot$ and ages of ∼1-5 Myr, the chromospheric noise converts to a limit of measurable mass accretion rates of $\sim 3 \cdot 10^{-10} M_\odot$/yr. The limit on the mass accretion rate set by the chromospheric noise is of the order of the lowest measured values of mass accretion rates in Class II objects.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/1705.10075

Can Dust Injected by SNe Explain the NIR-MIR Excess in Young Massive Stellar Clusters?

Sergio Martínez-González[1], Richard Wünsch[1] and Jan Palous[1]

[1] Astronomical Institute, Czech Academy of Sciences, Bo?n II 1401/1a Praha 4 141 00, Czech Republic

E-mail contact: martinez *at* asu.cas.cz

We present a physically-motivated model involving the different processes affecting supernova dust grains as they are incorporated into the thermalized medium within young massive star clusters. The model is used to explain the near- to mid-infrared (NIR-MIR) excess found in such clusters and usually modeled as a blackbody with temperature $\sim (400 - 1000)$ K. In our approach, dust grains are efficiently produced in the clumpy ejecta of core-collapse supernovae, fragmented into small pieces ($\lesssim$0.05 μm) as they are incorporated into the hot and dense ISM, heated via frequent collisions with electrons and the absorption of energetic photons. Grains with small sizes can more easily acquire the high temperatures ($\sim$ 1000 K) required to produce a NIR-MIR excess with respect to the emission of foreground PAHs and starlight. However, the extreme conditions inside young massive clusters make difficult for these small grains to have a persistent manifestation at NIR-MIR wavelengths as they are destroyed by efficient thermal sputtering. Nevertheless, the chances for a persistent manifestation are increased by taking into account that small grains become increasingly transparent to their impinging ions as their size decreases. For an individual SN event, we find that the NIR-MIR excess last longer if the time required to incorporate all the grains into the thermalized medium is also longer, and in some cases, comparable to the characteristic interval between supernova explosions. Our models, can successfully explain the near-infrared excesses found in the star clusters observed in M33 (Relaño et al. 2016) assuming a low heating efficiency and mass-loading. In this scenario, the presence of the NIR-MIR excess is an indication of efficient dust production in SNe and its subsequent destruction.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1705.08899

The Role of Disc Self-Gravity in Circumbinary Planet Systems: II. Planet Evolution

Matthew M. Mutter[1,2], Arnaud Pierens[3,4], Richard P. Nelson[1,2]

[1] Astronomy Unit, Queen Mary University of London, Mile End Rd, London, E1 4NS, UK

[2] Kavli Institute for Theoretical Physics, University of California, Santa Barbara, CA 93106, USA

[3] Université de Bordeaux, Observatoire Aquitain des Sciences de lUnivers, BP89 33271 Floirac Cedex, France

[4] Laboratoire d'Astrophysique de Bordeaux, Univ. Bordeaux, CNRS, B18N, allé Geoffroy Saint-Hilaire, 33615 Pessac, France

E-mail contact: m.m.mutter *at* qmul.ac.uk

We present the results of hydrodynamic simulations examining migration and growth of planets embedded in self-gravitating circumbinary discs. The binary star parameters are chosen to mimic those of the Kepler-16, -34 and -35 systems; the aim of this study is to examine the role of disc mass in determining the stopping locations of migrating planets at the edge of the cavity created by the central binary. Disc self-gravity can cause significant shrinkage of the cavity for disc masses in excess of 5–10 $\times$ the minimum mass solar nebula model. Planets forming early in the disc lifetime can migrate through the disc and stall at locations closer to the central star than is normally the case for lower mass discs, resulting in closer agreement between simulated and observed orbital architecture. The presence of

a planet orbiting in the cavity of a massive disc can prevent the cavity size from expanding to the size of a lower mass disc. As the disc mass reduces over long time scales, this indicates that circumbinary planet systems retain memory of their initial conditions. Our simulations produce planetary orbits in good agreement with Kepler-16b without the need for self-gravity; Kepler-34 analogue systems produce wide and highly eccentric cavities, and self-gravity improves the agreement between simulations and data. Kepler-35b is more difficult to explain in detail due to it's relatively low mass, which results in the simulated stopping location being at a larger radius than that observed.

Accepted by MNRAS

http://arxiv.org/pdf/1705.03035

Bowshocks in a newly discovered maser source in IRAS 20231+3440

C. S. Ogbodo[1,3,7], R. A. Burns[3,4], T. Handa[3], T. Omodaka[3], A. Nakagawa[3], T. Nagayama[2], M. Honma[2], J. O. Chibueze[1,5,6], A. A. Ubachukwu[1] and R. N. C. Eze[1]

[1] Department of Physics and Astronomy, Faculty of Physical Sciences, University of Nigeria, Carver Building, 1 University Road, Nsukka, Nigeria

[2] Mizusawa VLBI Observatory, National Astronomical Observatory of Japan, 2-12 Hoshi-ga-oka, Mizusawa-ku, Oshu, Iwate 023-0861, Japan

[3] Graduate School of Science and Engineering, Kagoshima University, 1-21-35 Korimoto, Kagoshima, Kagoshima 890-0065, Japan

[4] Joint Institute for VLBI ERIC, Postbus 2, 7990 AA Dwingeloo, The Netherlands

[5] SKA Africa, 3rd Floor, The Park, Park Road, Pinelands, Cape Town, 7405, South Africa

[6] Space Research Unit, Physics Department, NorthWest University, Private Bag X6001, Potchefstroom, 2520, South Africa

[7] Department of Physics/Geology/Geophysics, Federal University Ndufu-Alike, Ikwo, Ebonyi State, Nigeria

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

From measuring the annual parallax of water masers over one and a half years with VERA, we present the trigonometric parallax and corresponding distance of another newly identified water maser source in the region of IRAS 20231+3440 as $\pi = 0.611 \pm 0.022$ mas and $D = 1.64 \pm 0.06$ kpc respectively. We measured the absolute proper motions of all the newly detected maser spots (30 spots) and presented two pictures describing the possible spatial distribution of the water maser as the morphology marks out an arc of masers whose average proper motion velocity in the jet direction was 14.26 km s^{-1}. As revealed by the ALLWISE composite image, and by applying the colour-colour method of YSO identification and classification on photometric archived data, we identified the driving source of the north maser group to be a class I, young stellar object. To further probe the nature of the progenitor, we used the momentum rate maximum value (1.2×10^{-4} $M_\odot$ yr^{-1} km s^{-1}) of the outflow to satisfy that the progenitor under investigation is a low mass young stellar object concurrently forming alongside an intermediate-mass YSO $\sim 60,000$ au (~ 37 arcsecs) away from it.

Accepted by Monthly Notices of the Royal Astronomical Society

https://arxiv.org/pdf/1705.02557.pdf

The complexity of Orion : an ALMA view
I. Data and first results

Laurent Pagani[1], Ccile Favre[2], Paul F. Goldsmith[3], E.A. Bergin[4], R. Snell[5] and G. Melnick[6]

[1] LERMA, UMR8112, CNRS & Observatoire de Paris, PSL, UMPC, Paris, France

[2] Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France

[3] JPL, Pasadena, California, USA

[4] Department of Astronomy, Univ. of Michigan, 311 West Hall, 1085 S. University Ave, Ann Arbor, MI 48109, USA

[5] Department of Astronomy, University of Massachusetts, Amherst, MA, 01003, USA

[6] Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts, USA

E-mail contact: laurent.pagani *at* obspm.fr

Aims We wish to improve our understanding of the Orion central star formation region (Orion-KL) and disentangle

its complexity.
Method We collected data with ALMA during cycle 2 in 16 GHz of total bandwidth spread between 215.1 and 252.0 GHz with a typical sensitivity of 5 mJy/beam (2.3 mJy/beam from 233.4 to 234.4 GHz) and a typical beam size of $1.7'' \times 1.0''$ (average pos. angle of 89 degr). We produced a continuum map and studied the emission lines in 9 remarkable infrared spots in the region including the Hot Core and the Compact Ridge, plus the recently discovered Ethylene Glycol peak.
Results We present the data, and report the detection of several species not previously seen in Orion, including n- and i-propyl cyanide (C_3H_7CN), and tentative detection of a number of other species including glycolaldehyde ($CH_2(OH)CHO$). The first detections of gGg′ ethylene glycol (gGg′ $(CH_2OH)_2$) and of acetic acid (CH_3COOH) in Orion are presented in a companion paper. We also report for the first time in Orion the detection of several vibrationally excited states of cyanoacetylene (HC_3N), and of its ^{13}C isotopologues. We could not detect the $^{16}O^{18}O$ line predicted based on our detection of O_2 with Herschel due to blending with a nearby line of vibrationally excited ethyl cyanide. We do not confirm the tentative detection of hexatriynyl (C_6H) and cyanohexatriyne (HC_7N) reported previously, nor of hydrogen peroxide (H_2O_2) emission. We report a complex velocity structure only partially revealed before. Components as extreme as -7 and +19 $\mathrm{km\,s^{-1}}$ are detected inside the hot region. Thanks to different opacities of various velocity components, we can order in some cases the position of these components along the line of sight. We propose that systematic redshifted and blueshifted wings of several species observed in the northern part of the region are linked to the explosion that occurred ∼500 years ago. The compact ridge, noticeably further south displays extremely narrow lines ($\sim 1\,\mathrm{km\,s^{-1}}$) revealing a quiescent region that has not been affected by this explosion. This probably indicates that the compact ridge is either over 10,000 au in front or behind the rest of the region.
Conclusions Many lines remain unidentified, and only a detailed modeling of all known species, including vibrational states of isotopologues combined with the detailed spatial analysis offered by ALMA enriched with zero-spacing data, will allow new species to be detected.

Accepted by A&A

http://aramis.obspm.fr/~pagani/orion_data.pdf

No preferential spatial distribution for massive stars expected from their formation

Richard J. Parker[1] and James E. Dale[2]

[1] Department of Physics and Astronomy, The University of Sheffield, Hicks Building, Hounsfield Road, Sheffield, S3 7RH, UK
[2] Centre for Astrophysics Research, Science and Technology Research Institute, University of Hertfordshire, Hatfield, AL10 9AB, UK

E-mail contact: R.Parker *at* sheffield.ac.uk

We analyse N-body and Smoothed Particle Hydrodynamic (SPH) simulations of young star-forming regions to search for differences in the spatial distributions of massive stars compared to lower-mass stars. The competitive accretion theory of massive star formation posits that the most massive stars should sit in deeper potential wells than lower-mass stars. This may be observable in the relative surface density or spatial concentration of the most massive stars compared to other, lower-mass stars. Massive stars in cool–collapse N-body models do end up in significantly deeper potentials, and are mass segregated. However, in models of warm (expanding) star-forming regions, whilst the massive stars do come to be in deeper potentials than average stars, they are not mass segregated. In the purely hydrodynamical SPH simulations, the massive stars do come to reside in deeper potentials, which is due to their runaway growth. However, when photoionisation and stellar winds are implemented in the simulations, these feedback mechanisms regulate the mass of the stars and disrupt the inflow of gas into the clouds' potential wells. This generally makes the potential wells shallower than in the control runs, and prevents the massive stars from occupying deeper potentials. This in turn results in the most massive stars having a very similar spatial concentration and surface density distribution to lower-mass stars. Whilst massive stars do form via competitive accretion in our simulations, this rarely translates to a different spatial distribution and so any lack of primordial mass segregation in an observed star-forming region does not preclude competitive accretion as a viable formation mechanism for massive stars.

Accepted by MNRAS

https://arxiv.org/pdf/1705.04686

The dense-gas mass versus star formation rate relation: a misleading linearity?

Genevieve Parmentier[1]

[1] Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Heidelberg, Germany
E-mail contact: gparm *at* ari.uni-heidelberg.de

We model the star formation relation of molecular clumps in dependence of their dense-gas mass when their volume density profile is that of an isothermal sphere, i.e. $\rho_{clump}(r) \propto r^{-2}$. Dense gas is defined as gas whose volume density is higher than a threshold $\rho_{th} = 700\, M_{\odot}.pc^{-3}$, i.e. HCN(1-0)-mapped gas. We divide the clump into two regions: a dense inner region (where $\rho_{clump}(r) \geq \rho_{th}$), and low-density outskirts (where $\rho_{clump}(r) < \rho_{th}$). We find that the total star formation rate of clumps scales linearly with the mass of their dense inner region, even when more than half of the clump star formation activity takes place in the low-density outskirts. We therefore emphasize that a linear star formation relation does not necessarily imply that star formation takes place exclusively in the gas whose mass is given by the star formation relation. The linearity of the star formation relation is strengthened when we account for the mass of dense fragments (e.g. cores, fibers) seeding star formation in the low-density outskirts, and which our adopted clump density profile $\rho_{clump}(r)$ does not resolve. We also find that the star formation relation is significantly tighter when considering the dense gas than when considering all the clump gas, as observed for molecular clouds of the Galactic plane. When the clumps have no low-density outskirts (i.e. they consist of dense gas only), the star formation relation becomes superlinear and progressively wider.

Accepted by The Astrophysical Journal

http://xxx.lanl.gov/pdf/1705.10827

The chemistry of episodic accretion in embedded objects. 2D radiation thermo-chemical models of the post-burst phase

Ch. Rab[1], V. Elbakyan[2], E. Vorobyov[3,2,1], M. Güdel[1], O. Dionatos[1], M. Audard[4], I. Kamp[5], W.-F. Thi[6], P. Woitke[7], and A. Postel[4]

[1] University of Vienna, Dept. of Astrophysics, Türkenschanzstr. 17, 1180 Wien, Austria
[2] Research Institute of Physics, Southern Federal University, Stachki 194, Rostov-on-Don, 344090, Russia
[3] Institute of Fluid Mechanics and Heat Transfer, TU Wien, 1060 Vienna, Austria
[4] Department of Astronomy, University of Geneva, Ch. d'Ecogia 16, 1290 Versoix, Switzerland
[5] Kapteyn Astronomical Institute, University of Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands
[6] Max-Planck-Institut für extraterrestrische Physik, Giessenbachstrasse 1, 85748 Garching, Germany
[7] SUPA, School of Physics & Astronomy, University of St. Andrews, North Haugh, St. Andrews KY16 9SS, UK
E-mail contact: christian.rab *at* univie.ac.at

Episodic accretion is an important process in the evolution of young stars and their environment. The observed strong luminosity bursts of young stellar objects likely have a long lasting impact on the chemical evolution of the disk and envelope structure. We want to investigate observational signatures of the chemical evolution in the post-burst phase for embedded sources. With such signatures it is possible to identify targets that experienced a recent luminosity burst. We present a new model for episodic accretion chemistry based on the 2D, radiation thermo-chemical disk code ProDiMo. We have extended ProDiMo with a proper treatment for envelope structures. For a representative Class I model, we calculated the chemical abundances in the post-burst phase and produced synthetic observables like intensity maps and radial profiles. During a burst many chemical species, like CO, sublimate from the dust surfaces. As the burst ends they freeze out again (post-burst phase). This freeze-out happens from inside-out due to the radial density gradient in the disk and envelope structure. This inside-out freeze-out produces clear observational signatures in spectral line emission, like rings and distinct features in the slope of radial intensity profiles. We fitted synthetic $C^{18}O$ $J = 2$–1 observations with single and two component fits and find that post-burst images are much better matched by the latter. Comparing the quality of such fits allows identification of post-burst targets in a model-independent way. Our models confirm that it is possible to identify post-burst objects from spatially resolved CO observations. However, to derive proper statistics, like frequencies of bursts, from observations it is important to consider aspects like the inclination and structure of the target and also dust properties as those have a significant impact on the freeze-out timescale.

Accepted by A&A

http://arxiv.org/pdf/1705.03946

The formation of double working surfaces in periodically variable jets

A. C. Raga[1] and J. Cantó[2]

[1] Instituto de Ciencias Nucleares, UNAM, México
[2] Instituto de Astronomía, UNAM, México

E-mail contact: raga *at* nucleares.unam.mx

It is a well known result that a periodic ejection variability in a hypersonic jet results in the production of a train of internal working surfaces (one working surface produced by each period of the ejection variability) travelling down the jet beam. This mechanism has been successfully applied to model the knot structures of Herbig-Haro (HH) jets. In this paper we explore the possibility of producing more than one working surface with each ejection variability period. We derive the mathematical criteria that have to be satisfied by the functional form of an ejection velocity variability that produces double working surfaces, and study a family of functions with appropriate properties.

Accepted by RMxAA

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

A spectroscopic survey of Orion KL between 41.5 and 50 GHz

J.R. Rizzo[1], B. Tercero[2], and J. Cernicharo[2]

[1] Departamento de Astrofisica, Centro de Astrobiología (INTA-CSIC), Ctra. M-108, km. 4, E-28850 Torrejón de Ardoz, Spain
[2] Grupo de Astrofisica Molecular, Instituto de Ciencia de Materiales de Madrid (CSIC), Calle Sor Juana Inés de la Cruz 3, Cantoblanco, E-28049 Madrid, Spain

E-mail contact: ricardo.rizzo *at* cab.inta-csic.es

Orion KL is one of the most frequently observed sources in the Galaxy, and the site where many molecular species have been discovered for the first time. With the availability of powerful wideband backends, it is nowadays possible to complete spectral surveys in the entire mm-range to obtain a spectroscopically unbiased chemical picture of the region. In this paper we present a sensitive spectral survey of Orion KL, made with one of the 34m antennas of the Madrid Deep Space Communications Complex in Robledo de Chavela, Spain. The spectral range surveyed is from 41.5 to 50 GHz, with a frequency spacing of 180 kHz (equivalent to about 1.2 km s^{-1}, depending on the exact frequency). The rms achieved ranges from 8 to 12 mK. The spectrum is dominated by the J = 1–0 SiO maser lines and by radio recombination lines (RRLs), which were detected up to $\Delta n = 11$. Above a 3-σ level, we identified 66 RRLs and 161 molecular lines corresponding to 39 isotopologues from 20 molecules; a total of 18 lines remain unidentified, two of them above a 5-σ level. Results of radiative modelling of the detected molecular lines (excluding masers) are presented. At this frequency range, this is the most sensitive survey and also the one with the widest band. Although some complex molecules like CH_3CH_2CN and CH_2CHCN arise from the hot core, most of the detected molecules originate from the low temperature components in Orion KL.

Accepted by A&A

http://arxiv.org/pdf/1705.07662

Constraints on interstellar dust models from extinction and spectro-polarimetry

Ralf Siebenmorgen[1], N.V. Voshchinnikov[2], S. Bagnulo[3] and N.L.J. Cox[4]

[1] European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching, Germany
[2] Sobolev Astronomical Institute, St. Petersburg University, Universitetskii prosp. 28, St. Petersburg, 198504 Russia
[3] Armagh Observatory and Planetarium, College Hill, Armagh BT61 9DG, UK
[4] Anton Pannekoek Institute for Astronomy, University of Amsterdam, NL-1090 GE Amsterdam, The Netherlands

E-mail contact: Ralf.Siebenmorgen *at* eso.org

We present polarisation spectra of seven stars in the lines-of-sight towards the Sco OB1 association. Our spectra were obtained within the framework of the Large Interstellar Polarization Survey carried out with the FORS instrument of the ESO VLT. We have modelled the wavelength-dependence of extinction and linear polarisation with a dust model for the diffuse interstellar medium which consists of a mixture of particles with size ranging from the molecular domain of 0.5 nm up to 350 nm. We have included stochastically heated small dust grains with radii between 0.5 and 6 nm made of graphite and silicate, as well as polycyclic aromatic hydrocarbon molecules (PAHs), and we have assumed that larger particles are prolate spheroids made of amorphous carbon and silicate. Overall, a dust model with eight free parameters best reproduces the observations. Reducing the number of free parameters leads to results that are inconsistent with cosmic abundance constraints. We found that aligned silicates are the dominant contributor to the observed polarisation, and that the polarisation spectra are best-fit by a lower limit of the equivolume sphere radius of aligned grains of 70 − 200 nm.

Accepted by Planetary and Space Science

https://arxiv.org/pdf/1705.07828.pdf

VLA Survey of Dense Gas in Extended Green Objects: Prevalence of 25 GHz Methanol Masers

A. P. M. Towner[1,2], C. L. Brogan[1], T. R. Hunter[1], C. J. Cyganowski[3], B. A. McGuire[1], R. Indebetouw[1,2], R. K. Friesen[4] and C. J. Chandler[5]

[1] National Radio Astronomy Observatory, 520 Edgemont Rd., Charlottesville, VA 22903, USA

[2] Department of Astronomy, University of Virginia, P.O. Box 3818, Charlottesville, VA 22903, USA

[3] Scottish Universities Physics Alliance (SUPA), School of Physics and Astronomy, University of St. Andrews, North Haugh, St Andrews, Fife KY16 9SS, UK

[4] Dunlap Institute for Astronomy and Astrophysics, University of Toronto, 50 St George St., Toronto, ON, M5S 3H4, Canada

[5] National Radio Astronomy Observatory, 1003 Lopezville Rd, Socorro, NM 87801, USA

E-mail contact: at4bu *at* virginia.edu

We present $\sim 1-4''$ resolution Very Large Array (VLA) observations of four CH_3OH $J_2 - J_1$-E 25 GHz transitions (J=3, 5, 8, 10) along with 1.3 cm continuum toward 20 regions of active massive star formation containing Extended Green Objects (EGOs), 14 of which we have previously studied with the VLA in the Class I 44 GHz and Class II 6.7 GHz maser lines (Cyganowski et al. 2009). Sixteen regions are detected in at least one 25 GHz line (J=5), with 13 of 16 exhibiting maser emission. In total, we report 34 new sites of CH_3OH maser emission and ten new sites of thermal CH_3OH emission, significantly increasing the number of 25 GHz Class I CH_3OH masers observed at high angular resolution. We identify probable or likely maser counterparts at 44 GHz for all 15 of the 25 GHz masers for which we have complementary data, providing further evidence that these masers trace similar physical conditions despite uncorrelated flux densities. The sites of thermal and maser emission of CH_3OH are both predominantly associated with the 4.5 μm emission from the EGO, and the presence of thermal CH_3OH emission is accompanied by 1.3 cm continuum emission in 9 out of 10 cases. Of the 19 regions that exhibit 1.3 cm continuum emission, it is associated with the EGO in 16 cases (out of a total of 20 sites), 13 of which are new detections at 1.3 cm. Twelve of the 1.3 cm continuum sources are associated with 6.7 GHz maser emission and likely trace deeply-embedded massive protostars.

Accepted by ApJS

https://arxiv.org/pdf/1705.06825

HD far infrared emission as a measure of protoplanetary disk mass

L. Trapman[1], A. Miotello[1], M. Kama[1], E.F. van Dishoeck[1,2], and S. Bruderer[2]

[1] Leiden Observatory, Leiden University, Niels Bohrweg 2, NL-2333 CA Leiden, The Netherlands

[2] Max-Planck-institute für extraterrestrische Physik, Giessenbachstrasse, D-85748 Garching, Germany

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

Protoplanetary disks around young stars are the sites of planet formation. While the dust mass can be estimated using standard methods, determining the gas mass — and thus the amount of material available to form giant planets — has proven to be very difficult. Hydrogen deuteride (HD) is a promising alternative to the commonly-used gas mass tracer, CO. We aim to examine the robustness of HD as tracer of the disk gas mass, specifically the effect of gas mass on the HD FIR emission and its sensitivity to the vertical structure. Deuterium chemistry reactions relevant for HD were implemented in the thermochemical code DALI and models were run for a range of disk masses and vertical structures. The HD $J = 1$–0 line intensity depends directly on the gas mass through a sublinear power law relation with a slope of ∼0.8. Assuming no prior knowledge about the vertical structure of a disk and using only the HD 1–0 flux, gas masses can be estimated to within a factor of 2 for low mass disks ($M_{\rm disk} < 10^{-3}\ M_\odot$). For more massive disks, this uncertainty increases to more than an order of magnitude. Adding the HD 2–1 line or independent information about the vertical structure can reduce this uncertainty to a factor of ∼3 for all disk masses. For TW Hya, using the radial and vertical structure from Kama et al. (2016b) the observations constrain the gas mass to $6 \times 10^{-3}\ M_\odot < M_{\rm disk} < 9 \times 10^{-3}\ M_\odot$. Future observations require a 5σ sensitivity of 1.8×10^{-20} W m^{-2} (2.5×10^{-20} W m^{-2}) and a spectral resolving power $R > 300$ (1000) to detect HD 1–0 (HD 2–1) for all disk masses above $10^{-5}\ M_\odot$ with a line-to-continuum ratio > 0.01. These results show that HD can be used as an independent gas mass tracer with a relatively low uncertainty and should be considered as an important science goal for future FIR missions.

Accepted by A&A

http://arxiv.org/pdf/1705.07671

On the existence of young embedded clusters at high Galactic latitude

D.G. Turner[1], G. Carraro[2], and E.A. Panko[3]

[1] Department of Astronomy and Physics, Saint Marys University, Halifax, NS B3H 3C3, Canada
[2] Dipartimento di Fisica e Astronomia, Universitá di Padova, Vicolo Osservatorio 3, I-35122, Padova, Italy
[3] Theoretical Physics and Astronomy Department, I. I. Mechnikov Odessa National University, Paster str, 42, Odessa, Ukraine

E-mail contact: turner *at* ap.smu.ca

Careful analyses of photometric and star count data available for the nine putative young clusters identified by Camargo et al. (2015, 2016) at high Galactic latitudes reveal that none of the groups contain early-type stars, and most are not significant density enhancements above field level. 2MASS colours for stars in the groups match those of unreddened late-type dwarfs and giants, as expected for contamination by (mostly) thin disk objects. A simulation of one such field using only typical high latitude foreground stars yields a colour-magnitude diagram that is very similar to those constructed by Camargo et al. (2015, 2016) as evidence for their young groups as well as the means of deriving their reddenings and distances. Although some of the fields are coincident with clusters of galaxies, one must conclude that there is no evidence that the putative clusters are extremely young stellar groups.

Accepted by MNRAS

http://arxiv.org/pdf/1705.06748

Analytic Expressions for the Inner-Rim Structure of Passively Heated Protoplanetary Disks

Takahiro Ueda[1], Satoshi Okuzumi[1], and Mario Flock[2]

[1] Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Meguro, Tokyo, 152-8551, Japan
[2] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109, USA

E-mail contact: t_ueda *at* geo.titech.ac.jp

We analytically derive the expressions for the structure of the inner region of protoplanetary disks based on the results from the recent hydrodynamical simulations. The inner part of a disk can be divided into four regions: dust-free region with gas temperature in the optically thin limit, optically thin dust halo, optically thick condensation front and the classical optically thick region in order from the inside. We derive the dust-to-gas mass ratio profile in the dust halo using the fact that partial dust condensation regulates the temperature to the dust evaporation temperature. Beyond the dust halo, there is an optically thick condensation front where all the available silicate gas condenses out. The curvature of the condensation surface is determined by the condition that the surface temperature must be nearly equal to the characteristic temperature ∼1200K. We derive the mid-plane temperature in the outer two regions using the two-layer approximation with the additional heating by the condensation front for the outermost region. As a result, the overall temperature profile is step-like with steep gradients at the borders between the outer three regions.

The borders might act as planet traps where the inward migration of planets due to gravitational interaction with the gas disk stops. The temperature at the border between the two outermost regions coincides with the temperature needed to activate magnetorotational instability, suggesting that the inner edge of the dead zone must lie at this border. The radius of the dead-zone inner edge predicted from our solution is ∼2–3 times larger than that expected from the classical optically thick temperature.

Accepted by ApJ

http://arxiv.org/pdf/1705.06888

Formation of Complex Molecules in Prestellar Cores: a Multilayer Approach

A.I. Vasyunin[1,2], P. Caselli[1], F. Dulieu[3], I. Jiménez-Serra[4]

[1] Max-Planck-Institute for Extraterrestrial Physics, Garching, Germany
[2] Ural Federal University, Ekaterinburg, Russia
[3] LERMA, Université de Cergy Pontoise, Sorbonne Universités, UPMC Univ. Paris 6, PSL Research University, Observatoire de Paris, UMR 8112 CNRS, 5 mail Gay Lussac 95000 Cergy Pontoise, France
[4] Queen Mary University, London, UK

E-mail contact: anton.vasyunin *at* gmail.com

We present the results of chemical modeling of complex organic molecules (COMs) under conditions typical for prestellar cores. We utilize an advanced gas-grain astrochemical model with updated gas-phase chemistry, with a multilayer approach to ice-surface chemistry and an up-to-date treatment of reactive desorption based on recent experiments of Minissale et al. (2016). With the chemical model, radial profiles of molecules including COMs are calculated for the case of the prototypical prestellar core L1544 at the timescales when the modeled depletion factor of CO becomes equal to that observed. We find that COMs can be formed efficiently in L1544 up to the fractional abundances of 10(-10) wrt. total hydrogen nuclei. Abundances of many COMs such as CH_3OCH_3, $HCOOCH_3$, and others peak at similar radial distances of ∼2000–4000 AU. Gas-phase abundances of COMs depend on the efficiency of reactive desorption, which in turn depends on the composition of the outer monolayers of icy mantles. In prestellar cores, the outer monolayers of mantles likely include large fractions of CO and its hydrogenation products, which may increase the efficiency of reactive desorption according to Minissale et al. (2016), and makes the formation of COMs efficient under conditions typical for prestellar cores, although this assumption is yet to be confirmed experimentally. The hydroxyl radical (OH) appears to play an important role in gas-phase chemistry of COMs, which makes it deserving further detailed studies.

Accepted by ApJ

http://arxiv.org/pdf/1705.04747

The effect of accretion on the pre-main-sequence evolution of low-mass stars and brown dwarfs

Eduard Vorobyov[1], Vardan Elbakyan[2], Takashi Hosokawa[3], Yuya Sakurai[4], Manuel Guedel[5] and Harold Yorke[6]

[1] Institute of Fluid Mechanics and Heat Transfer, TU Wien, Vienna, Austria
[2] Research Institute of Physics, Southern Federal University, Rostov-on-Don, Russia
[3] Department of Physics, Kyoto University, Sakyo-ku, Kyoto, Japan
[4] Department of Physics, Graduate School of Science, The University of Tokyo, Tokyo, Japan
[5] University of Vienna, Department of Astrophysics, Vienna, 1180, Austria
[6] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

E-mail contact: eduard.vorobiev *at* univie.ac.at

The pre-main-sequence evolution of low-mass stars and brown dwarfs is studied numerically starting from the formation of a protostellar/proto-brown dwarf seed and taking into account the mass accretion onto the central object during the initial several Myr of evolution. The stellar evolution was computed using the STELLAR evolution code developed by Yorke & Bodenheimer with recent modifications by Hosokawa et al. The mass accretion rates were taken from numerical hydrodynamics models of Vorobyov & Basu computing the circumstellar disk evolution starting from the gravitational collapse of pre-stellar cloud cores of various mass and angular momentum. The resulting stellar evolution tracks were compared with the isochrones and isomasses calculated using non-accreting models. We find that mass accretion in the initial several Myr of protostellar evolution can have a strong effect on the subsequent evolution of young stars and brown dwarfs as compared to the models without accretion. The disagreement between accreting and non-accreting models in terms of the total stellar luminosity L_*, stellar radius R_* and effective temperature $T_{\rm eff}$ depends on the thermal efficiency of accretion, i.e., on the fraction of accretion energy absorbed by the central object. The largest mismatch is found for the cold accretion case, in which essentially all accretion energy is radiated away. The relative deviations in L_* and R_* in this case can reach 50% for 1.0-Myr-old objects and remain notable even for 10-Myr-old objects. In the hot and hybrid accretion cases, in which a constant fraction of accretion energy is absorbed, the disagreement between accreting and non-accreting models becomes less pronounced, but still remains notable for 1.0-Myr-old objects. These disagreements may lead to the wrong age estimate for objects of (sub-)solar mass when using the isochrones based on non-accreting models, as was also previously noted by Baraffe et al. and Hosokawa et al. We find that objects with strong luminosity bursts exhibit notable excursions in the L_*–$T_{\rm eff}$ diagram, but the character of these excursions is distinct for hybrid/hot and cold accretion scenarios. In particular, the cold accretion scenario predicts peak luminosities that are greater than those of known FU-Orionis-type outbursts, which implies that cold accretion is physically less realistic. Mass accretion during the early stages of star and brown dwarf evolution is an important factor, but its effect depends on the details of how accretion energy is distributed within the star. Efforts should now be put to better understand the character of accretion in young protostellar objects.

Accepted by Astronomy & Astrophysics

Molecular gas toward the Gemini OB1 Giant Molecular Cloud Complex I: Observation data

Chen Wang[1,2,3], Ji Yang[1,2,4], Ye Xu[1,2], Facheng Li[1,2], Yang Su[1,2] and Shaobo Zhang[1,2]

[1] Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210008, China

[2] Key Laboratory of Radio Astronomy, Chinese Academy of Sciences, Nanjing 210008, China

[3] University of Chinese Academy of Sciences, 19A Yuquan Road, Shijingshan District, Beijing 100049, China

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

We present a large-scale mapping toward the GEM OB1 association in the galactic anti-center direction. The $9^\circ \times 6\overset{\circ}{.}5$ area was mapped in ^{12}CO, ^{13}CO, and C^{18}O with 50″ angular resolution at 30″ sampling. The region was divided into four main components based on spatial distribution and velocity: the Gemini OB1 Giant Molecular Cloud (GGMC) Complex, the Lynds Dark Clouds and the West Front Clouds, the Swallow and Horn, and the Remote Clouds. The GGMC Complex is located in the Perseus arm, while the Lynds Dark Clouds and the West Front Clouds are located in the Local arm. Swallow and Horn are revealed for the first time in this paper. The two clouds have a similar velocity interval ([11, 21] km s^{-1}) and have similar sizes (0.6 and 0.8 deg^2). We analyzed the structure of these clouds in detail and calculated their parameters (mass, temperature, etc.). Two elongated structures were discovered in a longitude-velocity map in the velocity interval [11, 30] km s^{-1}. We also found an interesting filament that shows a 0.8 km s^{-1} pc^{-1} gradient perpendicular to the direction of the long axis.

Accepted by ApJS

http://arxiv.org/pdf/1705.04446

An upper limit on the mass of the circumplanetary disk for DH Tau b

Schuyler G. Wolff[1], François Ménard[2], Claudio Caceres[3], Charlene Lefévre[4], Mickael Bonnefoy[2], Héctor Cánovas[5], Sébastien Maret[2], Christophe Pinte[2], Matthias R. Schreiber[6], and Gerrit van der Plas[2]

[1] Department of Physics and Astronomy, Johns Hopkins University, Baltimore, MD 21218, USA

[2] Université Grenoble-Alpes, CNRS, Institut de Planétologie et d'Astrophysique (IPAG), F-38000 Grenoble, France

[3] Departamento de Ciencias Fisicas, Facultad de Ciencias Exactas, Universidad Andres Bello. Av. Fernandez Concha 700, Las Condes, Santiago, Chile

[4] IRAM, 300 rue de la piscine, F-38406 Saint-Martin-d'Hères, France

[5] Departamento de Física Teórica, Universidad Autónoma de Madrid, Cantoblanco, 28049 Madrid, Spain

[6] Instituto de Física y Astronomía, Universidad de Valparaíso, Blanco 951, Valparaiso, Chile

E-mail contact: swolff9 *at* jh.edu

DH Tau is a young (∼1 Myr) classical T Tauri star. It is one of the few young PMS stars known to be associated with a planetary mass companion, DH Tau b, orbiting at large separation and detected by direct imaging. DH Tau b is thought to be accreting based on copious Hα emission and exhibits variable Paschen Beta emission. NOEMA observations at 230 GHz allow us to place constraints on the disk dust mass for both DH Tau b and the primary in a regime where the disks will appear optically thin. We estimate a disk dust mass for the primary, DH Tau A of 17.2±1.7 $M_\oplus$, which gives a disk-to-star mass ratio of 0.014 (assuming the usual Gas-to-Dust mass ratio of 100 in the disk). We find a conservative disk dust mass upper limit of 0.42 $M_\oplus$ for DH Tau b, assuming that the disk temperature is dominated by irradiation from DH Tau b itself. Given the environment of the circumplanetary disk, variable illumination from the primary or the equilibrium temperature of the surrounding cloud would lead to even lower disk mass estimates. A MCFOST radiative transfer model including heating of the circumplanetary disk by DH Tau b and DH Tau A suggests that a mass averaged disk temperature of 22 K is more realistic, resulting in a dust disk mass upper limit of 0.09 $M_\oplus$ for DH Tau b. We place DH Tau b in context with similar objects and discuss the consequences for planet formation models.

Accepted by AJ

http://arxiv.org/pdf/1705.08470

MHOs toward HMOs: A Search for Molecular Hydrogen emission-line Objects toward High-Mass Outflows

Grace Wolf-Chase[1,2], Kim Arvidsson[3] and Michael Smutko[4]

[1] Astronomy Department, Adler Planetarium, 1300 S. Lake Shore Drive, Chicago, IL 60605, USA
[2] Dept. of Astronomy and Astrophysics, University of Chicago, 5640 S. Ellis Ave., Chicago, IL 60637, USA
[3] Trull School of Science and Mathematics, Schreiner University, 2100 Memorial Blvd., Kerrville, TX 78028, USA
[4] CIERA and Dept. of Physics and Astronomy, Northwestern University, 2131 Tech Drive, Evanston, IL 60208, USA

E-mail contact: gwolfchase *at* adlerplanetarium.org

We present the results of a narrow-band near-infrared imaging survey for Molecular Hydrogen emission-line Objects (MHOs) toward 26 regions containing high-mass protostellar candidates and massive molecular outflows. We have detected a total of 236 MHOs, 156 of which are new detections, in 22 out of the 26 regions. We use H_2 2.12-μm/H_2 2.25-μm flux ratios, together with morphology, to separate the signatures of fluorescence associated with photo-dissociation regions (PDRs) from shocks associated with outflows in order to identify the MHOs. PDRs have typical low flux ratios of ∼ 1.5 - 3, while the vast majority of MHOs display flux ratios typical of C-type shocks (∼ 6-20). A few MHOs exhibit flux ratios consistent with expected values for J-type shocks (∼ 3-4), but these are located in regions that may be contaminated with fluorescent emission. Some previously reported MHOs have low flux ratios, and are likely parts of PDRs rather than shocks indicative of outflows. We identify a total of 36 outflows across the 22 target regions where MHOs were detected. In over half these regions, MHO arrangements and fluorescent structures trace features present in CO outflow maps, suggesting the CO emission traces a combination of dynamical effects, which may include gas entrained in expanding PDRs as well as bipolar outflows. Where possible, we link MHO complexes to distinct outflows and identify candidate driving sources.

Accepted by ApJ

https://arxiv.org/pdf/1706.00375.pdf

ALMA Images of the Orion Hot Core at 349 GHz

M.C.H. Wright[1], R.L. Plambeck[1]

[1] Radio Astronomy Laboratory, University of California, Berkeley, CA 94720, USA

E-mail contact: wright *at* astro.berkeley.edu

We present ALMA images of the dust and molecular line emission in the Orion Hot Core at 349 GHz. At 0.″2 angular resolution the images reveal multiple clumps in an arc ∼1″ east of Orion Source I, the protostar at the center of the Kleinmann-Low Nebula, and another chain of peaks from IRc7 towards the southwest. The molecular line images

show narrow filamentary structures at velocities >10 km s^{-1} away from the heavily resolved ambient cloud velocity ∼5 km s^{-1}. Many of these filaments trace the SiO outflow from Source I, and lie along the edges of the dust emission. Molecular line emission at excitation temperatures 300–2000 K, and velocities >10 km s^{-1} from the ambient cloud, suggest that the Hot Core may be heated in shocks by the outflow from Source I or from the BN/Source I explosion. The spectral line observations also reveal a remarkable molecular ring, ∼2″ south of Source I, with a diameter ∼600 AU. The ring is seen in high excitation transitions of HC_3N, HCN v2=1, and SO_2. An impact of ejecta from the BN/Source I explosion with a dense dust clump could result in the observed ring of shocked material.

Accepted by ApJ

http://arxiv.org/pdf/1705.03957

Gas versus solid-phase deuterated chemistry: HDCO and D_2CO in massive star-forming regions

Sarolta Zahorecz[1,2,3,4,5], Izaskun Jimenez-Serra[6], Leonardo Testi[4,7,9], Katharina Immer[4], Francesco Fontani[7], Paola Caselli[8], Ke Wang[4] and L. Viktor Toth[5]

[1] Department of Physical Science, Graduate School of Science, Osaka Prefecture University, 1-1 Gakuen-cho, Naka-ku, Sakai, Osaka 599-8531, Japan

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

[3] Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, 1121 Budapest, Konkoly Thege Miklós út 15-17, Hungary

[4] European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748, Garching bei München, Germany

[5] Eötvös Loránd University, Department of Astronomy, Pázmány Péter sétány 1/A, 1117, Budapest, Hungary

[6] School of Physics and Astronomy, Queen Mary University of London, Mile End Road, E1 4NS London, United Kingdom

[7] INAF-Osservatorio Astrofisico di Arcetri, L.go E. Fermi 5, 50125 Firenze, Italy

[8] Max-Planck-Institut für Extraterrestrische Physik, Giessenbachstrasse 1, 85748 Garching bei München, Germany

[9] Excellence Cluster Universe, Boltzmannstr. 2, 85748, Garching bei München, Germany

E-mail contact: s.zahorecz *at* p.s.osakafu-u.ac.jp

The formation of deuterated molecules is favoured at low temperatures and high densities. Therefore, the deuteration fraction (D_{frac}) is expected to be enhanced in cold, dense prestellar cores and to decrease after protostellar birth. Previous studies have shown that the deuterated forms of species such as N_2H^+ (formed in the gas phase) and CH_3OH (formed on grain surfaces) can be used as evolutionary indicators and to constrain their dominant formation processes and timescales.

Formaldehyde (H_2CO) and its deuterated forms can be produced both in the gas phase and on grain surfaces. However, the relative importance of these two chemical pathways is unclear. Comparison of the deuteration fraction of H_2CO with respect to that of N_2H^+, NH_3 , and CH_3OH can help us to understand its formation processes and timescales.

With the new SEPIA Band 5 receiver on APEX, we have observed the J=3→2 rotational lines of HDCO and D_2CO at 193 GHz and 175 GHz toward three massive star-forming regions hosting objects at different evolutionary stages: two high-mass starless cores (HMSC), two high-mass protostellar objects (HMPOs), and one ultracompact HII region (UC HII). By using previously obtained H_2CO J=3→2 data, the deuteration fractions HDCO/H_2CO and D_2CO/HDCO are estimated.

Our observations show that singly deuterated H_2CO is detected toward all sources and that the deuteration fraction of H_2CO increases from the HMSC to the HMPO phase and then sharply decreases in the latest evolutionary stage (UCHII). The doubly deuterated form of H_2CO is detected only in the earlier evolutionary stages, with D_2CO/H_2CO showing a pattern that is qualitatively consistent with the pattern of HDCO/H_2CO, within current uncertainties.

Our initial results show that H_2CO may display a similar D_{frac} pattern as that of CH_3OH in massive young stellar objects. This finding suggests that solid-state reactions dominate its formation.

Accepted by A&A Letters

https://arxiv.org/pdf/1705.03456

Optical and Near-Infrared Spectra of σ Orionis Isolated Planetary-mass Objects

M.R. Zapatero Osorio[1], V.J.S. Béjar[2], K. Peña Ramírez

[1] Centro de Astrobiología (CSIC-INTA), Crta. Ajalvir km 4, E-28850 Torrejón de Ardoz, Madrid, Spain

[2] Instituto de Astrofísica de Canarias, C/. Vía Láctea s/n, E-38205 La Laguna, Tenerife, Spain

[3] Unidad de Astronomía de la Universidad de Antofagasta, Av. U. de Antofagasta. 02800 Antofagasta, Chile

E-mail contact: mosorio *at* cab.inta-csic.es

We have obtained low-resolution optical (0.7–0.98 μm) and near-infrared (1.11–1.34 μm and 0.8–2.5 μm) spectra of twelve isolated planetary-mass candidates ($J = 18.2$–19.9 mag) of the 3-Myr σ Orionis star cluster with a view to determining the spectroscopic properties of very young, substellar dwarfs and assembling a complete cluster mass function. We have classified our targets by visual comparison with high- and low-gravity standards and by measuring newly defined spectroscopic indices. We derived L0–L4.5 and M9–L2.5 using high- and low-gravity standards, respectively. Our targets reveal clear signposts of youth, thus corroborating their cluster membership and planetary masses (6–13 $M_{\rm jup}$). These observations complete the σ Orionis mass function by spectroscopically confirming the planetary-mass domain to a confidence level of $\sim$75 percent. The comparison of our spectra with BT-Settl solar metallicity model atmospheres yields a temperature scale of 2350–1800 K and a low surface gravity of $\log g \sim 4.0$ [cm s^{-2}], as would be expected for young planetary-mass objects. We discuss the properties of the cluster least-massive population as a function of spectral type. We have also obtained the first optical spectrum of S Ori 70, a T dwarf in the direction of σ Orionis. Our data provide reference optical and near-infrared spectra of very young L dwarfs and a mass function that may be used as templates for future studies of low-mass substellar objects and exoplanets. The extrapolation of the σ Orionis mass function to the solar neighborhood may indicate that isolated planetary-mass objects with temperatures of 200–300 K and masses in the interval 6–13 $M_{\rm jup}$ may be as numerous as very low-mass stars.

Accepted by ApJ

http://arxiv.org/pdf/1705.01336

New Jobs

Postdoctoral position on theoretical studies of protoplanetary disks

The astrophysics group at School of Arts & Science, University of Tokyo invites applications for a postdoctoral position, to work with Prof. Takeru SUZUKI on theoretical studies of protoplanetary disks (PPDs). The position is funded by Grants-in-Aid for Scientific Research from the MEXT of Japan, 17H01105 (PI: Takeru SUZUKI), and is initially 2 years, with the possibility of extension of 1 year.

The project aims to develop a theoretical framework of the evolution of gas and solid (from dust to protoplanets) during a long-time evolution of PPDs with taking into account magnetically driven disk winds. Researchers with an experience background in any area of theoretical or computational astrophysics are invited to apply, but we are particularly interested in applicants with a strong background in one (or more than one) of the following areas. (i) theoretical and/or computational (magneto)hydrodynamics (ii) particle-based (N-body) simulations (iii) radiative processes

Please contact Takeru Suzuki (stakeru_at_ea.c.u-tokyo.ac.jp) for details.

http://ea.c.u-tokyo.ac.jp/astro/Members/stakeru/english/research_eng.html

Applicants must possess (or be near completion of) a relevant PhD. Applications should include CV (including the list of publications and talks) and a brief research statement (2 pages max) describing past work and future interest. Please create a single pdf file with the name "YourName.pdf" that includes all the above documents, and upload the file via http://ea.c.u-tokyo.ac.jp/astro/Members/stakeru/application In addition, please have 2 letters of recommendation sent to stakeru_at_ea.c.u-tokyo.ac.jp, with applicant's name in the subject, before the July 10th deadline.

Summary of Upcoming Meetings

Comparing simulations and observations of the varying scales of star formation
26 - 27 June 2017, Prague, Czech Republic
http://eas.unige.ch/EWASS2017/session.jsp?id=S3

Galactic Star Formation with Surveys
3 - 7 July 2017, Heidelberg, Germany
http://www.mpia.de/homes/sc2017/index.html

Current and Future Perspectives of Chemical Modelling in Astrophysics
17 - 19 July 2017, Hamburg, Germany
http://www.hs.uni-hamburg.de/astromodel2017

Measuring Star Formation in the Radio, Millimetre, and Submillimetre
24 - 26 July 2017, Manchester, United Kingdom
http://www.alma.ac.uk/index.php/meetings/uk-arc-node-meetings/106-measuring-star-formation-in-the-radio-mill

Star Formation in Different Environments: From Local Clouds to Galaxies
6 - 12 August 2017, Quy Nhon, Vietnam
http://rencontresduvietnam.org/conferences/2017/sfde2017/

Cosmic Dust
14 - 18 August 2017, Mitaka, Japan
https://www.cps-jp.org/~dust/

Ages^2: Taking stellar ages to the next power
18 - 22 September 2017, Elba, Italy
http://www.stsci.edu/institute/conference/ages2017

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

The Initial Mass Function: From Top to Bottom
10 November 2017, London, UK
https://rasimf2017.wordpress.com

Exoplanets and Planet Formation
11 - 15 December 2017, Shang Hai, China
https://indico.leeinst.sjtu.edu.cn/event/25/

Magnetic Fields or Turbulence: Which is the critical factor for the formation of stars and planetary disks?
6 - 9 February 2018, Hsinchu, Taiwan
http://events.asiaa.sinica.edu.tw/workshop/20180206/index.php

EPoS 2018 The Early Phase of Star Formation - Archetypes
13 - 18 May 2018, Ringberg Castle, Tegernsee, Germany
http://www.mpia.de/homes/stein/EPoS/epos.php

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

Short Announcements

CALL FOR PROPOSALS - Balloon-borne Observations with the Next Generation BLAST Polarimeter (BLAST-TNG)

The BLAST collaboration is soliciting proposals for observing time for our 2017 Long Duration Balloon flight over Antarctica. Our upgraded experiment is designed to observe polarized thermal emission from interstellar dust over degree scales with sub-arcminute resolution, and to thereby investigate interstellar magnetic fields and dust properties over a wide range of densities. During our planned 28-day flight, we will obtain simultaneous measurements in three broad bands centered at 250, 350, and 500 microns.

Deadline for letters of intent: June 2, 2017

Deadline for proposals: September 1, 2017

Our Antarctic launch is scheduled for December 2017. Up to 140 hours will be allocated to shared risk proposals from the general astronomical community. Proposers may request maps in linear polarization or total intensity. For information on proposal submission please visit our web page at:

http://sites.northwestern.edu/blast/

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.