THE STAR FORMATION NEWSLETTER

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

No. 315 — 18 March 2019 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

The Star Formation Newsletter

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

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Cover Picture

The image shows a small area of Cygnus X as observed by Spitzer. Cygnus X is a rich region of star formation at an approximate distance of 1.7 kpc and containing thousands of young low-mass stars and numerous OB stars. Blue represents light at 3.6 microns; 4.5-micron light is blue-green; 8.0-micron light is green; and 24-micron light is red.

Image courtesy the Spitzer Space Telescope.

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

Robert Wilson

in conversation with Bo Reipurth

Q: *What was the topic of your PhD, and who was your advisor?*

A: My thesis was titled "Observations of the Galactic Plane at 960 Mc/s" and my advisor was John Bolton (John returned to Australia before I finished and Maarten Schmidt stood in for him at the end). I used one of the 90 foot OVRO antennas prior to their operating as an interferometer and mapped all of the Galactic plane which was visible from the Owens Valley. For most of the plane, I would drive the antenna to a point 10 deg. West of the plane and let the Earth's rotation scan the beam across the plane to 10 deg. East. The output came on chart paper and I would draw a baseline with a meter stick from the flat region on one side of the plane to the other and measure above that baseline. By comparing with other surveys, I determined properties of the discrete sources and divided the more general radiation into free-free and synchrotron components.

Q: *What was known about dark clouds back then?*

A: I don't remember thinking much about dark clouds in those days. They were certainly known to contain 'dust', but I don't remember any talk of molecules, or even star formation. I think that even in 1970 there was little awareness of the possibility of molecular regions in interstellar space even though Solomon & Wickramasinghe showed that dense clouds with a hydrogen density $n > 100cm^{-3}$ would all be molecular clouds with molecular hydrogen H_2 as the dominant constituent and very little atomic hydrogen. Interstellar CH and CN and CH^+ had been known in diffuse clouds from their optical absorption lines since the late 1930s. In a talk in 1955, Charles Townes suggested radio astronomers should look for a number of transitions in simple molecules, including OH, NH_3, H_2O, and CO. In 1963 Sander Weinreb detected OH as the second significant radio line. In 1968 and 1969, ammonia, water, and formaldehyde were found, but none of these pointed to extensive molecular clouds.

Q: *In 1963 you moved to Bell Laboratories at Crawford Hill in New Jersey. What did you plan to do there?*

A: A big attraction at Bell Labs was the 20 foot Horn-reflector and the availability of traveling wave MASER amplifiers which were the lowest noise amplifiers which existed then and could compensate for the small antenna. The horn-reflector has very low back and side lobes so it could potentially be used to measure the brightness of a region of the sky with reference to only a lab noise reference. No other part of the sky need be referenced. In my thesis, I had used the fact that the Milky Way is very much thinner than its diameter and ignored any residual radiation 10 degrees away from the plane. The horn-reflector was also small enough that we could have a source in its far field and accurately measure its gain. Thus it could do two fundamental measurements which most radio telescopes could not - absolute brightness of the sky and absolute flux of a discrete source. A second attraction of Bell Labs was that I could see that if I tired of doing radio astronomy, there were many other technical opportunities there which I would enjoy working on.

I joined Arno Penzias who had been at Bell Labs for more than a year and we decided to do those and several other measurements for which the horn-reflector was suitable. It had a 4 GHz (7.5 cm) MASER on it which was made for the Telstar project and we had been promised a 21cm MASER which could be adapted from a cold war radar receiver developed by Bell Labs. Our plan was to first make accurate flux measurements of several bright radio sources (such as CasA). These would be useful for radio astronomy and for calibrating satellite Earth stations which used the 4 GHz communications band as the down link for communications satellites. Then we would measure the brightness of the sky away from the plane of the Galaxy. Extrapolations from lower frequencies indicated that we should measure something close to 0K at 4 GHz. Having proven our measuring system, we would measure the background at 21cm. As most astronomers know, this control measurement failed and after almost a year of trying to find the "problem" it lead to the discovery of the Cosmic Microwave Radiation from the Big Bang. [1]

Q: *In 1970 you and a small group of colleagues went to observe with the newly completed NRAO 36 foot antenna. During this observing run you discovered CO. What were the circumstances?*

A: The story starts shortly after propagation through a

[1] For a more complete description of the discovery, see my Nobel Lecture: *The Cosmic Microwave Background Radiation*, R. W. Wilson,Science, Vol. 205, No. 4409, pp. 866-874, August 31, 1979 https://www.cfa.harvard.edu/~rwilson/WilsonNobelLecture.pdf

waveguide was demonstrated at AT&T in 1932. Calculations showed that the TE_{01} mode in a circular waveguide had low loss which decreased with increasing frequency. The Holmdel group (later Crawford Hill) was charged with improving long distance transmission and kept this fact in mind. By the time I joined they were intensely developing a long distance waveguide system using a 2 inch circular waveguide to transmit 38-120 GHz for wide band, long distance communication. Although the development of low loss optical fiber soon caused them to switch to optical transmission, Charles Burrus had developed Schottky barrier diodes which he incorporated into low noise millimeter wave receivers for that system.

After the initial excitement of the CMB discovery had settled down, Arno and I were reminded that our charter was to do radio astronomy half time and more relevant communications work the other half. We both took on communications related projects, but Arno had a project at NRAO and became aware of the 36 foot antenna and that NRAO did not have very good millimeter wave receivers for it. Charlie Burrus offered to make a mixer for us and we asked for observing time on the 36'. In 1968 we took an 85 GHz receiver there and had an observing run. The 36' was not ready for serious observations and little science came of that effort.

Arno had been a student of Charles Townes and was aware of his list of molecules to look for. By the Spring of 1970 Sandy Weinreb of NRAO had offered to provide a filter bank spectrometer and a phase lock system to control the frequency of the Klystron Local Oscillators at the 36'. Charlie Burrus offered to make us a mixer in the 90-140 GHz band and we proposed to look for rotational transitions in simple molecules. After consulting with Phil Solomon (who suggested CO again) and Pat Thaddeus (who reminded us that CN has a transition near CO 1-0) we decided to look for CO, then CN and if those failed, we would look for the recombination line H38α at a nearby frequency. Since formaldehyde had been seen in the ISM, I thought that of the molecules we were considering, CO was quite likely as it would be a breakdown product of H_2CO. We did not know if CN would be in equilibrium with the CMB and therefore invisible. Arno invited Keith Jefferts, an atomic physicist at Murray Hill he had worked with, to join in on this effort.

Sandy sent a 36' receiver box and a rack of control equipment to Crawford Hill. Keith and I spent a frantic two weeks wiring our receiver to their equipment. We had not quite finished when we had to ship it to Tucson. Sandy, Keith and I went to the 36' and spent several days trying to make it all work simultaneously. It seemed that every time we fixed one thing, something else would break. After three days Sandy had to leave for a meeting in Charlottesville and felt quite discouraged. The next day, however, Keith and I got it all working in the control room and put the receiver at the focus. Remarkably it continued to work, so I looked at our list of sources. Orion was up, so I asked the operator to point to the BN-KL region. The spectrometer required frequency switching. It had a mode where the integrators at the output of the phase detectors on each channel operated as 2 second time constants. The whole thing was analog and each channel had its unique gain and offset. There was an oscilloscope display showing the 50 spectral channels. It was a cloud of points near the zero line. I was watching it when some of the central points shifted up. I asked the operator and was told that the telescope had just arrived at the source. I asked him to move off the source and the points moved down. Thus after much work making the most sensitive receiver we could, we discovered CO in a few seconds. This and the follow on were truly exhilarating. [2]

Q: *After your discovery of CO in the BN-KL region, what were your next steps?*

A: The first thing I did was to explore around the BN-KL region and discover that the source was quite extended. After Orion set we got some much needed sleep while the plane of the Galaxy was down. The next day we found CO in a number of other Galactic HII regions. During that first run I made a careful spectrum of the BN-KL region using two different local oscillator settings (the spectrometer was not wide enough to contain the whole line and enough baseline). That spectrum appeared in our first paper. My one regret is that we did not recognize that the wings of the line were much wider than an extension of the core of the line. In 1976 Ben Zuckerman pointed out the high velocity outflow from the central source.

In our next observing run we observed CN in Orion and W51 as well as preliminary measurements in Sgr A and Sgr B. We also started observing less abundant isotopes of carbon and oxygen in CO.

Since the NRAO spectrometer could only store its integrations on magnetic tape and there was no facility to read those tapes on Kitt Peak, Keith and I put together a data capture and reduction system over the summer using a minicomputer he had bought for lab use. This greatly increased our efficiency. By the following spring we published strip maps of a number of sources and isotope ratios of the CO species ^{12}CO, ^{13}CO and $C^{18}O$.

We went on to discover other molecules, isotopes and sources. We pushed our luck with isotopes, discovering deuterated species and learning about chemical evolution of the Galaxy.

[2] A fuller description of the discovery can be found in *Discovering CO and other Interstellar Molecules with the NRAO 36 Foot Antenna* in 'Frontiers of Astrophysics: A Celebration of NRAO's 50th Anniversary'. ASP Conference Series, Vol. 395 or https://www.cfa.harvard.edu/~rwilson/DiscoveryCOforNRAO50.pdf

When I look back at Phil Solomon's 1973 paper in Physics Today, it is clear that we and the growing community of millimeter-wave observers had gotten a lot right in two and a half years. By comparing the lines of molecules with different dipole moments and molecules with more- and less abundant isotopes, it was understood that the excitation of the molecules was by collisions with hydrogen molecules. From that cloud densities and therefore cloud masses could be determined. Molecular clouds were known to be centers of star formation, more massive than the associated HII regions, and an important component of the Galaxy's mass. Dark clouds were seen to contain CO extended over degrees. Mapping of them was beginning and was showing intense emission in spots. Isotope ratios were seen to be near terrestrial except for deuterium, for which chemical fractionation was a proposed explanation. The formation of diatomic molecules in the gas phase was beginning to be understood.

The 1970's were an amazing time and I had a lot of fun. We had many joint projects with Pat Thaddeus, Phil Solomon, and their students. We worked hard and were constantly alert to equipment failures (I still jump when I hear a Sonalert). The Bell Labs group had the only receiver above 100 GHz for several years, so we were pretty much free to observe what we wanted to and that contributed to rapid advances. We had a lot of instant gratification with new sources, new molecules, or new insights from every observing run. After a while I found that 24 hours of searching for something new and not finding it became depressing.

Q: *In 1978 you received the Nobel Prize in Physics together with Pyotr Kapitsa and Arno Penzias for the discovery of the cosmic microwave background. Did your interests shift to cosmology or did you continue your work on molecular clouds?*

A: By that time, we were thoroughly converted to millimeter astronomy. CMB work required very specialized equipment which did not seem feasible at Bell Labs. We had designed, bought and outfitted the 7-meter antenna at Bell Labs, but it served a dual purpose, doing satellite communication research when the weather was bad and mm-wave astronomy when it was good.

Q: *You have taken part in an astonishing technical evolution in millimeter astronomy culminating with the ALMA observatory. Where do you see the next technological frontier?*

A: Yes, the advances in the technology used for astronomy in my professional lifetime is indeed amazing. Equally important is the simultaneous advances in theoretical understanding. This is especially true of the CMB where the increase of many orders of magnitude in sensitivity coupled with theory advances results in a page full of numbers about the universe coming from WMAP and PLANCK observations. In millimeter wave work, ALMA allows observations we didn't dream of in 1970.

By now, the whole electromagnetic spectrum has been explored and Gravity waves are the new unexplored source. I don't feel competent to predict what is next, just amazed and pleased at the experience I have had.

Abstracts of recently accepted papers

Near-infrared spectroscopy of the massive stellar population of W51: evidence for multi-seeded star formation

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The interplay between the formation of stars, stellar feedback and cloud properties strongly influences the star formation history of giant molecular clouds. The formation of massive stars leads to a variety of stellar clusters, ranging from low stellar density OB associations to dense, gravitationally bound starburst clusters. We aimed at identifying the massive stellar content and reconstructing the star formation history of the W51 giant molecular cloud. We performed near-infrared imaging and K-band spectroscopy of the massive stars in W51. We analyzed the stellar populations using colour-magnitude and colour-colour diagrams and compared the properties of the spectroscopically identified stars with stellar evolution models. We derived the ages of the different sub-clusters in W51 and, based on our spectroscopy derived an age for W51 of 3 Myrs or less. The age of the P Cygni star LS1 and the presence of two still forming proto-clusters suggests that the star formation history of W51 is more complex than a single burst. We did not find evidence for triggered star formation and we concluded that the star formation in W51 is multi seeded. We finally concluded that W51 is a OB association where different sub-clusters form over a time span of at least 3-5 Myrs.

Accepted by Astronomy and Astrophysics

https://arxiv.org/pdf/1902.05460

Simulating the atomic and molecular content of molecular clouds using probability distributions of physical parameters

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Modern observations of the interstellar medium (ISM) in galaxies detect a variety of atomic and molecular species. The goal is to connect these observations to the astrochemical properties of the ISM. 3D hydro-chemical simulations attempt this but due to extreme computational cost, they have to rely on simplified chemical networks and are bound to individual case studies. We present an alternative approach which models the ISM at larger scales by an ensemble of pre-calculated 1D thermo-chemical photodissociation region (PDR) calculations that determine the abundance and excitation of atomic and molecular species. We adopt lognormal distributions of column density (A_V-PDFs) for which each column density is linked to a volume density as derived by hydrodynamical simulations. We consider two lognormal A_V-PDFs: a diffuse, low density medium with average visual extinction of $\overline{\mathrm{A}_V} = 0.75\,\mathrm{mag}$ and dispersion of $\sigma = 0.5$ and a denser giant molecular cloud with $\overline{\mathrm{A}_V} = 4\,\mathrm{mag}$ and $\sigma = 0.8$. We treat the UV radiation field, cosmic-ray ionization rate and metallicity as free parameters. We find that the low density medium remains fully HI- and CII-dominated under all explored conditions. The denser cloud remains almost always molecular (i.e. H_2-dominated) while its carbon phase (CO, CI and CII) is sensitive to the above free parameters, implying that existing methods of tracing H_2-rich gas may require adjustments depending on environment. Our numerical framework can be used to

estimate the PDR properties of large ISM regions and quantify trends with different environmental parameters as it is fast, covers wide parameter space, and is flexible for extensions.

Accepted by MNRAS

https://arxiv.org/pdf/1901.11306

Formation of planetary systems by pebble accretion and migration: Growth of gas giants

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Giant planets migrate though the protoplanetary disc as they grow. We investigate how the formation of planetary systems depends on the radial flux of pebbles through the protoplanetary disc and on the planet migration rate. Our N-body simulations confirm previous findings that Jupiter-like planets in orbits outside the water ice line originate from embryos starting out at 20–40 AU when using nominal type-I and type-II migration rates and a pebble flux of 100–200 Earth masses per million years, enough to grow Jupiter within the lifetime of the solar nebula. The planetary embryos placed up to 30 AU migrate into the inner system ($r < 1$ AU) and form super-Earths or hot and warm gas giants, producing systems that are inconsistent with the configuration of the solar system, but consistent with some exoplanetary systems. We also explore slower migration rates which allow the formation of gas giants from embryos originating from the 5–10AU region, which are stranded exterior to 1 AU at the end of the gas-disc phase. We identify a pebble flux threshold below which migration dominates and moves the planetary core to the inner disc, where the pebble isolation mass is too low for the planet to accrete gas efficiently. Giant planet growth requires a sufficiently-high pebble flux to enable growth to out-compete migration. Even higher pebble fluxes produce systems with multiple gas giants. We show that planetary embryos starting interior to 5 AU do not grow into gas giants, even if migration is slow and the pebble flux is large. Instead they grow to the mass regime of super-Earths. This stunted growth is caused by the low pebble isolation mass in the inner disc and is independent of the pebble flux. Additionally we show that the long term evolution of our formed planetary systems can produce systems with hot super-Earths and outer gas giants as well as systems of giants on eccentric orbits.

Accepted by A&A

http://arxiv.org/pdf/1902.08771

Unveiling a cluster of protostellar disks around the massive protostar GGD27 MM1

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Context. Most stars form in clusters, and thus it is important to characterize the protostellar disk population in dense environments to assess whether the environment plays a role in the subsequent evolution; specifically, whether planet

formation is altered with respect to more isolated stars formed in dark clouds.
Aims. Investigate the properties of the protostellar disks in the GGD 27 cluster and compare them with those obtained from disks formed in nearby regions.
Methods. We used ALMA to observe the star-forming region GGD 27 at 1.14 mm with an unprecedented angular resolution, 40 mas ($\sim$ 56 au) and sensitivity ($\sim 0.002\ M_{\odot}$).
Results. We detected a cluster of 25 continuum sources, most of which are likely tracing disks around Class 0/I protostars. Excluding the two most massive objects, disks masses are in the range 0.003-0.05 $M_{\odot}$. The analysis of the cluster properties indicates that GGD 27 displays moderate subclustering. This result combined with the dynamical timescale of the radio jet ($\sim 10^4$ years) suggests the youthfulness of the cluster. The lack of disk mass segregation signatures may support this too. We found a clear paucity of disks with $R_{\rm disk} > 100$ au. The median value of the radius is 34 au, smaller than the median of 92 au for Taurus but comparable to the value found in Ophiuchus and in the Orion Nebula Cluster. In GGD 27 there is no evidence of a distance-dependent disk mass distribution (i.e., disk mass depletion due to external photoevaporation), most likely due to the cluster youth. There is a clear deficit of disks for distances < 0.02 pc. Only for distances > 0.04 pc stars can form larger and more massive disks, suggesting that dynamical interactions far from the cluster center are weaker, although the small disks found could be the result of disk truncation. This work demonstrates the potential to characterize disks from low-mass YSOs in distant and massive (still deeply embedded) clustered environments.

Accepted by Astronomy & Astrophysics Letters

https://arxiv.org/pdf/1902.07581

Methylamine and other simple N-bearing species in the hot cores NGC 6334I MM1-3

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In the search for the building blocks of life, nitrogen-bearing molecules are of particular interest since nitrogen-containing bonds are essential for the linking of amino acids and ultimately the formation of larger biological structures. The elusive molecule methylamine (CH_3NH_2) is thought to be a key pre-biotic species but has so far only been securely detected in the giant molecular cloud Sgr B2. We identify CH_3NH_2 and other simple nitrogen-bearing species towards three hot cores in NGC 6334I. Column density ratios are derived in order to investigate the relevance of the individual species as precursors of biotic molecules. Observations obtained with ALMA were used to study transitions of CH_3NH_2, CH_2NH, NH_2CHO, and the ^{13}C- and ^{15}N-methyl cyanide (CH_3CN) isotopologues. Column densities are derived for each species assuming LTE and excitation temperatures in the range 220–340 K for CH_3NH_2, 70–110 K for the CH_3CN isotopologues, and 120–215 K for NH_2CHO and CH_2NH. We report the first detections of CH_3NH_2 towards NGC 6334I with column density ratios with respect to CH_3OH of 5.9×10^{-3}, 1.5×10^{-3}, and 5.4×10^{-4} for the three hot cores MM1, MM2, and MM3, respectively. These values are slightly lower than the values derived for Sgr B2 but higher by more than order of magnitude as compared with the values derived for the low-mass protostar IRAS 16293−2422B. The detections of CH_3NH_2 in the hot cores of NGC 6334I hint that CH_3NH_2 is generally common in the interstellar medium, albeit high-sensitivity observations are essential for its detection. The good agreement between model predictions of CH_3NH_2 ratios and the observations towards NGC 6334I indicate a main formation pathway via radical recombination on grain surfaces.

Accepted by A&A

http://arxiv.org/pdf/1902.07060

The central 1000 AU of a pre-stellar core revealed with ALMA. I. 1.3 mm continuum observations

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Stars like our Sun form in self-gravitating dense and cold structures within interstellar clouds, called pre-stellar cores. Although much is known about the physical structure of dense clouds just before and soon after the switch-on of a protostar, the central few thousand astronomical units (au) of pre-stellar cores are unexplored. It is within these central regions that stellar systems assemble and fragmentation may take place, with the consequent formation of binaries and multiple systems. We present ALMA Band 6 observations (ACA and 12m array) of the dust continuum emission of the $8\,M_\odot$ pre-stellar core L1544, with angular resolution of $2'' \times 1.6''$ (linear resolution $270\,\mathrm{au} \times 216\,\mathrm{au}$). Within the primary beam, a compact region of $0.1\,M_\odot$, which we call a "kernel", has been unveiled. The kernel is elongated, with a central flat zone with radius $R_{\rm ker} \simeq 10''$ ($\simeq$1400 au). The average number density within $R_{\rm ker}$ is $\simeq 1\times10^6\,\mathrm{cm}^{-3}$, with possible local density enhancements. The region within $R_{\rm ker}$ appears to have fragmented, but detailed analysis shows that similar substructure can be reproduced by synthetic interferometric observations of a smooth centrally concentrated dense core with a similar central flat zone. The presence of a smooth kernel within a dense core is in agreement with non-ideal magneto-hydro-dynamical simulations of a contracting cloud core with a peak number density of $1\times10^7\,\mathrm{cm}^{-3}$. Dense cores with lower central densities are completely filtered out when simulated 12m-array observations are carried out. These observations demonstrate that the kernel of dynamically evolved dense cores can be investigated at high angular resolution with ALMA.

Accepted by The Astrophysical Journal

http://arxiv.org/pdf/1902.05299

An in depth study of the hypercompact HII region G24.78+0.08 A1

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The earliest phases of the evolution of a massive star are tightly related to the developement of an HII region. Hypercompact HII regions are the most interesting in this respect because they are very young and hence best suited to study the beginning of the expansion of the ionized gas inside the parental core. We aim to analyse the geometrical and physical structure of the hypercompact HII region G24.78+0.08 A1, making use of new continuum and hydrogen recombination line (H41α, H63α, H66α, H68α) data as well as data from the literature (H30α, H35α). We fit the continuum spectrum with a homogenous, isothermal shell of ionized gas at 10^4 K and derive the size of the HII region and the Lyman continuum luminosity of the ionizing star. We also fit the recombination line spectra emitted from the same shell with a model taking into account expansion at constant speed. The best fits to the continuum and line spectra allow derivation of the Lyman continuum luminosity of the ionizing star, HII region size, geometrical thickness of the shell, and expansion velocity. Comparison between the 5 cm and 7 mm brightness temperature distributions demonstrates that a thin layer of ionized gas of a few 1000 K at the surface of the HII region is necessary to reproduce the morphology of the continuum emission at both wavelengths. We confirm that the G24.78+0.08 A1 hypercompact HII region consists of a thin shell ionized by an O9.5 star. The shell is expanding at a speed comparable to the sound speed in the ionized gas. The radius of the HII region exceeds the critical value needed to trap the ionized gas by the gravitational field of the star, consistent with the observed expansion.

Accepted by Astronomy and Astrophysics

http://www.arcetri.astro.it/~cesa/preprints/g24hchii.pdf

A New Equation of State for Dense Hydrogen/Helium Mixtures

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We present a new equation of state (EOS) for dense hydrogen/helium mixtures that covers a range of densities from 10^{-8} to 10^{6} g cm^{-3}, pressures from 10^{-9} to 10^{13}GPa, and temperatures from 10^{2} to 10^{8} K. The calculations combine the EOS of Saumon, Chabrier & van Horn in the low-density, low-temperature molecular/atomic domain, the EOS of Chabrier & Potekhin in the high-density, high-temperature fully ionized domain, the limits of which differ for H and He, and ab initio quantum molecular dynamics calculations in the regime of intermediate density and temperature, characteristic of pressure dissociation and ionization. The EOS for the H/He mixture is based on the so-called additive volume law and thus does not take into account the interactions between the two species. A major improvement of the present calculations over existing ones is that we calculate the entropy over the entire density-temperature domain, a necessary quantity for calculations of stellar or planetary evolution. The EOS results are compared with existing experimental data, namely Hugoniot shock experiments for pure H and He, and with first-principles numerical simulations for both the single elements and the mixture. This new EOS covers a wide range of physical and astrophysical conditions, from Jovian planets to solar-type stars, and recovers the existing relativistic EOS at very high densities, in the domains of white dwarfs and neutron stars. All the tables are made publicly available.

Accepted by Astrophysical Journal (2019, 872, A51)

https://arxiv.org/pdf/1902.01852.pdf

A VLT/FLAMES survey for massive binaries in Westerlund 1: VI. Properties of X-ray bright massive cluster members

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Despite the first detection of X-rays from massive stars occurring four decades ago, the physical dependence of the emission mechanism(s) on the underlying stellar and binary properties of the emitters remains uncertain. The young massive cluster Westerlund 1 provides an ideal testbed for understanding this phenomenon, with over 50 cluster members detected in historical X-ray observations. In the decade since these data were obtained, significant new multi-epoch observations of the cluster have been made, allowing a fundamental reappraisal of the nature of both X-ray bright and dark stars. A total of 45 X-ray sources within Wd1 now have precise spectral classifications. These observations identify 16 candidate and confirmed massive binaries; by comparison 22 stars have X-ray properties that imply a contribution from a wind collision zone. X-ray emission appears confined to O9–B0.5 supergiants, Wolf-Rayets and a small group of highly luminous interacting/post-interaction binaries. Despite their presence in large numbers, no emission is seen from earlier, less evolved O stars or later, cooler B super-/hypergiants. We suppose that the lack of X-ray emission from O giants is due to their comparatively low bolometric luminosities if, as expected, they follow the canonical $L_{\rm X}/L_{\rm bol}$ relation for hot stars. The transition away from X-ray emission for OB supergiants occurs at the location of the bistability jump; we speculate that below this limit, stellar wind velocities are insufficient for internal, X-ray emitting shocks to form. Our results are consistent with recent findings that massive binaries are not uniformly brighter than single stars of comparable luminosity and spectral type, although it is noteworthy that the brightest and hardest stellar X-ray sources within Wd1 are all either confirmed or candidate massive, interacting/post-interaction binaries.

Accepted by A&A

http://arxiv.org/pdf/1902.05322

A new view of the corona of classical T Tauri stars: Effects of flaring activity in circumstellar disks

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Classical T Tauri stars (CTTSs) are young low-mass stellar objects accreting mass from their circumstellar disks. They are characterized by high levels of coronal activity as revealed by X-ray observations. This activity may affect the disk stability and the circumstellar environment. Here we investigate if an intense coronal activity due to flares occurring close to the accretion disk may perturb the inner disk stability, disrupt the inner part of the disk and, possibly, trigger accretion phenomena with rates comparable with those observed. We model a magnetized protostar surrounded by an accretion disk through 3D magnetohydrodinamic simulations. We explore cases characterized by a dipole plus an octupole stellar magnetic field configuration and different density of the disk or by different levels of flaring activity. As a result of the simulated intense flaring activity, we observe the formation of several loops that link the star to the disk; all these loops build up a hot extended corona with an X-ray luminosity comparable with typical values observed in CTTSs. The intense flaring activity close to the disk can strongly perturb the disk stability. The flares trigger overpressure waves which travel through the disk and modify its configuration. Accretion funnels may be triggered by the flaring activity, thus contributing to the mass accretion rate of the star. Accretion rates synthesized from the simulations are in a range between 10^{-10} and 10^{-9} $M_{\odot}$ yr^{-1} The accretion columns can be perturbed by the flares and they can interact with each other, possibly merging together in larger streams. As a result, the accretion pattern can be rather complex: the streams are highly inhomogeneous, with a complex density structure, and clumped.

Accepted by A&A

http://arxiv.org/pdf/1902.07048

ISPY - the NaCo Imaging Survey for Planets around Young stars: A young companion candidate embedded in the R CrA cloud

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Within the NaCo-ISPY exoplanet imaging program, we aim at detecting and characterizing the population of low-mass companions at wide separations (>10AU), focusing in particular on young stars either hosting a known protoplanetary disk or a debris disk. R CrA is one of the youngest (1-3 Myr) and most promising objects in our sample because of two previous studies that suggested the presence of a close companion. Our aim is to directly image and characterize the companion for the first time. We observed R CrA twice with the NaCo instrument at VLT in the L' filter with a one year time baseline in between. The high-contrast imaging data were reduced and analyzed, and in both datasets the companion candidate was detected. We used artificial negative signals to determine the position and brightness of the companion and the related uncertainties. The companion is detected at a separation of $196.8 \pm 4.5/196.6 \pm 5.9$ mas ($18.7 \pm 1.3/18.7 \pm 1.4$ AU) and position angle of $134.7 \pm 0.5°/133.7 \pm 0.7°$ in the first/second epoch observation. We measure a contrast of $7.29 \pm 0.18/6.70 \pm 0.15$ mag with respect to the primary. Stellar proper motion study rejects the hypothesis of the signal being a background object. The companion candidate orbits in the clockwise direction and, if on a face-on circular orbit, its period is $\sim 43 - 47$ yr. This value disagrees with the estimated orbital motion and therefore a face-on circular orbit may be excluded. Depending on the assumed age, extinction and brightness of the primary, the stellar companion has a mass between $0.10 \pm 0.02\,M_\odot$ and $1.03^{+0.20}_{-0.18}\,M_\odot$ range, if no contribution from circumsecondary material is taken into account. As already hypothesized by previous studies, we have directly detected a low-mass stellar companion orbiting the young Herbig Ae/Be star R CrA. Depending on the age assumptions, the companion is among the youngest forming companions imaged to date, and its presence needs to be taken into account when analyzing the complex circumstellar environment of R CrA.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/1902.04092

Consistent dust and gas models for protoplanetary disks IV. A panchromatic view of protoplanetary disks

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Context: Consistent modeling of protoplanetary disks requires the simultaneous solution of both continuum and line radiative transfer, heating/cooling balance between dust and gas and, of course, chemistry. Such models depend on panchromatic observations that can provide a complete description of the physical and chemical properties and energy balance of protoplanetary systems. Along these lines we present a homogeneous, panchromatic collection of data on a sample of 85 T Tauri and Herbig Ae objects for which data cover a range from X-rays to centimeter wavelengths. Datasets consist of photometric measurements, spectra, along with results from the data analysis such as line fluxes from atomic and molecular transitions. Additional properties resulting from modeling of the sources such as disc mass and shape parameters, dust size and PAH properties are also provided for completeness.
Aims: The purpose of this data collection is to provide a solid base that can enable consistent modeling of the properties of protoplanetary disks. To this end, we performed an unbiased collection of publicly available data that were combined to homogeneous datasets adopting consistent criteria. Targets were selected based on both their properties but also on the availability of data.
Methods: Data from more than 50 different telescopes and facilities were retrieved and combined in homogeneous datasets directly from public data archives or after being extracted from more than 100 published articles. X-ray data for a subset of 56 sources represent an exception as they were reduced from scratch and are presented here for the first time.

Results: Compiled datasets along with a subset of continuum and emission-line models are stored in a dedicated database and distributed through a publicly accessible online system. All datasets contain metadata descriptors that allow to backtrack them to their original resources. The graphical user interface of the online system allows the user to visually inspect individual objects but also compare between datasets and models. It also offers to the user the possibility to download any of the stored data and metadata for further processing.

Accepted by A&A

https://arxiv.org/pdf/1902.11204

Pebble accretion in self-gravitating protostellar discs

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Pebble accretion has become a popular component to core accretion models of planet formation, and is especially relevant to the formation of compact, resonant terrestrial planetary systems. Pebbles initially form in the inner protoplanetary disc, sweeping outwards in a radially expanding front, potentially forming planetesimals and planetary cores via migration and the streaming instability. This pebble front appears at early times, in what is typically assumed to be a low mass disc. We argue this picture is in conflict with the reality of young circumstellar discs, which are massive and self-gravitating. We apply standard pebble accretion and streaming instability formulae to self-gravitating protostellar disc models. Fragments will open a gap in the pebble disc, but they will likely fail to open a gap in the gas, and continue rapid inward migration. If this does not strongly perturb the pebble disc, our results show that disc fragments will accrete pebbles efficiently. We find that in general the pebble-to-gas-density ratio fails to exceed 0.01, suggesting that the streaming instability will struggle to operate. It may be possible to activate the instability if 10 cm grains are available, and spiral structures can effectively concentrate them in regions of low gravito-turbulence. If this occurs, lunar mass cores might be assembled on timescales of a few thousand years, *but this is likely to be rare, and is far from proven*. In any case, this work highlights the need for study of how self-gravitating protostellar discs define the distribution and properties of solid bodies, for future planet formation by core accretion.

Accepted by MNRAS

http://arxiv.org/pdf/1902.05385

Misaligned accretion disc formation via Kozai-Lidov oscillations

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We investigate the formation and evolution of misaligned accretion discs around the secondary component of a binary through mass transfer driven by Kozai-Lidov oscillations of the circumprimary disc's eccentricity and inclination. We perform SPH simulations to study the amount of mass transferred to the secondary star as a function of both the disc and binary parameters. For the range of parameters we explore, we find that increasing the disc aspect ratio, viscosity parameter and initial inclination as well as decreasing the binary mass ratio leads to larger amount of mass transfer, up to a maximum of about ten per cent of the initial mass of the primary disc. The circumsecondary disc forms with a high eccentricity and a high inclination and is also able to undergo KL oscillations. The circumsecondary disc oscillations have a shorter period than those in the disc around the primary. We find that some of the material that escapes the Roche-lobe of the two components forms a narrow misaligned circumbinary accretion disc. This study has implications for disc evolution in young binary star systems.

Accepted by MNRAS

http://arxiv.org/pdf/1902.04090

Identifying Variability in Deeply Embedded Protostars with ALMA and CARMA

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Variability of pre-main-sequence stars observed at optical wavelengths has been attributed to fluctuations in the mass accretion rate from the circumstellar disk onto the forming star. Detailed models of accretion disks suggest that young deeply embedded protostars should also exhibit variations in their accretion rates, and that these changes can be tracked indirectly by monitoring the response of the dust envelope at mid-IR to millimeter wavelengths. Interferometers such as ALMA offer the resolution and sensitivity to observe small fluctuations in brightness at the scale of the disk where episodic accretion may be driven. In this work, we present novel methods for comparing interferometric observations and apply them to CARMA and ALMA 1.3mm observations of deeply embedded protostars in Serpens taken 9 years apart. We find no brightness variation above the limits of our analysis of a factor of $\gtrsim$50%, due to the limited sensitivity of the CARMA observations and small number of sources common to both epochs. We further show that follow up ALMA observations with a similar sample size and sensitivity may be able to uncover variability at the level of a few percent, and discuss implications for future work.

Accepted by ApJ

http://arxiv.org/pdf/1902.00588

Magnetic braking of supermassive stars through winds

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Supermassive stars (SMSs) are candidates for being progenitors of supermassive quasars at high redshifts. However, their formation process requires strong mechanisms that would be able to extract the angular momentum of the gas that the SMSs accrete. We investigate under which conditions the magnetic coupling between an accreting SMS and its winds can remove enough angular momentum for accretion to proceed from a Keplerian disc. We numerically computed the rotational properties of accreting SMSs that rotate at the $\Omega\Gamma$-limit and estimated the magnetic field that is required to maintain the rotation velocity at this limit using prescriptions from magnetohydrodynamical simulations of stellar winds. We find that a magnetic field of 10 kG at the stellar surface is required to satisfy the constraints on stellar rotation from the $\Omega\Gamma$-limit. Magnetic coupling between the envelope of SMSs and their winds could allow for SMS formation by accretion from a Keplerian disc, provided the magnetic field is at the upper end of present-day observed stellar fields. Such fields are consistent with primordial origins.

Accepted by A&A

https://arxiv.org/pdf/1903.00020

Magnetic topologies of young suns: The weak-line T Tauri stars TWA 6 and TWA 8A

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We present a spectropolarimetric study of two weak-line T Tauri stars (wTTSs), TWA 6 and TWA 8A, as part of the MaTYSSE (Magnetic Topologies of Young Stars and the Survival of close-in giant Exoplanets) program. Both stars display significant Zeeman signatures that we have modelled using Zeeman Doppler Imaging (ZDI). The magnetic field of TWA 6 is split equally between poloidal and toroidal components, with the largest fraction of energy in higher-order modes, with a total unsigned flux of 840 G, and a poloidal component tilted 35° from the rotation axis. TWA 8A has a 70 per cent poloidal field, with most of the energy in higher-order modes, with an unsigned flux of 1.4 kG (with a magnetic filling factor of 0.2), and a poloidal field tilted 20° from the rotation axis. Spectral fitting of the very strong field in TWA 8A (in individual lines, simultaneously for Stokes *I* and *V*) yielded a mean magnetic field strength of 6.0±0.5 kG. The higher field strengths recovered from spectral fitting suggests that a significant proportion of magnetic energy lies in small-scale fields that are unresolved by ZDI. So far, wTTSs in MaTYSSE appear to show that the poloidal-field axisymmetry correlates with the magnetic field strength. Moreover, it appears that classical T Tauri stars (cTTSs) and wTTSs are mostly poloidal and axisymmetric when mostly convective and cooler than ∼4300 K, with hotter stars being less axisymmetric and poloidal, regardless of internal structure.

Accepted by MNRAS

http://arxiv.org/pdf/1902.06725

Initial phases of high-mass star formation: A multiwavelength study towards the extended green object G12.42+0.50

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We present a multiwavelength study of the extended green object, G12.42+0.50 in this paper. The associated ionized, dust, and molecular components of this source are studied in detail employing various observations at near-, mid- and far-infrared, submillimeter and radio wavelengths. Radio continuum emission mapped at 610 and 1390 MHz, using the Giant Meterwave Radio Telescope, India, advocates for a scenario of coexistence of an UC H II region and an ionized thermal jet possibly powered by the massive young stellar object, IRAS 18079-1756 with an estimated spectral type of B1 − B0.5. Shock-excited lines of H_2 and [FeII], as seen in the near-infrared spectra obtained with UKIRT-UIST, lend support to this picture. Cold dust emission shows a massive clump of mass 1375 $M_\odot$ enveloping G12.42+0.50. Study of the molecular gas kinematics using the MALT90 and JCMT archival data unravels the presence of both infall activity and large-scale outflow suggesting an early stage of massive star formation in G12.42+0.50. A network of filamentary features are also revealed merging with the massive clump mimicking a hub-filament layout. Velocity structure along these indicate bulk inflow motion.

Accepted by MNRAS

https://arxiv.org/pdf/1902.03724

The Early Stage of Molecular Cloud Formation by Compression of Two-phase Atomic Gases

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We investigate the formation of molecular clouds from atomic gas by using three-dimensional magnetohydrodynamic simulations, including non-equilibrium chemical reactions and heating/cooling processes. We consider super-Alfvénic head-on colliding flows of atomic gas possessing the two-phase structure that consists of HI clouds and surrounding warm diffuse gas. We examine how the formation of molecular clouds depends on the angle θ between the upstream flow and the mean magnetic field. We find that there is a critical angle $\theta_{\rm cr}$ above which the shock-amplified magnetic field controls the post-shock gas dynamics. If the atomic gas is compressed almost along the mean magnetic field ($\theta \ll \theta_{\rm cr}$), super-Alfvénic anisotropic turbulence is maintained by the accretion of the highly inhomogeneous upstream atomic gas. As a result, a greatly extended turbulence-dominated post-shock layer is generated. Around $\theta \sim \theta_{\rm cr}$, the shock-amplified magnetic field weakens the post-shock turbulence, leading to a dense post-shock layer. For $\theta \gg \theta_{\rm cr}$, the strong magnetic pressure suppresses the formation of cold dense clouds. Efficient molecular cloud formation is expected if θ is less than a few times $\theta_{\rm cr}$. Developing an analytic model and performing a parameter survey, we obtain an analytic formula for the critical angle as a function of the mean density, collision speed, and field strength of the upstream atomic gas. The critical angle is found to be less than $\sim 15^\circ$ as long as the field strength is larger than 1 μG, indicating that the probability of occurrence of compression with $\theta < \theta_{\rm cr}$ is limited if shock waves come from various directions.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1806.03824

The Synthetic ALMA Multiband Analysis of the Dust Properties of the TW Hya Protoplanetary Disk

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Analyzing multiband observations of dust continuum emission is one of the useful tools to constrain dust properties which help us to understand the physical properties of the disks. We perform the synthetic ALMA multiband analysis to find the best ALMA band set for constraining the dust properties of the TW Hya protoplanetary disk. We find that the Band [10,6,3] set is the best set among the possible combinations of ALMA Band [3,4,5,6,7,8,9,10]. We also find two conditions for the good ALMA band sets providing narrow constraint ranges on dust properties; (1) Band 9 or 10 is included in the band set and (2) Enough frequency intervals between the bands. These are related with the conditions which give good constraints on dust properties: the combination of optically thick and thin bands are required, and large β (β is the power-law index of dust opacity), and low dust temperature are preferable. To examine our synthetic analysis results, we apply the multiband analysis to ALMA archival data of the TW Hya disk at Band 4, 6, 7, and 9. Band [9,6,4] set provides the dust properties close to the model profile, while Band [7,6,4] set gives the dust properties deviating from the model at all radii with too broad constraint range to specify the accurate values of dust temperature, optical depth, and β. Since these features are expected by the synthetic multiband analysis, we confirm that the synthetic multiband analysis is well consistent with the results derived from real data.

Accepted by ApJ

http://arxiv.org/pdf/1902.00168

Resolving the MYSO binaries PDS 27 and PDS 37 with VLTI/PIONIER

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Binarity and multiplicity appear to be a common outcome in star formation. In particular, the binary fraction of massive (OB-type) stars can be very high. In many cases, the further stellar evolution of these stars is affected by binary interactions at some stage during their lifetime. The origin of this high binarity and the binary parameters are poorly understood because observational constraints are scarce, which is predominantly due to a dearth of known young massive binary systems. We aim to identify and describe massive young binary systems in order to fill in the gaps of our knowledge of primordial binarity of massive stars, which is crucial for our understanding of massive star formation. We observed the two massive young stellar objects (MYSOs) PDS 27 and PDS 37 at the highest spatial resolution provided by VLTI/PIONIER in the H-band (1.3 mas). We applied geometrical models to fit the observed squared visibilities and closure phases. In addition, we performed a radial velocity analysis using published VLT/FORS2 spectropolarimetric and VLT/X-shooter spectroscopic observations. Our findings suggest binary companions for both objects at 12 mas (30 au) for PDS 27 and at 22-28 mas (42-54 au) for PDS 37. This means that they are among the closest MYSO binaries resolved to date. Our data spatially resolve PDS 27 and PDS 37 for the first time, revealing two of the closest and most massive (> 8 M$_\odot$) YSO binary candidates to date. PDS 27 and PDS 37 are rare but great laboratories to quantitatively inform and test the theories on formation of such systems.

Accepted by Astronomy & Astrophysics

https://www.aanda.org/articles/aa/pdf/forth/aa34624-18.pdf

The dynamical evolution of molecular clouds near the Galactic Centre - II. Spatial structure and kinematics of simulated clouds

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The evolution of molecular clouds in galactic centres is thought to differ from that in galactic discs due to a significant influence of the external gravitational potential. We present a set of numerical simulations of molecular clouds orbiting on the 100-pc stream of the Central Molecular Zone (the central $\sim$500 pc of the Galaxy) and characterise their morphological and kinematic evolution in response to the background potential and eccentric orbital motion. We find that the clouds are shaped by strong shear and torques, by tidal and geometric deformation, and by their passage through the orbital pericentre. Within our simulations, these mechanisms control cloud sizes, aspect ratios, position angles, filamentary structure, column densities, velocity dispersions, line-of-sight velocity gradients, spin angular momenta, and kinematic complexity. By comparing these predictions to observations of clouds on the Galactic Centre 'dust ridge', we find that our simulations naturally reproduce a broad range of key observed morphological and kinematic features, which can be explained in terms of well-understood physical mechanisms. We argue that the accretion of gas clouds onto the central regions of galaxies, where the rotation curve turns over and the tidal field

is fully compressive, is accompanied by transformative dynamical changes to the clouds, leading to collapse and star formation. This can generate an evolutionary progression of cloud collapse with a common starting point, which either marks the time of accretion onto the tidally-compressive region or of the most recent pericentre passage. Together, these processes may naturally produce the synchronised starbursts observed in numerous (extra)galactic nuclei.

Accepted by MNRAS

http://arxiv.org/pdf/1902.01860

Gaia-2MASS 3D maps of Galactic interstellar dust within 3 kpc

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Gaia data are revolutionizing our knowledge of the evolutionary history of the Milky Way. 3D maps of the interstellar dust provide complementary information and are a tool for a wide range of uses. We aimed at building 3D maps of the dust in the Local arm and surrounding regions. To do so, Gaia DR2 photometric data were combined with 2MASS measurements to derive extinction towards stars that possess accurate photometry and relative uncertainties on DR2 parallaxes smaller than 20%. We applied to the extinctions a new hierarchical inversion algorithm adapted to large datasets and to a inhomogeneous target distribution. Each step associates regularized Bayesian inversions along radial directions and a subsequent inversion in 3D of their results. Each inverted distribution serves as a prior for the subsequent step and the spatial resolution is progressively increased. We present the resulting 3D distribution of the dust in a $6 \times 6 \times 0.8$ kpc^3 volume around the Sun. Its main features are found to be elongated along different directions that vary from below to above the mid-plane: the outer part of Carina-Sagittarius, mainly located above the mid-plane, the Local arm/Cygnus Rift around and above the mid-plane and the fragmented Perseus arm are oriented close to the direction of circular motion. The long spur (nicknamed the split) that extends between the Local Arm and Carina-Sagittarius, the compact near side of Carina-Sagittarius and the Cygnus Rift below the Plane are oriented along l=40 to 55 deg. Dust density images in vertical planes reveal in some regions a wavy pattern and show that the solar neighborhood within 500 pc remains atypical by its extent above and below the Plane. We show several comparisons with the locations of molecular clouds, HII regions, O stars and masers. The link between the dust concentration and these tracers is markedly different from one region to the other.

Accepted by A&A

http://arxiv.org/pdf/1902.04116

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

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We perform ideal MHD high resolution AMR simulations with driven turbulence and self-gravity and find that long filamentary molecular clouds are formed at the converging locations of large-scale turbulence flows and the filaments are bounded by gravity. The magnetic field helps shape and reinforce the long filamentary structures. The main filamentary cloud has a length of ~ 4.4 pc. Instead of a monolithic cylindrical structure, the main cloud is shown to be a collection of fiber/web-like sub-structures similar to filamentary clouds such as L1495. Unless the line-of-sight is close to the mean field direction, the large-scale magnetic field and striations in the simulation are found roughly perpendicular to the long axis of the main cloud, similar to L1495. This provides strong support for a large-scale moderately strong magnetic field surrounding L1495. We find that the projection effect from observations can lead to incorrect interpretations of the true three-dimensional physical shape, size, and velocity structure of the clouds.

Helical magnetic field structures found around filamentary clouds that are interpreted from Zeeman observations can be explained by a simple bending of the magnetic field that pierces through the cloud. We demonstrate that two dark clouds form a T-shape configuration which are strikingly similar to the Infrared dark cloud SDC13 leading to the interpretation that SDC13 results from a collision of two long filamentary clouds. We show that a moderately strong magnetic field ($M_A \sim 1$) is crucial for maintaining a long and slender filamentary cloud for a long period of time ~ 0.5 million years.

Accepted by MNRAS

http://arxiv.org/pdf/1901.04593

CLIcK: a Continuum and Line fItting Kit for circumstellar disks

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Infrared spectroscopy with medium to high spectral resolution is essential to characterize the gas content of circumstellar disks. Unfortunately, conducting continuum and line radiative transfer of thermochemical disk models is too time-consuming to carry out large parameter studies. Simpler approaches using a slab model to fit continuum-subtracted spectra require the identification of either the global or local continuum. Continuum subtraction, particularly when covering a broad wavelength range, is challenging but critical in rich molecular spectra as hot (several hundreds K) molecular emission lines can also produce a pseudo continuum. In this work, we present CLIcK, a flexible tool to simultaneously fit the continuum and line emission. The DDN01 continuum model (Dullemond et al. 2001) and a plane-parallel slab of gas in local thermodynamic equilibrium are adopted to simulate the continuum and line emission respectively, both of them are fast enough for homogeneous studies of large disk samples. We applied CLIcK to fit the observed water spectrum of the AA Tau disk and obtained water vapor properties that are consistent with literature results. We also demonstrate that CLIcK properly retrieves the input parameters used to simulate the water spectrum of a circumstellar disk. CLIcK will be a versatile tool for the interpretation of future James Webb Space Telescope spectra.

Accepted by A&A

http://arxiv.org/pdf/1902.03891

Structure of a Protobinary System: An Asymmetric Circumbinary Disk and Spiral Arms

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We investigate the gas structures around young binary stars by using three-dimensional numerical simulations. Each model exhibits circumstellar disks, spiral arms, and a circumbinary disk with an inner gap or cavity. The circumbinary disk has an asymmetric pattern rotating at an angular velocity of approximately one-fourth of the binary orbit of the moderate-temperature models. Because of this asymmetry, the circumbinary disk has a density bump and a vortex, both of which continue to exist until the end of our calculation. The density bump and vortex are attributed to enhanced angular momentum, which is promoted by the gravitational torque of the stars. In a hot model ($c \geq 2.0$), the

asymmetry rotates considerably more slowly than in the moderate-temperature models. The cold models ($c \leq 0.02$) exhibit eccentric circumbinary disks, the precession of which is approximated by a secular motion of the ballistic particles. The asymmetry in the circumbinary disk does not depend on the mass ratio, but it becomes less clear as the specific angular momentum of the infalling envelope increases. The relative accretion rate onto the stars is sensitive to the angular momentum of the infalling envelope. For envelopes with constant angular momentum, the secondary tends to have a higher accretion rate than the primary, except in very low angular momentum cases. For envelopes with a constant angular velocity, the primary has a higher accretion rate than the secondary because gas with low specific angular momentum falls along the polar directions.

Accepted by ApJ

https://arxiv.org/pdf/1812.01626

A new HLLD Riemann solver with Boris correction for reducing Alfvén speed

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A new Riemann solver is presented for the ideal magnetohydrodynamics (MHD) equations with the so-called Boris correction. The Boris correction is applied to reduce wave speeds, avoiding an extremely small timestep in MHD simulations. The proposed Riemann solver, Boris-HLLD, is based on the HLLD solver. As done by the original HLLD solver, (1) the Boris-HLLD solver has four intermediate states in the Riemann fan when left and right states are given, (2) it resolves the contact discontinuity, Alfvén waves, and fast waves, and (3) it satisfies all the jump conditions across shock waves and discontinuities except for slow shock waves. The results of a shock tube problem indicate that the scheme with the Boris-HLLD solver captures contact discontinuities sharply and shock waves without any overshoot when using the minmod limiter. The stability tests show that the scheme is stable when $|u| \lesssim 0.5c$ for a low Alfvén speed ($V_A \lesssim c$), where u, c, and V_A denote the gas velocity, speed of light, and Alfvén speed, respectively. For a high Alfvén speed ($V_A \gtrsim c$), where the plasma beta is relatively low in many cases, the stable region is large, $|u| \lesssim (0.6-1)c$. We discuss the effect of the Boris correction on physical quantities using several test problems. The Boris-HLLD scheme can be useful for problems with supersonic flows in which regions with a very low plasma beta appear in the computational domain.

Accepted by ApJ

https://arxiv.org/pdf/1902.02810

Could 1I/Oumuamua be an Icy Fractal Aggregate?

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1I/Oumuamua is the first interstellar interloper to be detected, and it shows a non-gravitational acceleration that cannot be accounted for by outgassing, given the strict upper limits of outgassing evident from Spitzer observations, unless the relative abundances of the common volatiles are very different to those in comets. As an alternative, it has been suggested that its peculiar acceleration is due to radiation pressure, requiring a planar-sheet geometry of an unknown natural or artificial origin. Here we assess whether or not the internal structure of 1I/Oumuamua, rather than its geometry, could support a radiation-pressure-driven scenario. We adopt a mass fractal structure and find that the type of aggregate that could yield the required area-to-mass ratio would have to be extraordinarily porous, with a density $\sim 10^{-5}$ g cm^{-3}. Such porous aggregates can naturally arise from the collisional grow of icy dust particles beyond the snowline of a protoplanetary disk, and we propose that 1I/Oumuamua might be a member of this population. This is a hypothesis worth investigating because, if this were the case, 1I/Oumuamua would have

opened a new observation window on to the study of the building blocks of planets around other stars. This could set unprecedented constraints on planet formation models.

Accepted by Astrophysical Journal Letters

http://arxiv.org/pdf/1902.4100

Formation of planetary systems by pebble accretion and migration: Growth of gas giants

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Argon, krypton, xenon, carbon, nitrogen, sulfur, and phosphorus have all been measured enriched by a quasi uniform factor in the 2–4 range, compared to their protosolar values, in the atmosphere of Jupiter. To elucidate the origin of these volatile enrichments, we investigate the possibility of inward drift of particles made of amorphous ice and adsorbed volatiles, and their ability to enrich in heavy elements the gas phase of the protosolar nebula once they cross the amorphous-to-crystalline ice transition zone, following the original idea formulated by Monga & Desch (2015). To do so, we use a simple accretion disk model coupled to modules depicting the radial evolution of icy particles and vapors, assuming growth, fragmentation and crystallization of amorphous grains. We show that it is possible to accrete supersolar gas from the nebula onto proto-Jupiter's core to form its envelope, and allowing it to match the observed volatile enrichments. Our calculations suggest that nebular gas with a metallicity similar to that measured in Jupiter can be accreted by its envelope if the planet formed in the $\sim$0.5–2 Myr time range and in the 0.5–20 AU distance range from the Sun, depending on the adopted viscosity parameter of the disk. These values match a wide range of Jupiter's formation scenarios, including in situ formation and migration/formation models.

Accepted by ApJ

http://arxiv.org/pdf/1902.08924

The core and stellar mass functions in massive collapsing filaments

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The connection between the pre-stellar core mass function (CMF) and the stellar initial mass function (IMF) lies at the heart of all star formation theories. In this paper, we study the earliest phases of star formation with a series of high-resolution numerical simulations that include the formation of sinks. In particular, we focus on the transition from cores to sinks within a massive molecular filament. We compare the CMF and IMF between magnetized and unmagnetized simulations, and between different resolutions. We find that selecting cores based on their kinematic virial parameter excludes collapsing objects because they host large velocity dispersions. Selecting only the thermally unstable magnetized cores, we observe that their mass-to-flux ratio spans almost two orders of magnitude for a given mass. We also see that, when magnetic fields are included, the CMF peaks at higher core mass values with respect to pure hydrodynamical simulations. Nonetheless, all models produce sink mass functions with a high-mass slope consistent with Salpeter. Finally, we examine the effects of resolution and find that, in isothermal simulations, even models with very high dynamical range fail to converge in the mass function. Our main conclusion is that, although the resulting CMFs and IMFs have similar slopes in all simulations, the cores have slightly different sizes and kinematical properties when a magnetic field is included. However, a core selection based on the mass-to-flux ratio alone is not enough to alter the shape of the CMF, if we do not take thermal stability into account. Finally, we conclude that extreme care should be given to resolution issues when studying sink formation with an isothermal equation of state.

Accepted by A&A

http://arxiv.org/pdf/1902.05744

A dynamically young, gravitationally stable network of filaments in Orion B

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Filaments are a key step on the path that leads from molecular clouds to star formation. However, their characteristics (for instance their width) are heavily debated, and the exact processes that lead to their formation and fragmentation into dense cores still remain to be fully understood. We aim at characterising the mass, kinematics, and stability against gravitational collapse of a statistically significant sample of filaments in the Orion B molecular cloud, which is renown for its very low star formation efficiency. We characterise the gas column densities and kinematics over a field of 1.9 deg^2, using C^{18}O$(J = 1-0)$ data from the IRAM-30m large programme ORION-B, at angular and spectral resolutions of $23.5''$ and 49.5 kHz, respectively. Using two different Hessian-based filters, we extract and compare two filamentary networks, each containing over 100 filaments. Independent of the extraction method, the filament networks have consistent characteristics. The filaments have widths of $\sim 0.12 \pm 0.04$ pc, and show a wide range of linear ($\sim 1 - 100\, M_{\odot}\mathrm{pc}^{-1}$) and volume densities ($\sim 2 \times 10^3 - 2 \times 10^5$ cm^{-3}). Compared to previous studies, the filament population is dominated by low-density, thermally sub-critical structures, suggesting that most of the identified filaments are not collapsing to form stars. In fact, only $\sim 1\%$ of the Orion B cloud mass covered by our observations can be found in super-critical, star-forming filaments, explaining the low star formation efficiency of the region. The velocity profiles observed across the filaments show quiescence in the center, and coherency in the plane of the sky, despite being mostly supersonic. The filaments in Orion B apparently belong to a continuum which contains a few elements comparable to already studied star-forming filaments (e.g. in the IC 5146, Aquila or Taurus regions) as well as many lower-density, gravitationally unbound structures. This comprehensive study of the Orion B filaments shows that the mass fraction in super-critical filaments is a key factor in determining star formation efficiency.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/1902.02077

The consequences of planetary migration on the minor bodies of the early Solar System

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Pebble accretion is an efficient mechanism able to build up the core of the giant planets within the lifetime of the protoplanetary disc gas-phase. The core grows via this process until the protoplanet reaches its pebble isolation mass and starts to accrete gas. During the growth, the protoplanet undergoes a rapid, large-scale, inward migration due to the interactions with the gaseous protoplanetary disc. In our work, we investigate how this early migration would have affected the minor body populations in our solar system. In particular, we focus on the Jupiter Trojans and the

Hildas asteroids. We found that a massive and eccentric Hilda group is captured during the migration from a region between 5 and 8 au and subsequently depleted during the late instability of the giant planets. Our simulations also show that inward migration of the giant planets always produces a Jupiter Trojans' leading swarm more populated than the trailing one, with a ratio comparable to the current observed Trojan asymmetry ratio. The in situ formation of Jupiter, on the other hand, produces symmetric leading/trailing swarms. The reason for the asymmetry is the relative drift between the migrating planet and the particles in the coorbital resonance. The capture happens during the growth of Jupiter's core and Trojan asteroids are afterwards carried along during the giant planet's migration to their final orbits. The asymmetry and eccentricity of the captured Trojans correspond well to observations, but their inclinations are near zero and their total mass is 3–4 orders of magnitude higher than the current population. Future modelling will be needed to understand whether the dynamical evolution of the Trojans over billions of years will raise the inclinations and deplete the masses to observed values.

Accepted by A&A

http://arxiv.org/pdf/1902.04591

Organic molecules in the protoplanetary disk of DG Tau revealed by ALMA

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Planets form in protoplanetary disks and inherit their chemical compositions. It is thus crucial to map the distribution and investigate the formation of simple organics, such as formaldehyde and methanol, in protoplanetary disks. We analyze ALMA observations of the nearby disk-jet system around the T Tauri star DG Tau in the o-H_2CO $3_{1,2}-2_{1,1}$ and CH_3OH $3_{-2,2}-4_{-1,4}$ E, $5_{0,5}-4_{0,4}$ A transitions at an unprecedented resolution of ~ 0.15", i.e., ~ 18 au at a distance of 121 pc. The H_2CO emission originates from a rotating ring extending from ~ 40 au with a peak at ~ 62 au, i.e., at the edge of the 1.3 mm dust continuum. CH_3OH emission is not detected down to an r.m.s. of 3 mJy/beam in the 0.162 $\mathrm{km\,s^{-1}}$ channel. Assuming an ortho-to-para ratio of $1.8-2.8$ the ring- and disk-height-averaged H_2CO column density is $\sim 0.3-4\times10^{14}$ cm^{-2}, while that of CH_3OH is $< 0.04-0.7\times10^{14}$ cm^{-2}. In the inner 40 au no o-H_2CO emission is detected with an upper limit on its beam-averaged column density of $\sim 0.5-6\times10^{13}$ cm^{-2}. The H_2CO ring in the disk of DG Tau is located beyond the CO iceline ($R_{CO}\sim 30$ au). This suggests that the H_2CO abundance is enhanced in the outer disk due to formation on grain surfaces by the hydrogenation of CO ice. The emission peak at the edge of the mm dust continuum may be due to enhanced desorption of H_2CO in the gas phase caused by increased UV penetration and/or temperature inversion. The CH_3OH/H_2CO abundance ratio is < 1, in agreement with disk chemistry models. The inner edge of the H_2CO ring coincides with the radius where the polarization of the dust continuum changes orientation, hinting at a tight link between the H_2CO chemistry and the dust properties in the outer disk and at the possible presence of substructures in the dust distribution.

Accepted by A&A Letters

http://arxiv.org/pdf/1902.02720

The nitrogen carrier in protoplanetary disks

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The dominant reservoirs of elemental nitrogen in protoplanetary disks have not yet been observationally identified. Likely candidates are HCN, NH_3 and N_2. The relative abundances of these carriers determine the composition of planetesimals as a function of disk radius due to strong differences in their volatility. A significant sequestration of nitrogen in carriers less volatile than N_2 is likely required to deliver even small amounts of nitrogen to the Earth and potentially habitable exo-planets. While HCN has been detected in small amounts in inner disks (<10 au), so far only relatively insensitive upper limits on inner disk NH_3 have been obtained. We present new Gemini-TEXES high resolution spectroscopy of the 10.75 μm band of warm NH_3, and use 2-dimensional radiative transfer modeling to improve previous upper limits by an order of magnitude to $[NH_3/H_{nuc}] < 10^{-7}$ at 1 au. These NH_3 abundances are significantly lower than those typical for ices in circumstellar envelopes ($[NH_3/H_{nuc}] \sim 3 \times 10^{-6}$). We also consistently retrieve the inner disk HCN gas abundances using archival Spitzer spectra, and derive upper limits on the HCN ice abundance in protostellar envelopes using archival ground-based 4.7 μm spectroscopy ($[HCN_{ice}]/[H_2O_{ice}] < 1.5$–9%). We identify the NH_3/HCN ratio as an indicator of chemical evolution in the disk, and use this ratio to suggest that inner disk nitrogen is efficiently converted from NH_3 to N2, significantly increasing the volatility of nitrogen in planet-forming regions.

Accepted by ApJ

http://arxiv.org/pdf/1902.03647

Observing the gas component of circumplanetary disks around wide-orbit planet-mass companions in the (sub)mm regime

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Several detections of wide-orbit planet-mass/sub-stellar companions around young solar-like stars were reported in the last decade. The origin of those possible planets is still unclear but accretion tracers and VLT/SPHERE observations indicate that they are surrounded by circumplanetary material or even a circumplanetary disk. We want to investigate if the gas component of disks around wide-orbit companions is detectable with current and future (sub)mm telescopes and what constraints such gas observations can provide on the nature of the circumplanetary material and on the mass of the companion. We applied the radiation thermo-chemical disk code ProDiMo to model the dust and gas component of passive circumplanetary disks and produced realistic synthetic observables. We considered different companion properties, disk parameters and radiative environments and compared the resulting synthetic observables to telescope sensitivities and to existing dust observations. The main criterion for a successful detection is the size of the circumplanetary disk. At a distance of about 150 pc, a circumplanetary disk with an outer radius of about 10 au is detectable with ALMA in about 6 hours in optically thick CO lines. Other aspects such as the companion's luminosity, disk inclination and background radiation fields are also relevant and should be considered to optimize the observing strategy for detection experiments. For most of the known wide-orbit planet-mass companions, their maximum theoretical disk size of one third of the Hill radius would be sufficient to allow detection of CO lines. It is therefore feasible to detect their gas disks and constrain the mass of the companion through the kinematic signature. Even in the case of non-detections such observations will provide stringent constraints on disk size and gas mass, information crucial for formation theories.

Accepted by A&A

https://arxiv.org/pdf/1902.04096

A high resolution mid-infrared survey of water emission from protoplanetary disks

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We present the largest survey of spectrally resolved mid-infrared water emission to date, with spectra for 11 disks obtained with the Michelle and TEXES spectrographs on Gemini North. Water emission is detected in 6 of 8 disks around classical T Tauri stars. Water emission is not detected in the transitional disks SR 24 N and SR 24 S, in spite of SR 24 S having pre-transitional disk properties like DoAr 44, which does show water emission (Salyk et al. 2015). With R∼100,000, the TEXES water spectra have the highest spectral resolution possible at this time, and allow for detailed lineshape analysis. We find that the mid-IR water emission lines are similar to the "narrow component" in CO rovibrational emission (Banzatti & Pontoppidan 2015), consistent with disk radii of a few AU. The emission lines are either single peaked, or consistent with a double peak. Single-peaked emission lines cannot be produced with a Keplerian disk model, and may suggest that water participates in the disk winds proposed to explain single-peaked CO emission lines (Bast et al. 2011, Pontoppidan et al. 2011). Double-peaked emission lines can be used to determine the radius at which the line emission luminosity drops off. For HL Tau, the lower limit on this measured dropoff radius is consistent with the 13 AU dark ring (ALMA partnership et al. 2015). We also report variable line/continuum ratios from the disks around DR Tau and RW Aur, which we attribute to continuum changes and line flux changes, respectively. The reduction in RW Aur line flux corresponds with an observed dimming at visible wavelengths (Rodriguez et al. 2013).

Accepted by ApJ

http://arxiv.org/pdf/1902.02708

ALMA High Angular Resolution Polarization Study: An Extremely Young Class 0 Source, OMC-3/MMS 6

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Using the ≈16 km long baseline data obtained with the Atacama Large Millimeter/submillimeter Array (ALMA), we imaged the Stokes *I* emission and linearly polarized intensity (PI) in the 1.1 mm continuum band of a very young intermediate-mass protostellar source, MMS 6, in the Orion Molecular Cloud-3. The achieved angular resolution,

$0''02\times0''03$ ($\approx$10 au), shows for the first time a wealth of data on the dust emission polarization in the central 200 au of a protostar. The PI peak is offset to the southeast (SE) by $\approx$20 au with respect to the Stokes I peak. Its polarization degree is 11% with its E-vector orientation of the position angle $\approx$135. A partial ringlike structure with a radius of $\approx$80 au is detected in PI but not in the Stokes I. Northwest (NW) and SE parts of the ring are bright, with a high polarization degree of $\geq$10%, and their E-vector orientations are roughly orthogonal to those observed near the center. We also detected an armlike polarized structure, extending to 1000 au scale to the north, with the E-vectors aligned along the minor axis of the structure. We explored possible origins of the polarized emission by comparing them with magnetohydrodynamical simulations of the toroidal wrapping of the magnetic field. The simulations are consistent with the PI emission in the ringlike and the extended armlike structures observed with ALMA. However, the current simulations do not completely reproduce observed polarization characteristics in the central 50 au. Although the self-scattering model can explain the polarization pattern and positional offset between the Stokes I and PI in the central 50 au, this model is not able to reproduce the observed high degree of polarization.

Accepted by Astrophysical Journal

http://adsabs.harvard.edu/pdf/2019ApJ...872...70T
http://arxiv.org/pdf/1812.03189

Polarization of stars with debris disks: comparing observations with models

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The *Herschel* Space telescope carried out an unprecedented survey of nearby stars for debris disks. The dust present in these debris disks scatters and polarizes stellar light in the visible part of the spectrum. We explore what can be learned with aperture polarimetry and detailed radiative transfer modelling about stellar systems with debris disks. We present a polarimetric survey, with measurements from the literature, of candidate stars observed by DEBRIS and DUNES *Herschel* surveys. We perform a statistical analysis of the polarimetric data with the detection of far-infrared excess by *Herschel* and *Spitzer* with a sample of 223 stars. Monte Carlo simulations were performed to determine the effects of various model parameters on the polarization level and find the mass required for detection with current instruments. Eighteen stars were detected with a polarization $0.01 \leq P \leq 0.1$ per cent and $\geq 3\sigma_P$, but only two of them have a debris disk. No statistically significant difference is found between the different groups of stars, with, without, and unknown status for far-infrared excess, and presence of polarization. The simulations show that the integrated polarization is rather small, usually < 0.01 per cent for typical masses detected by their far-infrared excess for hot and most warm disks. Masses observed in cold disks can produce polarization levels above 0.01 per cent since there is usually more dust in them than in closer disks. We list five factors which can explain the observed low-polarization detection rate. Observations with high-precision polarimeters should lead to additional constraints on models of unresolved debris disks.

Accepted by Monthly Notices of the Royal Astronomical Society (2019, Vol. 483, pp. 3510 - 3528)

http://arxiv.org/pdf/1811.04889

The survivability of planetary systems in young and dense star clusters

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We perform a simulation using the Astrophysical Multipurpose Software Environment of the Orion Trapezium star cluster in which the evolution of the stars and the dynamics of planetary systems are taken into account. The initial conditions are selected from earlier simulations in which the size and mass distributions of the observed circum-stellar disks in this cluster are satisfactorily reproduced. Four, five or size planets per star were introduced in orbit around the 500 solar-like stars with a maximum orbital separation of 400 au. Our study focuses on the production of free-floating planets. From a total of 2522 planets in the initial conditions of the simulation, a total of 357 become unbound. Of these, 281 leave the cluster within the crossing time-scale of the star cluster, the others remain bound to the cluster as free-floating intra-cluster planets. Five of these free-floating intra-cluster planets are captured at a later time by another star. The two main mechanisms by which planets are lost from their host star, ejection upon a strong encounter with another star or internal planetary scattering, drive the evaporation independently of planet mass of orbital separation at birth. The effect of small perturbations due to slow changes in the cluster potential are important for the evolution of planetary systems. In addition, the probability for a star losing a planet is independent of the planet mass and independent of its initial orbital separation. As a consequence, the mass-distribution of free-floating planets is indistinguishable from the mass distribution of planets bound to their host star.

Accepted by A&A

http://arxiv.org/pdf/1902.04652

Spatial segregation of dust grains in transition disks. SPHERE observations of 2MASS J16083070-3828268 and RXJ1852.3-3700

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Context. The mechanisms governing the opening of cavities in transition disks are not fully understood. Several processes have been proposed, but their occurrence rate is still unknown.
Aims. We present spatially resolved observations of two transition disks, and aim at constraining their vertical and radial structure using multiwavelength observations that probe different regions of the disks and can help understanding the origin of the cavities. Methods. We have obtained near-infrared scattered light observations with VLT/SPHERE of the transition disks 2MASS J16083070-3828268 (J1608) and RXJ1852.3-3700 (J1852), located in the Lupus and Corona Australis star-forming regions respectively. We complement our datasets with archival ALMA observations, and with unresolved photometric observations covering a wide range of wavelengths. We performed radiative transfer modeling to analyze the morphology of the disks, and then compare the results with a sample of 20 other transition

disks observed with both SPHERE and ALMA.
Results. We detect scattered light in J1608 and J1852 up to a radius of 0.54" and 0.4" respectively. The image of J1608 reveals a very inclined disk (i∼74deg), with two bright lobes and a large cavity. We also marginally detect the scattering surface from the rear-facing side of the disk. J1852 shows an inner ring extending beyond the coronagraphic radius up to 15 au, a gap and a second ring at 42au. Our radiative transfer model of J1608 indicates that the millimeter-sized grains are less extended vertically and radially than the micron-sized grains, indicating advanced settling and radial drift. We find good agreement with the observations of J1852 with a similar model, but due to the low inclination of the system, the model remains partly degenerate. The analysis of 22 transition disks shows that, in general, the cavities observed in scattered light are smaller than the ones detected at millimeter wavelengths.
Conclusions. The analysis of a sample of transition disks indicates that the small grains, well coupled to the gas, can flow inward of the region where millimeter grains are trapped. While 15 out of the 22 cavities in our sample could be explained by a planet of less than 13 Jupiter masses, the others either require the presence of a more massive companion or of several low-mass planets.

Accepted by Astronomy and Astrophysics

https://arxiv.org/pdf/1902.04612.pdf

Ejection History of the IRAS 04166+2706 Molecular Jet

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The high-velocity molecular jet driven by Class 0 protostar IRAS 04166+2706 exhibits a unique saw-tooth velocity pattern. It consists of a series of well-aligned symmetric knots with similar averaged speeds, whose speeds at peaks of emission decreases roughly linearly away from the origin. Recent ALMA observations of knots R6 and B6 reveal kinematic behavior with expansion velocity increasing linearly from the axis to the edge. This pattern can be formed by a spherically expanding wind with axial density concentration. In this picture, the diverging velocity profile naturally possesses an increasing expansion velocity away from the axis, resulting in a tooth-like feature on the position-velocity diagram through projection. Such geometric picture predicts a correspondence between the slopes of the teeth and the outflow inclination angles, and the same inclination angle of 52° of the IRAS 04166+2706 can generally explain the whole pattern. Aided by numerical simulations in the framework of unified wind model by Shang et al. (2006), the observed velocity pattern can indeed be generated. A proper geometrical distribution of the jet and wind material is essential to the reconstruction the ejection history of the system.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1902.06038

Luminosity outburst chemistry in protoplanetary discs: going beyond standard tracers

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The chemical influence of luminosity outbursts on the environments of young solar-type stars is explored. Species are categorised into several types according to their response to the outburst. The first and second types imply chemical changes only during the outburst (with slightly different behaviours). These response types are mostly observed close to the star and are caused by icy mantle evaporation. However, mantles recover after the outburst almost immediately. A notable exception is benzene ice, which is accumulated on dust surfaces during and after the outburst, so that its abundance exceeds the pre-outburst level by orders of magnitude. The third type of response is mostly seen at the disc

periphery and implies alteration of abundances during the outburst and preservation of these 'abnormal' abundances for centuries. This behaviour is typical of organic compounds, like $HCOOCH_3$, CH_3CN, CH_2CO. Their presence in the dark disc regions can be a manifestation of the past outburst. CO and CO_2 only trace past outbursts at the remote disc regions. The outburst changes the C/O ratio, but it quickly returns to the pre-outburst value almost everywhere in the disc. An important factor determining the sensitivity of molecular composition to the outburst is the dust size distribution. The duration of the pre-outburst stage and of the outburst itself influence the chemical effects, if the burst duration is shorter than 50 yr and the duration of the quiescent phase between the bursts is shorter than 100 kyr.

Accepted by MNRAS

http://arxiv.org/pdf/1902.07475

External photoevaporation of protoplanetary discs in Cygnus OB2: linking discs to star formation dynamical history

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Many stars form in regions of enhanced stellar density, wherein the influence of stellar neighbours can have a strong influence on a protoplanetary disc (PPD) population. In particular, far ultraviolet (FUV) flux from massive stars drives thermal winds from the outer edge of PPDs, accelerating disc destruction. In this work, we present a novel technique for constraining the dynamical history of a star forming environment using PPD properties in a strongly FUV irradiated environment. Applying recent models for FUV induced mass loss rates to the PPD population of Cygnus OB2, we constrain how long ago primordial gas was expelled from the region; 0.5 Myr ago if the Shakura & Sunyaev α-viscosity parameter is $\alpha = 10^{-2}$ (corresponding to a viscous timescale of $\tau_{\rm visc} \approx 0.5$ Myr for a disc of scale radius 40 au around a 1 $M_\odot$ star). This value of α is effectively an upper limit, since it assumes efficient extinction of FUV photons throughout the embedded phase. With this gas expulsion timescale we are able to produce a full dynamical model that fits kinematic and morphological data as well as disc fractions. We suggest Cygnus OB2 was originally composed of distinct massive clumps or filaments, each with a stellar mass $\sim 10^4\ M_\odot$. Finally we predict that in regions of efficient FUV induced mass loss, disc mass $M_{\rm disc}$ as a function of stellar host mass $m_{\rm star}$ follows a power law with $M_{\rm disc} \approx {m_{\rm star}}^{\beta}$, where $\beta \gtrsim 2.7$ (depending on disc initial conditions and FUV exposure). This is steeper than observed correlations in regions of moderate FUV flux ($1 < \beta < 1.9$), and offers a promising diagnostic to establish the influence of external photoevaporation in a given region.

Accepted by MNRAS

http://arxiv.org/pdf/1902.04586

The Distances to Molecular Clouds at High Galactic Latitudes based on GAIA DR2

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We report the distances of molecular clouds at high Galactic latitudes ($|b| > 10°$) derived from parallax and G band extinction (AG) measurements in the second Gaia data release, Gaia DR2. Aided by Bayesian analyses, we determined distances by identifying the breakpoint in the extinction AG towards molecular clouds and using the extinction AG of Gaia stars around molecular clouds to confirm the breakpoint. We use nearby star-forming regions, such as Orion, Taurus, Cepheus, and Perseus, whose distances are well-known to examine the reliability of our method. By comparing with previous results, we found that the molecular cloud distances derived from this method are reliable. The systematic error in the distances is approximately 5%. In total, 52 molecular clouds have their distances well

determined, most of which are at high Galactic latitudes, and we provide reliable distances for 13 molecular clouds for the first time.

Accepted by A&A

http://arxiv.org/pdf/1902.02052

An Ordered Envelope-disk Transition in the Massive Protostellar Source G339.88-1.26

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We report molecular line observations of the massive protostellar source G339.88-1.26 with the Atacama Large Millimeter/Submillimeter Array. The observations reveal a highly collimated SiO jet extending from the 1.3 mm continuum source, which connects to a slightly wider but still highly collimated CO outflow. Rotational features perpendicular to the outflow axis are detected in various molecular emissions, including SiO, SO_2, H_2S, CH_3OH, and H_2CO emissions. Based on their spatial distributions and kinematics, we find that they trace different parts of the envelope-disk system. The SiO emission traces the disk and inner envelope in addition to the jet. The CH_3OH and H_2CO emissions mostly trace the infalling-rotating envelope, and are enhanced around the transition region between envelope and disk, i.e., the centrifugal barrier. The SO_2 and H_2S emissions are enhanced around the centrifugal barrier, and also trace the outer part of the disk. Envelope kinematics are consistent with rotating-infalling motion, while those of the disk are consistent with Keplerian rotation. The radius and velocity of the centrifugal barrier are estimated to be about 530 au and 6 km s^{-1}, leading to a central mass of about 11 $M_\odot$, consistent with estimates based on spectral energy distribution fitting. These results indicate that an ordered transition from an infalling-rotating envelope to a Keplerian disk through a centrifugal barrier, accompanied by changes of types of molecular line emissions, is a valid description of this massive protostellar source. This implies that at least some massive stars form in a similar way as low-mass stars via Core Accretion.

Accepted by ApJ

https://arxiv.org/pdf/1811.04381

The Weakening Outburst of the Young Eruptive Star V582 Aur

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V582 Aur is a pre-main-sequence FU Orionis type eruptive star, which entered a brightness minimum in 2016 March due to changes in the line-of-sight extinction. Here, we present and analyze new optical B, V, R_C, and I_C band multiepoch observations and new near-infrared J, H, and K_S band photometric measurements from 2018 January–

2019 February, as well as publicly available midinfrared Wide-field Infrared Survey Explorer (WISE) data. We found that the source shows a significant optical–near-infrared variability, and the current brightness minimum has not completely finished yet. If the present dimming originates from the same orbiting dust clump that caused a similar brightness variation in 2012, then our results suggest a viscous spreading of the dust particles along the orbit. Another scenario is that the current minimum is caused by a dust structure, that is entering and leaving the inner part of the system. The WISE measurements could be consistent with this scenario. Our long-term data, as well as an accretion disk modeling hint at a general fading of V582 Aur, suggesting that the source will reach the quiescent level in ~80 years.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1902.03673.pdf

Abstract submission deadline

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

Abstracts of recently accepted major reviews

The role of magnetic field in molecular cloud formation and evolution

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We review the role that magnetic field may have on the formation and evolution of molecular clouds. After a brief presentation and main assumptions leading to ideal MHD equations, their most important correction, namely the ion-neutral drift is described. The nature of the multi-phase interstellar medium (ISM) and the thermal processes that allows this gas to become denser are presented. Then we discuss our current knowledge of compressible magnetized turbulence, thought to play a fundamental role in the ISM. We also describe what is known regarding the correlation between the magnetic and the density fields. Then the influence that magnetic field may have on the interstellar filaments and the molecular clouds is discussed, notably the role it may have on the prestellar dense cores as well as regarding the formation of stellar clusters. Finally we briefly review its possible effects on the formation of molecular clouds themselves. We argue that given the magnetic intensities that have been measured, it is likely that magnetic field is i) responsible of reducing the star formation rate in dense molecular cloud gas by a factor of a few, ii) strongly shaping the interstellar gas by generating a lot of filaments and reducing the numbers of clumps, cores and stars, although its exact influence remains to be better understood. Moreover at small scales, magnetic braking is likely a dominant process that strongly modifies the outcome of the star formation process. Finally, we stress that by inducing the formation of more massive stars, magnetic field could possibly enhance the impact of stellar feedback.

Accepted by Frontiers in Astronomy and Space Sciences

http://arxiv.org/pdf/1902.00798

Interferometric Observations of Magnetic Fields in Forming Stars

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The magnetic field is a key ingredient in the recipe of star formation. However, the importance of the magnetic field in the early stages of the formation of low- and high-mass stars is still far from certain. Over the past two decades, the millimeter and submillimeter interferometers BIMA, OVRO, CARMA, SMA, and most recently ALMA have made major strides in unveiling the role of the magnetic field in star formation at progressively smaller spatial scales; ALMA observations have recently achieved spatial resolutions of up to ~ 100 au and $\sim 1{,}000$ au in nearby low- and high-mass star-forming regions, respectively. From the kiloparsec scale of molecular clouds down to the inner few hundred au immediately surrounding forming stars, the polarization at millimeter and submillimeter wavelengths is dominated by polarized thermal dust emission, where the dust grains are aligned relative to the magnetic field. Interferometric studies have focused on this dust polarization and occasionally on the polarization of spectral-line emission. We review the current state of the field of magnetized star formation, from the first BIMA results through the latest ALMA observations, in the context of several questions that continue to motivate the studies of high- and low-mass

star formation. By aggregating and analyzing the results from individual studies, we come to several conclusions: (1) Magnetic fields and outflows from low-mass protostellar cores are randomly aligned, suggesting that the magnetic field at ~ 1000 au scales is not the dominant factor in setting the angular momentum of embedded disks and outflows. (2) Recent measurements of the thermal and dynamic properties in high-mass star-forming regions reveal small virial parameters, challenging the assumption of equilibrium star formation. However, we estimate that a magnetic field strength of a fraction of a mG to several mG in these objects could bring the dense gas close to a state of equilibrium. Finally, (3) We find that the small number of sources with hourglass-shaped magnetic field morphologies at 0.01–0.1 pc scales cannot be explained purely by projection effects, suggesting that while it does occur occasionally, magnetically dominated core collapse is not the predominant mode of low- or high-mass star formation.

Published in Frontiers in Astronomy and Space Sciences

https://www.frontiersin.org/articles/10.3389/fspas.2019.00003/full
https://arxiv.org/pdf/1903.03177

The Role of Magnetic Fields in Setting the Star Formation Rate and the Initial Mass Function

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Star-forming gas clouds are strongly magnetized, and their ionization fractions are high enough to place them close to the regime of ideal magnetohydrodyamics on all but the smallest size scales. In this review we discuss the effects of magnetic fields on the star formation rate (SFR) in these clouds, and on the mass spectrum of the fragments that are the outcome of the star formation process, the stellar initial mass function (IMF). Current numerical results suggest that magnetic fields by themselves are minor players in setting either the SFR or the IMF, changing star formation rates and median stellar masses only by factors of ∼2–3 compared to non-magnetized flows. However, the indirect effects of magnetic fields, via their interaction with star formation feedback in the form of jets, photoionization, radiative heating, and supernovae, could have significantly larger effects. We explore evidence for this possibility in current simulations, and suggest avenues for future exploration, both in simulations and observations.

Accepted by Frontiers of Astronomy and Space Science

http://arxiv.org/pdf/1902.02557

Summary of Upcoming Meetings

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Moving ... ??

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