The Star Formation Newsletter

A community newsletter on Star and Planet Formation research

No. 337 — 20 January 2021
Editor: João Alves
www.starformation.news

Links to sections

Cover image caption

Detail of the interaction between stellar feedback and the gas in NGC 2174. NGC 2174 is a poorly studied H_{II} emission nebula located at a distance of about 2 kpc towards the Galactic anti-center (in the constellation of Orion but not associated with the well known Orion Star Formation region). The region, also known as Sh 2-252, is associated with the young star cluster NGC 2175. Credits: NASA, ESA, and the Hubble Heritage Team (STScI/AURA).

Note from the Editor

The Star Formation Newsletter is now on the web at **www.starformation.news**. This PDF file contains the monthly Abstracts and links to the different Newsletter sections. Red text in this PDF is a url link. Submitting an abstract to the SFN is as simple as entering the arXiv ID (e.g., 2006.10139) in a web form on the SFN web site. We extract the title, authors, and the abstract's text directly from the arXiv, so make sure not to remove the LaTeX formatting when submitting to the arXiv. If you do, your abstract will not look great either at the arXiv (which uses MathJax to convert LaTeX math symbols to the web) or the SFN.

Abstracts

1. Filament rotation in the California L1482 cloud

Rodrigo H. Álvarez-Gutiérrez, Amelia M. Stutz, Chi Y. Law, Stefan Reissl, Ralf S. Klessen, Nathan W. C. Leigh, Hong-Li Liu, Rodrigo A. Reeves We analyze the gas mass distribution, the gas kinematics, and the young stellar object (YSO) content of the California Molecular Cloud (CMC) L1482 filament. We derive a Gaia DR2 YSO distance of 511^{+17}_{-16} pc. We derive scale-free power-laws for the mean gas line-mass (M/L) profiles; we calculate the gravitational potential and field profiles consistent with these. We present IRAM 30 m $C^{18}O$ (1-0) (and other tracers) position-velocity (PV) diagrams that exhibit complex velocity twisting and turning structures. We find a rotational profile in $C^{18}O$ perpendicular to the southern filament ridgeline. The profile is regular, confined ($r \lesssim 0.4$ pc), anti-symmetric, and to first order linear with a break at $r \sim 0.25$ pc. The timescales of the inner (outer) gradients are $\sim$0.7 (6.0) Myr. We show that the centripetal force, compared to gravity, increases toward the break; when the ratio of forces approaches unity, the profile turns over, just before filament breakup is achieved. The timescales and relative roles of gravity to rotation indicate that the structure is stable, long lived ($\sim$ a few times 6 Myr), and undergoing outside-in evolution. Moreover, this filament has practically no star formation, a perpendicular Planck plane-of-the-sky (POS) magnetic field morphology, and POS "zig-zag" morphology, which together with the rotation profile lead to the suggestion that the 3D shape is a corkscrew filament with a helical magnetic field. These results, combined with results in Orion and G035.39-00.33, suggest evolution toward higher densities as rotating filaments shed angular momentum. Thus, magnetic fields may be an essential feature of high-mass ($M \sim 10^5$ $M_\odot$) cloud filament evolution toward cluster formation.

2. Dust polarized emission observations of NGC 6334; BISTRO reveals the details of the complex but organized magnetic field structure of the high-mass star-forming hub-filament network

BISTRO collaboration - D. Arzoumanian et al. [Abridged] Filaments and hubs have received special attention recently thanks to studies showing their role in star formation. While the column density and velocity structures of both filaments and hubs have been studied, their magnetic fields (B-field) are not yet characterized. We aim to understand the role of the B-field in the dynamical evolution of the NGC 6334 hub-filament network. We present new observations of the dust polarized emission at 850μm towards NGC 6334 obtained with the JCMT/POL-2. We study the distribution and dispersion of the polarized intensity (PI), the polarization fraction (PF), and the B-field angle (θ_B). We derive the power spectrum of the intensity and θ_B along the ridge crest. Our analyses show a complex B-field structure when observed over the whole region ($\sim$ 10 pc), however, at smaller scales ($\sim$ 1 pc), θ_B varies coherently along the filaments. The observed power spectrum of θ_B can be well represented with a power law function with a slope -1.33 ± 0.23, which is $\sim$ 20% shallower than that of I. This result is compatible with the properties of simulated filaments and may indicate the processes at play in the formation of filaments. θ_B rotates from

being mostly perpendicular to the filament crests to mostly parallel as they merge with the hubs. This variation of θ_B may be tracing local velocity flows of matter in-falling onto the hubs. Our analysis suggests a variation of the energy balance along the crests of these filaments, from magnetically critical/supercritical at their far ends to magnetically subcritical near the hubs. We detect an increase of PF towards the high-column density star cluster-forming hubs that may result from the increase of grain alignment efficiency due to stellar radiation from the newborn stars.

3. Photodissociation Region Diagnostics Across Galactic Environments

Thomas G. Bisbas, Jonathan C. Tan, Kei E. I. Tanaka We present three-dimensional astrochemical simulations and synthetic observations of magnetised, turbulent, self-gravitating molecular clouds. We explore various galactic interstellar medium environments, including cosmic-ray ionization rates in the range of $\zeta_{\rm CR} = 10^{-17}$-$10^{-14}\,{\rm s}^{-1}$, far-UV intensities in the range of $G_0 = 1$-10^3 and metallicities in the range of $Z = 0.1$-$2\,{\rm Z}_\odot$. The simulations also probe a range of densities and levels of turbulence, including cases where the gas has undergone recent compression due to cloud-cloud collisions. We examine: i) the column densities of carbon species across the cycle of CII, CI and CO, along with OI, in relation to the HI-to-H_2 transition; ii) the velocity-integrated emission of [CII] 158μm, [^{13}CII] 158μm, [CI] 609μm and 370μm, [OI] 63μm and 146μm, and of the first ten ^{12}CO rotational transitions; iii) the corresponding Spectral Line Energy Distributions; iv) the usage of [CII] and [OI] 63μm to describe the dynamical state of the clouds; v) the behavior of the most commonly used ratios between transitions of CO and [CI]; and vi) the conversion factors for using CO and CI as H_2-gas tracers. We find that enhanced cosmic-ray energy densities enhance all aforementioned line intensities. At low metallicities, the emission of [CII] is well connected with the H_2 column, making it a promising new H_2 tracer in metal-poor environments. The conversion factors of $X_{\rm CO}$ and $X_{\rm CI}$ depend on metallicity and the cosmic-ray ionization rate, but not on FUV intensity. In the era of ALMA, SOFIA and the forthcoming CCAT-prime telescope, our results can be used to understand better the behaviour of systems in a wide range of galactic and extragalactic environments.

4. Linear Stability Analysis of a Magnetic Rotating Disk with Ohmic Dissipation and Ambipolar Diffusion

Indrani Das, Shantanu Basu We perform a linear analysis of the stability of isothermal, rotating, magnetic, self-gravitating sheets that are weakly ionized. The magnetic field and rotation axis are perpendicular to the sheet. We include a self-consistent treatment of thermal pressure, gravitational, rotational, and magnetic (pressure and tension) forces together with two nonideal magnetohydrodynamic (MHD) effects (Ohmic dissipation and ambipolar diffusion) that are treated together for their influence on the properties of gravitational instability for a rotating sheet-like cloud or disk. Our results show that there is always a preferred lengthscale and associated minimum timescale for gravitational instability. We investigate their dependence on important dimensionless free parameters of the problem: the initial normalized mass-to-flux ratio μ_0, the rotational Toomre parameter Q, the dimensionless Ohmic diffusivity $\tilde{\eta}_{\rm OD,0}$, and the dimensionless neutral-ion collision time $\tilde{\tau}_{\rm ni,0}$ that is a measure of the ambipolar diffusivity. One consequence of $\tilde{\eta}_{\rm OD,0}$ is that there is a maximum preferred lengthscale of instability that occurs in the transcritical ($\mu_0 \gtrsim 1$) regime, qualitatively similar to the effect of $\tilde{\tau}_{\rm ni,0}$, but with quantitative differences. The addition of rotation leads to a generalized Toomre criterion (that includes a magnetic dependence) and modified lengthscales and timescales for collapse. When nonideal MHD effects are also included, the Toomre criterion reverts back to the hydrodynamic value. We apply our results to protostellar disk properties in the early embedded phase and find that the preferred scale of instability can significantly exceed the thermal (Jeans) scale and the peak preferred fragmentation mass is likely to be $\sim 10 - 90\ M_{\rm Jup}$.

5. The sonic scale revealed by the world's largest supersonic turbulence simulation

Christoph Federrath, Ralf S. Klessen, Luigi Iapichino, James R. Beattie Understanding the physics of turbulence is crucial for many applications, including weather, industry, and astrophysics. In the interstellar medium (ISM), supersonic turbulence plays a crucial role in controlling the gas density and velocity structure, and ultimately the birth of stars. Here we present a simulation of interstellar turbulence with a grid resolution of 10048^3 cells that allows us to determine the position and width of the sonic scale (l_s) - the transition from supersonic to subsonic turbulence. The simulation simultaneously resolves the supersonic and subsonic cascade, $v(l) \propto l^p$, where we measure $p_{sup} = 0.49$ +/- 0.01 and $p_{sub} = 0.39$ +/- 0.02, respectively. We find that l_s agrees with the relation l_s / L = phi_s $Mach^{(-1/p_{sup})}$, where Mach is the three-dimensional Mach number, and L is either the driving scale of turbulence or the diameter of a molecular cloud. If L is the driving scale, we measure phi_s = 0.42 (+0.12) (-0.09), primarily because of the separation between the driving scale and the start of the supersonic cascade. For a supersonic cascade extending beyond the cloud scale, we get phi_s = 0.91 (+0.25) (-0.20). In both cases, $phi_s < 1$, because we find that the supersonic cascade transitions smoothly to the subsonic cascade over a factor of 3 in scale, instead of a sharp transition. Our measurements provide quantitative input for turbulence-regulated models of filament structure and star formation in molecular clouds.

6. Physical and chemical structure of the Serpens filament – fast formation and gravity-driven accretion

Y. Gong, A. Belloche, F. J. Du, K. M. Menten, C. Henkel, G. X. Li, F. Wyrowski, R. Q. Mao The Serpens filament, a prominent elongated structure in a relatively nearby molecular cloud, is believed to be at an early evolutionary stage, so studying its physical and chemical properties can shed light on filament formation and early evolution. The main goal is to address the physical and chemical properties as well as the dynamical state of the Serpens filament at a spatial resolution of $\sim$0.07 pc and a spectral resolution of $\lesssim$0.1 km s^{-1}. We performed ^{13}CO (1–0), C^{18}O (1–0), C^{17}O (1–0), ^{13}CO (2–1), C^{18}O (2–1), and C^{17}O (2–1) imaging observations toward the Serpens filament with the Institut de Radioastronomie Millimétrique 30-m (IRAM-30 m) and Atacama Pathfinder EXperiment (APEX) telescopes. Widespread narrow ^{13}CO (2–1) self-absorption is observed in this filament, causing the ^{13}CO morphology to be different from the filamentary structure traced by C^{18}O and C^{17}O. Our excitation analysis suggests that the opacities of C^{18}O transitions become higher than unity in most regions, and this analysis confirms the presence of widespread CO depletion. Further we show that the local velocity gradients have a tendency to be perpendicular to the filament's long axis in the outskirts and parallel to the large-scale magnetic field direction. The magnitudes of the local velocity gradients decrease toward the filament's crest. The observed velocity structure can be a result of gravity-driven accretion flows. The isochronic evolutionary track of the C^{18}O freeze-out process indicates the filament is young with an age of $\lesssim$2 Myr. We propose that the Serpens filament is a newly-formed slightly-supercritical structure which appears to be actively accreting material from its ambient gas.

7. Water and Methanol Ice in L1544

Miwa Goto, A. I. Vasyunin, B. M. Giuliano, I. Jiménez-Serra, P. Caselli, C. G. Román-Zúñiga, J. Alves Methanol and complex organic molecules have been found in cold starless cores, where a standard warm-up scenario would not work because of the absence of heat sources. A recent chemical model attributed the presence of methanol and large organics to the efficient chemical desorption and a class of neutral-neutral reactions that proceed fast at low temperatures in the gas phase. The model calls for a high abundance of methanol ice at the edge of the CO freeze-out zone in cold cloud cores. We performed medium resolution spectroscopy toward 3 field stars behind the starless core L1544 at 3 μm to constrain the methanol ice abundance and compare it with the model predictions. One of the field stars shows a methanol-ice abundance of 11% with respect to water ice. This is higher than the typical methanol abundance previously found in cold cloud cores (4%), but is 4.5 times smaller than predicted. The reason for the disagreement between the observations and the model calculations is not yet understood.

8. Searching for active low-mass stars in CMa star-forming region: multi-band photometry with T80S

J. Gregorio-Hetem, F. Navarete, A. Hetem, T. Santos-Silva, P. A. B. Galli, B. Fernandes, T. Montmerle, V. Jatenco-Pereira, M. Borges Fernandes, H. D. Perottoni, W. Schoenell, T. Ribeiro, A. Kanaan An exotic environment surrounds the young stellar groups associated with the Canis Major (CMa) OB1/R1 region, which probably was formed under feedback from at least three supernova events having occurred a few million years ago. We use astrometric data from the Gaia-DR2 to confirm the membership of the stars in CMa R1, based on proper motion and parallax, which revealed 514 new members and candidates. The mean age of 5 Myr estimated from the color-magnitude diagram characterizes the sources as likely pre-main sequence candidates. In total, a sample of 694 stars detected with the T80-South telescope was analyzed according to different color-color diagrams, which were compared with theoretical colors from evolutionary models, aiming to reveal the objects that exhibit color excess due to accretion processes. Accretion and magnetic activity were also explored on the basis of empirical flux-flux relation, such as F660 and F861 that are related to Halpha and Ca II triplet emission, respectively. A low fraction (3 percent) of the sample have Halpha excess and other colors expected for stars exhibiting chromospheric activity. The number of Class I and Class II objects, identified by the infrared (WISE) colors, indicates a disk fraction of 6 percent, which is lower than the expected for stellar clusters with similar age. A such large sample of objects associated with CMa R1 without evidences of circumstellar accretion can be interpreted as a lack of disk-bearing stars, unusual for young star-forming regions. However, this may be explained as the result of supernova events.

9. Feedback-limited Accretion: Variable Luminosity from Growing Planets

Matías Gárate, Jorge Cuadra, Matias Montesinos, Patricia Arévalo Planets form in discs of gas and dust around stars, and continue to grow by accretion of disc material while available. Massive planets clear a gap in their protoplanetary disc, but can still accrete gas through a circumplanetary disk. For high enough accretion rates the planet should be detectable at infrared wavelengths. As the energy of the gas accreted on to the planet is released, the planet surroundings heat up in a feedback process. We aim to test how this planet feedback affects the gas in the coorbital region and the accretion rate itself. We modified the 2D code FARGO-AD to include a prescription for the accretion and feedback luminosity of the planet and use it to model giant planets on 10 au circular and eccentric orbits around a solar mass star. We find that this feedback reduces but does not halt the accretion on to the planet, although this result might depend on the near-coincident radial ranges

where both recipes are implemented. Our simulations also show that the planet heating gives the accretion rate a stochastic variability with an amplitude $\Delta\dot{M}_p \sim 0.1\dot{M}_p$. A planet on an eccentric orbit ($e = 0.1$) presents a similar variability amplitude, but concentrated on a well-defined periodicity of half the orbital period and weaker broadband noise, potentially allowing observations to discriminate between both cases. Finally, we find that the heating of the coorbital region by the planet feedback alters the gas dynamics, reducing the difference between its orbital velocity and the Keplerian motion at the edge of the gap, which can have important consequences for the formation of dust rings.

10. Measuring Turbulence with Young Stars in the Orion Complex

Trung Ha, Yuan Li, Siyao Xu, Marina Kounkel, Hui Li Stars form in molecular clouds in the interstellar medium (ISM) with a turbulent kinematic state. Newborn stars therefore should retain the turbulent kinematics of their natal clouds. Gaia DR2 and APOGEE-2 surveys in combination provide three-dimensional (3D) positions and 3D velocities of young stars in the Orion Molecular Cloud Complex. Using the full 6D measurements, we compute the velocity structure functions (VSFs) of the stars in six different groups within the Orion Complex. We find that the motions of stars in all diffuse groups exhibit strong characteristics of turbulence. Their first-order VSFs have a power-law exponent ranging from $\sim 0.2 - 0.5$ on scales of a few to a few tens of pc, generally consistent with Larson's relation. On the other hand, dense star clusters, such as the Orion Nebula Cluster (ONC), have experienced rapid dynamical relaxation, and have lost the memory of the initial turbulent kinematics. The VSFs of several individual groups and the whole Complex all show features supporting local energy injection from supernovae. The measured strength of turbulence depends on the location relative to the supernova epicenters and the formation history of the groups. Our detection of turbulence traced by young stars introduces a new method of probing the turbulent kinematics of the ISM. Unlike previous gas-based studies with only projected measurements accessible to observations, we utilize the full 6D information of stars, presenting a more complete picture of the 3D interstellar turbulence.

11. Hunting for the elusive methylene radical

A. M. Jacob, K. M. Menten, Y. Gong, P. Bergman, M. Tiwari, S. Bruenken, A. O. H. Olofsson CH2 transitions between 68 and 71 GHz were first detected toward the Orion-KL and W51 Main SFRs. Given their upper level energies of 225 K, they were thought to arise in dense, hot molecular cores near newly formed stars. However, this has not been confirmed by further observations of these lines and their origin has remained unclear. Generally, there is a scarcity of observational data for CH2 and, while it is an important compound in the astrochemical context, its actual occurrence in astronomical sources is poorly constrained. The present study, along with other recent observations of the Orion region we report, rule out the possibility of an association with gas that is both hot and dense. We find that the distribution of the CH2 emission closely follows that of the [CII] 158 um emission, while CH2 is undetected toward the hot core itself. The observations suggest, rather, that its extended emission arises from hot but dilute layers of PDRs and not from the denser parts of such regions as in the case of the Orion Bar. This hypothesis was corroborated by comparisons of the observed CH2 line profiles with those of CRRLs, well-known PDR tracers. In addition, we report the detection of the 70 GHz fine- and hfs lines of o-CH2 toward the W51E, W51M, W51N, W49N, W43, W75N, DR21, and S140 SFRs, and three of the fine- and hfs lines between 68-71 GHz toward W3 IRS5. Furthermore, using a non-LTE radiative transfer analysis, we can constrain the gas temperatures and H2 density to 163 K and 3.4e3 cm^{-3}, respectively. This analysis confirms our hypothesis that CH2 originates in warm and dilute PDR layers. Our analysis suggests that for the excitation conditions under the physical conditions that prevail in such regions, these lines are masering, with weak level inversion. The resulting amplification of the lines' spontaneous emission greatly aids in their detection.

12. Eruptive Behavior of Magnetically Layered Protoplanetary Disks in Low Metallicity Environments

Kundan Kadam, Eduard Vorobyov, Ágnes Kóspál A protoplanetary disk typically forms a dead zone near its midplane at the distance of a few au from the central protostar. Accretion through such a magnetically layered disk can be intrinsically unstable and has been associated with episodic outbursts in young stellar objects. We present the first investigation into the effects of low metallicity environment on the structure of the dead zone as well as the resulting outbursting behavior of the protoplanetary disk. We conducted global numerical hydrodynamic simulations of protoplanetary disk formation and evolution in the thin-disk limit. The consequences of metallicity were considered via its effects on the gas and dust opacity of the disk, the thickness of the magnetically active surface layer, and the temperature of the prestellar cloud core. We show that the metal poor disks accumulate much more mass in the innermost regions, as compared to the solar metallicity counterparts. The duration of the outbursting phase also varies with metallicity - the low metallicity disks showed more powerful luminosity eruptions with a shorter burst phase, which was confined mostly to the early, embedded stages of the disk evolution. The lowest metallicity disks with the higher cloud core temperature showed the most significant differences. The occurrence of outbursts was relatively rare in the disks around low mass stars and this was especially true at lowest metallicities. We conclude that the metal content of the disk environment can have profound effects on both the disk structure and evolution in terms of episodic accretion.

13. Three-dimensional continuum radiative transfer of polarized radiation in exoplanetary atmospheres

Moritz Lietzow, Sebastian Wolf, Robert Brunngräber Polarimetry is about to become a powerful tool for determining the atmospheric properties of exoplanets. To provide the basis for the interpretation of observational results and for predictive studies to guide future observations, sophisticated analysis tools are required. Our goal is to develop a radiative transfer tool that contains all the relevant continuum polarization mechanisms for the comprehensive analysis of the polarized flux resulting from the scattering in the atmosphere of, on the surface of, and in the local planetary environment (e.g., planetary rings, exomoons) of extra-solar planets. Furthermore, our goal is to avoid common simplifications such as locally plane-parallel planetary atmospheres, the missing cross-talk between latitudinal and longitudinal regions, or the assumption of either a point-like star or plane-parallel illumination. As a platform for the newly developed numerical algorithms, we use the 3D Monte Carlo radiative transfer code POLARIS. The code is extended and optimized for the radiative transfer in exoplanetary atmospheres. We investigate the reflected flux and its degree of polarization for different phase angles for a homogeneous cloud-free atmosphere and an inhomogeneous cloudy atmosphere. To take advantage of the 3D radiative transfer and to demonstrate the potential of the code, the impact of an additional circumplanetary ring on the reflected polarized flux is studied. The presence of a circumplanetary ring consisting of small water-ice particles has a noticeable impact on the reflected polarized radiation. In particular, the reflected flux strongly increases at larger phase angles if the planetary orbit is seen edge-on because the considered particles tend to scatter forwards. In contrast, the degree of polarization decreases at these phase angles.

14. The CALYPSO IRAM-PdBI survey of jets from Class 0 protostars. Are jets ubiquitous in young stars?

L. Podio, B. Tabone, C. Codella, F. Gueth, A. Maury, S. Cabrit, B. Lefloch, S. Maret, A. Belloche, P. André, S. Anderl, M. Gaudel, L. Testi As a part of the CALYPSO large programme, we constrain the properties of protostellar jets and outflows in a sample of 21 Class 0 protostars with internal luminosities, Lint, from 0.035 to 47 Lsun. We analyse high angular resolution (0.5"-1") IRAM PdBI observations in CO (2-1), SO ($5_6 - 4_5$), and SiO (5-4). CO (2-1), which probes outflowing gas, is detected in all the sources (for the first time in SerpS-MM22 and SerpS-MM18b). Collimated high-velocity jets in SiO (5-4) are detected in 67% of the sources (for the first time in IRAS4B2, IRAS4B1, L1448-NB, SerpS-MM18a), and 77% of these also show jet/outflow emission in SO ($5_6 - 4_5$). In 5 sources (24% of the sample) SO ($5_6 - 4_5$) probes the inner envelope and/or the disk. The CALYPSO survey shows that the outflow phenomenon is ubiquitous and that the detection rate of high-velocity jets increases with protostellar accretion, with at least 80% of the sources with Lint>1 Lsun driving a jet. The protostellar flows exhibit an onion-like structure, where the SiO jet (opening angle 10^o) is nested into a wider angle SO (15^o) and CO (25^o) outflow. On scales >300 au the SiO jets are less collimated than atomic jets from Class II sources (3^o). Velocity asymmetry between the two jet lobes are detected in one third of the sources, similarly to Class II atomic jets, suggesting that the same launching mechanism is at work. Most of the jets are SiO rich (SiO/H2 from >2.4e-7 to >5e-6), which indicates efficient release of >1%-10% of silicon in gas phase likely in dust-free winds, launched from inside the dust sublimation radius. The mass-loss rates (from 7e-8 to 3e-6 Msun/yr) are larger than what was measured for Class II jets. Similarly to Class II sources, the mass-loss rates are 1%-50% of the mass accretion rates suggesting that the correlation between ejection and accretion in young stars holds from 1e4 yr up to a few Myr.

15. The Carina Nebula and Gum 31 molecular complex III: The distribution of the 1-3 GHz radio continuum across the whole nebula

David Rebolledo, Anne J. Green, Michael G. Burton, Shari L. Breen, Guido Garay We report the most detailed $1 - 3$ GHz radio continuum emission map of the nearest region of massive star formation, the Carina Nebula. As part of a large program with the Australia Telescope Compact Array, we have covered ~ 12 deg^2, achieving an angular resolution of ~ 16 arcsec, representing the largest and most complete map of the radio continuum to date. Our continuum map shows a spectacular and complex distribution of emission across the nebula, with multiple structures such as filaments, shells, and fronts across a wide range of size scales. The ionization fronts have advanced far into the southern and northern region of the Galactic Plane, as fronts are clearly detected at distances ~ 80 pc from the stellar clusters in the center. We estimated an ionization photon luminosity $Q_{\rm H} = (7.8 \pm 0.8) \times 10^{50}$ s^{-1} which corresponds to $\sim 85\%$ of the total value obtained from stellar population studies. Thus, approximately 15% of the ionizing flux has escaped from the nebula into the diffuse Galactic Interstellar Medium. Comparison between radio continuum and the hydrogen atomic and molecular gas maps offers a clear view of the bipolar outflow driven by the energy released by the massive stellar clusters that also affects the fraction of molecular gas across the nebula. Comparison between 8μm and 70μm emission maps and the radio continuum reveals how the hot gas permeates through the molecular cloud, shapes the material into features such as pillars, small shells and arc-like structures, and ultimately, escapes.

16. Chemical analysis of early-type stars with planets

C. Saffe, P. Miquelarena, J. Alacoria, M. Flores, M. Jaque Arancibia, D. Calvo, G. Martín Girardi, M. Grosso, A. Collado Aims. To explore the chemical pattern of early-type stars with planets, searching for a possible signature of planet formation. In particular, we study a likely relation between the lambda Bootis chemical pattern and the presence of giant planets. Methods. We performed a detailed abundance determination in a sample of early-type stars with and without planets via spectral synthesis. Results. We compared the chemical pattern of the stars in our sample (13 stars with planets and 24 stars without detected planets) with those of lambda Bootis and other chemically peculiar stars. We have found four lambda Bootis stars in our sample, two of which present planets and circumstellar disks (HR 8799 and HD 169142) and one without planets detected (HD 110058). We have also identified the first lambda Bootis star orbited by a brown dwarf (zeta Del). This interesting pair lambda Bootis star + brown dwarf could help to test stellar formation scenarios. We found no unique chemical pattern for the group of early-type stars bearing giant planets. However, our results support, in principle, a suggested scenario in which giant planets orbiting pre-main-sequence stars possibly block the dust of the disk and result in a lambda Bootis-like pattern. On the other hand, we do not find a lambda Bootis pattern in different hot-Jupiter planet host stars, which do not support the idea of possible accretion from the winds of hot-Jupiters, recently proposed in the literature. Then, other mechanisms should account for the presence of the lambda Bootis pattern between main-sequence stars. Finally, we suggest that the formation of planets around lambda Bootis stars such as HR 8799 and HD 169142 is also possible through the core accretion process and not only gravitational instability [abridged]

17. ALMA observations of the early stages of substellar formation in the Lupus 1 and 3 molecular clouds

A. Santamaría-Miranda, I. de Gregorio-Monsalvo, A. L. Plunkett, N. Huélamo, C. López, Á. Ribas, M. R. Schreiber, K. Mužić, A. Palau, L. B. G. Knee, A. Bayo, F. Comerón, A. Hales The dominant mechanism leading to the formation of brown dwarfs (BDs) remains uncertain. The most direct keys to formation, which are obtained from younger objects (pre-BD cores and proto-BDs), are limited by the very low number statistics available. We aim to identify and characterize a set of pre- and proto-BDs as well as Class II BDs in the Lupus 1 and 3 molecular clouds to test their formation mechanism. We performed ALMA band 6 (1.3 mm) continuum observations of a selection of 64 cores previously identified from AzTEC/ASTE data (1.1 mm), along with previously known Class II BDs in the Lupus 1 and 3 molecular clouds. Surveyed archival data in the optical were used to complement these observations. We expect these ALMA observations prove efficient in detecting the youngest sources in these regions, since they probe the frequency domain at which these sources emit most of their radiation. We detected 19 sources from 15 ALMA fields. Considering all the pointings in our observing setup, the ALMA detection rate was ∼23% and the derived masses of the detected sources were between ∼0.18 and 124 M_{Jup}. We classified these sources according to their spectral energy distribution as 5 Class II sources, 2 new Class I/0 candidats, and 12 new possible pre-BD or deeply embedded protostellar candidates. We detected a promising candidate for a Class 0/I proto-BD source and inferred the disk dust mass of a bona fide Class II BD. The pre-BD cores might be the byproduct of an ongoing process of large-scale collapse. The Class II BD disks follow the correlation between disk mass and the mass of the central object that is observed at the low-mass stellar regime. We conclude that it is highly probable that the sources in the sample are formed as a scaled-down version of low-mass star formation, although disk fragmentation may be responsible for a considerable fraction of BDs.

18. Characterizing the line emission from molecular clouds. Stratified random sampling of the Perseus cloud

M. Tafalla, A. Usero, A. Hacar *Context*. The traditional approach to characterize the structure of molecular clouds is to map their line emission. *Aims*. We aim to test and apply a stratified random sampling technique that can characterize the line emission from molecular clouds more efficiently than mapping. *Methods*. We sampled the molecular emission from the Perseus cloud using the H2 column density as a proxy. We divided the cloud into ten logarithmically spaced column density bins, and we randomly selected ten positions from each bin. The resulting 100 cloud positions were observed with the IRAM 30m telescope, covering the 3mm-wavelength band and parts of the 2 and 1mm bands. *Results*. We focus our analysis on 11 molecular species detected toward most column density bins. In all cases, the line intensity is tightly correlated with the H2 column density. For the CO isotopologs, the trend is relatively flat, while for high-dipole moment species such as HCN, CS, and HCO+ the trend is approximately linear. We reproduce this behavior with a cloud model in which the gas density increases with column density, and where most species have abundance profiles characterized by an outer photodissociation edge and an inner freeze-out drop. The intensity behavior of the high-dipole moment species arises from a combination of excitation effects and molecular freeze out, with some modulation from optical depth. This quasi-linear dependence with the H2 column density makes the gas at low column densities dominate the cloud-integrated emission. It also makes the emission from most high-dipole moment species proportional to the cloud mass inside the photodissociation edge. *Conclusions*. Stratified random sampling is an efficient technique for characterizing the emission from whole molecular clouds. It shows that despite the complex appearance of Perseus, its molecular emission follows a relatively simple pattern.

19. Behavior of Hydroxyl Radicals on Water Ice at Low Temperatures

Masashi Tsuge, Naoki Watanabe Because chemical reactions on/in cosmic ice dust grains covered by amorphous solid water (ASW) play important roles in generating a variety of molecules, many experimental and theoretical studies have focused on the chemical processes occurring on the ASW surface. In laboratory experiments, conventional spectroscopic and mass-spectrometric detection of stable products is generally employed to deduce reaction channels and mechanisms. However, despite their importance, the details of chemical reactions involving reactive species (i.e., free radicals) have not been clarified because of the absence of experimental methods for in situ detection of radicals. Because OH radicals can be easily produced in interstellar conditions by not only the photolysis and/or ion bombardments of H2O but also the reaction of H and O atoms, they are thought to be one of the most abundant radicals on ice dust. In this context, the development of a close monitoring method of OH radicals on the ASW surface may help to elucidate the chemical reactions occurring on the ASW surface.

20. Distinguishing between different mechanisms of FU-Orionis-type luminosity outbursts

Eduard I. Vorobyov, Vardan G. Elbakyan, Hauyu Baobab Liu, Michihiro Takami Aims. Accretion and luminosity bursts triggered by three distinct mechanisms: the magnetorotational instability in the inner disk regions, clump infall in gravitationally fragmented disks and close encounters with an intruder star, were studied to determine the disk kinematic characteristics that can help to distinguish between these burst mechanisms. Methods. Numerical hydrodynamics simulations in the thin-disk limit were employed to model the bursts in disk environments that are expected for each burst mechanism. Results. We found that the circumstellar disks featuring accretion bursts can bear kinematic features that are distinct for different burst mechanisms, which can be useful when identifying the burst origin. The disks in the stellar encounter and clump-infall models are characterized by tens of percent deviations from the Keplerian rotation, whie the disks in the MRI models are characterized only a few percent deviation, which is mostly caused by the gravitational instability that fuels the MRI bursts. Velocity channel maps also show distinct kinks and wiggles, which are caused by gas disk flows that are peculiar to each considered burst mechanism. The deviations of velocity channels in the burst-hosting disks from a symmetric pattern typical of Keplerian disks are strongest for the clump-infall and collision models, and carry individual features that may be useful for the identification of the corresponding burst mechanism. The considered burst mechanisms produce a variety of light curves with the burst amplitudes varying in the Δ m=2.5-3.7 limits, except for the clump-infall model where Δ m can reach 5.4, although the derived numbers may be affected by a small sample and boundary conditions. Conclusions. Burst triggering mechanisms are associated with distinct kinematic features in the burst-hosting disks that may be used for their identification. Abridged.

21. HII regions and high-mass starless clump candidates II. Fragmentation and induced star formation at 0.025 pc scale: An ALMA continuum study

S. Zhang, A. Zavagno, A. López-Sepulcre, H. Liu, F. Louvet, M. Figueira, D. Russeil, Y. Wu, J. Yuan, T. G. S. Pillai The ionization feedback from HII regions modifies the properties of high-mass starless clumps (HMSCs, of several hundred to a few thousand solar masses with a size of 0.1-1 pc), such as temperature and turbulence, on the clump scale. The question of whether the presence of HII regions modifies the core-scale fragmentation and star formation in HMSCs remains to be explored. We aim to investigate the difference of 0.025 pc-scale fragmentation between candidate HMSCs that are strongly impacted by HII regions and less disturbed ones. We also search for evidence of mass shaping and induced star formation in the impacted HMSCs. Using the ALMA 1.3 mm continuum with a resolution of 1.3", we imaged eight candidate HMSCs, including four impacted by HII regions and another four situated in the quiet environment. The less-impacted HMSCs are selected on the basis of their similar mass and distance compared to the impacted ones to avoid any possible bias linked to these parameters. A total of 51 cores were detected in eight clumps, with three to nine cores for each clump. Within our limited sample, we did not find a clear difference in the 0.025 pc-scale fragmentation between impacted and non-impacted HMSCs, even though HII regions seem to affect the spatial distribution of the fragmented cores. Both types of HMSCs present a thermal fragmentation with two-level hierarchical features at the clump thermal Jeans length $\lambda^{th}_{J,clump}$ and $0.3\lambda^{th}_{J,clump}$. The ALMA emission morphology of the impacted HMSCs AGAL010.214-00.306 and AGAL018.931-00.029 sheds light on the capacities of HII regions to shape gas and dust in their surroundings and possibly to trigger star formation at 0.025 pc-scale in HMSCs. Future ALMA surveys covering a large number of impacted HMSCs with high turbulence are needed to confirm the trend of fragmentation indicated in this study.