THE STAR FORMATION NEWSLETTER

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

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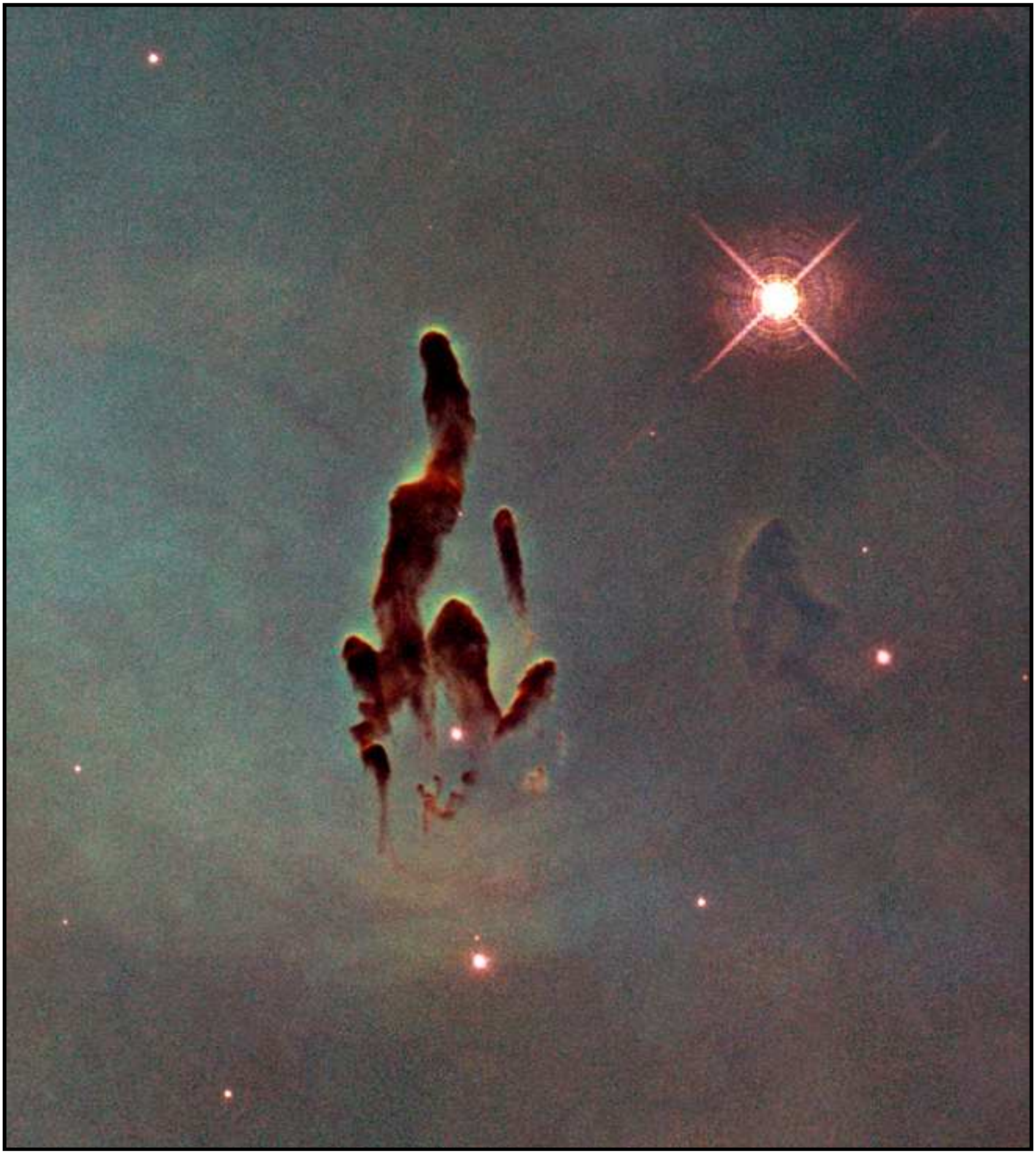

The Star Formation Newsletter

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

Newsletter Archive

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

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Cover Picture

The wellknown elephant trunks in M16, imaged by HST, are accompanied by miniature windswept globule splinters like the one portrayed on the cover. The image is a composite of exposures obtained through [O III], Hα, [S II], wide Y, and near-infrared H-band filters.

Credits: NASA/ESA/Hubble Heritage Team (STScI/AURA)/J. Hester, P. Scowen (Arizona State U.)

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

Bill Langer

in conversation with Bo Reipurth

Q: *You got your PhD in Physics from Yale in 1968 on a theoretical study of vibrating neutron stars. That is far from your subsequent observational work in millimeter astronomy. What motivated that transition?*

A: To answer your question I need discuss how my work on neutron stars led me to NYU where that transition took place. In graduate school I was interested in particle physics and astrophysics. In 1966 I met my PhD thesis advisor, Alastair G. W. Cameron, who was an Adjunct Professor at Yale, and had students modeling supernovae, nucleosynthesis, and neutron stars. Pulsars had not yet been detected or identified as neutron stars. It was thought that a supernova collapse would lead to a rapidly vibrating neutron star with a millisecond period and a rapidly pulsating X-ray source might identify a neutron star, unless the vibrations damped rapidly.

Sachiko Tsuruta, Cameron's student, calculated the loss of vibrational energy via the production of neutrinos and anti-neutrinos, as the energy of the neutron and proton Fermi seas changed with the pulsations. She found it would take thousands of years to damp the vibrations, and a search for pulsating X-rays might detect young neutron stars. Cameron suggested that I study a related process involving hyperons deep in the core of more massive neutron stars. In my thesis I showed that these neutron stars would damp too rapidly to be detected. However, by the time I defended my PhD thesis the pulsar-neutron star connection was made and searches for pulsating radio signals, rather than pulsating X-rays, was the hot topic.

I continued to work on neutron star equations of state at high densities and Fermi energies sufficient to produce hyperons, first as a Postdoc at the Goddard Institute for Space Studies, and then as a NSF-NATO Postdoc at the Niels Bohr Institute. This work culminated in a paper on a quark-gluon equation of state and possible quark stars.

My next position was a Research Assistant Professorship at NYU with Al Glassgold, who was interested in neutron star properties. I arrived in New York in the Fall of 1971 when observations of the interstellar medium with mm radio astronomy were growing rapidly. I believe it was Pat Thaddeus who told Al about the exciting new results in this field. CO was detected by Bob Wilson, Keith Jefferts, and Arno Penzias in July 1970, and followed up by surveys of CO, and the detection of new molecules such as CS, HCN, and methyl alcohol. In addition, the *Copernicus Satellite* would be launched in 1972 and promised another rich data set on the interstellar medium (ISM) based on UV absorption measurements. Al suggested we form a reading group on this topic at NYU. Then in the summer of 1972 he arranged a visit to Charles Townes' group at Berkeley. The group read like a who's who of future leaders in the field, Mike Werner was finishing his postdoc, Neal Evans was finishing his PhD, and Paul Goldsmith was a graduate student. At Berkeley I read a recent review of heating and ionization of HI regions by Dalgarno and McCray, and the 1969 papers by Field, Goldsmith, and Habing on the three-phase (but only two stable) model of the diffuse ISM. This pressure–density model started me thinking whether something similar might take place in molecular clouds, whereby molecule formation would change the cooling and thereby the gas pressure. I wondered if there were chemical–thermal effects leading to equilibrium phases and whether they could trigger a transition to different stable states. (It would be 1976 before this idea bore any fruit in a paper on the role of the C^+ to CO transition on the state of the gas.) However, to explore this idea, I first had to learn how molecules formed.

Returning from Berkeley, Al and I embarked on developing models of diffuse atomic and molecular clouds in which we followed the conversion from H to H_2, and incorporated ionization, heating, cooling, gas phase and grain chemistry. The models grew steadily in complexity to include the simpler carbon and oxygen molecules. By the end of 1974 our models showed the transition from C^+ to CO as a function of position and time. In 1976 I branched out on my own to work on carbon isotope abundances in the cloud models, including isotopic fractionation reactions.

Q: *You started out as a theoretician and modeler, yet at some point you expanded your interests to observations. How did that happen?*

A: I credit Arno Penzias with my observing career. He invited me out to Crawford Hill on an occasional basis as a sort of theorist in residence. At some point he said something along the lines of, "How do you know your models are correct?" So, I asked him how I could get started observing to test my cloud chemical models. On my next visit he took me into Bob Wilson's office and asked him to help me plan an observing program with the Bell Labs

7-meter telescope. I also had help from Michel Guélin, who was a postdoc with Pat Thaddeus. The 7-meter then had only a 3-mm receiver so Michel, Bob, and I studied deuterium fractionation in HCO^+.

I remember my first observing experience. I was in the control room of the 7-meter telescope when Bob displayed our first HCO^+ spectrum. It sounds trite, but I had an almost spiritual experience – photons from a molecule changing its rotational state, fascinating in itself, traveled hundreds of light years, concentrated by the antenna onto a receiver that could "see" and transform them into a spectrum. I felt connected to the universe in a more direct way than through my modeling work.

Q: *You and Paul Goldsmith have written many papers together, how did that collaboration start, was it from your time at Berkeley?*

A: I have been privileged to work with many fine scientists in my career, and Paul is one of them. Although I met Paul at Berkeley, we did not connect until shortly after he arrived at AT&T Bell Labs. He was interested in models to interpret his observations, and I was interested in observations to test my models, so we were at the same place but coming at it from different directions. With all the new molecules being discovered we wondered how these would affect the thermal balance in dense cores. Our 1978 paper on Molecular Cooling and Thermal Balance of Dense Interstellar Clouds, is my second most cited paper.

Q: *Margaret Frerking and you and Bob Wilson wrote, back in 1982, a highly cited paper on the relationship between carbon monoxide abundance and visual extinction in interstellar clouds. What was the origin of that project and what did you find?*

A: Peg Frerking is another scientist from the Bell Labs group with whom I have collaborated on many projects. The CO to visual extinction project was Peg's idea. CO is so important as a tracer of dense molecular gas that it was critical to calibrate the CO–to–H_2 relationship. Peg had noticed a pair of papers by Elias in 1978 on Taurus and ρ Oph using infrared photometry to determine visual extinction up to about 20 magnitudes. The goal was to compare ^{13}CO, the weaker $C^{18}O$, and visual extinction, A_v. My role was to help with modeling and interpretation of isotopic enhancement effects and opacity. The paper provided an important yardstick for observers.

Q: *You went on to study the carbon and oxygen isotope fractionation in molecular clouds in the 1980s with several collaborators. These papers are still today frequently cited.*

A: After working on CO versus extinction with Peg and Bob the question of the role of isotopic fractionation continued to interest me because the 13-carbon isotopologues were widely used to study cloud properties, as the main 12-carbon lines were frequently optically thick. My isotope research took the following two paths.

John Bally and I were studying the H II region S68 in three CO isotopologues and were surprised to find that the ratio of antenna temperatures $T_A(^{13}CO)/T_A(C^{18}O)$ was greater than 40, assuming optically thin lines, where the ^{12}CO indicated a kinetic temperature around 28K. At such a high temperature the 13-carbon fractionation reaction would only enhance ^{13}CO slightly and the ratio should have been of order 5 to 10. In all likelihood the ^{13}CO was not optically thin which only made matters worse. It struck me that this ratio could be explained by self-shielding of the photodissociating lines of CO, similar to what I was familiar with from my work on the transition from H to H_2 in diffuse clouds. There was little known about the photodissociation of CO and it had been assumed that there were transitions to the continuum in addition to state-to-state transitions. But this assumption was wrong. In fact, there was no dissociation to the continuum for UV photons below the Lyman limit – it was all line dissociation. Thus the more abundant CO isotopologues would self-shield and so the less abundant $C^{18}O$ was being photodissociated at a faster rate than ^{13}CO, while their production rates were similar. I presented the results in the summer of 1981 at a conference in Penticton, and we later published a more extensive analysis in 1982. Our results changed the interpretation of the distribution of CO isotopologues in clouds. In 1985, with Al Glassgold and Patrick Huggins, I followed up this initial idea with a more precise model of the C^+ to CO transition.

While the photodissociation properties of CO, along with the 13-carbon fractionation reaction, influenced the isotopologue ratios in the PDRs, it was generally believed that in the deep shielded cores the CO isotopologue ratio reflected the actual isotope ratio. For all practical purposes this statement is true for CO, without UV almost all the 13– and 12–carbon goes into CO in proportion to their elemental isotopic abundances. Indeed many observers were using 13-carbon isotopologues of other, much less abundant species such as HCO^+, HCN, and CS, to interpret conditions by scaling up the column densities assuming a fixed isotope ratio. But the assumption that the 12 to 13 ratio in these non-CO species is elemental is not necessarily correct because of a subtle effect due to the $^{13}C^+$ fractionation reaction with ^{12}CO depleting $^{13}C^+$ with respect to $^{12}C^+$, and hence trace molecules formed from C^+. It was to understand the full array of the isotopic abundances that Peg Frerking and I collaborated with Tom Graedel of Bell Labs in order to take advantage of his BellChem code designed to study gas phase chemistry. Three papers were written on dense cloud chemistry, and showed that in some trace species the 12 to 13 ratio was enhanced as opposed to the reverse in CO.

Q: *Subsequently you wrote a couple of papers on the Bok* *globule B335, also with Margaret Frerking and Bob Wilson. Why B335?*

A: We were interested in prestellar cores and the Bok globule B335 seemed to be ideal for testing models of quiescent core structure and collapse. It was an isolated cloud with a simple elliptical shape and very narrow $C^{18}O$ linewidths $\sim$0.3 km s^{-1}, not much more than thermal. We mapped it in several CO isotopologues and observed the center in many other molecular tracers. We were able to derive a radial density and mass profile and examine its dynamics, which we published in 1987 with Peg as first author.

Q: *In the early 90's you and Arno Penzias studied the $^{12}C/^{13}C$ isotope ratio in the local interstellar medium and across the Galaxy. What were your conclusions?*

A: In the early 90's I thought it was time to bring some closure to my work on carbon isotope ratios. Arno and I decided that the most direct way to measure the 12– to 13–isotope ratio with CO was to observe the weakest isotopologue, $^{13}C^{18}O$. These weak lines had a peak antenna temperature of order 20 to 50 mK, and it would require a lot of telescope time to achieve high signal–to–noise spectra (about 500 hours), which was only feasible on the 7-m. In our 1990 paper we reported a systematic Galactic gradient in the $^{12}C/^{13}C$ ratio from 24 at the Center to about 70 at 12 kpc. Our 1993 paper found an average value of 62$\pm$4 in the local interstellar medium (distances $\leq$500 pc). In general these results were consistent with previous studies, but provided much tighter constraints on the ratio and minimized any ambiguities arising from opacity.

Q: *In recent years you have focused on ionized carbon [C II] in different environments. What is special about [C II]?*

A: [C II] traces every component of the ISM (e.g. Warm Ionized Medium, Cold Neutral HI Medium, PDRs, and diffuse molecular clouds) except the dense shielded cores where carbon resides in CO. Carbon monoxide has by now been extensively mapped in the Galaxy, as well as in extragalactic sources. However, CO is estimated to trace only 30 to 50% of the H_2 in our Galaxy and possibly only 10% in metal poor galaxies. So without C^+ we have only a partial view of the distribution of ISM gas. Fortunately, C^+ has a fine-structure far-IR emission line at 1.9 THz (158 μm), [C II], but cannot be observed from the ground.

Q: *You have been with the Jet Propulsion Laboratory (JPL) for more than 25 years. Which projects have you been involved with?*

A: When I first came to JPL in 1991 I continued my research on dense molecular cores, the structure of molecular clouds, and isotopic chemistry. Although JPL focused on space missions there were opportunities for ground based radio astronomy with the Deep Space Network, the Caltech Submillimeter Observatory, and the Owens Valley Radio Observatory (OVRO) array. Thangasamy Velusamy and I worked on cores and outflows using these facilities.

In 1992 there was a call for Small Explorer Missions (SMEX) and I decided here was an opportunity to survey [C II]. I discussed the idea with Peg Frerking, who had come to JPL in 1980. Peg brought to the collaboration a knowledge of missions and instruments, having built radiometers for JPL missions. In 1993 I proposed a spectroscopic [C II] and [N II] survey called Galactic Explorer Mission (GEM) with Peg as the Project Manager. It wasn't selected, but it prepared me for my later work with the *Herschel Space Observatory*. Over the next decade I continued to promote a stand alone [C II] mission survey, but unsuccessfully.

In the late 1990s NASA decided to support a contribution to an ESA far-IR mission (later *Herschel*). I became the JPL pre-project science lead for *Herschel*. I worked closely with Caltech's Tom Phillips, who was a driving force for the US effort. Around 2000 I was appointed the NASA Project Scientist for *Herschel*. However, my role was brief because I became the Manager of the Science Division in August 2001. I kept up my research by collaborating with Karen Willacy and Velusamy on disks and cores. However, with over 350 scientists and staff in the Division, it was not possible to continue my *Herschel* role. In 2009 I left line management to return to my research full time.

Q: *Can you tell me about your recent work with Herschel observations of [C II]?*

A: I wrote a successful *Herschel* Open Time Key Program, Galactic Observations of Terahertz C+ (GOT C+), which was a Galactic plane survey of spectrally resolved [C II]. The key GOT C+ team members were Paul Goldsmith, Jorge Pineda, and Velusamy. *Herschel* had a 12″ beam at 1.9 THz and it was impossible to map a portion of the Galactic disk within any reasonable time. My approach in GOT C+ was to conduct a sparse [C II] survey of the plane over 360^o in approximately equal galactic volume samples. We could analyze the ISM in a statistical sense using this sample. We derived from GOT C+ the first 3D approximate distribution of [C II] in the plane. GOT C+ and follow-up observations of [C II] and [N II] changed our view of the ISM as presented in about ten papers. Some highlights from these papers are: 1) [C II] emission is mostly associated with spiral arms and is weak in the outer Galaxy, 2) about 45% comes from PDRs and 30% from diffuse CO-dark H_2 clouds, 3) the fraction of CO-dark H_2 gas increases with Galactic radius due to lower metallicity, 4) [C II] and the star formation rate (SFR) are well correlated at Galactic scales with a proportionality found in extragalactic sources, 5) the CO-dark H_2 scale height is $\sim$200 pc, and, 6) [C II] and [N II] detect a compressed WIM at the leading edges of spiral arms, and dense ionized boundary layers of molecular clouds. I continue to study the ISM using [C II] and [N II] SOFIA observations and model galactic and extragalactic ISM properties.

Abstracts of recently accepted papers

The jet of the young star RW Aur A and related problems

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Comparing the images of the jet of the young star RW Aur A, separated by a period of 21.3 years, we found that the outermost jet's knots have emerged ≈ 350 yr ago. We argue that at that moment the jet itself has appeared and intensive accretion onto the star has began due to the rearrangement of its protoplanetary disk structure caused by the tidal effect of the companion RW Aur B. More precisely, we assume that the increase of accretion is a response to changing conditions in the outer disk regions, which followed after the sound wave, generated by these changes, crossed the disk in a radial direction. The difference in the parameters of the blue and red lobes of the RW Aur A jet, according to our opinion, is a result of the asymmetric distribution of the circumstellar matter above and below the disk, due to a fly-by of the companion. It was found from the analysis of RW Aur historical light curve that deep and long ($\Delta t > 150$ days) dimmings of RW Aur A observed after 2010 yr, had no analogues in the previous 110 years. We also associate the change in the character of the photometric variability of the star with the rearrangement of the structure of inner ($r < 1$ a.u.) regions of its protoplanetary disk and discuss why these changes began only 350 years after the beginning of the active accretion phase.

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https://arxiv.org/pdf/1708.08488

Searching for new young stars in the northern hemisphere: The Pisces Moving Group

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Using the kinematically unbiased technique described in Binks, Jeffries & Maxted (2015), we present optical spectra for a further 122 rapidly-rotating (rotation periods < 6 days), X-ray active FGK stars, selected from the SuperWASP survey. We identify 17 new examples of young, probably single stars with ages of < 200 Myr and provide additional evidence for a new northern hemisphere kinematic association: the Pisces Moving Group (MG). The group consists of 14 lithium-rich G- and K-type stars, that have a dispersion of only ~ 3 km s^{-1} in each Galactic space velocity coordinate. The group members are approximately co-eval in the colour-magnitude diagram, with an age of 30–50 Myr, and have similar, though not identical, kinematics to the Octans-Near MG.

Accepted by Monthly Notices of the Royal Astronomical Society

http://arxiv.org/pdf/1708.09541

The Young Substellar Companion ROXs 12 B: Near-Infrared Spectrum, System Architecture, and Spin-Orbit Misalignment

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ROXs 12 (2MASS J16262803−2526477) is a young star hosting a directly imaged companion near the deuterium-burning limit. We present a suite of spectroscopic, imaging, and time-series observations to characterize the physical and environmental properties of this system. Moderate-resolution near-infrared spectroscopy of ROXs 12 B from Gemini-North/NIFS and Keck/OSIRIS reveals signatures of low surface gravity including weak alkali absorption lines and a triangular H-band pseudo-continuum shape. No signs of Paβ emission are evident. As a population, however, we find that about half (46±14%) of young ($\lesssim$15 Myr) companions with masses $\lesssim$20 $M_{\rm Jup}$ possess actively accreting subdisks detected via Paβ line emission, which represents a lower limit on the prevalence of circumplanetary disks in general as some are expected to be in a quiescent phase of accretion. The bolometric luminosity of the companion and age of the host star (6^{+4}_{-2} Myr) imply a mass of 17.5±1.5 $M_{\rm Jup}$ for ROXs 12 B based on hot-start evolutionary models. We identify a wide (5100 AU) tertiary companion to this system, 2MASS J16262774−2527247, which is heavily accreting and exhibits stochastic variability in its *K2* light curve. By combining $v \sin i_*$ measurements with rotation periods from *K2*, we constrain the line-of-sight inclinations of ROXs 12 A and 2MASS J16262774−2527247 and find that they are misaligned by 60^{+7}_{-11}°. In addition, the orbital axis of ROXs 12 B is likely misaligned from the spin axis of its host star ROXs 12 A, suggesting that ROXs 12 B formed akin to fragmenting binary stars or in an equatorial disk that was torqued by the wide stellar tertiary.

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Seeds of Life in Space (SOLIS) III. Formamide in protostellar shocks: evidence for gas-phase formation

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Context: Modern versions of the Miller-Urey experiment claim that formamide (NH_2CHO) could be the starting point for the formation of metabolic and genetic macromolecules. Intriguingly, formamide is indeed observed in regions forming Solar-type stars as well as in external galaxies.
Aims: How NH_2CHO is formed has been a puzzle for decades: our goal is to contribute to the hotly debated question of whether formamide is mostly formed via gas-phase or grain surface chemistry.
Methods: We used the NOEMA interferometer to image NH_2CHO towards the L1157-B1 blue-shifted shock, a well known interstellar laboratory, to study how the components of dust mantles and cores released into the gas phase triggers the formation of formamide.
Results: We report the first spatially resolved image (size ∼ 9 arcsec, ∼ 2300 AU) of formamide emission in a shocked region around a Sun-like protostar: the line profiles are blueshifted and have a FWHM $\simeq$ 5 km s^{-1}. A column density of $N_{\rm NH_2CHO} = 8 \times 10^{12}$ cm^{-1}, and an abundance (with respect to H-nuclei) of 4×10^{-9} are derived. We show a spatial segregation of formamide with respect to other organic species. Our observations, coupled with a chemical modelling analysis, indicate that the formamide observed in L1157-B1 is formed by gas-phase chemical process, and not on grain surfaces as previously suggested.
Conclusions: The SOLIS interferometric observations of formamide provide direct evidence that this potentially crucial brick of life is efficiently formed in the gas-phase around Sun-like protostars.

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http://arxiv.org/pdf/1708.04663

High signal-to-noise spectral characterization of the planetary-mass object HD 106906 b

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We spectroscopically characterize the atmosphere of HD 106906 b, which is a young low-mass companion near the deuterium burning limit. The wide separation from its host star of 7.1″ makes it an ideal candidate for high S/N and high-resolution spectroscopy. We aim to derive new constraints on the spectral type, effective temperature, and luminosity of HD 106906 b and also to provide a high S/N template spectrum for future characterization of extrasolar planets. We obtained 1.1–2.5 μm integral field spectroscopy with the VLT/SINFONI instrument with a spectral resolution of R≈2000–4000. New estimates of the parameters of HD 106906 b are derived by analyzing spectral features, comparing the extracted spectra to spectral catalogs of other low-mass objects, and fitting with theoretical isochrones. We identify several spectral absorption lines that are consistent with a low mass for HD 106906 b. We derive a new spectral type of L1.5 ± 1.0, which is one subclass earlier than previous estimates. Through comparison with other young low-mass objects, this translates to a luminosity of $\log(L/L_\odot)=-3.65 \pm 0.08$ and an effective temperature of $T_{\rm eff} = 1820 \pm 240$ K. Our new mass estimates range between $M = 11.9^{+1.7}_{-0.8}\,M_{\rm Jup}$ (hot start) and $M = 14.0^{+0.2}_{-0.5}\,M_{\rm Jup}$ (cold start). These limits take into account a possibly finite formation time, i.e., HD 106906 b is allowed to be 0–3 Myr younger than its host star. We exclude accretion onto HD 106906 b at rates $\dot{M} > 4.8\times10^{-10}\,M_{\rm Jup}{\rm yr}^{-1}$ based on the fact that we observe no hydrogen (Paschen-β, Brackett-γ) emission. This is indicative of little or no circumplanetary gas. With our new observations, HD 106906 b is the planetary-mass object with one of the highest S/N spectra yet. We make the spectrum available for future comparison with data from existing and next-generation (e.g., ELT and JWST) spectrographs.

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http://arxiv.org/pdf/1708.05747

Methanol masers reveal the magnetic field of the high-mass protostar IRAS 18089−1732

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Context. The importance of the magnetic field in high-mass-star formation is not yet fully clear and there are still many open questions concerning its role in the accretion processes and generation of jets and outflows. In the past few years, masers have been successfully used to probe the magnetic field morphology and strength at scales of a few au around massive protostars, by measuring linear polarisation angles and Zeeman splitting. The massive protostar IRAS 18089−1732 is a well studied high-mass-star forming region, showing a hot core chemistry and a disc-outflow system. Previous SMA observations of polarised dust revealed an ordered magnetic field oriented around the disc of

IRAS 18089−1732.
Aims. We want to determine the magnetic field in the dense region probed by 6.7 GHz methanol maser observations and compare it with observations in dust continuum polarisation, to investigate how the magnetic field in the compact maser region relates to the large-scale field around massive protostars.
Methods. We reduced MERLIN observations at 6.7 GHz of IRAS 18089−1732 and we analysed the polarised emission by methanol masers.
Results. Our MERLIN observations show that the magnetic field in the 6.7 GHz methanol maser region is consistent with the magnetic field constrained by the SMA dust polarisation observations. A tentative detection of circularly polarised line emission is also presented.
Conclusions. We found that the magnetic field in the maser region has the same orientation as in the disk. Thus the large-scale field component, even at the au scale of the masers, dominates over any small-scale field fluctuations. We obtained, from the circular polarisation tentative detection, a field strength along the line of sight of 5.5 mG which appeared to be consistent with the previous estimates.

Accepted by A&A

http://arxiv.org/pdf/1708.02961

Photometric determination of the mass accretion rates of pre-main sequence stars. V. Recent star formation in the 30 Dor nebula

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We report on the properties of the low-mass stars that recently formed in the central $\sim 2.7' \times 2.7'$ of 30 Dor including the R 136 cluster. Using the photometric catalogue of De Marchi et al. (2011c), based on observations with the *Hubble Space Telescope* (HST), and the most recent extinction law for this field, we identify 1 035 bona-fide pre-main sequence (PMS) stars showing $H\alpha$ excess emission at the $4\,\sigma$ level with $H\alpha$ equivalent width of 20 Å or more. We find a wide spread in age spanning the range $\sim 0.1-50$ Myr. We also find that the older PMS objects are placed in front of the R 136 cluster and are separated from it by a conspicuous amount of absorbing material, indicating that star formation has proceeded from the periphery into the interior of the region. We derive physical parameters for all PMS stars, including masses m, ages t, and mass accretion rates $\dot{M}_{\rm acc}$. To identify reliable correlations between these parameters, which are intertwined, we use a multivariate linear regression fit of the type $\log \dot{M}_{\rm acc} = a \times \log t + b \times \log m + c$. The values of a and b for 30 Dor are compatible with those found in NGC 346 and NGC 602. We extend the fit to a uniform sample of 1 307 PMS stars with $0.5 < m/M_\odot < 1.5$ and $t < 16$ Myr in six star forming regions in the Large and Small Magellanic Clouds and Milky Way with metallicities in the range $0.1-1.0\,Z_\odot$. We find $a = -0.59 \pm 0.02$ and $b = 0.78 \pm 0.08$. The residuals are systematically different between the six regions and reveal a strong correlation with metallicity Z, of the type $c = (-3.69 \pm 0.02) - (0.30 \pm 0.04) \times \log Z/Z_\odot$. A possible interpretation of this trend is that when the metallicity is higher so is the radiation pressure and this limits the accretion process, both in its rate and duration.

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Embedded filaments in IRAS 05463+2652: early stage of fragmentation and star formation activities

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We present a multi-wavelength data analysis of IRAS 05463+2652 (hereafter I05463+2652) to study star formation mechanisms. A shell-like structure around I05463+2652 is evident in the *Herschel* column density map, which is not associated with any ionized emission. Based on the *Herschel* sub-millimeter images, several parsec-scale filaments (including two elongated filaments, "s-fl" and "nw-fl" having lengths of ∼6.4 and ∼8.8 pc, respectively) are investigated in I05463+2652 site. *Herschel* temperature map depicts all these features in a temperature range of ∼11–13 K. 39 clumps are identified and have masses between ∼70–945 $M_\odot$. A majority of clumps (having $M_{clump} \geq 300$ $M_\odot$) are distributed toward the shell-like structure. 175 young stellar objects (YSOs) are selected using the photometric 1–5 μm data and a majority of these YSOs are distributed toward the four areas of high column density ($\geq 5 \times 10^{21}$ cm^{-2}; A_V ∼5.3 mag) in the shell-like structure, where massive clumps and a spatial association with filament(s) are also observed. The knowledge of observed masses per unit length of elongated filaments and critical mass length reveals that they are supercritical. The filament "nw-fl" is fragmented into five clumps (having M_{clump} ∼100–545 $M_\odot$) and contains noticeable YSOs, while the other filament "s-fl" is fragmented into two clumps (having M_{clump} ∼ 170–215 $M_\odot$) without YSOs. Together, these observational results favor the role of filaments in star formation process in I05480+2545. This study also reveals the filament "s-fl", containing two starless clumps, at an early stage of fragmentation.

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A deep staring campaign in the σ Orionis cluster. Variability in substellar members

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Deep optical imaging is used to study time-domain properties of young brown dwarfs in σ Orionis over typical rotational time-scales and to search for new substellar and planetary-mass cluster members. We used VIMOS at the VLT to monitor a $24' \times 16'$ field in the *I*-band. Using the individual images from this run we investigated the photometric time series of nine substellar cluster members with masses from 10 to 60 $M_{\rm j}$. The deep stacked image shows cluster members down to ≈ 5 $M_{\rm j}$. We search for new planetary mass objects by combining our deep *I*-band photometry with public *J*-band magnitudes and by examining the nearby environment of known very low mass members for possible companions. We find two brown dwarfs, with significantly variable, aperiodic light curves, both with masses around 50 $M_{\rm j}$, one of which was previously unknown to be variable. The physical mechanism responsible for the observed variability is likely different for the two objects. The variability of the first object, a single-lined spectroscopic binary, is most likely linked to its accretion disc, the second may be caused by variable extinction by large grains. We find five new candidate members from the colour-magnitude diagram and three from a search for companions within 2000 au. We rule all eight sources out as potential members based on non-stellar shape and/or infrared colours. The *I*-band photometry is made available as a public dataset. We present two variable brown dwarfs. One is consistent with ongoing accretion, the other, exhibiting apparent transient variability without presence of an accretion disc. Our analysis confirms the existing census of substellar cluster members down to ≈ 7 $M_{\rm j}$. The zero result from our companion search agrees with the low occurrence rate of wide companions to brown dwarfs found in other works.

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The HIP 79977 debris disk in polarized light

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We present observations of the known edge-on debris disk around HIP 79977 (HD 146897, F star in Upper Sco, 123 pc), taken with the ZIMPOL differential polarimeter of the SPHERE instrument in the Very Broad Band filter ($\lambda_c = 735$ nm, $\Delta\lambda = 290$ nm) with a spatial resolution of about 25 mas. We measure the polarization flux along and perpendicular to the disk spine of the highly inclined disk for projected separations between 0.2" (25 AU) and 1.6" (200 AU) and investigate the diagnostic potential of such data with model simulations. The polarized flux contrast ratio for the disk is $F_{pol}/F_* = (5.5 \pm 0.9)10^{-4}$. The surface brightness reaches a maximum of 16.2 mag arcsec^{-2} at a separation of $0.2'' - 0.5''$ along the disk spine with a maximum surface brightness contrast of 7.64 mag arcsec^{-2}. The polarized flux has a minimum near the star $< 0.2''$ because no or only little polarization is produced by forward or backward scattering in the disk section lying in front of or behind the star. The data are modeled as a circular dust belt with an inclination $i = 85(\pm 1.5)^\circ$ and a radius between $r_0 = 60$ AU and 90 AU. The radial density dependence is described by $(r/r_0)^\alpha$ with a steep power law index $\alpha = 5$ inside r_0 and a more shallow index $\alpha = -2.5$ outside r_0. The scattering asymmetry factor lies between $g = 0.2$ and 0.6 adopting a scattering angle-dependence for the fractional polarization as for Rayleigh scattering. Our data are qualitatively very similar to the case of AU Mic and they confirm that edge-on debris disks have a polarization minimum at a position near the star and a maximum near the projected separation of the main debris belt. The comparison of the polarized flux contrast ratio F_{pol}/F_* with the fractional infrared excess provides strong constraints on the scattering albedo of the dust.

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The onset of energetic particle irradiation in Class 0 protostars

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The early stages of low-mass star formation are likely to be subject to intense ionization by protostellar energetic MeV particles. As a result, the surrounding gas is enriched in molecular ions, such as HCO^+ and N_2H^+. Nonetheless, this phenomenon remains poorly understood for Class 0 objects. Recently, based on Herschel observations taken as part of the key program Chemical HErschel Surveys of Star forming regions (CHESS), a very low HCO^+/N_2H^+ abundance ratio of about 3–4, has been reported toward the protocluster OMC-2 FIR4. This finding suggests a cosmic-ray ionization rate in excess of 10^{-14} s^{-1}, much higher than the canonical value of $\zeta = 3 \times 10^{-17}$ s^{-1} (value expected in quiescent dense clouds). To assess the specificity of OMC-2 FIR4, we have extended this study to a sample of sources in low- and intermediate mass. More specifically, we seek to measure the HCO^+/N_2H^+ abundance ratio from high energy lines ($J \geq 6$) toward this source sample in order to infer the flux of energetic particles in the warm and dense gas surrounding the protostars. We use observations performed with the Heterodyne Instrument for the FarInfrared spectrometer on board the Herschel Space Observatory toward a sample of 9 protostars. We report HCO^+/N_2H^+ abundance ratios in the range of 5 up to 73 toward our source sample. The large error bars do not allow us to conclude whether OMC-2 FIR4 is a peculiar source. Nonetheless, an important result is that the measured HCO^+/N_2H^+ ratio does not vary with the source luminosity. At the present time, OMC-2 FIR4 remains the only source where a high flux of energetic particles is clearly evident. More sensitive and higher angular resolution observations are required to further investigate this process.

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A CO survey on a sample of Herschel cold clumps

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The physical state of cold cloud clumps has a great impact on the process and efficiency of star formation and the masses of the forming stars inside these objects. The sub-millimetre survey of the Planck space observatory and the far-infrared follow-up mapping of the Herschel space telescope provide an unbiased, large sample of these cold objects. We have observed ^{12}CO(1–0) and ^{13}CO(1–0) emission in 35 clumps in 26 Herschel fields sampling different environments in the Galaxy. Densities and temperatures were calculated from both the dust continuum and the molecular line data, kinematic distances were derived using ^{13}CO line velocities and clump sizes and masses were calculated by fitting 2D Gaussian functions to the optical depth distribution maps. Clump masses and virial masses were estimated assuming an upper and lower limit on the kinetic temperatures and considering uncertainties due to distance limitations. The excitation temperatures are between 8.5–19.5 K, while the Herschel-derived dust colour temperatures are 12–16 K. The sizes (0.1–3 pc), ^{13}CO column densities (0.5–44 $\times$ 10^{15} cm^{-2}) and masses (from less than 0.1 $M_\odot$ to more than 1500 $M_\odot$) of the objects span broad ranges. Eleven gravitationally unbound clumps were found, many of them smaller than 0.3 pc, but large, parsec-scale clouds with a few hundred solar masses appear as well. Colder clumps have generally high column densities but warmer objects appear at both low and higher column densities. The clump column densities derived from the line and dust observations correlate well, but are heavily affected by uncertainties of the dust properties, varying molecular abundances and optical depth effects.

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A Three-dimensional View of Turbulence: Constraints on Turbulent Motions in the HD 163296 Protoplanetary Disk Using DCO+

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Gas kinematics are an important part of the planet formation process. Turbulence influences planetesimal growth and migration from the scale of sub-micron dust grains through gas-giant planets. Radio observations of resolved molecular line emission can directly measure this non-thermal motion and, taking advantage of the layered chemical structure of disks, different molecular lines can be combined to map the turbulence throughout the vertical extent of a protoplanetary disk. Here we present ALMA observations of three molecules (DCO$^+$(3-2), C^{18}O(2-1) and CO(2-1)) from the disk around HD 163296. We are able to place stringent upper limits ($v_{\rm turb}$ <0.06c$_s$, <0.05c$_s$ and <0.04c$_s$ for CO(2-1), C^{18}O(2-1) and DCO$^+$(3-2) respectively), corresponding to $\alpha \lesssim 3\times10^{-3}$, similar to our prior limit derived from CO(3-2). This indicates that there is little turbulence throughout the vertical extent of the disk, contrary to theoretical predictions based on the magneto-rotational instability and gravito-turbulence. In modeling the DCO$^+$ emission we also find that it is confined to three concentric rings at 65.7±0.9 au, $149.9^{+0.5}_{-0.7}$ au and 259±1 au, indicative

of a complex chemical environment.

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The Formation of Uranus and Neptune: Fine Tuning in Core Accretion

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Uranus and Neptune are ice giants with ∼15% atmospheres by mass, placing them in an intermediate category between rocky planets and gas giants. These atmospheres are too massive to have been primarily outgassed, yet they never underwent runaway gas accretion. The ice giants never reached critical core mass ($M_{\rm crit}$) in a full gas disk, yet their cores are $\gtrsim M_{\rm crit}$, suggesting that their envelopes were mainly accreted at the end of the disk lifetime. Pebble accretion calls into question traditional slow atmospheric growth during this phase. We show that the full-sized ice giants predominantly accreted gas from a disk depleted by at least a factor of ∼100. Such a disk dissipates in $\lesssim 10^5$ years. Why would both cores stay sub-critical for the entire ∼Myr disk lifetime, only to reach $M_{\rm crit}$ in the final 10^5 years? This is fine tuned. Ice giants in the outer disk have atmospheric mass fractions comparable to the disk gas-to-solid ratio during the bulk of their gas accretion. This point in disk evolution coincides with a dynamical upheaval: the gas loses its ability to efficiently damp the cores' random velocities, allowing them to be gravitationally excited by Jupiter and Saturn. We suggest that the ice giants' cores began growing on closer-in orbits (staying sub-critical), and migrated out during this dynamical instability. There, their orbits circularized after accreting much of their mass in solids. Finally, they accreted their envelopes from a depleted nebula, where the sparseness of feeding zone gas prevented runaway.

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CARMA $\lambda = 1$ cm Spectral Line Survey of Orion-KL

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Orion-KL is a well known high mass star forming region that has long been the target of spectral line surveys and searches for complex molecules. One spectral window where the region had never been surveyed is around wavelengths of λ=1 cm. This is an important window to observe due to the fundamental and low energy transitions of numerous complex molecules that indicate the maximum spatial extent of the molecular species; knowing the spatial distribution of a molecule aids in determining the formation mechanism(s) of that molecule. Additionally, there are fewer transitions in this window, reducing confusion caused by blended lines that can be very problematic at shorter wavelengths (λ<3 mm). In this work, we present the first spectral line survey at λ=1 cm of the Orion-KL region. A total of 89 transitions were detected from 14 molecular species and isotopologues and two atomic species. The observations were conducted with the Combined Array for Research in Millimeter-wave Astronomy in both interferometric and single dish modes.

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Probing the cold dust emission in the AB Aur disk: a dust trap in a decaying vortex?

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One serious challenge for planet formation is the rapid inward drift of pebble-sized dust particles in protoplanetary disks. Dust trapping at local maxima in the disk gas pressure has received much theoretical attention but still lacks observational support. The cold dust emission in the AB Aur disk forms an asymmetric ring at a radius of about 120 au, which is suggestive of dust trapping in a gas vortex. We present high spatial resolution ($0\farcs58\times0\farcs78 \sim 80\times110$ au) NOEMA observations of the 1.12 mm and 2.22 mm dust continuum emission from the AB Aur disk. Significant azimuthal variations of the flux ratio at both wavelengths indicate a size segregation of the large dust particles along the ring. Our continuum images also show that the intensity variations along the ring are smaller at 2.22 mm than at 1.12 mm, contrary to what dust trapping models with a gas vortex have predicted. Our two-fluid (gas+dust) hydrodynamical simulations demonstrate that this feature is well explained if the gas vortex has started to decay due to turbulent diffusion, and dust particles are thus losing the azimuthal trapping on different timescales depending on their size. The comparison between our observations and simulations allows us to constrain the size distribution and the total mass of solid particles in the ring, which we find to be of the order of 30 Earth masses, enough to form future rocky planets.

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Deep-Down Ionization of Protoplanetary Disks

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The possible occurrence of dead zones in protoplanetary disks subject to the magneto-rotational instability highlights the importance of disk ionization. We present a closed-form theory for the deep-down ionization by X-rays at depths below the disk surface dominated by far-ultraviolet radiation. Simple analytic solutions are given for the major ion classes, electrons, atomic ions, molecular ions and negatively charged grains. In addition to the formation of molecular ions by X-ray ionization of H_2 and their destruction by dissociative recombination, several key processes that operate in this region are included, e.g., charge exchange of molecular ions and neutral atoms and destruction of ions by grains. Over much of the inner disk, the vertical decrease in ionization with depth into the disk is described by simple power laws, which can easily be included in more detailed modeling of magnetized disks. The new ionization theory is used to illustrate the non-ideal MHD effects of Ohmic, Hall and Ambipolar diffusion for a magnetic model of a T Tauri star disk using the appropriate Elsasser numbers.

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Magnetic activity and radial velocity filtering of young Suns: The weak-line T Tauri stars Par 1379 and Par 2244

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We report the results of our spectropolarimetric monitoring of the weak-line T-Tauri stars (wTTSs) Par 1379 and Par 2244, within the MaTYSSE (Magnetic Topologies of Young Stars and the Survival of close-in giant Exoplanets) programme. Both stars are of a similar mass (1.6 and 1.8 $M_\odot$) and age (1.8 and 1.1 Myr), with Par 1379 hosting an evolved low-mass dusty circumstellar disc, and with Par 2244 showing evidence of a young debris disc. We detect profile distortions and Zeeman signatures in the unpolarized and circularly polarized lines for each star, and have modelled their rotational modulation using tomographic imaging, yielding brightness and magnetic maps. We find that Par 1379 harbours a weak (250 G), mostly poloidal field tilted 65° from the rotation axis. In contrast, Par 2244 hosts a stronger field (860 G) split 3:2 between poloidal and toroidal components, with most of the energy in higher order modes, and with the poloidal component tilted 45° from the rotation axis. Compared to the lower mass wTTSs, V819 Tau and V830 Tau, Par 2244 has a similar field strength, but is much more complex, whereas the much less complex field of Par 1379 is also much weaker than any other mapped wTTS. We find moderate surface differential rotation of 1.4× and 1.8× smaller than Solar, for Par 1379 and Par 2244, respectively. Using our tomographic maps to predict the activity related radial velocity (RV) jitter, and filter it from the RV curves, we find RV residuals with dispersions of 0.017 km s^{-1} and 0.086 km s^{-1} for Par 1379 and Par 2244, respectively. We find no evidence for close-in giant planets around either star, with 3σ upper limits of 0.56 and 3.54 $M_{\rm jup}$ (at an orbital distance of 0.1 au).

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The chemistry of protoplanetary fragments formed via gravitational instabilities

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In this paper, we model the chemical evolution of a 0.25 $M_\odot$ protoplanetary disc surrounding a 1 $M_\odot$ star that undergoes fragmentation due to self-gravity. We use Smoothed Particle Hydrodynamics including a radiative transfer scheme, along with time-dependent chemical evolution code to follow the composition of the disc and resulting fragments over approximately 4000 yrs. Initially, four quasi-stable fragments are formed, of which two are eventually disrupted by tidal torques in the disc. From the results of our chemical modelling, we identify species that are abundant in the fragments (e.g. H_2O, H_2S, HNO, N_2, NH_3, OCS, SO), species that are abundant in the spiral shocks within the disc (e.g. CO, CH_4, CN, CS, H_2CO), and species which are abundant in the circumfragmentary material (e.g. HCO^+). Our models suggest that in some fragments it is plausible for grains to sediment to the core before releasing their volatiles into the planetary envelope, leading to changes in, e.g., the C/O ratio of the gas and ice components. We would therefore predict that the atmospheric composition of planets generated by gravitational instability should not necessarily follow the bulk chemical composition of the local disc material.

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High-resolution near-infrared observations of a small cluster associated with a bright-rimmed cloud in W5

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We have carried out near-infrared (IR) observations to examine star formation toward the bright-rimmed cloud SFO 12, of which the main exciting star is O7V star in W5-W. We found a small young stellar object (YSO) cluster of six members embedded in the head of SFO 12 facing its exciting star, aligned along the UV radiation incident direction from the exciting star. We carried out high-resolution near-IR observations with the Subaru adaptive optics (AO) system and revealed that three of the cluster members appear to have circumstellar envelopes, one of which shows an arm-like structure in its envelope. Our near-IR and L^{prime}-band photometry and *Spitzer* IRAC data suggest that formation of two members at the tip side occurred in advance of other members toward the central part, under our adopted assumptions. Our near-IR data and previous studies imply that more YSOs are distributed in the region just outside the cloud head on the side of the main exciting star, but there is little sign of star formation toward the opposite side. We infer that star formation has been sequentially occurring from the exciting star side to the central part. We examined archival data of far-infrared and CO (J = 3-2) which reveals that, unlike in the optical image, SFO 12 has a head-tail structure that is along the UV incident direction. This suggests that SFO 12 is affected by strong UV from the main exciting star. We discuss the formation of this head-tail structure and star formation there by comparing with a radiation-driven implosion (RDI) model.

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The Green Bank Ammonia Survey: Dense Cores Under Pressure in Orion A

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We use gas temperature and velocity dispersion data from the Green Bank Ammonia Survey and core masses and sizes from the James Clerk Maxwell Telescope Gould Belt Survey to estimate the virial states of dense cores within the Orion A molecular cloud. Surprisingly, we find that almost none of the dense cores are sufficiently massive to be bound when considering only the balance between self-gravity and the thermal and non-thermal motions present in the dense gas. Including the additional pressure binding imposed by the weight of the ambient molecular cloud material and additional smaller pressure terms, however, suggests that most of the dense cores are pressure confined.

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HP2 survey: III The California Molecular Cloud– A Sleeping Giant Revisited

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We present new high resolution and dynamic range dust column density and temperature maps of the California Molecular Cloud derived from a combination of *Planck* and *Herschel* dust-emission maps and 2MASS NIR dust-extinction maps. We used these data to determine the ratio of the 2.2 micron extinction coefficient to the 850 micron opacity and found the value to be close to that found in a similar study of the Orion B cloud but significantly higher than that characterizing the Orion A and Perseus clouds, indicating that significant variations in the fundamental optical properties of dust exist between local clouds. We show that over a wide range of extinction, the column density probability distribution function (pdf) of the cloud can be well described by a simple power law (i.e., $\mathrm{PDF}_N \propto A_K^{-\mathrm{n}}$) with an index ($n = 4.0 \pm 0.1$) that represents a steeper decline with A_K than found ($n \approx 3$) in similar studies of the Orion and Perseus clouds. Using only the protostellar population of the cloud and our extinction maps we investigate the Schmidt relation, that is, the relation between the protostellar surface density, Σ_*, and extinction, A_K, within the cloud. We show that Σ_* is directly proportional to the ratio of the protostellar and cloud pdfs, i.e., $\Sigma_* \propto \mathrm{PDF}_*(A_K)/\mathrm{PDF}_N(A_K)$. We use the cumulative distribution of protostars to infer the functional forms for both Σ_* and PDF_*. We find that Σ_* is best described by two power-law functions. At extinctions $A_K < 2.5$ mag, $\Sigma_* \propto A_K^{\beta}$ with $\beta = 3.3$ while at higher extinctions $\beta = 2.5$, both values steeper than those (≈ 2) found in other local giant molecular clouds (GMCs). We find that PDF_* is a declining function of extinction also best described by two power-laws whose behavior mirrors that of Σ_*. Our observations suggest that variations both in the slope of the Schmidt relation and in the sizes of the protostellar populations between GMCs are largely driven by variations in the slope, n, of $\mathrm{PDF}_N(A_K)$. This confirms earlier studies suggesting that cloud structure plays a major role in setting the global star formation rates in GMCs.

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Mid-Infrared Polarization of Herbig Ae/Be Discs

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We measured mid-infrared polarization of protoplanetary discs to gain new insight into their magnetic fields. Using CanariCam at the 10.4 m Gran Telescopio Canarias, we detected linear polarization at 8.7, 10.3, and 12.5 μm from discs around eight Herbig Ae/Be stars and one T-Tauri star. We analyzed polarimetric properties of each object to find out the most likely interpretation of the data. While the observed mid-infrared polarization from most objects is consistent with polarized emission and/or absorption arising from aligned dust particles, we cannot rule out polarization due to dust scattering for a few objects in our sample. For those objects for which polarization can be explained by polarized emission and/or absorption, we examined how the derived magnetic field structure correlates with the disc position angle and inclination. We found no preference for a certain type of magnetic field. Instead, various configurations (toroidal, poloidal, or complex) are inferred from the observations. The detection rate (64 per cent) of polarized mid-infrared emission and/or absorption supports the expectation that magnetic fields and suitable conditions for grain alignment are common in protoplanetary discs around Herbig Ae/Be stars.

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The Formation of Stellar Clusters in Magnetized, Filamentary Infrared Dark Clouds

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Star formation in a filamentary infrared dark cloud (IRDC) is simulated over a dynamic range of 4.2 pc to 28 au for a period of 3.5×10^5 yr, including magnetic fields and both radiative and outflow feedback from the protostars. At the end of the simulation, the star formation efficiency is 4.3 per cent and the star formation rate per free fall time is $\epsilon_{\rm ff} \approx 0.04$, within the range of observed values (Krumholz et al. 2012a). The total stellar mass increases as $\sim t^2$, whereas the number of protostars increases as $\sim t^{1.5}$. We find that the density profile around most of the simulated protostars is $\sim \rho \propto r^{-1.5}$, as predicted by Murray & Chang (2015). At the end of the simulation, the protostellar mass function approaches the Chabrier (2005) stellar initial mass function. We infer that the time to form a star of median mass 0.2 $M_\odot$ is about 1.4×10^5 yr from the median mass accretion rate. We find good agreement among the protostellar luminosities observed in the large sample of Dunham et al. (2013), our simulation, and a theoretical estimate, and conclude that the classical protostellar luminosity problem Kenyon et al. (1990) is resolved. The multiplicity of the stellar systems in the simulation agrees to within a factor 2 of observations of Class I young stellar objects; most of the simulated multiple systems are unbound. Bipolar protostellar outflows are launched using a sub-grid model, and extend up to 1 pc from their host star. The mass-velocity relation of the simulated outflows is consistent with both observation and theory.

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The properties of the inner disk around HL Tau: Multi-wavelength modeling of the dust emission

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We conducted a detailed radiative transfer modeling of the dust emission from the circumstellar disk around HL Tau. The goal of our study is to derive the surface density profile of the inner disk and its structure. In addition to the Atacama Large Millimeter/submillimeter Array images at Band 3 (2.9mm), Band 6 (1.3mm), and Band 7 (0.87mm), the most recent Karl G. Jansky Very Large Array (VLA) observations at 7mm were included in the analysis. A simulated annealing algorithm was invoked to search for the optimum model. The radiative transfer analysis demonstrates that most radial components (i.e., >6AU) of the disk become optically thin at a wavelength of 7mm, which allows us to constrain, for the first time, the dust density distribution in the inner region of the disk. We found that a homogeneous grain size distribution is not sufficient to explain the observed images at different wavelengths simultaneously, while models with a shallower grain size distribution in the inner disk work well. We found clear evidence that larger grains are trapped in the first bright ring. Our results imply that dust evolution has already taken place in the disk at a relatively young (i.e., ∼1 Myr) age. We compared the midplane temperature distribution, optical depth, and properties of various dust rings with those reported previously. Using the Toomre parameter, we briefly discussed the gravitational instability as a potential mechanism for the origin of the dust clump detected in the first bright ring via the VLA observations.

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Protoplanetary disc 'isochrones' and the evolution of discs in the $\dot{M}$–$M_{\rm d}$ plane

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In this paper, we compare simple viscous diffusion models for the disc evolution with the results of recent surveys of the properties of young protoplanetary discs. We introduce the useful concept of 'disc isochrones' in the accretion rate - disc mass plane and explore a set of Montecarlo realization of disc initial conditions. We find that such simple viscous models can provide a remarkable agreement with the available data in the Lupus star forming region, with the key requirement that the average viscous evolutionary timescale of the discs is comparable to the cluster age. Our models produce naturally a correlation between mass accretion rate and disc mass that is shallower than linear, contrary to previous results and in agreement with observations. We also predict that a linear correlation, with a tighter scatter, should be found for more evolved disc populations. Finally, we find that such viscous models can reproduce the observations in the Lupus region only in the assumption that the efficiency of angular momentum transport is a growing function of radius, thus putting interesting constraints on the nature of the microscopic processes that lead to disc accretion.

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Extreme infrared variables from UKIDSS - II. an end-of-survey catalogue of eruptive YSOs and unusual stars

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We present a catalogue of 618 high amplitude infrared variable stars ($1 < \Delta K < 5$ mag) detected by the two widely separated epochs of 2.2 μm data in the UKIDSS Galactic plane survey, from searches covering 1470 deg^2. Most were discovered by a search of all fields at $30 < l < 230°$. Sources include new dusty Mira variables, three new CV candidates, a blazar and a peculiar source that may be an interacting binary system. However, ∼60 per cent are YSOs, based on spatial association with star forming regions at distances ranging from 300 pc to over 10 kpc. This confirms our initial result in Contreras Pena et al.(Paper I) that YSOs dominate the high amplitude infrared variable sky in the Galactic disc. It is also supported by recently published VVV results at $295 < l < 350°$. The spectral energy distributions of the YSOs indicate class I or flat spectrum systems in most cases, as in the VVV sample. A large number of variable YSOs are associated with the Cygnus X complex and other groups are associated with the North America/Pelican nebula, the Gemini OB1 molecular cloud, the Rosette complex, the Cone nebula, the W51 star forming region and the S86 and S236 HII regions. Most of the YSO variability is likely due to variable/episodic accretion on timescales of years, albeit usually less extreme than classical FUors and EXors. Luminosities at the 2010 WISE epoch range from ∼0.1 $L_\odot$ to $10^3 L_\odot$ but only rarely exceed $10^{2.5}$ $L_\odot$.

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The structure of young embedded protostellar discs

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Young protostellar discs provide the initial conditions for planet formation. The properties of these discs may be different from those of late-phase (T Tauri) discs due to continuing infall from the envelope and protostellar variability resulting from irregular gas accretion. We use a set of hydrodynamic simulations to determine the structure of discs forming in collapsing molecular clouds. We examine how radiative feedback from the host protostar affects the disc properties by examining three regimes: without radiative feedback, with continuous radiative feedback and with episodic feedback, similar to FU Ori-type outbursts. We find that the radial surface density and temperature profiles vary significantly as the disc accretes gas from the infalling envelope. These profiles are sensitive to the presence of spiral structure, induced by gravitational instabilities, and the radiative feedback provided by the protostar, especially in the case when the feedback is episodic. We also investigate whether mass estimates from position-velocity (PV) diagrams are accurate for early-phase discs. We find that the protostellar system mass (i.e. the mass of the protostar and its disc) is underestimated by up to 20%, due to the impact of an enhanced radial pressure gradient on the gas. The mass of early-phase discs is a significant fraction of the mass of the protostar, so position-velocity diagrams cannot accurately provide the mass of the protostar alone. The enhanced radial pressure gradient expected in young discs may lead to an increased rate of dust depletion due to gas drag, and therefore to a reduced dust-to-gas ratio.

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The Infrared and Radio Flux Densities of Galactic HII Regions

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We derive infrared and radio flux densities of all ∼ 1000 known Galactic H II regions in the Galactic longitude range $17^\circ\!.5 < \ell < 65^\circ$. Our sample comes from the Wide-Field Infrared Survey Explorer (WISE) catalog of Galactic H II regions (Anderson et al. 2014). We compute flux densities at six wavelengths in the infrared (*Spitzer* GLIMPSE 8 μm, WISE 12 μm and 22 μm, *Spitzer* MIPSGAL 24 μm, and *Herschel* Hi-GAL 70 μm and 160 μm) and two in the radio (MAGPIS 20 cm and VGPS 21 cm). All H II region infrared flux densities are strongly correlated with their ∼ 20 cm flux densities. All H IIregions used here, regardless of physical size or Galactocentric radius, have similar infrared to radio flux density ratios and similar infrared colors, although the smallest regions ($r < 1$ pc), have slightly elevated IR to radio ratios. The colors $\log_{10}(F_{24\,\mu\mathrm{m}}/F_{12\,\mu\mathrm{m}}) \geq 0$ and $\log_{10}(F_{70\,\mu\mathrm{m}}/F_{12\,\mu\mathrm{m}}) \geq 1.2$, and $\log_{10}(F_{24\,\mu\mathrm{m}}/F_{12\,\mu\mathrm{m}}) \geq 0$ and $\log_{10}(F_{160\,\mu\mathrm{m}}/F_{70\,\mu\mathrm{m}}) \leq 0.67$ reliably select H II regions, independent of size. The infrared colors of ∼ 22% of H II regions, spanning a large range of physical sizes, satisfy the IRAS color criteria of Wood & Churchwell (1989a) for H II regions, after adjusting the criteria to the wavelengths used here. Since these color criteria are commonly thought to select only ultra-compact H II regions, this result indicates that the true ultra-compact H II region population is uncertain. Comparing with a sample of IR color indices from star-forming galaxies, H II regions show higher $\log_{10}(F_{70\,\mu\mathrm{m}}/F_{12\,\mu\mathrm{m}})$ ratios. We find a weak trend of decreasing infrared to ∼ 20 cm flux density ratios with increasing R_{gal}, in agreement with previous extragalactic results, possibly indicating a decreased dust abundance in the outer Galaxy.

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YSO jets in the Galactic Plane from UWISH2: IV - Jets and outflows in Cygnus-X

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We have performed an unbiased search for outflows from young stars in Cygnus-X using 42 deg^2 of data from the UKIRT Widefield Infrared Survey for H_2 (UWISH2 survey), to identify shock-excited near-IR H_2 emission in the 1–0 S(1) 2.122 μm line. We uncovered 572 outflows, of which 465 are new discoveries, increasing the number of known objects by more than 430%. This large and unbiased sample allows us to statistically determine the typical properties of outflows from young stars.
We found 261 bipolar outflows and 16% of these are parsec-scale. The typical bipolar outflow is 0.45pc in length and has gaps of 0.025 to 0.1pc between large knots. The median luminosity in the 1–0 S(1) line is $10^{-3}\,L_\odot$. The bipolar flows are typically asymmetrical, with the two lobes misaligned by 5°, one lobe 30% shorter than the other, and one lobe twice as bright as the other. Of the remaining outflows, 152 are single-sided and 159 are groups of extended, shock-excited H_2 emission without identifiable driving sources. Half of all driving sources have sufficient WISE data to determine their evolutionary status as either protostars (80%) or classical T-Tauri stars (20%). One fifth of the driving sources are variable by more than 0.5mag in the K-band continuum over several years.
Several of the newly-identified outflows provide excellent targets for follow up studies. We particularly encourage the study of the outflows and young stars identified in a bright-rimmed cloud near IRAS 20294+4255, which seems to represent a textbook example of triggered star formation.

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Coorbital thermal torques on low-mass protoplanets

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Using linear perturbation theory, we investigate the torque exerted on a low-mass planet embedded in a gaseous protoplanetary disc with finite thermal diffusivity. When the planet does not release energy into the ambient disc, the main effect of thermal diffusion is the softening of the enthalpy peak near the planet, which results in the appearance of two cold and dense lobes on either side of the orbit, of size smaller than the thickness of the disc. The lobes exert torques of opposite sign on the planet, each comparable in magnitude to the one-sided Lindblad torque. When the planet is offset from corotation, the lobes are asymmetric and the planet experiences a net torque, the "cold" thermal torque, which has a magnitude that depends on the relative value of the distance to corotation to the size of the lobes $\sim \sqrt{\chi/\Omega_\mathrm{p}}$, χ being the thermal diffusivity and Ω_p the orbital frequency. We believe that this effect corresponds to the phenomenon named "cold finger" recently reported in numerical simulations, and we argue that it constitutes the dominant mode of migration of sub-Earth mass objects. When the planet is luminous, the heat released into the ambient disc results in an additional disturbance that takes the form of hot, low-density lobes. They give a torque, named heating torque in previous work, that has an expression similar, but of opposite sign, to the cold thermal torque.

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Characterization of exoplanets from their formation III: The statistics of planetary luminosities

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This paper continues a series in which we predict the main observable characteristics of exoplanets based on their formation. In Paper I we described our global planet formation and evolution model. In Paper II we studied the planetary mass-radius relationship. Here we present an extensive study of the statistics of planetary luminosities during both formation and evolution. Our results can be compared with individual directly imaged (proto)planets as well as statistical results from surveys. We calculated three synthetic planet populations assuming different efficiencies of the accretional heating by gas and planetesimals. We describe the temporal evolution of the planetary mass-luminosity relation. We study the shock and internal luminosity during formation. We predict a statistical version of the post-formation mass versus entropy "tuning fork" diagram. We find high nominal post-formation luminosities for hot and cold gas accretion. Individual formation histories can still lead to a factor of a few spread in the post-formation luminosity at a given mass. However, if the gas and planetesimal accretional heating is unknown, the post-formation luminosity may exhibit a spread of as much as 2–3 orders of magnitude at a fixed mass covering cold, warm, and hot states. As a key result we predict a flat log-luminosity distribution for giant planets, and a steep increase towards lower luminosities due to the higher occurrence rate of low-mass planets. Future surveys may detect this upturn. During formation an estimate of the planet mass may be possible for cold gas accretion if the gas accretion rate can be estimated. Due to the "core-mass effect" planets that underwent cold gas accretion can still have high post-formation entropies. Once the number of directly imaged exoplanets with known ages and luminosities increases, the observed distributions may be compared with our predictions.

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Constraints from Dust Mass and Mass Accretion Rate Measurements on Angular Momentum Transport in Protoplanetary Disks

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In this paper, we investigate the relation between disk mass and mass accretion rate to constrain the mechanism of angular momentum transport in protoplanetary disks. We find a correlation between dust disk mass and mass accretion rate in Chamaeleon I with a slope that is close to linear, similar to the one recently identified in Lupus. We investigate the effect of stellar mass and find that the intrinsic scatter around the best-fit $M_{\rm dust}$–$M_\star$and $\dot{M}_{\rm acc}$–$M_\star$relations is uncorrelated. We simulate synthetic observations of an ensemble of evolving disks using a Monte Carlo approach, and find that disks with a constant α viscosity can fit the observed relations between dust mass, mass accretion rate, and stellar mass, but over-predict the strength of the correlation between disk mass and mass accretion rate when using standard initial conditions. We find two possible solutions. In the first one, the observed scatter in $M_{\rm dust}$and $\dot{M}_{\rm acc}$is not primordial, but arises from additional physical processes or uncertainties in estimating the disk gas mass. Most likely grain growth and radial drift affect the observable dust mass, while variability on large time scales affects the mass accretion rates. In the second scenario, the observed scatter is primordial, but disks have not evolved substantially at the age of Lupus and Chamaeleon I due to a low viscosity or a large initial disk radius. More accurate estimates of the disk mass and gas disk sizes in a large sample of protoplanetary disks, either through direct observations of the gas or spatially resolved multi-wavelength observations of the dust with `ALMA`, are needed to discriminate between both scenarios or to constrain alternative angular momentum transport mechanisms such as MHD disk winds.

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FUV Irradiation and the Heat Signature of Accretion in Protoplanetary Disk Atmospheres

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Although stars accrete mass throughout the first few million years of their lives, the physical mechanism that drives disk accretion in the T Tauri phase is uncertain, and diagnostics that probe the nature of disk accretion have been elusive, particularly in the planet formation region of the disk. Here we explore whether an accretion process such as the magnetorotational instability could be detected through its "heat signature", the energy it deposits in the disk atmosphere. To examine this possibility, we investigate the impact of accretion-related mechanical heating and energetic stellar irradiation (FUV and X-rays) on the thermal-chemical properties of disk atmospheres at planet formation distances. We find that stellar FUV irradiation (Lyα and continuum), through its role in heating and photodissociation, affects much of the upper warm (400–2000 K) molecular layer of the atmosphere, and the properties of the layer are generally in good agreement with the observed molecular emission features of disks at UV, near-infrared, and mid-infrared wavelengths. At the same time, the effect of FUV irradiation is restricted to the upper molecular layer of the disk, even when irradiation by Lyα is included. The region immediately below the FUV-heated layer is potentially dominated by accretion-related mechanical heating. As cooler (90–400 K) CO, water, and other molecules are potential diagnostics of the mechanically heated layer, emission line studies of these diagnostics might be used to search for evidence of the magnetorotational instability in action.

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The Carina Nebula and Gum 31 molecular complex: II. The distribution of the atomic gas revealed in unprecedented detail

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We report high spatial resolution observations of the HI 21cm line in the Carina Nebula and the Gum 31 region obtained with the Australia Telescope Compact Array. The observations covered $\sim$12 deg^2 centred on $l = 287.^\circ5, b = -1^\circ$, achieving an angular resolution of $\sim 35''$. The HI map revealed complex filamentary structures across a wide range of velocities. Several "bubbles" are clearly identified in the Carina Nebula Complex, produced by the impact of the massive star clusters located in this region. An HI absorption profile obtained towards the strong extragalactic radio source PMN J1032–5917 showed the distribution of the cold component of the atomic gas along the Galactic disk, with the Sagittarius-Carina and Perseus spiral arms clearly distinguishable. Preliminary calculations of the optical depth and spin temperatures of the cold atomic gas show that the HI line is opaque ($\tau \gtrsim 2$) at several velocities in the Sagittarius-Carina spiral arm. The spin temperature is $\sim$100 K in the regions with the highest optical depth, although this value might be lower for the saturated components. The atomic mass budget of Gum 31 is $\sim$35% of the total gas mass. HI self absorption features have molecular counterparts and good spatial correlation with the regions of cold dust as traced by the infrared maps. We suggest that in Gum 31 regions of cold temperature and high density are where the atomic to molecular gas phase transition is likely to be occurring.

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What pebbles are made of: Interpretation of the V883 Ori disk

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Recently, an Atacama Large Millimeter/submillimeter Array (ALMA) observation of the water snow line in the protoplanetary disk around the FU Orionis star V883 Ori was reported. The radial variation of the spectral index at mm-wavelengths around the snow line was interpreted as being due to a pileup of particles interior to the snow line. However, radial transport of solids in the outer disk operates on timescales much longer than the typical timescale of an FU Ori outburst (10^1–10^2 yr). Consequently, a steady-state pileup is unlikely. We argue that it is only necessary to consider water evaporation and re-coagulation of silicates to explain the recent ALMA observation of V883 Ori because these processes are short enough to have had their impact since the outburst. Our model requires the inner disk to have already been optically thick before the outburst, and our results suggest that the carbon content of pebbles is low.

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Satellitesimal Formation via Collisional Dust Growth in Steady Circumplanetary Disks

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The icy satellites around Jupiter are considered to have formed in a circumplanetary disk. While previous models focused on the formation of satellites starting from satellitesimals, the question of how satellitesimals form from smaller dust particles has not been addressed so far. In this work, we study the possibility that satellitesimals form in situ in a circumplanetary disk. We calculate the radial distribution of the surface density and representative size of icy dust particles that grow by colliding with each other and drift toward the central planet in a steady circumplanetary disk with a continuous supply of gas and dust from the parent protoplanetary disk. The radial drift barrier is overcome if the ratio of the dust to gas accretion rates onto the circumplanetary disk, $\dot{M}_{\rm d}/\dot{M}_{\rm g}$, is high and the strength of turbulence, , is not too low. The collision velocity is lower than the critical velocity of fragmentation when is low. Taken together, we find that the conditions for satellitesimal formation via dust coagulation are given by $\dot{M}_{\rm d}/\dot{M}_{\rm g} \geq 1$ and $10^{-4} \leq \alpha \leq 10^{-2}$. The former condition is generally difficult to achieve, suggesting that the in-situ satellitesimal formation via particle sticking is viable only under an extreme condition. We also show that neither satellitesimal formation via the collisional growth of porous aggregates nor via streaming instability is viable as long as $\dot{M}_{\rm d}/\dot{M}_{\rm g}$ is low.

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The 2014-2017 outburst of the young star ASASSN-13db: A time-resolved picture of a very low-mass star between EXors and FUors

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Context: Accretion outbursts are key elements in star formation. ASASSN-13db is a M5-type star with a protoplanetary disk, the lowest mass star known to experience accretion outbursts. Since its discovery in 2013, it has experienced two outbursts, the second of which started in November 2014 and lasted until February 2017.
Aims: We explore the photometric and spectroscopic behavior of ASASSN-13db during the 2014-2017 outburst.
Methods: We use high- and low-resolution spectroscopy and time-resolved photometry from the ASAS-SN survey, the LCOGT and the Beacon Observatory to study the lightcurve of ASASSN-13db and the dynamical and physical

properties of the accretion flow.
Results: The 2014-2017 outburst lasted for nearly 800 days. A 4.15d period in the lightcurve likely corresponds to rotational modulation of a star with hot spot(s). The spectra show multiple emission lines with variable inverse P-Cygni profiles and a highly variable blueshifted absorption below the continuum. Line ratios from metallic emission lines (Fe I/Fe II, Ti I/Ti II) suggest temperatures of ~5800-6000 K in the accretion flow.
Conclusions: Photometrically and spectroscopically, the 2014-2017 event displays an intermediate behavior between EXors and FUors. The accretion rate ($\dot{M}$=1-3$\times10^{-7}M_\odot$/yr), about 2 orders of magnitude higher than the accretion rate in quiescence, is not significantly different from the accretion rate observed in 2013. The absorption features in the spectra suggest that the system is viewed at a high angle and drives a powerful, non-axisymmetric wind, maybe related to magnetic reconnection. The properties of ASASSN-13db suggest that temperatures lower than those for solar-type stars are needed for modeling accretion in very low-mass systems. Finally, the rotational modulation during the outburst reveals that accretion-related structures settled after the begining of the outburst and can be relatively stable and long-lived. Our work also demonstrates the power of time-resolved photometry and spectroscopy to explore the properties of variable and outbursting stars.

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SMA Observations of the Hot Molecular Core IRAS 18566+0408

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We present Submillimeter Array (SMA) observations toward the high-mass star-forming region IRAS 18566+0408. Observations at 1.3 mm continuum and in several molecular line transitions were performed in the compact (2."4 angular resolution) and very-extended (~0."4 angular resolution) configurations. The continuum emission from the compact configuration shows a dust core of 150 $M_\odot$, while the very-extended configuration reveals a dense (2.6 $\times$ 10^7 cm^{-3}) and compact (~4,000 AU) condensation of 8 $M_\odot$. We detect 31 molecular transitions from 14 species including CO isotopologues, SO, CH_3OH, OCS, and CH_3CN. Using the different *k*-ladders of the CH_3CN line, we derive a rotational temperature at the location of the continuum peak of 240 K. The $^{12}CO(2–1)$, $^{13}CO(2–1)$, and SO(6_5–5_4) lines reveal a molecular outflow at PA~135^o centered at the continuum peak. The extended $^{12}CO(2–1)$ emission has been recovered with the IRAM 30 m telescope observations. Using the combined data set, we derive an outflow mass of 16.8 $M_\odot$. The chemically rich spectrum and the high rotational temperature confirm that IRAS 18566+0408 is harboring a hot molecular core. We find no clear velocity gradient that could suggest the presence of a rotational disk-like structure, even at the high resolution observations obtained with the very-extended configuration.

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A Theoretical Model of X-ray Jets from Young Stellar Objects

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There is a subclass of the X-ray jets from young stellar objects which are heated very close to the footpoint of the jets, particularly DG Tau jets. Previous models attribute the strong heating to shocks in the jets. However, the mechanism that localizes the heating at the footpoint remains puzzling. We presented a different model of such X-ray jets, in which the disk atmosphere is magnetically heated. Our disk corona model is based on the so-called nanoflare model for the solar corona. We show that the magnetic heating near the disks can result in the formation of a hot corona with a temperature of $>10^6$ K even if the average field strength in the disk is moderately weak, >1 G. We determine the density and the temperature at the jet base by considering the energy balance between the heating and cooling. We derive the scaling relations of the mass loss rate and terminal velocity of jets. Our model is applied to the DG Tau jets. The observed temperature and estimated mass loss rate are consistent with the prediction of our model in the case of the disk magnetic field strength of ∼20 G and the heating region of <0.1 au. The derived scaling relation of the temperature of X-ray jets could be a useful tool to estimate the magnetic field strength. We also found that the jet X-ray can have a significant impact on the ionization degree near the disk surface and the dead-zone size.

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Physical properties of dusty protoplanetary disks in Lupus: evidence for viscous evolution?

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The formation of planets strongly depends on the total amount as well as on the spatial distribution of solids in protoplanetary disks. Thanks to the improvements in resolution and sensitivity provided by ALMA, measurements of the surface density of mm-sized grains are now possible on large samples of disks. Such measurements provide statistical constraints that can be used to inform our understanding of the initial conditions of planet formation.
We aim to analyze spatially resolved observations of 36 protoplanetary disks in the Lupus star forming complex from our ALMA survey at 890μm, aiming to determine physical properties such as the dust surface density, the disk mass and size, and to provide a constraint on the temperature profile.
We fit the observations directly in the UV-plane using a two-layer disk model that computes the 890 μm emission by solving the energy balance at each disk radius.
For 22 out of 36 protoplanetary disks we derive robust estimates of their physical properties. The sample covers stellar masses between ∼0.1 and $\sim 2\,M_\odot$, and we find no trend in the relationship between the average disk temperatures and the stellar parameters. We find, instead, a correlation between the integrated sub-mm flux (a proxy for the disk mass) and the exponential cut-off radii (a proxy of the disk size) of the Lupus disks. Comparing these results with observations at similar angular resolution of Taurus-Auriga and Ophiuchus disks found in literature and scaling them to the same distance, we observe that the Lupus disks are generally fainter and larger at a high level of statistical significance. Considering the 1-2 Myr age difference between these regions, it is possible to tentatively explain the offset in the disk mass-size relation with viscous spreading, however with the current measurements other mechanisms cannot be ruled out.

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Formation of freely floating sub-stellar objects via close encounters

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We numerically studied close encounters between a young stellar system hosting a massive, gravitationally fragmenting disk and an intruder diskless star with the purpose to determine the evolution of fragments that have formed in the disk prior to the encounter. Numerical hydrodynamics simulations in the non-inertial frame of reference of the host star were employed to simulate the prograde and retrograde co-planar encounters. The initial configuration of the target system (star plus disk) was obtained via a separate numerical simulation featuring the gravitational collapse of a solar-mass pre-stellar core. We found that close encounters can lead to the ejection of fragments that have formed in the disk of the target prior to collision. In particular, prograde encounters are more efficient in ejecting the fragments than the retrograde encounters. The masses of ejected fragments are in the brown-dwarf mass regime. They also carry away an appreciable amount of gas in their gravitational radius of influence, implying that these objects may possess extended disks or envelopes, as also suggested by Thies et al. (2015). Close encounters can also lead to the ejection of entire spiral arms, followed by fragmentation and formation of freely-floating objects straddling the planetary mass limit. However, numerical simulations with a higher resolution are needed to confirm this finding.

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An ALMA Dynamical Mass Estimate of the Proposed Planetary-mass Companion FW Tau C

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Dynamical mass estimates down to the planet-mass regime can help to understand planet formation. We present Atacama Large Millimeter/submillimeter Array (ALMA) 1.3 mm observations of FW Tau C, a proposed $\sim$10 $M_{\rm Jup}$ planet-mass companion at $\sim$330 au from the host binary FW Tau AB. We spatially and spectrally resolve the accretion disk of FW Tau C in ^{12}CO (2–1). By modeling the Keplerian rotation of gas, we derive a dynamical mass of $\sim 0.1 M_\odot$. Therefore, FW Tau C is unlikely a planet, but rather a low-mass star with a highly inclined disk. This also suggests that FW Tau is a triple system consisting of three $\sim$0.1 $M_\odot$ stars.

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Gas kinematics and star formation in the filamentary molecular cloud G47.06+0.26

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We performed a multi-wavelength study toward the filamentary cloud G47.06+0.26 to investigate the gas kinematics and star formation. We present the ^{12}CO (J=1–0), ^{13}CO (J=1–0) and C^{18}O (J=1–0) observations of G47.06+0.26

obtained with the Purple Mountain Observation (PMO) 13.7 m radio telescope to investigate the detailed kinematics of the filament. The ^{12}CO (J=1–0) and ^{13}CO (J=1–0) emission of G47.06+0.26 appear to show a filamentary structure. The filament extends about 45′ (58.1 pc) along the east-west direction. The mean width is about 6.8 pc, as traced by the ^{13}CO (J=1–0) emission. G47.06+0.26 has a linear mass density of about 361.5 $M_\odot$/pc. The external pressure (due to neighboring bubbles and H II regions) may help preventing the filament from dispersing under the effects of turbulence. From the velocity-field map, we discern a velocity gradient perpendicular to G47.06+0.26. From the Bolocam Galactic Plane Survey (BGPS) catalog, we found nine BGPS sources in G47.06+0.26, that appear to these sources have sufficient mass to form massive stars. We obtained that the clump formation efficiency (CFE) is about 18% in the filament. Four infrared bubbles were found to be located in, and adjacent to, G47.06+0.26. Particularly, infrared bubble N98 shows a cometary structure. CO molecular gas adjacent to N98 also shows a very intense emission. H II regions associated with infrared bubbles can inject the energy to surrounding gas. We calculated the kinetic energy, ionization energy, and thermal energy of two H II regions in G47.06+0.26. From the GLIMPSE I catalog, we selected some Class I sources with an age of about 100000 yr, which are clustered along the filament. The feedback from the H II regions may cause the formation of a new generation of stars in filament G47.06+0.26.

Accepted by A&A

http://arxiv.org/pdf/1708.09098

1000 au Exterior Arcs Connected to the Protoplanetary Disk around HL Tau

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Aim. The protoplanetary disk around HL Tau is so far the youngest candidate of planet formation, and it is still embedded in a protostellar envelope with a size of thousands of au. In this work, we study the gas kinematics in the envelope and its possible influence on the embedded disk.
Method. We present our new ALMA cycle 3 observational results of HL Tau in the ^{13}CO (2–1) and C^{18}O (2–1) emission at resolutions of 0.″8 (110 au), and we compare the observed velocity pattern with models of different kinds of gas motions.
Results. Both the ^{13}CO and C^{18}O emission lines show a central compact component with a size of 2″ (280 au), which traces the protoplanetary disk. The disk is clearly resolved and shows a Keplerian motion, from which the protostellar mass of HL Tau is estimated to be 1.8±0.3 $M_\odot$, assuming the inclination angle of the disk to be 47° from the plane of the sky. The ^{13}CO emission shows two arc structures with sizes of 1000–2000 au and masses of 3×10^{-3} $M_\odot$ connected to the central disk. One is blueshifted and stretches from the northeast to the northwest, and the other is redshifted and stretches from the southwest to the southeast. We find that simple kinematical models of infalling and (counter-)rotating flattened envelopes cannot fully explain the observed velocity patterns in the arc structures. The gas kinematics of the arc structures can be better explained with three-dimensional infalling or outflowing motions. Nevertheless, the observed velocity in the northwestern part of the blueshifted arc structure is ∼60–70% higher than the expected free-fall velocity. We discuss two possible origins of the arc structures: (1) infalling flows externally compressed by an expanding shell driven by XZ Tau and (2) outflowing gas clumps caused by gravitational instabilities in the protoplanetary disk around HL Tau.

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https://arxiv.org/pdf/1708.02384.pdf

Are fibres in molecular cloud filaments real objects?

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We analyse the morphology and kinematics of dense filamentary structures produced in a numerical simulation of a star–forming cloud of $1.4 \times 10^4\, M_\odot$ evolving under their own self–gravity in a magnetized medium. This study is motivated by recent observations of velocity–coherent substructures ("fibres") in star-forming filaments. We find such "fibres" ubiquitously in our simulated filament. We found that a fibre in one projection is not necessarily a fibre in another projection, and thus, caution should be taken into account when considering them as real objects. We found that only the densest parts of the filament ($\sim$30% of the densest volume, which contains $\sim$70% of the mass) belong to fibres in 2 projections. Moreover, it is quite common that they are formed by separated density enhancements superposed along the line of sight. Observations of fibres can yield insight into the level of turbulent substructure driven by gravity, but care should be taken in interpreting the results given the problem of line of sight superposition. We also studied the morphology and kinematics of the 3D skeleton (spine), finding that subfilaments accrete structured material mainly along the magnetic field lines, which are preferentially perpendicular to the skeleton. The magnetic field is at the same time dragged by the velocity field due to the gravitational collapse.

Accepted by MNRAS

http://arxiv.org/pdf/1708.01669

Dissertation Abstracts

Distances, Kinematics, and Structure of Nearby Star-forming Regions

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Ph.D dissertation directed by: Lee Hartmann

Ph.D degree awarded: August 2017

In this thesis I present an analysis of the structure and kinematics of the Orion Molecular Cloud Complex in an effort to better characterize the dynamical state of the closest region of the ongoing massive star formation and to provide a baseline for comparison of the upcoming results from the Gaia space telescope. In order to achieve this goal, I measured stellar parallax and proper motions, using very large baseline radio interferometry of non-thermally-emitting sources.. Based on these observations I measured the average distance in Orion A molecular cloud of 388$\pm$5 pc toward the Orion Nebula Cluster (ONC), 428$\pm$10 pc toward the southern portion of L1641, as well as the distance in Orion B of 388$\pm$10 pc toward NGC 2068, and roughly $\sim$420 pc toward NGC 2024. These are the first direct distance measurements with $< 5\%$ uncertainty to the regions within the Orion Complex outside of the ONC. Little can be said about the proper motions due to the sparcity of the sample size; however, I identified a number of binary systems and fitted their orbital motion, which allows for the direct measurement of the masses of the individual components. I also identified three stars that have been ejected from the ONC due to the gravitational interactions with its most massive stars.

I complemented the parallax and proper motion measurements with the observations of radial velocities (RV) of the stars toward the Orion Complex, probing the histories of both dynamic evolution and star formation in the region. I found that in the Orion A cloud and in NGC 2024 there exists an asymmetry between the stellar RVs and those of the molecular gas, with a small fraction of the stars stars being preferentially blueshifted relative to the gas. Several possible explanations for this have been proposed, although presently there is not yet a definitive solution. I also analyzed the multiplicity fraction of the spectroscopic binaries in the ONC, and found that it is largely consistent to what is observed in the nearby field stars.

Finally, I explored the substructure of the ONC by focusing on NGC 1980, a cluster that has previously been identified as foreground to and older than the ONC. I examined these claims to show that there is little evidence that there is a discrepancy in distance between the stellar populations of the ONC and NGC 1980. Additionally, while the stars of NGC 1980 are likely somewhat older than the ONC, their age is consistent with the stellar population of the rest of the Orion A molecular cloud.

New Jobs

Postdoctoral positions for analysis of JWST observations of protostars, brown dwarfs, and exoplanets

NASA Ames Research Center has postdoctoral positions available in the area of characterization of exoplanet, brown dwarf, and protostellar atmospheres with James Webb Space Telescope (JWST) spectroscopic and photometric data. We expect to offer one position in the analysis of time-series observations of transiting planets and one position in the analysis of protostar and brown dwarf spectra. The data will be obtained via guaranteed-time observations (GTO) and possibly general observer (GO) observations that are scheduled to start in April 2019.

The exoplanet postdoc will work closely with Tom Greene at NASA Ames in analyzing JWST NIRCam and MIRI transit and secondary eclipse spectra and images of warm planets that mostly have masses between Neptune and Jupiter. The primary duty is to optimize the data reduction by applying sophisticated de-correlation and / or statistical (i.e. Gaussian process) techniques. Experience in optimizing data reduction pipelines, systematic noise removal, and analysis of high precision time-series exoplanet data using Python is required.

The second postdoc will work with NASA Ames researchers Tom Roellig and Tom Greene in the analysis of brown dwarf and Class 0 protostar spectra, respectively. This analysis will largely consist of estimation of model parameters via statistical retrieval techniques (e.g., MCMC, MultiNest). We expect that the standard JWST pipelines will deliver data with sufficient quality for this task. Experience in data reduction and statistical analysis of stellar, brown dwarf, protostellar, or other similar infrared spectra using Python is required.

Both positions will also require working effectively with modest-sized teams distributed in the US and Europe. There will be opportunities for independent research, and we would particularly encourage and support work on related JWST GO proposals. Funding is available for research travel. We would like the positions to commence in the summer of 2018, several months before the JWST launch in October. We expect that each position will be funded for 2 years or more.

Applications are due to the NASA Postdoctoral Program (NPP) by November 1. Interested researchers should contact Tom Greene (tom.greene@nasa.gov) at least 3 weeks before this date to discuss suitability and the NPP application proposal.

Exoplanet position: https://npp.usra.edu/opportunities/details/?ro=19114
Brown dwarf / protostar position: https://npp.usra.edu/opportunities/details/?ro=19125

Postdoctoral Position in Astrochemistry at Leiden Observatory

A 3-year postdoctoral position is available within the Molecular Astrophysics group of Prof. dr. E.F. van Dishoeck located at Leiden Observatory focused on protostellar and protoplanetary disk chemistry models, with the ultimate goal to follow the chemistry from collapsing cores to exoplanet atmospheres.

The position is part of the Dutch Astrochemistry Network funded by the Netherlands Organisation for Scientific Research (NWO). The project is linked to guaranteed time JWST-MIRI observations and aims to develop non-LTE excitation models of small molecules to analyze the JWST spectra and infer abundances and physical parameters. In addition, the sensitivity of chemical networks to photodissociation branching ratios will be investigated. The postdoc is expected to co-supervise PhD or MSc students and is encouraged to also pursue a personal research program. The position can start anytime up to fall 2018.

Candidates with a Master degree in astronomy, chemistry or physics and with an interest in astrochemistry are encouraged to apply.

Leiden Observatory carries out observational, interpretative and theoretical research in the fields of astrochemistry, star and planet formation, laboratory astrophysics, galactic structure, the formation, dynamics and evolution of (high-redshift) galaxies and their nuclei, and cosmology. Leiden is a charming town, located close to a major airport.

Applications should include a curriculum vitae, publication list, and a brief statement of research experience and interests, and arrange for at least two letters of reference to be uploaded on the relevant website. Review of applications will start on November 1 2017.

Website for submission: http://jobs.strw.leidenuniv.nl/2017/dishoeckPD/

Dutch Astrochemistry Network: http://www.nwo.nl/en/research-and-results/programmes/Astrochemistry

Leiden Observatory: http://www.strw.leidenuniv.nl/~ewine/

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.

Meetings

Astrochemistry: Past, Present, and Future
A meeting in celebration of Ewine van Dishoeck

July 10th-13th, 2018, Caltech - Pasadena, CA, USA

Astrochemistry, the study of molecules in astrophysical environments, has become an invaluable part of astrophysical studies ranging from planet forming disks to high-z galaxies. This development was made possible by the arrival of a suite of new telescopes in the past decade Spitzer, Herschel and ALMA and was realized by the pioneering work and ongoing leadership by Ewine van Dishoeck. To honor Ewines outstanding contributions to astrochemistry this 4-day meeting will review the successes in astrochemistry in unveiling star and planet formation, present ongoing astrochemical theoretical and laboratory studies, and observational investigations focused on ALMA, and peer into the future of astrochemistry in the age of JWST.

The meeting is organized around five science themes:

1. The astrochemical water trail
2. Photon-dominated regions during star and planet formation
3. Origins of astrochemical complexity
4. Role of dust and grain growth for planet formation
5. Chemistry as a tracer of physics in astronomical environments

Within each theme, we imagine exploring the past, present, and future questions that characterize(d) it, and discuss how observations, theory, laboratory efforts and new instrumentation contribute(d) to solving these questions.

Invited (confirmed) speakers: Ted Bergin, John Black, Paola Caselli, Ilse Cleeves, Neal Evans, Edith Fayolle, Kenji Furuya, Thomas Henning, Eric Herbst, Lars Kristensen, Thanja Lamberts, Harold Linnartz, David Neufeld, Paola Pinilla, Nami Sakai, Leonardo Testi, Xander Tielens, Floris van der Tak & Catherine Walsh

For further information and pre-registration, please see the conference website at:

http://www.cfa.harvard.edu/events/2018/astrochem18

SOC: Agata Karska, Karin Öberg, Jes Jørgensen (co-chairs)
Ruud Visser, Nienke van der Marel, Frank Helmich, Michiel Hogerheijde, Maria Drozdovskaya, Geoff Blake

Star Formation and Young Stars in Cygnus

Keele University, UK, from 31st January - 2nd February 2018

The Cygnus star forming complex is the nearest truly massive star forming region to the Sun. It is home to hundreds of thousands of young stars and many thousands of massive O and B-type stars, in multiple star clusters and OB associations, including the prominent Cygnus OB2 association. In the massive Cygnus X giant molecular cloud star formation is still ongoing in numerous sites, particularly the DR21 molecular filament, which is actively forming massive stars. The region has drawn comparison with young massive clusters and star forming regions in our galaxy and in neighbouring galaxies, yet at a distance of only 1.4 kpc it can be studied at a level of detail not accessible to more distant regions.

Following many exciting results from NASA's Spitzer and Chandra space telescopes and ESA's Herschel Space Observatory we are poised to enter a new era of discovery thanks to upcoming data releases from ESA's astrometric Gaia satellite and forthcoming spectrosopic surveys with WEAVE/WHT. This workshop will bring together experts in the Cygnus region to present recent results and discuss our understanding of the entire Cygnus star forming complex.

The final day of the meeting will focus on planning the upcoming WHT/WEAVE survey of Cygnus (P.I. A. Herrero) and will be open to survey members and interested individuals from WEAVE member countries.

There is no registration fee for this meeting, but the number of participants will be limited so prior registration is required. If you would like to attend please send an email to nick.nwright@gmail.com including your full name and affiliation.

If you would like to present an oral contribution at the meeting please also send a title and brief abstract by 1st December 2017. We will endeavour to provide all attendees with an opportunity to present their work.

Organisers: Nick Wright (Keele University) and Artemio Herrero (Instituto de Astrofisica de Canarias)

Conference website: http://www.astro.keele.ac.uk/cygnus

Water during planet formation and evolution 2018

12-16 February 2016 University of Zurich, Switzerland

The workshop will focus on processes governing the delivery of water to planetary bodies in solar and exoplanetary systems, during their formation and long-term evolution. The respective roles of water (ice) inheritance from the interstellar medium, condensation in the protoplanetary nebula and processing and delivery during accretion will be discussed. We will further consider in detail the implications of the late-stage impact phase and long-term consequences for the remarkable diversity of processes affecting the water budget during the evolution of a planetary body. The goal of the workshop is to critically assess the interplay of theory and observations/experiments on the effects of water on planets and establish new research directions.

Confirmed speakers:

Til Birnstiel (LMU Munich), Ilsedore Cleeves (CfA Harvard), Jay Farihi (University College London), Keiko Hamano (ELSI, Tokyo Tech.), Alessandro Morbidelli (Nice Observatory), Lena Noack (FU Berlin), Chris Ormel (University of Amsterdam), Laura Schaefer (Arizona State University), Alice Stephant (Open University).

Meeting organisers:

Joanna Drazkowska (University of Zurich), Tim Lichtenberg (ETH Zurich), Caroline Dorn (University of Bern), Julia Venturini (University of Zurich).

Scientific advisory board:

Yann Alibert (University of Bern), Ravit Helled (University of Zurich), Anders Johansen (Lund University), Martin Jutzi (University of Bern), Alessandro Morbidelli (Nice Observatory), Sascha Quanz (ETH Zurich), Maria Schönbächler (ETH Zurich), Ewine van Dishoeck (Leiden University).

https://waterzurich.github.io/

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ALMA North America-Taiwan Joint Conference

Magnetic Fields or Turbulence: Which is the critical factor for the formation of stars and planetary disks?

6-9 February 2018 at the National Tsing-Hua University in Taiwan

The unprecedented high sensitivity of ALMA provides the best opportunity so far to resolve one of the most debated questions in star formation: whether magnetic fields or turbulence play a critical role?

Since ALMA has started to produce magnetic field measurements for a few years, we will host a conference in Taiwan to promote the discussion on this important question. We have invited a group of established as well as young and upcoming researchers to present reviews, new results from ALMA, and important complementary observations from other telescopes, including SMA, BLAST-pol, HAWC+ on SOFIA, etc.

While the focus of this conference is on magnetic fields and turbulence, you are welcome to present related work on star formation studies.

Participants with divergent backgrounds will be beneficial for discussion of our conference topic.

Confirmed invited speakers: Shantanu Basu, Blakesley Burkhart, Dick Crutcher, Edith Falgarone, Laura Fissel, Chat Hall, Hua-Bai Li, Zhi-Yun Li, Hauyu Baobab Liu, Susana Lizano, Anaelle Maury, Thushara Pillai, Qizhou Zhang.

Scientific Organizing Committee (SOC): Crystal Brogan (Deputy NRAO/ALMA program scientist), Josep Miquel Girart (CSIE-IEEC), Patrick Koch (ASIAA/EASAC), Shih-Ping Lai (NTHU/ANASAC, co-chair), Zhi-Yun Li (Virginia), Leslie Looney (UIUC, co-chair), Giles Novak (Northwestern/ANASAC), Ramprasad Rao (ASIAA), Ya-Wen Tang (ASIAA), Qizhou Zhang (CfA).

More detailed information and registration instructions (early bird registration rate until November 15!!) are published on the conference website:

http://events.asiaa.sinica.edu.tw/workshop/20180206/

We invite you to register for this conference, and we look forward to your contributions!

Sincerely, Crystal Brogan on behalf of the North American ALMA Science Center

Summary of Upcoming Meetings

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

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

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

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

Star Formation and Young Stars in Cygnus
31 Jan - 2 Feb 2018, Keele, UK
http://www.astro.keele.ac.uk/cygnus

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

Water during planet formation and evolution 2018
12-16 February 2016, Zürich, Switzerland
https://waterzurich.github.io/

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

The Olympian Symposium 2018: Gas and stars from milli- to mega- parsecs
28 May - 1 June 2018, Mt. Olympus, Greece
http://www.olympiansymposium.org

Astrochemistry: Past, Present, and Future
10 - 13 July, 2018, Pasadena, USA
http://www.cfa.harvard.edu/events/2018/astrochem18

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

Short Announcements

Fizeau exchange visitors program - call for applications

Dear colleagues!

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

The deadline for applications is October 15. Fellowships can be awarded for missions to be carried out between December2017 and May 2018!

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

The program is funded by OPTICON/H2020.

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

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