THE STAR FORMATION NEWSLETTER

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

No. 283 — 12 July 2016 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

The Star Formation Newsletter

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

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List of Contents

Cover Picture

The image, obtained with the Hubble Space Telescope, shows photoevaporating globules embedded in the Carina Nebula.

Image courtesy NASA, ESA, N. Smith (University of California, Berkeley), and The Hubble Heritage Team (STScI/AURA)

Submitting your abstracts

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Martin Cohen

in conversation with Bo Reipurth

Q: *What was your thesis about?*

A: My thesis was about T Tauri stars and their life cycles. I was influenced as a youngster in the U.K. by Patrick Moore's weekly show 'The Sky At Night' and when I chose Astronomy as a career path my mentors were David Allen and Len Kuhi.

Q: *The famous Cohen-Kuhi atlas of spectra of young stars appeared in 1979 and is one of the most cited papers about young stars. What was the genesis of that project?*

A: George Herbig had assembled a relatively small list of optically visible T Tauri stars which became the genesis of our multiwavelength atlas, enlarging this limited number of T Tauris and adding infrared observations to conventional data. It grew from infrared to multiwave length observations which required use of a wide range of telescopes and techniques to obtain the data. Optical data were obtained from Kitt Peak Observatory, the Mt. Lemmon and the Lick Observatory. Data reduction was conducted using a first-generation portable computer to convert the raw data to meaningful numbers. The project spanned 100 nights at Lick and 2 years at the Mt. Lemmon Observatory. These observations led to the recognition that T Tauris were of great interest even in the optical region. This further led to a better understanding of the life cycle of these stars.

Q: *In 1980 you published your RNO-catalog of red and nebulous objects which has been used a lot in studies of young stars as they emerge from their embedded state. What is the background for that project?*

A: This catalogue was generated over many nights at Kitt Peak Observatory during which the weather was too poor to open the telescope. As I didn't want to waste my time, I inspected archival optical images of large sections of the sky in which potentially interesting objects might be located. I observed some of the objects on the list at Lick Observatory seeking optical confirmation. Convinced that these were objects of interest, I released my catalogue of objects. Shortly thereafter, others began using and referring to the catalogue.

Q: *In the early 1980s, you and Dick Schwartz worked closely on determining the locations and properties of the driving sources of Herbig-Haro objects. What were the issues back then?*

At that time there were discussions about the nature of the energy sources of HH objects. Were they a special category of stars, or would all stars go through phases when they produced shocked outflows? While some of these HH driving sources were optically visible stars, many others were only detectable at infrared wavelengths, and they were a challenge to identify in the days of single-pixel detectors. The catalog of sources discovered by the IRAS satellite was an incredible new resource when it appeared in the mid-1980s, in a way that may be difficult to appreciate today when we have all-sky catalogs of, say, 2MASS, WISE, and AKARI. I worked with Dick Schwartz to determine the location, luminosities, and other properties of several dozen HH energy sources based on both groundbased and IRAS data. We were also interested in the short-term variability of these sources, and at Kitt Peak we did simultaneous observations, I covered the infrared and Dick covered the optical, and we observed our targets at exactly the same time. But shortly after we began, the two telescopes we used were closed. The field was changing towards the use of larger telescopes for cosmology, making it difficult to get data for small stellar projects.

Q: *In 1982 you, with John Bieging and Phil Schwartz, used the VLA to detect 4.8 GHz (6 cm) free-free radio continuum emission from 6 out of 24 T Tauri stars. This has of course today developed into an extremely powerful technique. What motivated you to search for such emission back then?*

A: I had met Phil Schwartz at the VLA and John Bieging was a colleague at UC Berkeley, and the subject was an obvious match of our interests. Later casual discussions led to the realization that it would be a natural extension to revisit the T Tauri stars at radio wavelengths to look for changes in their radio emission. And indeed, it extended what was known about the behavior of such radio variations over time.

Q: *In 1983 you were among the first to argue that T Tauri stars were surrounded by disks, specifically you suggested that HL Tauri had a disk, as ALMA spectacularly has recently imaged. What were the arguments?*

A: My belief in the presence of a disk around HL Tauri was based upon observations made on a wide variety of instruments. I decided that the effort should be combined with far infra-red data from the Kuiper Airborne Observatory which provided us with a huge amount of new data.

At this time, we were also leaning heavily on data in the radio region. Consequently, I worked to bring together all these disparate observations and techniques into a case for anisotropic mass-loss from T Tauri stars that built upon previous work that Gary Schmidt and I had published. With the Kuiper we were able to measure the emission from HL Tau at 52 and 100 μm at 11 positions around the star. We found essentially a point source but with possible elongation along a roughly NE to SW axis. The steeply rising far-infrared energy distribution of HL Tau turned out to be very different from the few other T Tauris that had been measured up to that time and which turned down beyond 20 μm. Combined with the detection of a blueshifted CO outflow and a 140° polarization vector, these data were best interpreted in terms of a disk. We also used as a paradigm those extreme carbon stars which were surrounded by dust rings. It is gratifying to see that work done under more primitive circumstances is confirmed by modern techniques. And it was far more exciting to fly in and observe from the Kuiper than to remain earthbound!

Q: *You have been studying cometary nebulae around young stars, for example PV Cephei and the Chamaeleon Infrared Nebula. What did you learn?*

A: Cometary nebulae represent an interesting phase when young stars emerge from their embedded state and begin illuminating their surroundings, and they were an interest of mine from my student days. There was a race between astronomers in Russia and myself to discover new ones. Although the Russians had access to the then largest ground-based telescope in the world, its optics was flawed. During my PhD years, I assiduously followed their efforts in the near-infrared which were less affected by these optical problems. Subsequently, I was delighted to be able to observe, using infrared techniques, many more cometary nebulae. Conducting this research allowed me to observe with a wide variety of telescopes around the world - quite a thrill for a young astronomer. These trips even led to a book. Unfortunately it is not as easy for young astronomers today to obtain time on many of these instruments.

Q: *At some point you switched from observing young stars to studying evolved stars. What motivated that change?*

A: The US Air Force had produced a large catalogue of objects whose existence was challenged by astronomers in Tucson. I received a grant to find a set of these objects and verify their existence and characteristics. Having achieved this goal, I realized that this would be an exciting new direction for my research. Mike Barlow and I attended a meeting on massive stars where I was able to adduce data proving that the Air Force catalog would be a major contribution to Astronomy. There were so many possibilities of things to look at within the Air Force catalog that it was necessary to whittle down the list which included several stars that were old friends. I selected quite a number of evolved stars, some of which were notoriously interesting. I then followed this line of research for a number of years.

Q: *In later years you have been heavily involved in the question of calibration issues in the infrared, and have published a long series of papers on the topic. How did you get involved in this problem, and what remains to be done?*

A: The early 1990s saw rapid and exciting growth in the infrared field, and everybody wanted to work in that wavelength region. It was easy to purchase custom-made filters. As a consequence one could encounter filters given the same wavelength name, but significantly different from observatory to observatory. This led to chaos and consequently I undertook a project to identify all the different infrared filters that were currently in use. To do this, I interviewed (pestered) as many colleagues as I could convince to share their information. The goal of this was to provide a unified set of filter bands. This led to a self-consistent network of mid-infrared stars that could be used as fiducial stars across the sky. We provided the locations and accurate flux densities for each star, and there the project might have come to an end if not for the US Air Force and the Department of Defense which requested an all sky network with a specified separation between stars so as to provide fiducial stars anywhere across the sky. DOD also specified that all stars of our network were to be absolutely accurate in their stated flux densities to an error below 1%. But in the early years of infrared astronomy, the assumption that every potential calibrator radiated as a blackbody at its effective temperature led to the neglect of important absorption features, resulting in specious 'bumps' and wrongly shaped continua. Instead we tied calibrations directly to Sirius and Vega. At that time I was also working with colleagues in Japan who were planning to launch a new satellite, the AKARI mission, but needed guaranteed accurate fiducial stars in the various parts of the sky that the satellite would observe. The opportunity to test out our network was too good to pass up. So I went back to Japan taking a list of about 200 fiducial stars as ammunition and these stars provided good support for that mission. From that point on, I was able to support missions launched by various space agencies around the world. Ultimately, this work grew into a 'cottage industry' that provided absolute spatial data for over 20,000 stars and it continues to be of value to the DOD and anyone who uses the material. Over three years, using MSX, the DOD compared in orbit the brightness of many stars and vindicated my predictions to within less than 1%. Interest in calibration waxes and wanes but I assume that in the future, the need for it will be recognized if not always provided for in the budgets of new missions.

Perspective

HR 8799: The Benchmark Directly-Imaged Planetary System

Thayne Currie

1 Introduction

In March 2008, Christian Marois noticed one (Figure 1, left panel), and then two, faint point sources located at a projected separation of 68 and 38 au from the nearby, dusty A5 star HR 8799. Follow-up observations in July–September 2008 confirmed that these objects were bound companions and added a third at $\rho \sim 24$ au (Marois et al. 2008, hereafter Ma08). Two years later, Marois et al. (2010) announced the discovery of a fourth companion at $\rho \sim 15$ au: HR 8799 e (Figure 1, right panel). Given the estimated age of the system ($t \sim 30$ Myr, Ma08, Baines et al. 2012), HR 8799 bcde's low luminosities imply masses of $\approx$ 5–7 M_J, below the deuterium-burning limit (≈ 13 M_J) nominally separating planets from brown dwarfs. Analyses focused on atmospheric modeling (Currie et al. 2011, hereafter Cu11), dynamical stability (Marois et al. 2010; Cu11), and formation (Kratter et al. 2010; Cu11) likewise corroborate the conclusion that HR 8799 bcde are bona fide planets, not brown dwarfs.

The HR 8799 planetary system resembles a scaled-up version of our outer solar system. The planets orbit in between a warm dust belt ($r_{inner} \approx$ 6-12 au) and a cold Kuiper belt-like structure at $r_{outer} \approx$ 90–145 au (Su et al. 2009; Booth et al. 2016). Due to HR 8799's higher luminosity, the planets and dust belt populations receive about as much energy as the solar system's gas/ice giant planets and asteroid belt/Kuiper belt receive from the Sun.

HR 8799 harbors arguably not just the *first* directly-imaged planets[1] but among the best studied ones. Photometry and/or low-resolution spectroscopy for HR 8799 bcde span 1–5 μm (e.g. Cu11; Barman et al. 2011; Galicher et al. 2011; Zurlo et al. 2016). HR 8799 bc have 1.4–2.5 μm medium-resolution spectroscopy (Konopacky et al. 2013; Barman et al. 2015). After the reported discovery of HR 8799 bcd, multiple studies revealed at least one of the HR 8799 planets from data between 1998 and 2007 (e.g. Lafreniere et al. 2009; Metchev et al. 2009; Soummer et al. 2011; Currie et al. 2012a). The planets have been imaged by nearly all other 5–8 m telescopes with adaptive optics systems (e.g. Cu11; Currie et al. 2014; Ingraham et al. 2014; Oppenheimer et al. 2013; Zurlo et al. 2016).

This wealth of data makes HR 8799 a benchmark system for studying the atmospheres, orbital properties, dynamical stability, and formation of young superjovian planets.

2 HR 8799 bcde as a Probe of Young Jovian Planet Atmospheres

HR 8799 bcde provide the first glimpse at how the atmospheric properties of young, self-luminous planets compare to both old field brown dwarfs and younger, lower-mass brown dwarfs. Typical luminosity evolution models (e.g. "hot start" models) predict that directly-imaged, superjovian (5–10 M_J) planets between 10 and 100 Myr old cover a temperature range of $\approx$ 600 to 1800 K characteristic of field early L to late T dwarfs (e.g. Baraffe et al. 2003; Burrows et al. 2006; Stephens et al. 2009). Coarsely speaking, the L to T transition at $\approx$ 1200–1400 K (for the field) covers a transition from an object with a near-infrared spectrum lacking methane absorption and a cloudy atmosphere to an object with near-infrared methane absorption and weaker/negligible clouds (Saumon & Marley 2008). For ages of ~ 30 Myr and masses of 5–7 M_J, standard luminosity evolution models predict that the HR 8799 planets should, if like field objects, have temperatures of T_{eff} $\approx$ 850–1100 K characteristic of mid/late field T dwarfs (Stephens et al. 2009).

Ma08 found hints of differences between the HR 8799 planets' infrared (IR) colors and the field L/T dwarf sequence. Subsequent studies that focused on a wider range of HR 8799 planet colors reveal clear departures from the field se-

[1] While Fomalhaut b was announced on the same day as HR 8799 bcd and claimed to produce variable, accretion-driven emission at 0.6 μm and thermal emission at longer wavelengths (Kalas et al. 2008), later work cast doubt on its existence (Janson et al. 2012) and then showed that instead Fomalhaut b is made visible entirely by circumplanetary dust emission (Currie et al. 2012b; Galicher et al. 2013). Thus, it is on slightly shakier ground and instead, as noted in Currie et al. (2012b), is likely a "planet [of unknown mass] identified by direct imaging but not a directly-imaged planet." While other planet-mass objects were announced prior to HR 8799 bcd (e.g. 2M 1207 B; Chauvin et al. 2004), their lower mass ratios (compared to the primary) and/or wider separations suggest that they represent the low-mass tail of the substellar mass function.

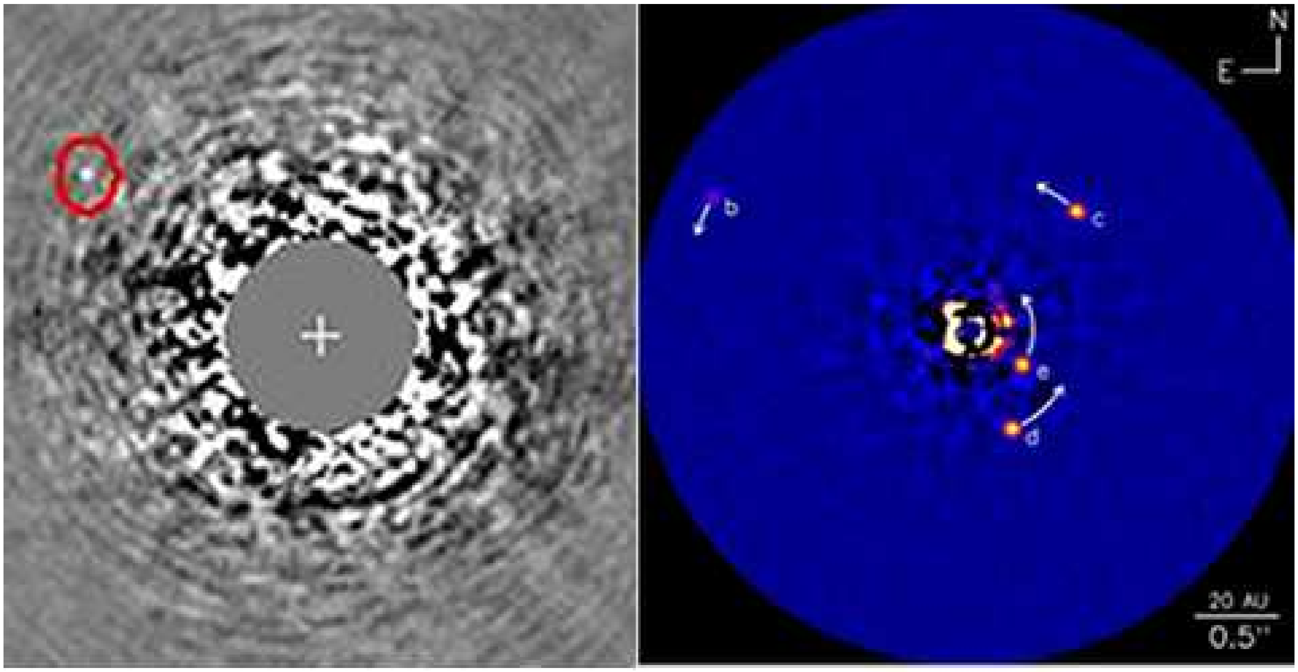

Figure 1: (left) The first direct image of an extrasolar planet: detection of HR 8799 b from October 2007 Gemini/NIRI data reduced in March 2008, the first of three planets (HR 8799 bcd) announced by Marois et al. (2008). (right) Image of HR 8799 bcde from November 2009 Keck/NIRC2 data (Marois et al. 2010) depicting the planets' counterclockwise orbital motion. The planets' discoveries were enabled by advances in observing and image processing techniques (e.g. Marois et al. 2006; Lafreniere et al. 2007).

quence (Bowler et al. 2010; Cu11). Compared to mid/late T dwarfs, HR 8799 b(cd) are up to 2.5 (1.5) magnitudes redder (Cu11). Generally speaking, HR 8799 bcde appear to lie on a reddened extension of the L dwarf sequence past the field L/T transition to fainter magnitudes, a sparsely populated region whose other members are almost unanimously young, low (planetary) mass, and low gravity (e.g. Bonnefoy et al. 2016).

The HR 8799 planets' IR spectral shapes likewise reveal differences with field objects but (imperfect) similarities with young, dusty, and low-gravity/mass brown dwarfs. Although formally no object appears well matched to HR 8799 bc's combined near-IR spectra and thermal IR photometry, reddened versions of the youngest T0 dwarf spectra reproduce their spectra well (Bonnefoy et al. 2016). HR 8799 de appear best matched by particularly red and dusty/low gravity L6-L8 dwarfs which likewise deviate from the field sequence. However, fitting near IR and thermal-IR data simultaneously remains challenging.

As shown in Cu11, the HR 8799 planets appear different than field brown dwarfs of the same effective temperatures in large part because they have thicker clouds (Figure 2). Thicker clouds change the optical depth profile as a function of wavelength, making it more uniform in and out of major molecular opacity sources (e.g. water) since the τ = 1 surface is achieved at a more uniform altitude. The planet spectrum appears redder and more blackbody like. Furthermore, the clouds may be non-uniformly distributed or "patchy" (Cu11) with 10-50% of the visible surface covered by thinner clouds/cloudless regions.

Additionally, at least some HR 8799 planets show clear evidence for non-equilibrium carbon chemistry (Barman et al. 2011a; Galicher et al. 2011; Skemer et al. 2012). In addition to the absence of strong CH_4 absorption in HR 8799 b's low-resolution near-IR spectrum, at longer wavelengths at least some of the planets exhibit weak to negligible methane absorption at 3.3 μm and enhanced CO absorption at 5 μm (Galicher et al. 2011; Skemer et al. 2012). Medium-resolution near-IR spectra for HR 8799 bc reveal molecular species in the planets' atmospheres and additional evidence for non-equilibrium carbon chemistry (Konopacky et al. 2013; Barman et al. 2015).

The planets' low surface gravities (and, thus, their youth and low mass) explain both thick clouds and non-equilibrium carbon chemistry. Lower gravities (log(g) $\sim$ 4 instead of $\sim$ 5 for field objects; Cu11, Konopacky et al. 2013) yield temperature-pressure profiles more characteristic of hotter, cloudier L dwarfs (Madhusudhan et al. 2011).

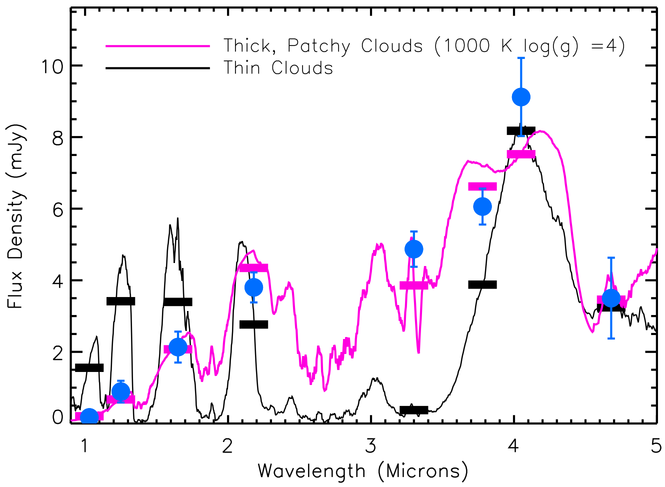

Figure 2: Modeling HR 8799 d. Thin cloud models (black) more appropriate for field T dwarfs overpredict (underpredict) HR 8799 bcde's brightness in the near (mid) IR. Those invoking thick, patchy clouds (90% very thick, 10% moderately thick) provide a far better match (Cu11).

Lower gravities also move the depth at which carbon-based chemical reactions (i.e. $CO+3H_2$ <-> CH_4+ H_20) are quenched deeper in the atmosphere, resulting in an over-abundance of CO (Barman et al. 2011a; Marley et al. 2012). Other young, directly-imaged 5–13 M_J planetary-mass objects with a range of temperatures also show evidence for thicker clouds and/or non-equilibrium carbon chemistry (e.g. ROXs 42Bb and 2M 1207 B, Currie et al. 2014b; Barman et al. 2011b), although the lowest mass, coldest and oldest imaged planets have very different spectra (Kuzuhara et al. 2013; Macintosh et al. 2015).

3 The Orbits of HR 8799 bcde

HR 8799 bcde's orbits provide crucial input for studying the configuration of multi-planet systems and a limit on the planets' masses. Soon after HR 8799 bcd were announced, Fabrycky & Murray-Clay (2010) noted that for nominal face-on orbits and nominal masses, the system would be dynamically unstable in 0.1 Myr, far less than the system age. Placing these planets in a 4:2:1 orbital resonance makes the system dynamically stable for tens of Myr up to masses of 10–20 M_J. However, a 4th planet at 15 au makes dynamical stability more challenging, favoring masses of 5 (7) M_J or less for HR 8799 b (cde) and precluding masses above 13 M_J (Marois et al. 2010; Cu11). Assuming different orbital properties (e.g. inclined orbits) further lowers the maximum allowable planet masses (e.g. less than 10 M_J; Sudol & Haghighipour 2012).

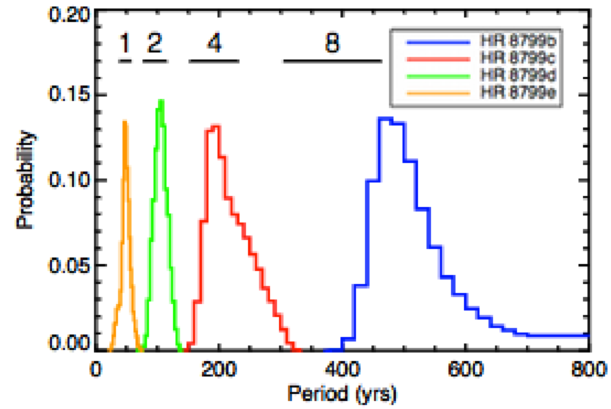

Figure 3: Range of orbital periods for different orbital solutions from Konopacky et al. (2016), showing that HR 8799 bcde may be in an 8:4:2:1 resonance.

HR 8799 bcde are not in face-on orbits but instead are inclined between 20 and 45^o from face-on (Soummer et al. 2011; Currie et al. 2012a; Pueyo et al. 2015; Konopacky et al. 2016), similar to HR 8799 A's rotation axis and the inclination of the star's cold debris disk (Reidemeister et al. 2009; Booth et al. 2016). Circular orbits are formally consistent with the data for all planets (Currie et al. 2012; Konopacky et al. 2016). HR 8799 bcd's allowable orbits include a stabilizing 4:2:1 resonance, a possible outcome of the planets' formation/migration histories (Figure 3, Konopacky et al. 2016; Gozdziewski & Migazewski 2014). However, it is unclear whether a 2:1 or 3:2 resonance is favored between HR 8799 d and e (Zurlo et al. 2016).

The planets' relative inclinations are uncertain. Currie et al. (2012) argue that coplanar orbits comprise a small fraction of acceptable orbits drawn from 1998-2010 measurements but are still possible; Pueyo et al. (2015) suggest that the planets' orbits are not coplanar. While Konopacky et al. (2016) find no evidence for non-coplanarity from a set of self-consistently reduced data sets originating from the same telescope/instrument configuration, they do not consider astrometry for HR 8799 d (bc) prior to 2007 (2004), measurements largely responsible for favoring non-coplanarity.

4 Formation

HR 8799 bcde are important tests of jovian planet formation. Forming 5–7 M_J planets at 25–70 au in situ by core accretion is extremely difficult, consistent with the fact that HR 8799-like planetary systems are extremely rare (e.g. Galicher et al. 2016). The mass ratios and separations of the HR 8799 planets are contiguous with the population of radial-velocity/transit detected planets, at least some of which formed by core accretion (Kratter et al. 2010; Cu11). Nevertheless, uncommon conditions – a particularly massive disk, very rapid and efficient build up of protoplanetary cores, and/or scattering of massive cores to wider separations prior to runaway gas accretion (e.g. Kenyon & Bromley 2009; Cu11; Lambrechts and Johansen 2012)– are likely required to explain HR 8799 bcde.

Atmospheric chemistry may also provide clues to HR 8799 bcde's formation. If the planets formed by disk instability, their atmospheres should have solar C/O ratios; if they formed by core accretion near their current locations with a modest intake of solids, they should have enhanced C/O (Oberg et al. 2011). While HR 8799 c may have an enhanced C/O ratio, HR 8799 b's C/O ratio is less constrained (Konopacky et al. 2013; Barman et al. 2015).

5 Future Prospects

Many challenges remain in better understanding the atmospheres, orbits, and formation of the HR 8799 planets. For example, HR 8799 b remains a sort of "Kobayashi Maru" test for planet atmosphere models[2], as not a single one has reproduced all of the planet's spectrophotometry while yielding parameters (e.g. mass, radius) that are physically plausible and consistent with other constraints (planet cooling models; dynamical stability limits). Likely (partial) solutions to this problem include updated near-IR opacities and a better understanding of clouds at low gravities. By 2019, we will have astrometric points for roughly 20% of HR 8799 d and e's orbit. New data combined with a self-consistent reanalysis of older astrometry will be needed to better constrain key orbital properties (e.g. resonances, eccentricities, and coplanarity).

The next generation of extremely large telescopes will provide powerful probes of the HR 8799 planets' chemical abundances, gravity, and formation history. For example, the *IRIS* integral field spectrograph on the *Thirty Meter Telescope* covers 0.8–2.5 μm and should be capable of providing high signal-to-noise spectra of all four planets at R = 4000–8000, building upon previous Keck/OSIRIS studies of HR 8799 bc at H and K_s bands (Konopacky et al. 2013; Barman et al. 2015). Such data should resolve multiple gravity sensitive lines and better determine abundances of multiple species. As a result, we may better constrain the C/O ratio and formation environment for planets of comparable mass from 15 au to 70 au.

[2]Portrayed in Star Trek II: The Wrath of Khan (and in the 2009 franchise reboot), the *Kobayashi Maru* test is simulation in which Starfleet cadets captain a starship to rescue a freighter and are subsequently ambushed by three Klingon battlecruisers. It is designed such that saving the ship is impossible, thus testing how cadets deal with a "no-win scenario". James T. Kirk nevertheless beat it by "changing the rules of the game" (cheating) to allow the ship to be saved. We cannot similarly change the atmospheres of extrasolar planets so that our models fit them.

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Abstracts of recently accepted papers

Mid Infrared View of the High Mass Star Formation Region W51A

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In this paper we present the results of a mid infrared study of G49.5−0.4, or W51A, part of the massive starbirth complex W51. Combining public data from the *Spitzer* IRAC camera, and Gemini mid infrared camera T-ReCS at 7.73, 9.69, 12.33 and 24.56 μm, with spatial resolution of $\sim 0\farcs5$, we have identified the mid infrared counterparts of 8 ultracompact HII regions, showing that two radio sources are deeply embedded in molecular clouds and another is a cloud of ionized gas. From the T-ReCS data we have unveiled the central core of W51 region, revealing massive young stellar candidates. We modeled the spectral energy distribution of the detected sources suggesting the embedded objects are sources with spectral types ranging from B3 to O5, but the majority of the fits indicate stellar objects with B1 spectral types. We also present an extinction map of IRS 2, showing that a region with lower extinction corresponds to the region where a proposed jet of gas has impacted the foreground cloud. From this map, we also derived the total extinction towards the enigmatic source IRS 2E, which amounts to ∼60 magnitudes in the V band. We calculated the color temperature due to thermal emission of the circumstellar dust of the detected sources; the temperatures are in the interval of ∼100–150 K, which corresponds to the emission of dust located at 0.1 pc from the central source. Finally, we show a possible mid infrared counterpart of a detected source at mm wavelengths that was found by Zapata et al. (2008, 2009) to be a massive young stellar object undergoing a high accretion rate.

Accepted by ApJ

http://arxiv.org/pdf/1606.03512

Astrometry and Expanding Bubble of a Deeply Embedded YSO in M17

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We measured the trigonometric parallax of H_2O maser source in M17 cluster forming region to be 0.491 ± 0.041 mas, corresponding to a distance of $2.04^{+0.16}_{-0.17}$ kpc with 8% accuracy. This result is consistent with VLBA previous parallax measurement of 12.2 GHz ch masers in M17-UC1. We performed the first measurement of the relative proper motions

of the H_2O maser feature 2 (of Johnson et al. 1998), and its morphology trace an expanding arcuate shell with mean motion of ~ 19.4 km s^{-1}. The redshifted maser component also show expanding motion. Fitting a uniformly expanding spherical flow model, we estimated the most probable position and motion of the driving source and propose that the motion of the masers trace and expanding bubble from a central source, with a dynamical time-scale of ~ 12.5 years. This is the first evidence that maser 2 cluster is driven internally. There is no known counterpart 2MASS, WISE or radio source around this H_2O masers. But Spitzer point source catalog has a source that is spatially coincident with the position of the H_2O masers. The was detected only in the Spitzer's 4.5 and 5.8 μm (magnitudes as 9.97±0.12 and 7.82±0.10 mag, respectively) bands. The non-detection at other wavelength could indicate that the source is yet at a very early formative stage, and/or very deeply embedded and obscured in its formative environment.

Accepted by MNRAS

Hot and dense water in the inner 25 AU of SVS13-A

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In the context of the ASAI (Astrochemical Surveys At IRAM) project, we carried out an unbiased spectral survey in the millimeter window towards the well known low-mass Class I source SVS13-A. The high sensitivity reached (3–12 mK) allowed us to detect at least 6 HDO broad (FWHM $\sim$ 4–5 km s^{-1}) emission lines with upper level energies up to $E_{\rm u} = 837$ K. A non-LTE LVG analysis implies the presence of very hot (150–260 K) and dense ($\geq 3 \times 10^7$ cm^{-3}) gas inside a small radius ($\sim$ 25 AU) around the star, supporting, for the first time, the occurrence of a hot corino around a Class I protostar.
The temperature is higher than expected for water molecules are sublimated from the icy dust mantles ($\sim$ 100 K). Although we cannot exclude we are observing the effects of shocks and/or winds at such small scales, this could imply that the observed HDO emission is tracing the water abundance jump expected at temperatures $\sim$ 220–250 K, when the activation barrier of the gas phase reactions leading to the formation of water can be overcome. We derive $X(HDO) \sim 3 \times 10^{-6}$, and a H_2O deuteration $\geq 1.5 \times 10^{-2}$, suggesting that water deuteration does not decrease as the protostar evolves from the Class 0 to the Class I stage.

Accepted by MNRAS Letters

http://arxiv.org/pdf/1606.06847

A hot Jupiter orbiting a 2-Myr-old solar-mass T Tauri star

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Hot Jupiters are giant Jupiter-like exoplanets that orbit 100x closer to their host stars than Jupiter does to the Sun. These planets presumably form in the outer part of the primordial disc from which both the central star and surrounding planets are born, then migrate inwards and yet avoid falling into their host star. It is however unclear whether this occurs early in the lives of hot Jupiters, when still embedded within protoplanetary discs, or later, once multiple planets are formed and interact. Although numerous hot Jupiters were detected around mature Sun-like stars, their existence has not yet been firmly demonstrated for young stars, whose magnetic activity is so intense that it overshadows the radial velocity signal that close-in giant planets can induce. Here we show that hot Jupiters around young stars can be revealed from extended sets of high-resolution spectra. Once filtered-out from the activity, radial velocities of V830 Tau derived from new data collected in late 2015 exhibit a sine wave of period 4.93 d and semi-amplitude 75 m s^{-1}, detected with a false alarm probability $<0.03\%$. We find that this signal is fully unrelated to the 2.741-d rotation period of V830 Tau and we attribute it to the presence of a 0.77 Jupiter mass planet orbiting at a distance of 0.057 au from the host star. Our result demonstrates that hot Jupiters can migrate inwards in <2 Myr, most likely as a result of planet-disc interactions, and thus yields strong support to the theory of giant planet migration in gaseous protoplanetary discs.

Accepted by Nature

http://arxiv.org/pdf/1606.06236

VLBA determination of the distance to nearby star-forming regions VII. Monoceros R2

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We present a series of sixteen Very Long Baseline Array (VLBA) high angular resolution observations of a cluster of suspected low-mass young stars in the Monoceros R2 region. Four compact and highly variable radio sources are detected; three of them in only one epoch, the fourth one a total of seven times. This latter source is seen in the direction to the previously known UCHii region VLA 1, and has radio properties that resemble those of magnetically active stars; we shall call it VLA 1*. We model its displacement on the celestial sphere as a combination of proper motion and trigonometric parallax. The fit obtained using a uniform proper motion yields a parallax $\varpi = 1.10 \pm 0.18$ mas, but with a fairly high post-fit dispersion. If acceleration terms (probably due to an undetected companion) are included, the quality of the fit improves dramatically, and the best estimate of the parallax becomes $\varpi = 1.12 \pm 0.05$ mas. The magnitude of the fitted acceleration suggest an orbital period of order a decade. The measured parallax corresponds to a distance $d = 893^{+44}_{-40}$ pc, in very good agreement with previous, indirect, determinations.

Accepted by ApJ

http://arxiv.org/pdf/1606.01757

A WISE Census of Young Stellar Objects in Canis Major

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With the Wide-Field Infrared Survey Explorer (WISE), we searched for young stellar objects (YSOs) in a 100 deg^2 region centered on the lightly studied Canis Major star forming region. Applying stringent magnitude cuts to exclude the majority of extragalactic contaminants, we find 144 Class I candidates and 335 Class II candidates. The sensitivity to Class II candidates is limited by their faintness at the distance to Canis Major (assumed as 1000 pc). More than half the candidates (53%) are found in 16 groups of more than four members, including four groups with more than 25 members each. The ratio of Class II to Class I objects, N_{II}/N_I, varies from 0.4 to 8.3 in just the largest four groups. We compare our results to those obtainable with combined Two Micron All Sky Survey (2MASS) and post-cryogenic Spitzer Space Telescope data; the latter approach recovers missing Class II sources. Via a comparison to protostars characterized with the Herschel Space Observatory, we propose new WISE color criteria for flat-spectrum and Class 0 protostars, finding 80 and seven of these, respectively. The distribution of YSOs in CMa OB1 is consistent with supernova-induced star formation, although the diverse N_{II}/N_I ratios are unexpected if this parameter traces age and the YSOs are due to the same supernova. Less massive clouds feature larger N_{II}/N_I ratios, suggesting that initial conditions play a role in determining this quantity.

Accepted by ApJ

http://arxiv.org/pdf/1606.01896

Gas absorption and dust extinction towards the Orion Nebula Cluster

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We characterise the relation between the gas and dust content of the interstellar medium towards young stellar objects in the Orion Nebula Cluster. X-ray observations provide estimates of the absorbing equivalent hydrogen column density N_H based on spectral fits. Near-infrared extinction values are calculated from intrinsic and observed colour magnitudes $(J-H)$ and $(H-K_s)$ as given by the VISTA Orion A survey. A linear fit of the correlation between column density and extinction values A_V yields an estimate of the N_H/A_V ratio. We investigate systematic uncertainties of the results by describing and (if possible) quantifying the influence of circumstellar material and the adopted extinction law, X-ray models, and elemental abundances on the N_H/A_V ratio. Assuming a Galactic extinction law with $R_V = 3.1$ and solar abundances by Anders & Grevesse (1989), we deduce an N_H/A_V ratio of $(1.39\pm0.14) \times 10^{21}$ cm^{-2} mag^{-1} for Class III sources in the Orion Nebula Cluster where the given error does not include systematic uncertainties. This ratio is consistent with similar studies in other star-forming regions and approximately 31% lower than the Galactic value. We find no obvious trends in the spatial distribution of N_H/A_V ratios. Changes in the assumed extinction law and elemental abundances are demonstrated to have a relevant impact on deduced A_V and N_H values, respectively. Large systematic uncertainties associated with metal abundances in the Orion Nebula Cluster represent the primary limitation for the deduction of a definitive N_H/A_V ratio and the physical interpretation of these results.

Accepted by A&A

http://arxiv.org/pdf/1606.07065

Striations in the Taurus molecular cloud: Kelvin-Helmholtz instability or MHD waves?

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The origin of striations aligned along the local magnetic field direction in the translucent envelope of the Taurus molecular cloud is examined with new observations of ^{12}CO and ^{13}CO J=2–1 emission obtained with the 10 m submillimeter telescope of the Arizona Radio Observatory. These data identify a periodic pattern of excess blue and redshifted emission that is responsible for the striations. For both ^{12}CO and ^{13}CO, spatial variations of the J=2–1 to J=1–0 line ratio are small and are not spatially correlated with the striation locations. A medium comprised of unresolved CO emitting substructures (cells) with a beam area filling factor less than unity at any velocity is required to explain the average line ratios and brightness temperatures. We propose that the striations result from the modulation of velocities and the beam filling factor of the cells as a result of either the Kelvin-Helmholtz instability or magnetosonic waves propagating through the envelope of the Taurus molecular cloud. Both processes are likely common features in molecular clouds that are sub-Alfvenic and may explain low column density, cirrus-like features similarly aligned with the magnetic field observed throughout the interstellar medium in far-infrared surveys of dust emission.

Accepted by MNRAS

http://arxiv.org/pdf/1606.08858

Hα Variability in PTFO8-8695 and the Possible Direct Detection of Emission from a 2 Million Year Old Evaporating Hot Jupiter

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We use high time cadence, high spectral resolution optical observations to detect excess Hα emission from the 2–3 Myr old weak lined T Tauri star PTFO8-8695. This excess emission appears to move in velocity as expected if it were produced by the suspected planetary companion to this young star. The excess emission is not always present, but when it is, the predicted velocity motion is often observed. We have considered the possibility that the observed excess emission is produced by stellar activity (flares), accretion from a disk, or a planetary companion; we find the planetary companion to be the most likely explanation. If this is the case, the strength of the Hα line indicates that the emission comes from an extended volume around the planet, likely fed by mass loss from the planet which is expected to be overflowing its Roche lobe.

Accepted by ApJ

http://arxiv.org/pdf/1606.02701

New Circumstellar Structure in the T Tauri System

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The immediate vicinity of T Tauri was observed with the new high-contrast imaging instrument SPHERE at the VLT to resolve remaining mysteries of the system, such as the putative small edge-on disk around T Tauri Sa, and the assignment of the complex outflow patterns to the individual stars. We used SPHERE IRDIS narrow-band classical imaging in Paβ, Brγ, and the $\nu = 1$-0 S(1) line of H_2, as well as in the nearby continua to obtain high spatial resolution and high contrast images over the NIR spectral range. Line maps were created by subtracting the nearby continuum. We also re–analyzed coronagraphic data taken with SPHERE's integral field spectrograph in J- and H-band with the goal to obtain a precise extinction estimate to T Tauri Sb, and to verify the recently reported claim of another stellar or substellar object in the system. A previously unknown coiling structure is observed southwest of the stars in reflected light, which points to the vicinity of T Tauri N. We map the circumbinary emission from T Tauri S in J- and H-band scattered light for the first time, showing a morphology which differs significantly from that observed in K-band. H_2 emission is found southwest of the stars, near the coiling structure. We also detect the H_2 emitting region T Tauri NW. The motion of T Tauri NW with respect to T Tauri N and S between previous images and our 2014 data, provides strong evidence that the Southeast-Northwest outflow triggering T Tauri NW is likely to be associated with T Tauri S. We further present accurate relative photometry of the stars, confirming that T Tauri Sa is brightening again. Our analysis rules out the presence of the recently proposed companion to T Tauri N with high confidence.

Accepted by A&A

http://arxiv.org/pdf/1606.00024

Making Planet Nine: Pebble Accretion at 250–750 AU in a Gravitationally Unstable Ring

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We investigate the formation of icy super-Earth mass planets within a gravitationally unstable ring of solids orbiting at 250–750 AU around a 1 $M_\odot$ star. Coagulation calculations demonstrate that a system of a few large oligarchs and a swarm of pebbles generates a super-Earth within 100–200 Myr at 250 AU and within 1–2 Gyr at 750 AU. Systems with more than ten oligarchs fail to yield super-Earths over the age of the solar system. As these systems evolve, destructive collisions produce detectable debris disks with luminosities of $10^{-5} - 10^{-3}$ relative to the central star.

Accepted by Astrophysical Journal

http://lanl.arxiv.org/pdf/1603.08010

Proplyds around a B1 star - 42 Orionis in NGC 1977

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We present the discovery of seven new proplyds (i.e. sources surrounded by cometary Hα emission characteristic of offset ionization fronts) in NGC 1977, located about 30' north of the Orion Nebula Cluster at a distance of ~ 400 pc. Each of these proplyds are situated at projected distances $0.04 - 0.27$ pc from the B1V star 42 Orionis (c Ori), which is the main source of UV photons in the region. In all cases the ionization fronts of the proplyds are clearly pointing toward the common ionizing source, 42 Ori, and 6 of the 7 proplyds clearly show tails pointing away from it. These are the first proplyds to be found around a B star, with previously known examples instead being located around O stars, including those in the Orion Nebula Cluster around θ^1 Ori C. The radii of the offset ionization fronts in our proplyds are between ~ 200 and 550 AU; two objects also contain clearly resolved central sources that we associate with disks of radii $50 - 70$ AU. The estimated strength of the FUV radiation field impinging on the proplyds is around $10 - 30$ times less than that incident on the classic proplyds in the Orion Nebula Cluster. We show that the observed proplyd sizes are however consistent with recent models for FUV photoevaporation in relatively weak FUV radiation

fields.

Accepted by Astrophysical Journal Letters

https://arxiv.org/pdf/1606.08271

Insights from Synthetic Star-forming Regions – III. Calibration of Measurement Techniques of Star-formation Rates

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Through an extensive set of realistic synthetic observations (produced in Paper I), we assess in this part of the paper series (Paper III) how the choice of observational techniques affects the measurement of star-formation rates (SFRs) in star-forming regions. We test the accuracy of commonly used techniques and construct new methods to extract the SFR, so that these findings can be applied to measure the SFR in real regions throughout the Milky Way. We investigate diffuse infrared SFR tracers such as those using 24 μm, 70 μm and total infrared emission, which have been previously calibrated for global galaxy scales. We set up a toy model of a galaxy and show that the infrared emission is consistent with the intrinsic SFR using extra-galactic calibrated laws (although the consistency does not prove their reliability). For local scales, we show that these techniques produce completely unreliable results for single star-forming regions, which are governed by different characteristic timescales. We show how calibration of these techniques can be improved for single star-forming regions by adjusting the characteristic timescale and the scaling factor and give suggestions of new calibrations of the diffuse star-formation tracers. We show that star-forming regions that are dominated by high-mass stellar feedback experience a rapid drop in infrared emission once high-mass stellar feedback is turned on, which implies different characteristic timescales. Moreover, we explore the measured SFRs calculated directly from the observed young stellar population. We find that the measured point sources follow the evolutionary pace of star formation more directly than diffuse star-formation tracers.

Accepted by ApJ

http://arxiv.org/pdf/1606.08845

V346 Normae: First post-outburst observations of an FU Orionis star

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During their formation phase stars gain most of their mass in violent episodic accretion events, such as observed in FU Orionis (FUor) and EXor stars. V346 Normae is a well-studied FUor that underwent a strong outburst beginning in $\sim$ 1980. Here, we report photometric and spectroscopic observations which show that the visual / near-infrared brightness has decreased dramatically between the 1990s and 2010 ($\Delta R \approx 10.9^{\mathrm{m}}$, $\Delta J \approx 7.8^{\mathrm{m}}$, $\Delta K \approx 5.8^{\mathrm{m}}$). The spectral properties of this fading event cannot be explained with variable extinction alone, but indicate a drop in accretion rate by 2-3 orders of magnitude, marking the first time that a member of the FUor class has been observed to switch to a very low accretion phase. Remarkably, in the last few years (2011-2015) V346 Nor has brightened again at all near-infrared wavelengths, indicating the onset of a new outburst event. The observed behaviour might be consistent

with the clustered luminosity bursts that have been predicted by recent gravitational instability and fragmentation models for the early stages of protostellar evolution. Given V346 Nor's unique characteristics (concerning outburst duration, repetition frequency, and spectroscopic diagnostics), our results also highlight the need for revisiting the FUor/EXor classification scheme.

Accepted by MNRAS Letters

http://www.skraus.eu/papers/kraus.v346nor.2016.pdf

Spot modelling of periodic weak-line T Tauri stars observed by CoRoT in NGC 2264

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The space telescope CoRoT has provided light curves of T Tauri stars belonging to the star-forming region of NGC 2264 with unprecedented continuity and precision in the framework of a coordinated multi-wavelength observational project. We perform spot modelling of the optical light curves of five weak-line T Tauri stars whose variability is dominated by starspots. We apply two-spot and evolving single spot models in the framework of a Bayesian Monte Carlo Markov Chain approach to derive the a posteriori distribution of the starspot parameters and the inclination of the star rotation axis. We focus on the rotation periods of the spots that can provide evidence for differential rotation in those stars. We find meaningful results in the case of three stars with an inclination higher than 50° and a slow variation of the light curve amplitude. The relative difference of the spot rotation periods ranges from 0.02 to 0.05 that is 3–10 times larger than the amplitude of the differential rotation found in similar stars with Doppler imaging techniques. We conclude that the intrinsic starspot evolution, although very slow, has a significant impact on the determination of the differential rotation by means of our spot modelling approach. We estimate typical timescales for the evolution of the starspot pattern between about 20 and 50 rotation periods in our stars.

Accepted by A&A

http://arxiv.org/pdf/1606.06055

Constructing multiscale gravitational energy spectra from molecular cloud surface density PDF – Interplay between turbulence and gravity

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Gravity is believed to be important on multiple physical scales in molecular clouds. However, quantitative constraints on gravity are still lacking. We derive an analytical formula which provides estimates on multiscale gravitational energy distribution using the observed surface density PDF. Our analytical formalism also enables one to convert the observed column density PDF into an estimated volume density PDF, and to obtain average radial density profile $\rho(r)$. For a region with $N_{\rm col} \sim N^{-\gamma_{\rm N}}$, the gravitational energy spectra is $E_{\rm p}(k) \sim k^{-4(1-1/\gamma_{\rm N})}$. We apply the formula to observations of molecular clouds, and find that a scaling index of -2 of the surface density PDF implies that $\rho \sim r^{-2}$ and $E_{\rm p}(k) \sim k^{-2}$. The results are valid from the cloud scale (a few parsec) to around ~ 0.1 pc. Because of the resemblance the scaling index of the gravitational energy spectrum and the that of the kinetic energy power spectrum of the Burgers turbulence (where $E \sim k^{-2}$), our result indicates that gravity can act effectively against turbulence over a multitude of physical scales. This is the critical scaling index which divides molecular clouds into two categories: clouds like Orion and Ophiuchus have shallower power laws, and the amount of gravitational energy is too large for turbulence to be effective inside the cloud. Because gravity dominates, we call this type of cloud *g-type* clouds. On the other hand, clouds like the California molecular cloud and the Pipe nebula have steeper power laws, and turbulence can overcome gravity if it can cascade effectively from the large scale. We call this type of cloud *t-type* clouds. The analytical formula can be used to determine if gravity is dominating cloud evolution when the column

density probability distribution function (PDF) can be reliably determined.

Accepted by MNRAS

http://arxiv.org/pdf/1603.04342

Debris Disks in the Scorpius-Centaurus OB Association Resolved by ALMA

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We present a CO(2-1) and 1240 μm continuum survey of 23 debris disks with spectral types B9-G1, observed at an angular resolution of 0.5-1" with the Atacama Large Millimeter/Submillimeter Array (ALMA). The sample was selected for large infrared excess and age $\sim$10 Myr, to characterize the prevalence of molecular gas emission in young debris disks. We identify three CO-rich debris disks, plus two additional tentative (3σ) CO detections. Twenty disks were detected in the continuum at the $> 3\sigma$ level. For the 12 disks in the sample that are spatially resolved by our observations, we perform an independent analysis of the interferometric continuum visibilities to constrain the basic dust disk geometry, as well as a simultaneous analysis of the visibilities and broad-band spectral energy distribution to constrain the characteristic grain size and disk mass. The gas-rich debris disks exhibit preferentially larger outer radii in their dust disks, and a higher prevalence of characteristic grain sizes smaller than the blowout size. The gas-rich disks do not exhibit preferentially larger dust masses, contrary to expectations for a scenario in which a higher cometary destruction rate would be expected to result in a larger mass of both CO and dust. The three debris disks in our sample with strong CO detections are all around A stars: the conditions in disks around intermediate-mass stars appear to be the most conducive to the survival or formation of CO.

Accepted by Astrophysical Journal

https://arxiv.org/pdf/1606.07068

Rotationally-Driven Fragmentation for the Formation of the Binary Protostellar System L1551 IRS 5

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Either bulk rotation or local turbulence is widely invoked to drive fragmentation in collapsing cores so as to produce multiple star systems. Even when the two mechanisms predict different manners in which the stellar spins and orbits are aligned, subsequent internal or external interactions can drive multiple systems towards or away from alignment thus masking their formation process. Here, we demonstrate that the geometrical and dynamical relationship between the binary system and its surrounding bulk envelope provide the crucial distinction between fragmentation models. We find that the circumstellar disks of the binary protostellar system L1551 IRS 5 are closely parallel not just with

each other but also with their surrounding flattened envelope. Measurements of the relative proper motion of the binary components spanning nearly 30 yr indicate an orbital motion in the same sense as the envelope rotation. Eliminating orbital solutions whereby the circumstellar disks would be tidally truncated to sizes smaller than are observed, the remaining solutions favor a circular or low-eccentricity orbit tilted by up to $\sim 25°$ from the circumstellar disks. Turbulence-driven fragmentation can generate local angular momentum to produce a coplanar binary system, but which bears no particular relationship with its surrounding envelope. Instead, the observed properties conform with predictions for rotationally-driven fragmentation. If the fragments were produced at different heights or on opposite sides of the midplane in the flattened central region of a rotating core, the resulting protostars would then exhibit circumstellar disks parallel with the surrounding envelope but tilted from the orbital plane as is observed.

Accepted by Astrophysical Journal

http://arxiv.org/pdf/1607.00323

Earliest phases of star formation (EPoS): Dust temperature distributions in isolated starless cores

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Constraining the temperature and density structure of dense molecular cloud cores is fundamental for understanding the initial conditions of star formation. We use Herschel observations of the thermal FIR dust emission from nearby isolated molecular cloud cores and combine them with ground-based submillimeter continuum data to derive observational constraints on their temperature and density structure. The aim of this study is to verify the validity of a ray-tracing inversion technique developed to derive the dust temperature and density structure of isolated starless cores directly from the dust emission maps and to test if the resulting temperature and density profiles are consistent with physical models. Using this ray-tracing inversion technique, we derive the dust temperature and density structure of six isolated starless cloud cores. We employ self-consistent radiative transfer modeling to the derived density profiles, treating the ISRF as the only heating source. The best-fit values of local strength of the ISRF and the extinction by the outer envelope are derived by comparing the self-consistently calculated temperature profiles with those derived by the ray-tracing method. We find that all starless cores are significantly colder inside than outside, with the core temperatures showing a strong negative correlation with peak column density. This suggests that their thermal structure is dominated by external heating from the ISRF and shielding by dusty envelopes. The temperature profiles derived with the ray-tracing inversion method can be well-reproduced with self-consistent radiative transfer models.

Accepted by A&A

http://arxiv.org/pdf/1606.04318

SPAMCART: a code for smoothed particle Monte Carlo radiative transfer

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We present a code for generating synthetic SEDs and intensity maps from Smoothed Particle Hydrodynamics simulation snapshots. The code is based on the Lucy (1999) Monte Carlo Radiative Transfer method, i.e. it follows discrete luminosity packets as they propagate through a density field, and then uses their trajectories to compute the radiative equilibrium temperature of the ambient dust. The sources can be extended and/or embedded, and discrete and/or diffuse. The density is not mapped onto a grid, and therefore the calculation is performed at exactly the same resolution as the hydrodynamics. We present two example calculations using this method. First, we demonstrate that the code strictly adheres to Kirchhoff's law of radiation. Second, we present synthetic intensity maps and spectra of

an embedded protostellar multiple system. The algorithm uses data structures that are already constructed for other purposes in modern particle codes. It is therefore relatively simple to implement.

Accepted by MNRAS

https://arxiv.org/pdf/1603.01223

The JCMT Gould Belt Survey: A First Look at Southern Orion A with SCUBA-2

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We present the JCMT Gould Belt Survey's first look results of the southern extent of the Orion A Molecular Cloud ($\delta \leq -5{:}31{:}27.5$). Employing a two-step structure identification process, we construct individual catalogues for large-scale regions of significant emission labelled as islands and smaller-scale subregions called fragments using the 850 μm continuum maps obtained using SCUBA-2. We calculate object masses, sizes, column densities, and concentrations. We discuss fragmentation in terms of a Jeans instability analysis and highlight interesting structures as candidates for follow-up studies. Furthermore, we associate the detected emission with young stellar objects (YSOs) identified by Spitzer and Herschel. We find that although the population of active star-forming regions contains a wide variety of sizes and morphologies, there is a strong positive correlation between the concentration of an emission region and its calculated Jeans instability. There are, however, a number of highly unstable subregions in dense areas of the map that show no evidence of star formation. We find that only ~72% of the YSOs defined as Class 0+I and flat-spectrum protostars coincide with dense 850 μm emission structures (column densities $> 3.7 \times 10^{21}$ cm^{-2}). The remaining 28% of these objects, which are expected to be embedded in dust and gas, may be misclassified. Finally, we suggest that there is an evolution in the velocity dispersion of young stellar objects such that sources which are more evolved are associated with higher velocities.

Accepted by MNRAS

http://arxiv.org/pdf/1606.08854

A Herschel view of protoplanetary disks in the σ Ori cluster

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We present new Herschel PACS observations of 32 T Tauri stars in the young (~3 Myr) σ Ori cluster. Most of our objects are K & M stars with large excesses at 24 μm. We used irradiated accretion disk models of D'Alessio et al. (2006) to compare their spectral energy distributions with our observational data. We arrive at the following six conclusions. (i) The observed disks are consistent with irradiated accretion disks systems. (ii) Most of our objects (60%) can be explained by significant dust depletion from the upper disk layers. (iii) Similarly, 61% of our objects can be modeled with large disk sizes ($R_d \geq 100$ AU). (iv) The masses of our disks range between 0.03 to 39 M_{Jup}, where 35% of our objects have disk masses lower than 1 Jupiter. Although these are lower limits, high mass (> 0.05 $M_{\odot}$) disks, which are present e.g, in Taurus, are missing. (v) By assuming a uniform distribution of objects around the brightest stars at the center of the cluster, we found that 80% of our disks are exposed to external FUV radiation of $300 \leq G_0 \leq 1000$, which can be strong enough to photoevaporate the outer edges of the closer disks. (vi) Within 0.6 pc from σ Ori we found forbidden emission lines of [NII] in the spectrum of one of our large disk (SO662), but no emission in any of our small ones. This suggests that this object may be an example of a photoevaporating disk.

Accepted by The Astrophysical Journal

Characterising the physical and chemical properties of a young Class 0 protostellar core embedded in the Orion B9 filament

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Deeply embedded low-mass protostars can be used as testbeds to study the early formation stages of solar-type stars, and the prevailing chemistry before the formation of a planetary system. The present study aims to characterise further the physical and chemical properties of the protostellar core Orion B9–SMM3. The Atacama Pathfinder EXperiment (APEX) telescope was used to perform a follow-up molecular line survey of SMM3. The observations were done using the single pointing (frequency range 218.2–222.2 GHz) and on-the-fly mapping methods (215.1–219.1 GHz). These new data were used in conjunction with our previous data taken by the APEX and Effelsberg 100 m telescopes. The following species were identified from the frequency range 218.2–222.2 GHz: ^{13}CO, C^{18}O, SO, *para*-H_2CO, and E_1-type CH_3OH. The mapping observations revealed that SMM3 is associated with a dense gas core as traced by DCO^+ and p-H_2CO. Altogether three different p-H_2CO transitions were detected with clearly broadened linewidths ($\Delta v \sim 8.2 - 11$ km s^{-1} in FWHM). The derived p-H_2CO rotational temperature, 64 ± 15 K, indicates the presence of warm gas. We also detected a narrow p-H_2CO line ($\Delta v = 0.42$ km s^{-1}) at the systemic velocity. The p-H_2CO abundance for the broad component appears to be enhanced by two orders of magnitude with respect to the narrow line value ($\sim 3 \times 10^{-9}$ versus $\sim 2 \times 10^{-11}$). The detected methanol line shows a linewidth similar to those of the broad p-H_2CO lines, which indicates their coexistence. The CO isotopologue data suggest that the CO depletion factor decreases from $\sim 27 \pm 2$ towards the core centre to a value of $\sim 8 \pm 1$ towards the core edge. In the latter position, the N_2D^+/N_2H^+ ratio is revised down to 0.14 ± 0.06. The origin of the subfragments inside the SMM3 core we found previously can be understood in terms of the Jeans instability if non-thermal motions are taken into account. The estimated fragmentation timescale, and the derived chemical abundances suggest that SMM3 is a few times 10^5 yr old, in good agreement with its Class 0 classification inferred from the spectral energy distribution analysis. The broad p-H_2CO and CH_3OH lines, and the associated warm gas provide the first clear evidence of a molecular outflow driven by SMM3.

Accepted by Astrophysics and Space Science

http://arxiv.org/pdf/1606.08771

New debris disks in nearby young moving groups

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A significant fraction of nearby young moving group members harbor circumstellar debris dust disks. Due to their proximity and youth, these disks are attractive targets for studying the early evolution of debris dust and planetesimal belts. Here we present 70 and 160μm, observations of 31 systems in the β Pic moving group, and in the Tucana-Horologium, Columba, Carina and Argus associations, using the Herschel Space Observatory. None of these stars were observed at far-infrared wavelengths before. Our Herschel measurements were complemented by photometry from the WISE satellite for the whole sample, and by submillimeter/millimeter continuum data for one source, HD 48370. We identified six stars with infrared excess, four of them are new discoveries. By combining our new findings with results from the literature, we examined the incidence and general characteristics of debris disks around Sun-like members of the selected groups. With their dust temperatures of <45 K the newly identified disks around HD 38397, HD 48370, HD 160305, and BD-20 951 represent the coldest population within this sample. For HD 38397 and HD 48370, the emission is resolved in the 70μm PACS images, the estimated radius of these disks is ~90 au. Together with the well-known disk around HD 61005, these three systems represent the highest mass end of the known debris disk population

around young G-type members of the selected groups. In terms of dust content, they resemble the hypothesized debris disk of the ancient Solar System.

Accepted by ApJ

http://adsabs.harvard.edu/pdf/2016arXiv160609179M

A study of the wiggle morphology of HH 211 through numerical simulations

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Recent high-resolution, high-sensitivity observations of protostellar jets have shown many to possess deviations to their trajectories. HH 211 is one such example where sub-mm observations with the Submillimeter Array (SMA) have revealed a clear reflection-symmetric wiggle. The most likely explanation is that the HH 211 jet source could be moving as part of a protobinary system. Here, we test this assumption by simulating HH 211 through 3D hydrodynamic jet propagation simulations using the PLUTO code with a molecular chemistry and cooling module, and initial conditions based on an analytical model derived from SMA observations. Our results show the reflection-symmetric wiggle can be recreated through the assumption of a jet source perturbed by binary motion at its base, and that a regular sinusoidal velocity variation in the jet beam can be close to matching the observed knot pattern. However, a more complex model with either additional heating from the protostar, or a shorter period velocity pulsation may be required to account for enhanced emission near the source, and weaker knot emission downstream. Positionvelocity diagrams along the pulsed jet beam show a complex structure with detectable signatures of knots and show caution must be exercised when interpreting radial velocity profiles through observations. Finally, we make predictions for future HH 211 observations with Atacama Large Millimeter Array.

Accepted by MNRAS

http://arxiv.org/pdf/1605.03174

Star forming activity in the H II regions associated with IRAS 17160-3707 complex

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We present a multiwavelength investigation of star formation activity towards the southern H II regions associated with IRAS 17160–3707, located at a distance of 6.2 kpc with a bolometric luminosity of 8.3×10^5 $L_\odot$. The ionised gas distribution and dust clumps in the parental molecular cloud are examined in detail using measurements at infrared, submillimeter and radio wavelengths. The radio continuum images at 1280 and 610 MHz obtained using Giant Metrewave Radio Telescope reveal the presence of multiple compact sources as well as nebulous emission. At submillimeter wavelengths, we identify seven dust clumps and estimate their physical properties like temperature: $24 - 30$ K, mass: $300 - 4800$ $M_\odot$ and luminosity: $9 - 317 \times 10^2$ $L_\odot$ using modified blackbody fits to the spectral energy distributions between 70 and 870 μm. We find 24 young stellar objects in the mid-infrared, with few of them coincident with the compact radio sources. The spectral energy distributions of young stellar objects have been fitted by the Robitaille models and the results indicate that those having radio compact sources as counterparts host massive objects in early evolutionary stages with best fit age ≤ 0.2 Myr. We compare the relative evolutionary stages of clumps using various signposts such as masers, ionised gas, presence of young stellar objects and infrared nebulosity and find six massive star forming clumps and one quiescent clump. Of the former, five are in a relatively advanced stage and one in an earlier stage.

Accepted by The Astronomical Journal

http://arxiv.org/pdf/1607.01267

Candidate Water Vapor Lines to Locate the H_2O Snowline through High-Dispersion Spectroscopic Observations I. The Case of a T Tauri Star

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Inside the H_2O snowline of protoplanetary disks, water evaporates from the dust-grain surface into the gas phase, whereas it is frozen out on to the dust in the cold region beyond the snowline. H_2O ice enhances the solid material in the cold outer part of a disk, which promotes the formation of gas-giant planet cores. We can regard the H_2O snowline as the surface that divides the regions between rocky and gaseous giant planet formation. Thus observationally measuring the location of the H_2O snowline is crucial for understanding the planetesimal and planet formation processes, and the origin of water on Earth. In this paper, we find candidate water lines to locate the H_2O snowline through future high-dispersion spectroscopic observations. First, we calculate the chemical composition of the disk and investigate the abundance distributions of H_2O gas and ice, and the position of the H_2O snowline. We confirm that the abundance of H_2O gas is high not only in the hot midplane region inside the H_2O snowline but also in the hot surface layer of the outer disk. Second, we calculate the H_2O line profiles and identify those H_2O lines which are promising for locating the H_2O snowline: the identified lines are those which have small Einstein A coefficients and high upper state energies. The wavelengths of the candidate H_2O lines range from mid-infrared to sub-millimeter, and they overlap with the regions accessible to ALMA and future mid-infrared high dispersion spectrographs (e.g., TMT/MICHI, SPICA).

Accepted by ApJ

http://arxiv.org/pdf/1606.05828

A Wide-Field Survey for Transiting Hot Jupiters and Eclipsing Pre-Main-Sequence Binaries in Young Stellar Associations

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The past two decades have seen a significant advancement in the detection, classification and understanding of exoplanets and binaries. This is due, in large part, to the increase in use of small-aperture telescopes (<20 cm) to survey large areas of the sky to milli-mag precision with rapid cadence. The vast majority of the planetary and binary systems studied to date consist of main-sequence or evolved objects, leading to a dearth of knowledge of properties at early times (<50 Myr). Only a dozen binaries and one candidate transiting Hot Jupiter are known among pre-main sequence objects, yet these are the systems that can provide the best constraints on stellar formation and planetary migration models. The deficiency in the number of well-characterized systems is driven by the inherent and aperiodic variability

found in pre-main-sequence objects, which can mask and mimic eclipse signals. Hence, a dramatic increase in the number of young systems with high-quality observations is highly desirable to guide further theoretical developments. We have recently completed a photometric survey of 3 nearby (<150 pc) and young (<50 Myr) moving groups with a small aperture telescope. While our survey reached the requisite photometric precision, the temporal coverage was insufficient to detect Hot Jupiters. Nevertheless, we discovered 346 pre-main-sequence binary candidates, including 74 high-priority objects for further study.

Accepted by AJ

http://arxiv.org/pdf/1606.02993

A Dwarf Transitional Protoplanetary Disk around XZ Tau B

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We report the discovery of a dwarf protoplanetary disk around the star XZ Tau B that shows all the features of a classical transitional disk but on a much smaller scale. The disk has been imaged with the Atacama Large Millimeter/Submillimeter Array (ALMA), revealing that its dust emission has a quite small radius of 3.4 au and presents a central cavity of 1.3 au in radius that we attribute to clearing by a compact system of orbiting (proto)planets. Given the very small radii involved, evolution is expected to be much faster in this disk (observable changes in a few months) than in classical disks (observable changes requiring decades) and easy to monitor with observations in the near future. From our modeling we estimate that the mass of the disk is large enough to form a compact planetary system.

Accepted by ApJL

http://arxiv.org/pdf/1606.03118

A cautionary note about composite Galactic star formation relations

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We explore the pitfalls which affect the comparison of the star formation relation for nearby molecular clouds with that for distant compact molecular clumps. We show that both relations behave differently in the ($\Sigma_{\rm gas}$, $\Sigma_{\rm SFR}$) space, where $\Sigma_{\rm gas}$ and $\Sigma_{\rm SFR}$ are, respectively, the gas and star formation rate surface densities, even when the physics of star formation is the same. This is because the star formation relation of nearby clouds relates gas and star surface densities measured locally, that is, within a given interval of gas surface density, or at a given protostar location. We refer to such measurements as local measurements, and the corresponding star formation relation as the local relation. In contrast, the stellar content of a distant molecular clump remains unresolved. Only the mean star formation rate can be obtained from e.g. the clump infrared luminosity. One clump therefore provides one single point to the ($\Sigma_{\rm gas}$, $\Sigma_{\rm SFR}$) space, that is, its mean gas surface density and star formation rate surface density. We refer to this star formation relation as a global relation since it builds on the global properties of molecular clumps. Its definition therefore requires an ensemble of cluster-forming clumps. We show that, although the local and global relations have different slopes, this per se cannot be taken as evidence for a change in the physics of star formation with gas surface density. It therefore appears that great caution should be taken when physically interpreting a composite star formation relation, that is, a relation combining together local and global relations.

Accepted by The Astrophysical Journal

http://arxiv.org/pdf/1605.07623

A *Herschel − SPIRE* Survey of the Mon R2 Giant Molecular Cloud: Analysis of the Gas Column Density Probability Density Function

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We present a far-IR survey of the entire Mon R2 GMC with *Herschel − SPIRE* cross-calibrated with *Planck − HFI* data. We fit the SEDs of each pixel with a greybody function and an optimal beta value of 1.8. We find that mid-range column densities obtained from far-IR dust emission and near-IR extinction are consistent. For the entire GMC, we find that the column density histogram, or N-PDF, is lognormal below $\sim10^{21}$ cm^{-2}. Above this value, the distribution takes a power law form with an index of -2.16. We analyze the gas geometry, N-PDF shape, and YSO content of a selection of subregions in the cloud. We find no regions with pure lognormal N-PDFs. The regions with a combination of lognormal and one power law N-PDF have a YSO cluster and a corresponding centrally concentrated gas clump. The regions with a combination of lognormal and two power law N-PDF have significant numbers of typically younger YSOs but no prominent YSO cluster. These regions are composed of an aggregate of closely spaced gas filaments with no concentrated dense gas clump. We find that for our fixed scale regions, the YSO count roughly correlates with the N-PDF power law index. The correlation appears steeper for single power law regions relative to two power law regions with a high column density cut-off, as a greater dense gas mass fraction is achieved in the former. A stronger correlation is found between embedded YSO count and the dense gas mass among our regions.

Accepted by MNRAS

http://arxiv.org/pdf/1606.01752

Mid-J CO Shock Tracing Observations of Infrared Dark Clouds III: SLED fitting

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Giant molecular clouds contain supersonic turbulence that can locally heat small fractions of gas to over 100 K. We run shock models for low-velocity, C-type shocks propagating into gas with densities between 10^3 and 10^5 cm^{-3} and find that CO lines are the most important cooling lines. Comparison to photodissociation region (PDR) models indicates that mid-J CO lines ($J = 8 \to 7$ and higher) should be dominated by emission from shocked gas. In papers I and II we presented CO $J = 3 \to 2$, $8 \to 7$, and $9 \to 8$ observations towards four primarily quiescent clumps within infrared dark clouds. Here, we fit PDR models to the combined spectral line energy distributions and show that the PDR models that best fit the low-J CO emission underpredict the mid-J CO emission by orders of magnitude, strongly hinting at a hot gas component within these clumps. The low-J CO data clearly show that the integrated intensity of both the CO $J = 8 \to 7$ and $9 \to 8$ lines are anomalously high, such that the line ratio can be used to characterize the hot gas component. Shock models are reasonably consistent with the observed mid-J CO emission, with models with densities near $10^{4.5}$ cm^{-3} providing the best agreement. Where this mid-J CO is detected, the mean volume filling factor of the hot gas is 0.1%. Much of the observed mid-J CO emission, however, is also associated with known protostars and may be due to protostellar feedback.

Accepted by ApJ

https://arxiv.org/pdf/1606.03089

Kompaneets Model Fitting of the Orion-Eridanus Superbubble II: Thinking Outside of Barnard's Loop

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The Orion star-forming region is the nearest active high-mass star-forming region and has created a large superbubble, the Orion-Eridanus superbubble. Recent work by Ochsendorf et al. (2015) has extended the accepted boundary of the superbubble. We fit Kompaneets models of superbubbles expanding in exponential atmospheres to the new, larger shape of the Orion-Eridanus superbubble. We find that this larger morphology of the superbubble is consistent with the evolution of the superbubble being primarily controlled by expansion into the exponential Galactic disk ISM if the superbubble is oriented with the Eridanus side farther from the Sun than the Orion side. Unlike previous Kompaneets model fits that required abnormally small scale heights for the Galactic disk (<40 pc), we find morphologically consistent models with scale heights of 80 pc, similar to that expected for the Galactic disk.

Accepted by ApJ

https://arxiv.org/pdf/1606.02296

Spectroscopic signatures of magnetospheric accretion in Herbig Ae/Be stars. I. The case of HD101412

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Models of magnetically-driven accretion and outflows reproduce many observational properties of T Tauri stars. This concept is not well established for the more massive Herbig Ae/Be stars. We intend to examine the magnetospheric accretion in Herbig Ae/Be stars and search for rotational modulation using spectroscopic signatures, in this first paper concentrating on the well-studied Herbig Ae star HD101412. We used near-infrared spectroscopic observations of the magnetic Herbig Ae star HD101412 to test the magnetospheric character of its accretion disk/star interaction. We reduced and analyzed 30 spectra of HD101412, acquired with the CRIRES and X-shooter spectrographs installed at the VLT (ESO, Chile). The spectroscopic analysis was based on the He I lambda 10,830 and Pa gamma lines, formed in the accretion region. We found that the temporal behavior of these diagnostic lines in the near-infrared spectra of HD101412 can be explained by rotational modulation of line profiles generated by accreting gas with a period P = 20.53+-1.68 d. The discovery of this period, about half of the magnetic rotation period P_m = 42.076 d previously determined from measurements of the mean longitudinal magnetic field, indicates that the accreted matter falls onto the star in regions close to the magnetic poles intersecting the line-of-sight two times during the rotation cycle. We intend to apply this method to a larger sample of Herbig Ae/Be stars.

Accepted by A&A

https://arxiv.org/pdf/1606.03817

The Radial Distribution of H2 and CO in TW Hya as Revealed by Resolved ALMA Observations of CO Isotopologues

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CO is widely used as a tracer of molecular gas. However, there is now mounting evidence that gas phase carbon is depleted in the disk around TW Hya. Previous efforts to quantify this depletion have been hampered by uncertainties regarding the radial thermal structure in the disk. Here we present resolved ALMA observations of ^{13}CO 3-2, C^{18}O 3-2, ^{13}CO 6-5, and C^{18}O 6-5 emission in TW Hya, which allow us to derive radial gas temperature and gas surface density profiles, as well as map the CO abundance as a function of radius. These observations provide a measurement of the surface CO snowline at ∼30 AU and show evidence for an outer ring of CO emission centered at 53 AU, a feature previously seen only in less abundant species. Further, the derived CO gas temperature profile constrains the freeze-out temperature of CO in the warm molecular layer to $<$ 21 K. Combined with the previous detection of HD 1-0, these data constrain the surface density of the warm H_2 gas in the inner $\sim$ 30 AU such that $\Sigma_{warm\,gas} = 4.7^{+3.0}_{-2.9}\,\mathrm{g\,cm^{-2}}\,(R/10\,\mathrm{AU})^{-1/2}$. We find that CO is depleted by two orders of magnitude from $R = 10 - 60$ AU, with the small amount of CO returning to the gas phase inside the surface CO snowline insufficient to explain the overall depletion. Finally, this new data is used in conjunction with previous modeling of the TW Hya disk to constrain the midplane CO snowline to 17-23 AU.

Accepted by The Astrophysical Journal

http://arxiv.org/pdf/1603.08520

Understanding the C_3H_2 cyclic-to-linear ratio in L1544

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Aims. We aim to understand the high cyclic-to-linear C_3H_2 ratio (32 ± 4) that has been observed toward L1544.
Methods. We combined a gas-grain chemical model with a physical model for L1544 to simulate the column densities of cyclic and linear C_3H_2 observed toward L1544. The most important reactions for the formation and destruction of both forms of C_3H_2 were identified, and their relative rate coefficients were varied to find the best match to the observations.
Results. We find that the ratio of the rate coefficients of $C_3H_3^+ + e^- \longrightarrow C_3H_2 + H$ for cyclic and linear C_3H_2 must be ~ 20 to reproduce the observations, depending on the branching ratios assumed for the $C_3H_3^+ + e^- \longrightarrow C_3H + H_2$ reaction. In current astrochemical networks it is assumed that cyclic and linear C_3H_2 are formed in a 1:1 ratio in the aforementioned reactions. Laboratory studies and/or theoretical calculations are needed to confirm the results of our chemical modeling, which is based on observational constraints.

Accepted by A&A (591, L1)

http://arxiv.org/pdf/1605.07379

Prestellar core modeling in the presence of a filament – The dense heart of L1689B

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We apply a new synergetic radiative transfer method: the derived 1D density profiles are both consistent with a cut through the Herschel PACS/SPIRE and JCMT SCUBA-2 continuum maps of L1689B and with a derived local interstellar radiation field. Choosing an appropriate cut along the filament major axis, we minimize the impact of the filament emission on the modeling. For the bulk of the core (5000–20000 au) an isothermal sphere model with a temperature of around 10 K provides the best fits. We show that the power law index of the density profile, as well as the constant temperature can be derived directly from the radial surface brightness profiles. For the inner region (<5000 au), we find a range of densities and temperatures that are consistent with the surface brightness profiles and the local interstellar radiation field. Based on our core models, we find that pixel-by-pixel single temperature spectral energy distribution fits are incapable of determining dense core properties. We conclude that, to derive physical core properties, it is important to avoid an azimuthal average of core and filament. Correspondingly, derived core masses are too high since they include some mass of the filament, and might introduce errors when determining core mass functions. The forward radiative transfer methods also avoids the loss of information owing to smearing of all maps to the coarsest spatial resolution. We find the central core region to be colder and denser than estimated in recent inverse radiative transfer modeling, possibly indicating the start of star formation in L1689B.

Accepted by A&A

http://arxiv.org/pdf/1606.07942

CARMA Large Area Star Formation Survey: Dense Gas in the Young L1451 Region of Perseus

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We present a 3 mm spectral line and continuum survey of L1451 in the Perseus Molecular Cloud. These observations are from the CARMA Large Area Star Formation Survey (CLASSy), which also imaged Barnard 1, NGC 1333, Serpens Main and Serpens South. L1451 is the survey region with the lowest level of star formation activity—it contains no confirmed protostars. HCO^+, HCN, and N_2H^+ (J=1–0) are all detected throughout the region, with HCO^+ the most spatially widespread, and molecular emission seen toward 90% of the area above $N(H_2)$ column densities of 1.9×10^{21} cm^{-2}. HCO^+ has the broadest velocity dispersion, near 0.3 km s^{-1} on average, compared to $\sim$0.15 km s^{-1} for the other molecules, thus representing a range from supersonic to subsonic gas motions. Our non-binary dendrogram analysis reveals that the dense gas traced by each molecule has similar hierarchical structure, and that gas surrounding the candidate first hydrostatic core (FHSC), L1451-mm, and other previously detected single-dish continuum clumps have similar hierarchical structure; this suggests that different sub-regions of L1451 are fragmenting on the pathway to forming young stars. We determined the three-dimensional morphology of the largest detectable dense gas structures to be relatively ellipsoidal compared to other CLASSy regions, which appeared more flattened at largest scales. A virial analysis shows the most centrally condensed dust structures are likely unstable against collapse. Additionally, we identify a new spherical, centrally condensed N_2H^+ feature that could be a new FHSC candidate. The overall results suggest L1451 is a young region starting to form its generation of stars within turbulent, hierarchical structures.

Accepted by ApJ

http://arxiv.org/pdf/1606.08852

Measuring Turbulence in TW Hya with ALMA: Methods and Limitations

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We obtain high spatial and spectral resolution images of the CO J=2–1, CN N=2–1 and CS J=5–4 emission with ALMA in Cycle 2. The radial distribution of the turbulent broadening is derived with three approaches: two 'direct' and one modelling. The first requires a single transition and derives $T_{\rm ex}$ directly from the line profile, yielding a $v_{\rm turb}$.

The second assumes two different molecules are co-spatial thus their relative linewidths allow for a calculation of $T_{\rm kin}$ and $v_{\rm turb}$. Finally we fit a parametric disk model where physical properties of the disk are described by power laws, to compare our 'direct' methods with previous values. The two direct methods were limited to the outer $r > 40$ au disk due to beam smear. The direct method found $v_{\rm turb}$ ranging from ≈ 130 m s^{-1} at 40 au, dropping to ≈ 50 m s^{-1} in the outer disk, qualitatively recovered with the parametric model fitting. This corresponds to roughly $0.2-0.4\ c_s$. CN was found to exhibit strong non-LTE effects outside $r \approx 140$ au, so $v_{\rm turb}$ was limited to within this radius. The assumption that CN and CS are co-spatial is consistent with observed linewidths only within $r \lesssim 100$ au, within which $v_{\rm turb}$ was found to drop from 100 m s^{-1} ($\approx\ 0.4\ c_s$) to nothing at 100 au. The parametric model yielded a near constant 50 m s^{-1} for CS ($0.2-0.4\ c_s$). We demonstrate that absolute flux calibration is and will be the limiting factor in all studies of turbulence using a single molecule. The magnitude of the dispersion is comparable with or below that predicted by the magneto-rotational instability theory. A more precise comparison would require to reach an absolute calibration precision of order 3%, or to find a suitable combination of light and heavy molecules which are co-located in the disk.

Accepted by A&A

http://arxiv.org/pdf/1606.00005

Brown dwarf disks with ALMA: Evidence for truncated dust disks in Ophiuchus

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The study of the properties of disks around young brown dwarfs can provide important clues on the formation of these very low mass objects and on the possibility of forming planetary systems around them. The presence of warm dusty disks around brown dwarfs is well known, based on near- and mid-infrared studies. High angular resolution observations of the cold outer disk are limited, we used ALMA to attempt a first survey of young brown dwarfs in the ρ-Oph star forming region with ALMA. All 17 young brown dwarfs in our sample were observed at 890 μm in the continuum at $\sim 0.''5$ angular resolution. The sensitivity of our observations was chosen to detect ~ 0.5 M$_\oplus$ of dust. We detect continuum emission in 11 disks (~ 65% of the total), the estimated mass of dust in the detected disks ranges from ~ 0.5 to ~ 6 M$_\oplus$. These disk masses imply that planet formation around brown dwarfs may be relatively rare and that the supra-Jupiter mass companions found around some brown dwarfs are probably the result of a binary system formation. We find evidence that the two brightest disks in ρ-Oph have sharp outer edges at R$\lesssim$25 AU, as opposite to disks around Taurus brown dwarfs. This difference may suggest that the different environment in ρ-Oph may lead to significant differences in disk properties. A comparison of the M$_{disk}$/M$_*$ ratio for brown dwarf and solar-mass systems also shows a possible deficit of mass in brown dwarfs, which could support the evidence for dynamical truncation of disks in the substellar regime. These findings are still tentative and need to be put on firmer grounds by studying the gaseous disks around brown dwarfs and by performing a more systematic and unbiased survey of the disk population around the more massive stars.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/1606.06448

Characterizing the Youngest Herschel-detected Protostars II. Molecular Outflows from the Millimeter and the Far-infrared

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We present CARMA CO ($J = 1 \rightarrow 0$) observations and *Herschel* PACS spectroscopy, characterizing the outflow properties toward extremely young and deeply embedded protostars in the Orion molecular clouds. The sample comprises a subset of the Orion protostars known as the PACS Bright Red Sources (PBRS) (Stutz et al.). We observed 14 PBRS with CARMA and 8 of these 14 with *Herschel*, acquiring full spectral scans from 55 μm to 200 μm. Outflows are detected in CO ($J = 1 \rightarrow 0$) from 8 of 14 PBRS, with two additional tentative detections; outflows are also detected from the outbursting protostar HOPS 223 (V2775 Ori) and the Class I protostar HOPS 68. The outflows have a range of morphologies, some are spatially compact, <10000 AU in extent, while others extend beyond the primary beam. The outflow velocities and morphologies are consistent with being dominated by intermediate inclination angles ($80° \geq i \geq 20°$). This confirms the interpretation of the very red 24 μm to 70 μm colors of the PBRS as a signpost of high envelope densities, with only one (possibly two) cases of the red colors resulting from edge-on inclinations. We detect high-J ($J_{up} > 13$) CO lines and/or H_2O lines from 5 of 8 PBRS and only for those with detected CO outflows. The far-infrared CO rotation temperatures of the detected PBRS are marginally colder (∼230 K) than those observed for most protostars (∼300 K), and only one of these 5 PBRS has detected [OI] 63 μm emission. The high envelope densities could be obscuring some [OI] emission and cause a ∼20 K reduction to the CO rotation temperatures.

Accepted by ApJ

http://arxiv.org/pdf/1607.00787

Cluster dynamics largely shapes protoplanetary disc sizes

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It is still on open question to what degree the cluster environment influences the sizes of protoplanetary discs surrounding young stars. Particularly so for the short-lived clusters typical for the solar neighbourhood in which the stellar density and therefore the influence of the cluster environment changes considerably over the first 10Myr. In previous studies often the effect of the gas on the cluster dynamics has been neglected, this is remedied here. Using the code NBody6++ we study the stellar dynamics in different developmental phases - embedded, expulsion, expansion - including the gas and quantify the effect of fly-bys on the disc size. We concentrate on massive clusters ($M_{cl} \geq 10^3 - 6 * 10^4 M_{sun}$), which are representative for clusters like the ONC or NGC 6611. We find that not only the stellar density but also the duration of the embedded phase matters. The densest clusters react fastest to the gas expulsion and drop quickly in density, here 98% of relevant encounters happen before gas expulsion. By contrast, discs in sparser clusters are initially less affected but as they expand slower 13% of discs are truncated after gas expulsion. For ONC-like clusters we find that usually discs larger than 500 AU are affected by the environment, which corresponds to the observation that 200 AU-sized discs are common. For NGC 6611-like clusters disc sizes are cut-down on average to roughly 100 AU. A testable hypothesis would be that the discs in the centre of NGC 6611 should be on average ≈20AU and therefore considerably smaller than in the ONC.

Accepted by The Astrophysical Journal

http://adsabs.harvard.edu/pdf/2016arXiv160607431V

Locally linear embedding: dimension reduction of massive protostellar spectra

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We present the results of the application of locally linear embedding (LLE) to reduce the dimensionality of dereddened and continuum subtracted near-infrared spectra using a combination of models and real spectra of massive protostars selected from the Red MSX Source survey database. A brief comparison is also made with two other dimension reduction techniques; Principal Component Analysis (PCA) and Isomap using the same set of spectra as well as a more advanced form of LLE, Hessian locally linear embedding. We find that whilst LLE certainly has its limitations, it significantly outperforms both PCA and Isomap in classification of spectra based on the presence/absence of emission lines and provides a valuable tool for classification and analysis of large spectral data sets.

Accepted by MNRAS

http://arxiv.org/pdf/1606.06915

Millimeter-sized grains in the protostellar envelopes: where do they come from?

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Grain growth during star formation affects the physical and chemical processes in the evolution of star-forming clouds. We investigate the origin of the millimeter (mm)-sized grains recently observed in Class I protostellar envelopes. We use the coagulation model developed in our previous paper and find that a hydrogen number density of as high as 10^{10} cm^{-3}, instead of the typical density 10^5 cm^{-3}, is necessary for the formation of mm-sized grains. Thus, we test a hypothesis that such large grains are transported to the envelope from the inner, denser parts, finding that gas drag by outflow efficiently "launches" the large grains as long as the central object has not grown to $\gtrsim$0.1 $M_\odot$. By investigating the shattering effect on the mm-sized grains, we ensure that the large grains are not significantly fragmented after being injected in the envelope. We conclude that the mm-sized grains observed in the protostellar envelopes are not formed in the envelopes but formed in the inner parts of the star-forming regions and transported to the envelopes before a significant mass growth of the central object, and that they survive in the envelopes.

Accepted by PASJ

http://arxiv.org/pdf/1606.03277

A multiwavelength investigation of the HII region S311: Young stellar population and star formation

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We present a multiwavelength investigation of the young stellar population and star formation activities around the HII region Sharpless 311. Using our deep near-infrared observations and archival *Spitzer*−IRAC observations, we have detected a total of 125 young stellar objects (YSOs) in an area of ∼86 arcmin^2. The YSOs sample include 8 Class I and 117 Class II candidate YSOs. The mass completeness of the identified YSOs sample is estimated to be 1.0 $M_\odot$. The ages and masses of the majority of the candidate YSOs are estimated to be in the range of ∼0.1−5 Myr and ∼0.3−6 $M_\odot$, respectively. The 8 μm image of S311 displays an approximately spherical cavity around the ionizing source which is possibly created due to the expansion of the HII region. The spatial distribution of the candidate YSOs reveals that a significant number of them are distributed systematically along the 8 μm emission with a majority clustered around the eastern border of the HII region. Four clumps/compact HII regions are detected in the radio continuum observations at 1280 MHz, which might have been formed during the expansion of the HII region. The estimated dynamical age of the region, main-sequence lifetime of the ionizing source, the spatial distribution and ages of the candidate YSOs indicate triggered star formation in the complex.

Accepted by MNRAS

http://arxiv.org/pdf/1606.03741

Abstracts of recently accepted major reviews

Young Massive Clusters: Their Population Properties, Formation and Evolution, and Their Relation to the Ancient Globular Clusters

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This review summarises the main properties of Young Massive Clusters (YMCs), including their population properties, particularly focusing on extragalactic cluster samples. We discuss potential biases and caveats that can affect the construction of cluster samples and how incompleteness effects can result in erroneous conclusions regarding the long term survival of clusters. In addition to the luminosity, mass and age distributions of the clusters, we discuss the size distribution and profile evolution of the clusters. We also briefly discuss the stellar populations within YMCs. The final part of the review focusses on the connections between YMCs and the ancient globular clusters, whether or not they are related objects and how we can use what we know about YMC formation and evolution to understand how GCs formed in the early universe and how they relate to galaxy formation/evolution.

Accepted by EES2015 – Stellar Clusters

http://arxiv.org/pdf/1606.09468

Light up the trail to planets. Dust in protoplanetary disks traced by scattered light.

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Ph.D degree awarded: February 2016

Direct imaging is the best investigation tool for most astronomical objects. However, protoplanetary disks are very small (a few hundreds of au). This requires observations with angular resolution much smaller than 1”. A very good angular resolution is a natural advantage of observations at optical and near-IR wavelengths. However, at these short wavelengths the stellar emission dominates over that of the disk. To alleviate this limit, many observational techniques have been implemented. Much of the current focus is on Polarimetric Differential Imaging (PDI), a technique exploiting the fact that the stellar light is mainly unpolarized, contrary to the scattered light from the disk. This type of observations traces micron-sized dust grains at the disk surface and is thus complementary to images at millimeter wavelengths.

This thesis studies PDI images of protoplanetary disks and aims to contribute to the understanding of the distribution of small dust particles in protoplanetary disks. The comparison with larger particles and an improved view of the architecture of disks provide new insight into both the morphology and the evolution of these intriguing objects.

We analyze the exquisite near-IR PDI data of a most known transition disk, around SAO 206462, obtained with the NACO instrument at the Very Large Telescope (VLT), at Cerro Paranal in Chile. These observations reveal a prominent double-spiral structure and a central cavity, which is significantly smaller than what was inferred at millimeter wavelengths. We explain this discrepancy with the different dynamics of micron- and mm-sized dust particles at the disk inner edge, in a scenario where the cavity is induced by a (yet unseen) giant planet. We also show VLT/NACO observations of three elusive disks and conclude that their flatness is the most probable reason for the absence of scattered light. This led us to obtain new VLT/NACO images of disks which are known to be flat. Also this second survey led to many non-detections leaving an aura of mystery around these objects.

New opportunities to image elusive disk features are provided by instruments like VLT/SPHERE. We analyzed the first SPHERE observations of HD100546, whose remarkable disk hosts two planet candidates. Any signposts of planet-disk interaction remain fairly elusive and this raises further questions on the mechanisms of planet formation. Nevertheless, the data reveal new intriguing forms of disk structures and are a showcase of the SPHERE’s capabilities.

Postdoctoral Research Fellow in Star Formation

Funded by the EU, you will work with Dr Stuart Lumsden and Professor Rene Oudmaijer on the observational study of clustering of stars and gas in young massive stellar clusters.

The Astrophysics Group in Leeds is leading a network, comprising Cardiff University, Universit Grenoble Alpes and a Spanish scientific software company Quasar Science Resources, S.L., on the project StarFormMapper (via call H2020-COMPET-2015). This programme aims to understand the formation and dissolution of the clustered environments in which massive stars form, by exploiting existing data from Herschel and up-coming data from Gaia.

Understanding mass segregation at the earliest stages is the key to understanding how young massive stellar clusters form and evolve (as well as the stars within them) and that is the eventual goal of this project. Your role will initially be to work with your colleagues in Grenoble on identifying substructure in young massive clusters, in particular in identifying how sub-structure in the gas and dust relates to that in the stars. You will test and develop appropriate statistical methods through application to simulated datasets provided by the Cardiff node before comparing those results with catalogues of Gaia stellar data and Herschel dust maps. Your work will feed into a software environment being developed by Quasar SR, which will provide a public portal to this project.

Opportunities for travel within the consortium will be provided. This international collaboration will afford the appointee unique opportunities to work with astronomers and computer scientists from a wide range of backgrounds and skill-sets. You will also have the opportunity to work with other members of the Leeds Astrophysics group to help develop future avenues for this project in the study of the most embedded young clusters.

You will have (or be about to obtain) a PhD in Astrophysics. Experience with statistical analysis of large datasets, especially with regard to spatial clustering, and/or star formation is desirable.

The University of Leeds' commitment to women in science has been recognised with a national accolade. The University has received the Athena SWAN Bronze Award and the Faculty of Mathematics and Physical Sciences holds the Athena SWAN Silver Award in recognition of our success in recruiting, retaining and developing/promoting women in Science, Engineering and Technology (SET). We are proud of our commitment to equality and inclusiveness.

The University offers generous terms and conditions of employment, a wide range of benefits, services, facilities and family friendly policies. Full details are available on the Human Resources web pages accessible at
http://www.leeds.ac.uk/hr/index.htm

In addition to completing the personal statement on your online application, please upload a copy of your current CV. The closing date is August 1st. Starting salary will be £25,769-34,576 depending on experience of the candidate.

Informal enquiries may be made to Dr Stuart Lumsden, tel +44 (0)113 343 6691, email s.l.lumsden@leeds.ac.uk.

Interviews are expected to be held in early September and the successful candidate is required to be in post before the end of 2016.

Applications should be made online via https://jobs.leeds.ac.uk/Vacancy.aspx?ref=MAPPA1032

Full professor in Astronomy at Chalmers University

Applications are invited for a tenured full professorship in the astronomy group of the Department of Earth and Space Sciences of Chalmers University of Technology in Gothenburg, Sweden.

Preference will be given to applicants that can lead a group within the field of Galactic Astronomy (e.g. ISM, star/planet formation, astro-chemistry), but exceptional candidates in other areas will be considered.

The active and growing astronomy and astrophysics group at Chalmers includes research groups on evolved stars, massive star-formation, extragalactic star formation, supermassive black holes, galaxy formation and evolution, and galaxy clusters. The group is mainly situated at the site of Onsala Space Observatory (OSO), the Swedish national facility for Radio Astronomy. The observatory operates telescopes in Sweden, including the local LOFAR station, 20m and 25m telescopes, which form part of the EVN/VLBI array, and also is a partner in the APEX telescope in Chile. OSO hosts the Nordic ALMA Regional Center and represents Sweden within the SKA Organisation. Members of the astronomy group have strong involvements in several space missions, such as e.g. Herschel, XMM Newton, JWST and other future instruments.

Applicants that can complement the existing research in the astronomy group and use the OSO related local and international facilities (such as ALMA and SKA) are specifically encouraged to apply. The successful applicant will have the opportunity to negotiate a generous startup package.

The application deadline is October 3rd 2016. Submission details can be found at:

http://www.chalmers.se/en/about-chalmers/vacancies/Pages/default.aspx?rmpage=job&rmjob=4182

For more information please contact Prof. Wouter Vlemmings (wouter.vlemmings.at.chalmers.se; Galactic Astronomy) or Prof. Susanne Aalto (susanne.aalto.at.chalmers.se; Extragalactic Astronomy).

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

SOFIA Splinter Meeting 12.-16.9. 2016

We would like to inform you about a splinter meeting on september, 15th during this fall's AG-Tagung in Bochum (12.-16.9.) on SOFIA, organized by the German SOFIA Science Working Group. This event will give us the opportunity to discuss recent SOFIA science results and ongoing SOFIA projects. The Splinter will also allow for up to 6 or more talks on SOFIA results and for poster presentations. Please register via the AG 2016 webpages

https://ag2016.de/Registration.php

The splinter will also have a talk discussing the special aspects of airbore observing, the SOFIA instruments and the proposal cycle, as well as 2 (or more) talks on the SOFIA sciene instruments. In addition, there will be short tutorials on the observing modes and time estimates for the SOFIA instruments.

The splinter Webpage is at —urlhttps://www.astro.uni-koeln.de/ag2016-sofia

Summary of Upcoming Meetings

The role of feedback in the formation and evolution of star clusters
18 - 22 July 2016 Sexten, Italy
http://www.sexten-cfa.eu/en/conferences/2016/details/72-the-role-of-feedback-in-the-formation-and-evolution-

Binary Stars
24 - 30 July 2016, Cambridge, UK
http://www.ast.cam.ac.uk/meetings/2016/binary.stars.cambridge.2016

Star Formation in Different Environments
25 - 29 July 2016, Quy Nhon, Viet Nam
http://sfde16.0x1115.org/

First Stars V
1 - 5 August 2016 Heidelberg, Germany
http://www.lsw.uni-heidelberg.de/FirstStarsV

Star Clusters: from Infancy to Teenagehood
8 - 12 August 2016, Heidelberg, Germany
http://wwwstaff.ari.uni-heidelberg.de/infant_clusters_2016/

CLOUDY: Emission Lines in Astrophysics
8 - 12 August 2016, Mexico City, Mexico
https://sites.google.com/a/astro.unam.mx/cloudy2016/

Cosmic Dust
15 - 19 August 2016, Sendaai, Japan
https://www.cps-jp.org/~dust/

Star Formation 2016
21-26 August 2016 Exeter, UK
http://www.astro.ex.ac.uk/sf2016

Heating and Cooling Processes in the ISM
7 -9 September 2016 Cologne, Germany
https://www.astro.uni-koeln.de/hac2016

Linking Exoplanet and Disk Compositions
12 - 14 September, 2016 Baltimore, USA
http://www.stsci.edu/~banzatti/images/workshop.pdf

Interstellar shocks: models, observations & experiments
14-16 September 2016, Torun, Poland
http://shocks2016.faj.org.pl

Half a Decade of ALMA: Cosmic Dawns Transformed 20 - 23 September 2016 Indian Wells, USA
http://www.cvent.com/events/half-a-decade-of-alma-cosmic-dawns-transformed/event-summary-12c52aba23024057862

VIALACTEA2016: The Milky Way as a Star Formation Engine
26 - 30 September 2016, Rome, Italy
http://vialactea2016.iaps.inaf.it

The ISM-SPP Olympian School of Astrophysics 2016
3 - 7 October 2016, Mt. Olympus, Greece
http://school2016.olympiancfa.org/

The Local Truth: Galactic Star-formation and Feed-back in the SOFIA Era - Celebrating 50 years of airborne astronomy
16 - 20 October 2016, Pacific Grove, USA
http://www.sofia.usra.edu/Science/workshops/SOFIA_Conference_2016

Search for life: from early Earth to exoplanets
12 - 16 December 2016, Quy Nhon, Vietnam
http://rencontresduvietnam.org/conferences/2016/search-for-life

Other meetings: http://www1.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/meetings/