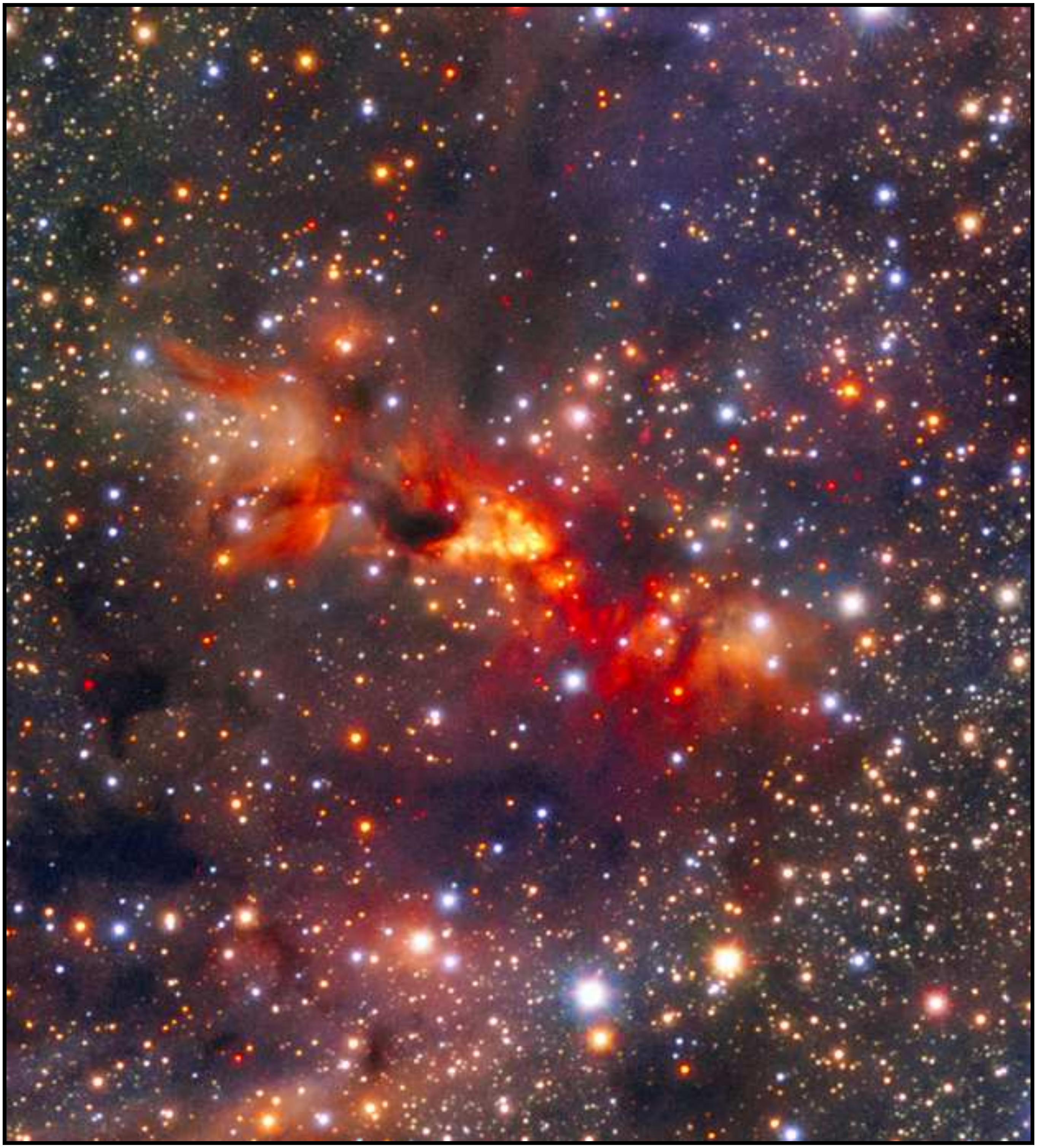
THE STAR FORMATION NEWSLETTER

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

No. 273 — 13 September 2015 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)



The Star Formation Newsletter

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

Newsletter Archive

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

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Cover Picture

This region of massive star formation, known as IRAS 16562–3959, is located near the Galactic plane in Scorpius. The main object is a $\sim$15 $M_\odot$ newly formed star, G345.4938+01.4677, which was recently studied with ALMA. A large disk was found around the newborn star, as well as an outflow. The image was obtained by ESO's VISTA (Visible and Infrared Survey Telescope for Astronomy) telescope at the Paranal Observatory.

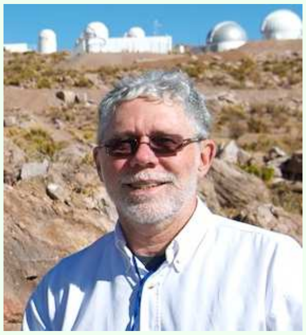
Image courtesy ESO/VVV Team/A. Guzmán

Submitting your abstracts

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

William Herbst

in conversation with Bo Reipurth



Q: *You published your first two papers as an undergraduate student. How did that come about?*

A: I was very fortunate to have Jim Gunn as my advisor during my junior year at Princeton and he suggested I compare the virial mass of the Local Group to the individual masses of the galaxies based on their stellar content. This led to a brief paper in the *PASP* that was not cited much but later played a positive role in my career. As a senior, I was again fortunate in advisors, working with Jerry Ostriker on an extension of work done by Jim Hesser to study the 71 second oscillation in the light of nova DQ Her. Somehow we managed to observe the low amplitude, ultra high frequency variability of this 14th magnitude star with a 36-inch telescope from Princeton's light-polluted campus. Looking back, I consider it miraculous! In those days, one centered the star by eye in a diaphragm, but this star was too faint to be seen on most nights with that telescope given the poor observing conditions. Using a blind offset I confidently observed the object for four hours one night, even though I couldn't see it. With the swagger of youth I delivered a box full of cards to the computing center that morning and, several hour later, picked up the output from the Fourier Transform code. There was a big, beautiful peak right at 71 seconds! At the time I was thrilled, but not surprised. As an experienced observer, I am now totally amazed that this worked. I sometimes wonder how life would have changed for me if it had not worked. Would I have lost my motivation for a career in astronomy – who knows?

Q: *Your PhD in 1974 dealt with R-associations. Can you describe some of that work?*

A: R-associations are clusters of reflection nebulae on the sky. My co-advisors Sidney van den Bergh and Renee Racine had pioneered this work finding that the illuminating stars were generally mid-B to A type. Many were Herbig Ae/Be stars so this was obviously a way to locate star forming regions that were producing intermediate mass stars, but not sufficiently massive stars to ionize the gas and create an HII region or OB association. My thesis work involved identifying and characterizing R associations in the southern hemisphere. It led to the discovery of one particularly interesting R-association, CMa R1, that lies long the edge of a large bubble of expanding gas with the characteristics of an old supernova remnant.

Q: *As a Carnegie Fellow after your PhD you studied a case of supernova induced star formation.*

A: Yes, my work on CMa R1 came at an interesting time since the cosmochemistry community was very excited about the clear evidence for live ^{26}Al in the primitive meteorite Allende, that had just been reported by a Cal Tech group. A nearby supernova was, and probably still is, the leading candidate for production of this short-lived radioactive isotope. The cross-disciplinary impact of my work fit well with the focus of the Carnegie Institution's Department of Terrestrial Magnetism and it was a great pleasure to spend two years there as a Post-Doctoral Fellow. Incidentally, I later learned from Vera Rubin, who had been on the search committee, that the fact I had a paper on galaxies – even if from my undergraduate days – on my resume, helped me get the job. The only regret from my days at DTM is that I did not take time out from star formation work to do something in collaboration with Vera, who was in the midst of her famous study of galaxy rotation curves with Kent Ford. I did make use of Kent's fabulous image tube spectrograph to begin work on the cluster NGC 2264 that would be a major focus for me for decades to come.

Q: *When you moved to Wesleyan University in 1978 you gained access to the 0.6m Perkin telescope, which you have used very efficiently to study the variability of young stars. Please describe this facility.*

A: The Perkin telescope belonged to Mr. Richard S. Perkin, a founder of Perkin-Elmer, and was originally in his backyard in New Canaan, CT. It was a classic Boller & Chivens 24-inch telescope, similar to those at many professional observatories, state-of-the-art in the 1960's. It had been on the Wesleyan campus, adjacent to the Van Vleck Observatory (i.e. right in the middle of campus!), since 1972 but not used much since it had only a photographic camera as an instrument. I arrived in 1978 and had some eager young students, including two who are now well known astronomers – Jon Holtzman and Taft Armandroff. They did visual observations of variable stars in the Orion Nebula Cluster. With help from Research Corporation we were able to equip the telescope with a single channel photometer and began professional-level work monitoring T Tauri stars. A big early success was discovery of the rotation period of T Tauri itself. Things really took off, though, when we were able to put a CCD camera on the telescope around 1990, thanks to the W. M. Keck Foundation and their funding of the Keck Northeast Astronomy Consortium. By focusing on young clusters we were able to monitor hundreds of T Tauri stars at a time, instead of just a few. With that advance in technology, the Perkin telescope became quite capable of professional level astronomy, even though it was just a small telescope at a mediocre observing site. Of course, it was the energy and enthusiasm of the Wesleyan students that made us almost as productive as we would have been with a robotic telescope. The Perkin telescope is still productive, and now mostly committed to the study of transiting exoplanets directed by my Wesleyan colleague Seth Redfield.

Q: *You and your students have extensively studied stellar rotation in the Orion Nebula Cluster and elsewhere. What are the main conclusions?*

A: With my students Jody Attridge and Phil Choi, we published the first surveys of the Orion Nebula Cluster for periodic variability and found a bimodal distribution of rotation periods. Collaborating with Suzan Edwards and Steve Strom and their groups, we argued that the cause of this phenomenon was "disk locking". This led to decades of follow-up studies, extension to other clusters, not a little controversy, several Ph.D. theses, and hopefully some improvement of our understanding of angular momentum evolution in low mass stars – although there is still much work to do! I believe it is fair to say that the original idea that stars lose (surface) angular momentum by magnetically interacting with their accretion disks is now well established and it is the cause of the bimodal distribution of periods in the stars we observed. We later extended this work to other clusters such as IC 348 and, in collaboration with Reinhard Mundt and his colleagues at MPIA, to NGC 2264, where we also found a bimodal period distribution. One of the difficulties going forward is that we have no way to know what is going on below the surfaces of these stars. Perhaps the techniques of helioseismology and asteroseismology that have been so successfully applied to some stars will one day allow us to probe the interiors of T Tauri stars.

Q: *You have also studied irregular variability of T Tauri stars. Is the variability mass or age dependent?*

A: We found early on that among the bright representatives of their classes, higher mass and/or older stars were less likely to be variable than lower mass and/or younger stars. I think two things are going on here - the obvious one is that the irregular variability comes from accretion rate variations and accretion disks disappear with time. The less obvious thing is that higher mass stars with accretion disks tend to accrete so rapidly that the disks overwhelm and crush their magnetospheres, leading to a much different sort of optical light variability. The more common, lower mass (T Tauri) stars have accretion variations modulated by their magnetic interactions with the disk. So, measured variability characteristics do vary with mass and age. We refer to the periodic variations caused by rotation of stars with cool spots on them – primarily older, Weak T Tauri stars – as "Type I", the irregular variations of Classical T Tauri stars as "Type II", and the variations of the "crushed magnetosphere" stars – generally more massive than CTTS – as "Type III".

Q: *You and Valerie Shevchenko have made detailed studies of Herbig Ae/Be stars, especially the UX Ori type stars. What is causing the major UX Ori variability?*

A: UX Ori is the prototype for Type III variables that I was just saying are common among the more massive pre-main sequence stars, generally of G-type or earlier, and including some Herbig Ae/Be stars, such as T Ori. These stars have been a favorite target of Russian astronomers, including my late friend and colleague Valerie Shevchenko and his former group at Maidanak Observatory in Uzbekistan. Vladimir Grinin showed that these stars have increased polarization and excess blue light when faint, demonstrating that obscuration of the photosphere by something causes their significant brightness drops and that we are seeing mostly scattered light when they are very faint. Beyond that, however, I don't believe we yet have a very good handle on what is going on with these objects. They have, unfortunately, not attracted as much attention as they probably deserve – hopefully that will be rectified soon.

Q: *You and your students have discovered and studied the now famous KH 15D = V582 Mon. What is the current view of this amazing object?*

A: It is a binary T Tauri star with a 48 day period and highly eccentric orbit embedded in a circumbinary ring that extends from $\sim$2 to 6 AU. The ring is tilted to the plane of the binary and, therefore, precesses on a timescale of $\sim$4 thousand years. By sheer good fortune the ring began occulting the orbit of the binary as seen from Earth a few decades ago, and completely covered it in 2009. Since the projected width of the ring on the sky is only slightly larger than the projected orbits of the stars, the stars stayed fully covered for only two years, during which KH 15D was quite faint but still visible by scattered starlight. Up until 2009 we were progressively covering the stars – now we are seeing the other side of the orbit (and a different star) being progressively revealed. Every 48 days we observe a "star-rise" and the star rises progressively higher. Since the node advances at the stately speed of 15 meters per second, full star-rise takes $\sim$4 years, and is just now completing. Obviously this is a really fascinating object that we are privileged to be catching in such an interesting phase. It continues to provide unique opportunities to probe the inner, planet-forming zone of a proto-Tatooine system.

Abstracts of recently accepted papers

ALMA Observations of the Transition from Infall Motion to Keplerian Rotation around the Late-phase Protostar TMC-1A

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We have observed the Class I protostar TMC-1A with Atacama Millimeter/submillimeter Array (ALMA) in ^{12}CO and C^{18}O (J=2–1), and 1.3-mm dust continuum emission. Continuum emission with a deconvolved size of $0''.50 \times 0''.37$, perpendicular to the ^{12}CO outflow, is detected. It most likely traces a circumstellar disk around TMC-1A, as previously reported. In contrast, a more extended structure is detected in C^{18}O although it is still elongated with a deconvolved size of $3''.3 \times 2''.2$, indicating that C^{18}O traces mainly a flattened envelope surrounding the disk and the central protostar. C^{18}O shows a clear velocity gradient perpendicular to the outflow at higher velocities, indicative of rotation, while an additional velocity gradient along the outflow is found at lower velocities. The radial profile of the rotational velocity is analyzed in detail, finding that it is given as a power-law $\propto r^{-a}$ with an index of $\sim$0.5 at higher velocities. This suggests that the rotation at higher velocities can be explained as Keplerian rotation orbiting a protostar with a dynamical mass of 0.68 $M_\odot$ (inclination-corrected). The additional velocity gradient of C^{18}O along the outflow is considered to be mainly infall motions in the envelope. Position–Velocity diagrams made from models consisting of an infalling envelope and a Keplerian disk are compared with the observations, revealing that the observed infall velocity is $\sim$0.3 times smaller than the free fall velocity yielded by the dynamical mass of the protostar. Magnetic fields could be responsible for the slow infall velocity. A possible scenario of Keplerian disk formation is discussed.

Accepted by ApJ

http://arxiv.org/pdf/1508.07013

On The History and Future of Cosmic Planet Formation

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We combine constraints on galaxy formation histories with planet formation models, yielding the Earth-like and giant planet formation histories of the Milky Way and the Universe as a whole. In the Hubble Volume (10^{13} Mpc^3), we expect there to be $\sim 10^{20}$ Earth-like and $\sim 10^{20}$ giant planets; our own galaxy is expected to host $\sim 10^9$ and $\sim 10^{10}$ Earth-like and giant planets, respectively. Proposed metallicity thresholds for planet formation do not significantly

affect these numbers. However, the metallicity dependence for giant planets results in later typical formation times and larger host galaxies than for Earth-like planets. The Solar System formed at the median age for existing giant planets in the Milky Way, and consistent with past estimates, formed after 80% of Earth-like planets. However, if existing gas within virialised dark matter haloes continues to collapse and form stars and planets, the Universe will form over 10 times more planets than currently exist. We show that this would imply at least a 92% chance that we are not the only civilisation the Universe will ever have, independent of arguments involving the Drake Equation.

Accepted by MNRAS

http://arxiv.org/pdf/1508.01202

A self-consistent, absolute isochronal age scale for young moving groups in the solar neighbourhood

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We present a self-consistent, absolute isochronal age scale for young (< 200 Myr), nearby (< 100 pc) moving groups in the solar neighbourhood based on homogeneous fitting of semi-empirical pre-main-sequence model isochrones using the τ^2 maximum-likelihood fitting statistic of Naylor & Jeffries in the $M_V, V-J$ colour-magnitude diagram. The final adopted ages for the groups are: 149^{+51}_{-19} Myr for the AB Dor moving group, 24 ± 3 Myr for the β Pic moving group (BPMG), 45^{+11}_{-7} Myr for the Carina association, 42^{+6}_{-4} Myr for the Columba association, 11 ± 3 Myr for the η Cha cluster, 45 ± 4 Myr for the Tucana-Horologium moving group (Tuc-Hor), 10 ± 3 Myr for the TW Hya association, and 22^{+4}_{-3} Myr for the 32 Ori group. At this stage we are uncomfortable assigning a final, unambiguous age to the Argus association as our membership list for the association appears to suffer from a high level of contamination, and therefore it remains unclear whether these stars represent a single population of coeval stars.

Our isochronal ages for both the BPMG and Tuc-Hor are consistent with recent lithium depletion boundary (LDB) ages, which unlike isochronal ages, are relatively insensitive to the choice of low-mass evolutionary models. This consistency between the isochronal and LDB ages instills confidence that our self-consistent, absolute age scale for young, nearby moving groups is robust, and hence we suggest that these ages be adopted for future studies of these groups.

Software implementing the methods described in this study is available from
http://www.astro.ex.ac.uk/people/timn/tau-squared/

Accepted by MNRAS

http://arxiv.org/pdf/1508.05955.pdf

AMBER/VLTI high spectral resolution observations of the Brγ emitting region in HD 98922. A compact disc wind launched from the inner disc region

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Context. High angular and spectral resolution observations can provide us with fundamental clues to the complex circumstellar structure of young stellar objects (YSOs) and to the physical processes taking place close to these sources.
Aims. We analyse the main physical parameters and the circumstellar environment of the young Herbig Be star HD 98922.
Methods. We present AMBER/VLTI high spectral resolution (R=12 000) interferometric observations across the Brγ line, accompanied by UVES high-resolution spectroscopy and SINFONI-AO assisted near-infrared (NIR) integral field spectroscopic data. To interpret our observations, we develop a magneto-centrifugally driven disc-wind model.
Results. Our analysis of the UVES spectrum shows that HD 98922 is a young ($\sim 5\times10^5$ yr) Herbig Be star (SpT=B9V), located at a distance of $440\pm^{60}_{50}$ pc, with a mass accretion rate ($\dot{M}_{acc}$) of $\sim(9\pm3)\times10^{-7}\,M_\odot\,yr^{-1}$. SINFONI *K*-band AO-assisted imaging shows a spatially resolved circumstellar disc-like region ($\sim$140 AU in diameter) with asymmetric brightness distribution. Our AMBER/VLTI UT observations indicate that the Brγ emitting region (ring-fit radius $\sim 0.31\pm0.04$ AU) is smaller than the continuum emitting region (inner dust radius $\sim 0.7\pm0.2$ AU), showing significant non-zero V-shaped differential phases (i.e. non S-shaped, as expected for a rotating disc). The value of the continuum-corrected pure Brγ line visibility at the longest baseline (89 m) is $\sim 0.8\pm0.1$, i.e. the Brγ emitting region is partially resolved. Our modelling suggests that the observed Brγ line-emitting region mainly originates from a disc wind with a half opening angle of 30°, and with a mass-loss rate ($\dot{M}_w$) of $\sim 2\times10^{-7}\,M_\odot\,yr^{-1}$. The observed V-shaped differential phases are reliably reproduced by combining a simple asymmetric continuum disc model with our Brγ disc-wind model.
Conclusions. In conclusion, the Brγ emission of HD 98922 can be modelled with a disc wind that is able to approximately reproduce all interferometric observations if we assume that the intensity distribution of the dust continuum disc is asymmetric.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1508.00798

Anisotropic Formation of Magnetized Cores in Turbulent Clouds

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In giant molecular clouds (GMCs), shocks driven by converging turbulent flows create high-density, strongly-magnetized regions that are locally sheetlike. In previous work, we showed that within these layers, dense filaments and embedded self-gravitating cores form by gathering material along the magnetic field lines. Here, we extend the parameter space of our three-dimensional, turbulent MHD core formation simulations. We confirm the anisotropic core formation model we previously proposed, and quantify the dependence of median core properties on the pre-shock inflow velocity and upstream magnetic field strength. Our results suggest that bound core properties are set by the total dynamic pressure (dominated by large-scale turbulence) and thermal sound speed c_s in GMCs, independent of magnetic field strength. For models with Mach number between 5 and 20, the median core masses and radii are comparable to the critical Bonnor-Ebert mass and radius defined using the dynamic pressure for $P_{\rm ext}$. Our results correspond to $M_{\rm core} = 1.2{c_s}^4(G^3\rho_0{v_0}^2)^{-1/2}$ and $R_{\rm core} = 0.34{c_s}^2(G\rho_0{v_0}^2)^{-1/2}$ for ρ_0 and v_0 the large-scale mean density and velocity. For our parameter range, the median $M_{\rm core} \sim 0.1$–$1\ M_\odot$, but a very high pressure cloud could have lower characteristic core mass. We find cores and filaments form simultaneously, and filament column densities are a factor $\sim$2 greater than the surrounding cloud when cores first collapse. We also show that cores identified in our simulations have physical properties comparable to those observed in the Perseus cloud. Superthermal cores in our models are generally also magnetically supercritical, suggesting that the same may be true in observed clouds.

Accepted by ApJ

http://arxiv.org/pdf/1508.02710

The effects of a magnetic field on planetary migration in laminar and turbulent discs

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We investigate the migration of low-mass planets (5 $M_\oplus$ and 20 $M_\oplus$) in accretion discs threaded with a magnetic field using 2D MHD code in polar coordinates. We observed that, in the case of a strong azimuthal magnetic field where the plasma parameter is $\beta \sim 1$–2, density waves at the magnetic resonances exert a positive torque on the planet and may slow down or reverse its migration. However, when the magnetic field is weaker (i.e., the plasma parameter β is relatively large), then non-axisymmetric density waves excited by the planet lead to growth of the radial component of the field and, subsequently, to development of the magneto-rotational instability, such that the disc becomes turbulent. Migration in a turbulent disc is stochastic, and the migration direction may change as such. To understand migration in a turbulent disc, both the interaction between a planet and individual turbulent cells, as well as the interaction between a planet and ordered density waves, have been investigated.

Accepted by MNRAS

http://arxiv.org/pdf/1508.03241

The Distribution of Main Sequence and Pre-Main Sequence Stars in the Young Anti-center Cluster NGC 2401

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Images obtained with the Gemini Multi-Object Spectrograph on Gemini South are used to examine the photometric properties and spatial distributions of main sequence (MS) and pre-main sequence (PMS) objects in the star cluster NGC 2401. The data sample several magnitudes fainter than previous studies, and a large population of candidate PMS (cPMS) stars are identified. The cPMS stars are traced out to $2'.4$ from the cluster center, and have a flatter spatial distribution than the brightest MS stars near the cluster center. The luminosity function of all MS and candidate PMS stars can be matched by a model that assumes a solar neighborhood mass function, suggesting that NGC 2401 has not yet shed significant numbers of members with masses in excess of 0.5 $M_\odot$. The frequency of wide binaries among the MS stars is $\sim$3 times higher than among the cPMS stars. It is argued that the difference in the spatial distributions of MS and PMS objects is not the consequence of secular dynamical evolution or structural evolution driven by near-catastrophic mass loss. Rather, it is suggested that the different spatial distributions of these objects is the fossil imprint of primordial sub-clustering that arises naturally if massive stars form preferentially in the highest density central regions of a protocluster.

Accepted by PASP

http://arxiv.org/pdf/1508.07976

High-Temperature Ionization in Protoplanetary Disks

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We calculate the abundances of electrons and ions in the hot (> 500 K), dusty parts of protoplanetary disks, treating for the first time the effects of thermionic and ion emission from the dust grains. High-temperature ionization modeling has involved simply assuming that alkali elements such as potassium occur as gas- phase atoms and are collisionally ionized following the Saha equation. We show that the Saha equation often does not hold, because free charges are produced by thermionic and ion emission and destroyed when they stick to grain surfaces. This means the ionization state depends not on the first ionization potential of the alkali atoms, but rather on the grains work functions. The charged species' abundances typically rise abruptly above about 800 K, with little qualitative dependence on the work function, gas density, or dust-to-gas mass ratio. Applying our results, we find that protoplanetary disks' dead zone, where high diffusivities stifle magnetorotational turbulence, has its inner edge located where the temperature exceeds a threshold value 1000 K. The threshold is set by ambipolar diffusion except at the highest densities, where it is set by Ohmic resistivity. We find that the disk gas can be diffusively loaded onto the stellar magnetosphere at temperatures below a similar threshold. We investigate whether the "short-circuit" instability of current sheets can operate in disks and find that it cannot, or works only in a narrow range of conditions; it appears not to be the chondrule formation mechanism. We also suggest that thermionic emission is important for determining the rate of Ohmic heating in hot Jupiters.

Accepted by The Astrophysical Journal

http://xxx.lanl.gov/pdf/1508.07878

Physical environment of massive star-forming region W42

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We present an analysis of multi-wavelength observations from various datasets and Galactic plane surveys to study the star formation process in the W42 complex. A bipolar appearance of W42 complex is evident due to the ionizing feedback from the O5-O6 type star in a medium that is highly inhomogeneous. The VLT/NACO adaptive-optics K and L′ images (resolutions ∼0.″2–0.″1) resolved this ionizing source into multiple point-like sources below ∼5000 AU scale. The position angle ∼15 degrees of W42 molecular cloud is consistent with the H-band starlight mean polarization angle which in turn is close to the Galactic magnetic field, suggesting the influence of Galactic field on the evolution of the W42 molecular cloud. *Herschel* sub-millimeter data analysis reveals three clumps located along the waist axis of the bipolar nebula, with the peak column densities of $\sim$3–5 $\times$ 10^{22} cm^{-2} corresponding to visual extinctions of A_V ∼32–53.5 mag. The *Herschel* temperature map traces a temperature gradient in W42, revealing regions of 20 K, 25 K, and 30–36 K. *Herschel* maps reveal embedded filaments (length ∼1–3 pc) which appear to be radially pointed to the denser clump associated with the O5-O6 star, forming a hub-filament system. 512 candidate young stellar objects (YSOs) are identified in the complex, ∼40% of which are present in clusters distributed mainly within the molecular cloud including the *Herschel* filaments. Our datasets suggest that the YSO clusters including the massive stars are located at the junction of the filaments, similar to those seen in Rosette Molecular Cloud.

Accepted by The Astrophysical Journal

http://arxiv.org/pdf/1508.04425v1.pdf

Observational Signatures of Planets in Protoplanetary Disks II: Spiral Arms Observed in Scattered Light Imaging Can be Induced by Planets

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Using 3D global hydro simulations coupled with radiative transfer calculations, we study the appearance of density waves induced by giant planets in direct imaging observations at near infrared wavelengths. We find that a $6M_{\rm J}$ planet in a typical disk around a $1M_{\odot}$ star can produce prominent and detectable spiral arms both interior and exterior to its orbit. The inner arms have (1) two well separated arms in roughly $m = 2$ symmetry, (2) exhibit $\sim 10 - 15°$ pitch angles, (3) $\sim 180 - 270°$ extension in the azimuthal direction, and (4) $\sim 150\%$ surface brightness enhancement, all broadly consistent with observed spiral arms in the SAO 206462 and MWC 758 systems. The outer arms cannot explain observations as they are too tightly wound given typical disk scale height. We confirm previous results that the outer density waves excited by a $1M_{\rm J}$ planet exhibit low contrast in the IR and are practically not detectable. We also find that 3D effects of the waves are important. Compared to isothermal models, density waves in adiabatic disks exhibit weaker contrast in surface density but stronger contrast in scattered light images, due to a more pronounced vertical structure in the former caused by shock heating and maybe hydraulic jump effect. To drive observed pairs of arms with an external companion on a circular orbit, a massive planet, possibly a brown dwarf, is needed at around [$r \sim 0.7$ *arcsec*, PA$\sim 10°$] (position angle PA from north to east) in SAO 206462 and [$r \sim 0.6$ *arcsec*, PA$\sim 10°$] in MWC 758. Their existence may be confirmed by direct imaging planet searches.

Accepted by ApJ

http://arxiv.org/pdf/1507.03596

Young Stellar Objects in the Gould Belt

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We present the full catalog of Young Stellar Objects (YSOs) identified in the 18 molecular clouds surveyed by the *Spitzer Space Telescope* "cores to disks" (c2d) and "Gould Belt" (GB) Legacy surveys. Using standard techniques developed by the c2d project, we identify 3239 candidate YSOs in the 18 clouds, 2966 of which survive visual inspection and form our final catalog of YSOs in the Gould Belt. We compile extinction corrected SEDs for all 2966 YSOs and calculate and tabulate the infrared spectral index, bolometric luminosity, and bolometric temperature for each object. We find that 326 (11%), 210 (7%), 1248 (42%), and 1182 (40%) are classified as Class 0+I, Flat-spectrum, Class II, and Class III, respectively, and show that the Class III sample suffers from an overall contamination rate by background

AGB stars between 25% and 90%. Adopting standard assumptions, we derive durations of 0.40 − 0.78 Myr for Class 0+I YSOs and 0.26 − 0.50 Myr for Flat-spectrum YSOs, where the ranges encompass uncertainties in the adopted assumptions. Including information from (sub)millimeter wavelengths, one-third of the Class 0+I sample is classified as Class 0, leading to durations of 0.13 − 0.26 Myr (Class 0) and 0.27 − 0.52 Myr (Class I). We revisit infrared color-color diagrams used in the literature to classify YSOs and propose minor revisions to classification boundaries in these diagrams. Finally, we show that the bolometric temperature is a poor discriminator between Class II and Class III YSOs.

Accepted by ApJS

http://arxiv.org/pdf/1508.03199

Gravitational instabilities in a protosolar-like disc I: dynamics and chemistry

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To date, most simulations of the chemistry in protoplanetary discs have used 1+1D or 2D axisymmetric α-disc models to determine chemical compositions within young systems. This assumption is inappropriate for non-axisymmetric, gravitationally unstable discs, which may be a significant stage in early protoplanetary disc evolution. Using 3D radiative hydrodynamics, we have modelled the physical and chemical evolution of a $0.17\,M_\odot$ self-gravitating disc over a period of 2000 yr. The $0.8\,M_\odot$ central protostar is likely to evolve into a solar-like star, and hence this Class 0 or early Class I young stellar object may be analogous to our early Solar System. Shocks driven by gravitational instabilities enhance the desorption rates, which dominate the changes in gas-phase fractional abundances for most species. We find that at the end of the simulation, a number of species distinctly trace the spiral structure of our relatively low-mass disc, particularly CN. We compare our simulation to that of a more massive disc, and conclude that mass differences between gravitationally unstable discs may not have a strong impact on the chemical composition. We find that over the duration of our simulation, successive shock heating has a permanent effect on the abundances of HNO, CN and NH_3, which may have significant implications for both simulations and observations. We also find that HCO^+ may be a useful tracer of disc mass. We conclude that gravitational instabilities induced in lower mass discs can significantly, and permanently, affect the chemical evolution, and that observations with high-resolution instruments such as ALMA offer a promising means of characterising gravitational instabilities in protosolar discs.

Accepted by MNRAS

http://arxiv.org/pdf/1508.00773v1

Warm Debris Disks Produced by Giant Impacts During Terrestrial Planet Formation

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In our solar system, Mars-sized protoplanets frequently collided with each other during the last stage of terrestrial planet formation called the giant impact stage. Giant impacts eject a large amount of material from the colliding protoplanets into the terrestrial planet region, which may form debris disks with observable infrared excesses. Indeed, tens of warm debris disks around young solar-type stars have been observed. Here, we quantitatively estimate the total mass of ejected materials during the giant impact stages. We found that ∼0.4 times the Earth's mass is ejected in total throughout the giant impact stage. Ejected materials are ground down by collisional cascade until micron-sized grains are blown out by radiation pressure. The depletion timescale of these ejected materials is determined primarily by the mass of the largest body among them. We conducted high-resolution simulations of giant impacts to accurately obtain the mass of the largest ejected body. We then calculated the evolution of the debris disks produced by a series of giant impacts and depleted by collisional cascades to obtain the infrared excess evolution of the debris disks. We found that the infrared excess is almost always higher than the stellar infrared flux throughout the giant impact stage (∼100 Myr) and is sometimes ∼10 times higher immediately after a giant impact. Therefore, giant impact stages would explain the infrared excess from most observed warm debris disks. The observed fraction of stars with warm debris disks indicates that the formation probability of our solar system-like terrestrial planets is approximately 10%.

Accepted by ApJ

http://arxiv.org/pdf/1508.00977

Planetesimal formation in self-gravitating discs — dust trapping by vortices

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The mechanism through which meter-sized boulders grow to km-sized planetesimals in protoplanetary discs is a subject of active research, since it is critical for planet formation. To avoid spiralling into the protostar due to aerodynamic drag, objects must rapidly grow from cm-sized pebbles, which are tightly coupled to the gas, to large boulders of 1–100 m in diameter. It is already well known that over-densities in the gaseous component of the disc provide potential sites for the collection of solids, and that significant density structures in the gaseous component of the disc (e.g., spiral density waves) can trap solids efficiently enough for the solid component of the disc to undergo further gravitational collapse due to their own self-gravity. In this work, we employ the PENCIL CODE to conduct local shearing sheet simulations of massive self-gravitating protoplanetary discs, to study the effect of anticyclonic transient vortices, or eddies, on the evolution of solids in these discs. We find that these types of structures are extremely efficient at concentrating small and intermediate-sized dust particles with friction times comparable to, or less than, the local orbital period of the disc. This can lead to significant over-densities in the solid component of the disc, with density enhancements comparable to, and even higher, than those within spiral density waves; increasing the rate of gravitational collapse of solids into bound structures.

Accepted by MNRAS

http://arxiv.org/pdf/1508.02879

Velocity-resolved [CII] emission and [CII]/FIR mapping along Orion with Herschel

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We present the first $\sim 7.5' \times 11.5'$ velocity-resolved (~ 0.2 km s^{-1}) map of the [C II] 158 μm line toward the Orion molecular cloud 1 (OMC 1) taken with the *Herschel*/HIFI instrument. In combination with far-infrared (FIR) photometric images and velocity-resolved maps of the H41α hydrogen recombination and CO J=2-1 lines, this data set provides an unprecedented view of the intricate small-scale kinematics of the ionized/PDR/molecular gas interfaces and of the radiative feedback from massive stars. The main contribution to the [C II] luminosity ($\sim$85 %) is from the extended, FUV-illuminated face of the cloud (G_0>500, $n_{\rm H}$>5×10^3 cm^{-3}) and from dense PDRs (G_0>10^4, $n_{\rm H}$>10^5 cm^{-3}) at the interface between OMC 1 and the HII region surrounding the Trapezium cluster. Around $\sim$15 % of the [C II] emission arises from a different gas component without CO counterpart. The [C II] excitation, PDR gas turbulence, line opacity (from [^{13}C II]) and role of the geometry of the illuminating stars with respect to the cloud are investigated. We construct maps of the L[C II]/$L_{\rm FIR}$ and $L_{\rm FIR}/M_{\rm Gas}$ ratios and show that L[C II]/$L_{\rm FIR}$ decreases from the extended cloud component ($\sim 10^{-2}$–10^{-3}) to the more opaque star-forming cores ($\sim 10^{-3}$–10^{-4}). The lowest values are reminiscent of the "[C II] deficit" seen in ultra-luminous IR galaxies hosting vigorous star formation. Spatial correlation analysis shows that the decreasing L[C II]/$L_{\rm FIR}$ ratio correlates better with the column density of dust through the molecular cloud than with $L_{\rm FIR}/M_{\rm Gas}$ (a proxy of the ionization parameter U). We conclude that the [C II] emitting column relative to the total dust column along each line of sight is responsible for the observed L[C II]/$L_{\rm FIR}$ variations through the cloud.

Accepted by ApJ

http://arxiv.org/pdf/1508.03801

Vortex Formation and Evolution in Planet Harboring Disks under Thermal Relaxation

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We study the evolution of planet-induced vortices in radially stratified disks, with initial conditions allowing for radial buoyancy. For this purpose we run global two dimensional hydrodynamical simulations, using the PLUTO code. Planet-induced vortices are a product of the Rossby wave instability (RWI) triggered in the edges of a planetary gap. In this work we assess the influence of radial buoyancy for the development of the vortices. We found that radial buoyancy leads to smoother planetary gaps, which generates weaker vortices. This effect is less pronounced for locally isothermal and quasi-isothermal (very small cooling rate) disks. We observed the formation of two generations of vortices. The first generation of vortices is formed in the outer wall of the planetary gap. The merged primary vortex induces accretion, depleting the mass on its orbit. This process creates a surface density enhancement beyond the primary vortex position. The second generation of vortices arise in this surface density enhancement, indicating that the bump in this region is sufficient to trigger the RWI. The merged secondary vortex is a promising explanation for the location of the vortex in the Oph IRS48 system. Finally, we observed a nonmonotonic behavior for the vortex lifetimes as a function of the thermal relaxation timescale, agreeing with previous studies. The birth times of the secondary vortices also display a nonmonotonic behavior, which is correlated with the growth time of the primary

vortex and its induced accretion.

Accepted by ApJ

http://arxiv.org/pdf/1508.00903

Detection of N_2D^+ in a protoplanetary disk

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Observations of deuterium fractionation in the solar system, and in interstellar and circumstellar material, are commonly used to constrain the formation environment of volatiles. Toward protoplanetary disks, this approach has been limited by the small number of detected deuterated molecules, i.e. DCO^+ and DCN. Based on ALMA Cycle 2 observations toward the disk around the T Tauri star AS 209, we report the first detection of N_2D^+ (J=3–2) in a protoplanetary disk. These data are used together with previous Submillimeter Array observations of N_2H^+ (J=3–2) to estimate a disk-averaged D/H ratio of 0.3–0.5, an order of magnitude higher than disk-averaged ratios previously derived for DCN/HCN and DCO^+/HCO^+ around other young stars. The high fractionation in N_2H^+ is consistent with model predictions. The presence of abundant N_2D^+ toward AS 209 also suggests that N_2D^+ and the N_2D^+/N_2H^+ ratio can be developed into effective probes of deuterium chemistry, kinematics, and ionization processes outside the CO snowline of disks.

Accepted by ApJL

http://arxiv.org/pdf/1508.03637

Study of infrared excess from circumstellar disks in binaries with Spitzer/IRAC

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The presence of excess emission at 3.6–8.0 μm was investigated in a sample of 27 binary systems located in two nearby star-forming regions, Taurus and Ophiuchus, by using Spitzer/Infrared Array Camera (IRAC) archival data. Angular (Projected) separations for the binaries are greater than 2"($\sim$280 AU), which allowed us to perform spatially resolved photometry of individual primary and secondary sources. The measured occurrence of infrared excess suggests that binarity plays a role in the evolution of circumstellar disks, even at such wide binary separations. Most of the binaries have excess emission from both the circumprimary and circumsecondary disks, or show photospheric levels for both components at all four wavelengths of IRAC. On the other hand, four systems (17^{+11}_{-8}%, designated by "mixed" systems) exhibit excess emission from a single binary component. This ratio is significantly smaller than that predicted by the random pairing of single stars, suggesting that circumprimary and circumsecondary disks are synchronously dispersed. In addition, the excess frequencies (EFs) of primary and secondary sources with a projected distance of $a_{\rm p}\simeq$280–450 AU are 100^{+0}_{-17}% and 91^{+8}_{-18}%, respectively, and significantly higher than that of single stars (70 ± 5%). We made a simple model describing the EF distribution as a function of the disk outer radius, $R_{\rm out}$. Comparisons with observations using the Kolmogorov-Smirnov test show that the observational data are consistent with the model when the EF $\simeq 1$ region is found at $R_{\rm out}\sim$30–100 AU. This disk radius is smaller than that typically estimated for single stars. The high EF of circumstellar disks with these radii may indicate a prolonged lifetime of dust in binary systems possibly because smaller disks counteract mass loss by photoevaporation.

Accepted by PASJ

http://arxiv.org/pdf/1508.05595

Interstellar Dust Charging in Dense Molecular Clouds: Cosmic Ray Effects

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The local cosmic-ray (CR) spectra are calculated for typical characteristic regions of a cold dense molecular cloud, to investigate two so far neglected mechanisms of dust charging: collection of suprathermal CR electrons and protons by grains, and photoelectric emission from grains due to the UV radiation generated by CRs. The two mechanisms add to the conventional charging by ambient plasma, produced in the cloud by CRs. We show that the CR-induced photoemission can dramatically modify the charge distribution function for submicron grains. We demonstrate the importance of the obtained results for dust coagulation: While the charging by ambient plasma alone leads to a strong Coulomb repulsion between grains and inhibits their further coagulation, the combination with the photoemission provides optimum conditions for the growth of large dust aggregates in a certain region of the cloud, corresponding to the densities $n(H_2)$ between $\sim 10^4$ cm^{-3} and $\sim 10^6$ cm^{-3}. The charging effect of CR is of generic nature, and therefore is expected to operate not only in dense molecular clouds but also in the upper layers and the outer parts of protoplanetary discs.

Accepted by ApJ

http://arxiv.org/pdf/1507.00692

Terrestrial Planet Formation Constrained by Mars and the Structure of the Asteroid Belt

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Reproducing the large Earth/Mars mass ratio requires a strong mass depletion in solids within the protoplanetary disk between 1 and 3 AU. The Grand Tack model invokes a specific migration history of the giant planets to remove most of the mass initially beyond 1 AU and to dynamically excite the asteroid belt. However, one could also invoke a steep density gradient created by inward drift and pile-up of small particles induced by gas-drag, as has been proposed to explain the formation of close-in super Earths. Here we show that the asteroid belt's orbital excitation provides a crucial constraint against this scenario for the Solar System. We performed a series of simulations of terrestrial planet formation and asteroid belt evolution starting from disks of planetesimals and planetary embryos with various radial density gradients and including Jupiter and Saturn on nearly circular and coplanar orbits. Disks with shallow density gradients reproduce the dynamical excitation of the asteroid belt by gravitational self-stirring but form Mars analogs significantly more massive than the real planet. In contrast, a disk with a surface density gradient proportional to $r^{?5.5}$ reproduces the Earth/Mars mass ratio but leaves the asteroid belt in a dynamical state that is far colder than the real belt. We conclude that no disk profile can simultaneously explain the structure of the terrestrial planets and asteroid belt. The asteroid belt must have been depleted and dynamically excited by a different mechanism such as, for instance, in the Grand Tack scenario.

Accepted by MNRAS

http://arxiv.org/pdf/1508.01365

The OH-streamer in Sgr A revisited: analysis of Hydroxyl absorption with in 10 pc from the Galactic centre

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We study the structure and kinematics of the OH-streamer and the +80 $\mathrm{km\,s^{-1}}$ cloud, and their interactions with the Circumnuclear Disk (CND) and other molecular clouds in the vicinity of the Galactic centre (GC), and to map OH absorption at about 6" resolution at $R \leq 10$ pc from the GC, with about 9 $\mathrm{km\,s^{-1}}$ of velocity resolution.
The VLA was used to map OH line absorption at the 1665 and 1667 MHz lambda doublet main lines of the $^2\Pi_{3/2}$ state towards the Sagittarius A complex.
Strong OH absorption was found in the OH-streamer, the Southern streamer (SS), the +20, +50, and +80 $\mathrm{km\,s^{-1}}$ molecular clouds, the Molecular belt, the CND, the expanding molecular ring (EMR), and the high negative velocity gas (HNVG). The OH-streamer was found to comprise of three parts, Head, Mid and Tail, and to interact with the SS/+20, +80 $\mathrm{km\,s^{-1}}$ clouds and the CND. Optical depths and column densities relative to H_2 have been calculated for the OH-streamer and the +80 $\mathrm{km\,s^{-1}}$ cloud.
The OH-streamer, the SS, the +20 and +80 $\mathrm{km\,s^{-1}}$ clouds, and the CND are intimately related in position and velocity space. The OH-streamer was found to be a clumpy object stretching in projection from the inner radius of the CND, at about 1.8 pc from Sgr A*, towards, and partly engulfing Sgr A*. We found the OH-streamer to be closely linked to the +80 $\mathrm{km\,s^{-1}}$ cloud and the CND. Interactions between the OH-streamer, the +20 and +80 $\mathrm{km\,s^{-1}}$ cloud, and the SW lobe of the CND were found. As a side result of our data a possible link between the near side of the EMR and the CND southwest lobe was found. Additionally, we found OH absorption against all four of the previously known Compact H II Regions A - D, located east of Sgr A East, indicating their close association with the +50 $\mathrm{km\,s^{-1}}$ cloud.
The paper includes maps of the 1665 and 1667 MHz data cubes. These data cubes are available in electronic form at the CDS at http://vizier.u-strasbg.fr/viz-bin/VizieR

Accepted by A&A

http://www.aanda.org/articles/aa/pdf/forth/aa24426-14.pdf

Collisional Cascade Calculations for Irregular Satellite Swarms in Fomalhaut b

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We describe an extensive suite of numerical calculations for the collisional evolution of irregular satellite swarms around 1–300 $M_\oplus$ planets orbiting at 120 AU in the Fomalhaut system. For 10–100 $M_\oplus$ planets, swarms with initial masses of roughly 1% of the planet mass have cross-sectional areas comparable to the observed cross-sectional area of Fomalhaut b. Among 30–300 $M_\oplus$ planets, our calculations yield optically thick swarms of satellites for ages of 1–10 Myr. Observations with HST and ground-based AO instruments can constrain the frequency of these systems around stars in the β Pic moving group and possibly other nearby associations of young stars.

Accepted by Astrophysical Journal

http://arxiv.org/pdf/1508.03350

The O- and B-Type Stellar Population in W3: Beyond the High-Density Layer

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We present the first results from our survey of the star-forming complex W3, combining VRI photometry with multiobject spectroscopy to identify and characterize the high-mass stellar population across the region. With 79 new spectral classifications, we bring the total number of spectroscopically-confirmed O- and B-type stars in W3 to 105. We find that the high-mass slope of the mass function in W3 is consistent with a Salpeter IMF, and that the extinction toward the region is best characterized by an R_V of approximately 3.6. B-type stars are found to be more widely dispersed across the W3 giant molecular cloud (GMC) than previously realized: they are not confined to the high-density layer (HDL) created by the expansion of the neighboring W4 H II region into the GMC. This broader B-type population suggests that star formation in W3 began spontaneously up to 8–10 Myr ago, although at a lower level than the more recent star formation episodes in the HDL. In addition, we describe a method of optimizing sky subtraction for fiber spectra in regions of strong and spatially-variable nebular emission.

Accepted by ApJ

http://arxiv.org/pdf/1509.00081

Outflows and Bubbles in Taurus: Star-formation Feedback Sufficient to Maintain Turbulence

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We have identified outflows and bubbles in the Taurus molecular cloud based on the ~ 100 deg^2 Five College Radio Astronomy Observatory ^{12}CO(1-0) and ^{13}CO(1-0) maps and the *Spitzer* young stellar object catalogs. In the main 44 deg^2 area of Taurus, we found 55 outflows, of which 31 were previously unknown. We also found 37 bubbles in the entire 100 deg^2 area of Taurus, none of which had been found previously. The total kinetic energy of the identified outflows is estimated to be $\sim 3.9 \times 10^{45}$ erg, which is 1% of the cloud turbulent energy. The total kinetic energy of the detected bubbles is estimated to be $\sim 9.2 \times 10^{46}$ erg, which is 29% of the turbulent energy of Taurus. The energy injection rate from outflows is $\sim 1.3 \times 10^{33}$ erg s^{-1}, which is 0.4 - 2 times the dissipation rate of the cloud turbulence. The energy injection rate from bubbles is $\sim 6.4 \times 10^{33}$ erg s^{-1}, which is 2 - 10 times the turbulent dissipation rate of the cloud. The gravitational binding energy of the cloud is $\sim 1.5 \times 10^{48}$ erg, that is, 385 and 16 times the energy of outflows and bubbles, respectively. We conclude that neither outflows nor bubbles can provide sufficient energy to balance the overall gravitational binding energy and the turbulent energy of Taurus. However, in the current epoch, stellar feedback is sufficient to maintain the observed turbulence in Taurus.

Accepted by ApJS

http://arxiv.org/pdf/1507.06512

The Distribution and Chemistry of H_2CO in the DM Tau Protoplanetary Disk

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H_2CO ice on dust grains is an important precursor of complex organic molecules (COMs). H_2CO gas can be readily observed in protoplanetary disks and may be used to trace COM chemistry. However, its utility as a COM probe is currently limited by a lack of constraints on the relative contributions of two different formation pathways: on icy grain surfaces and in the gas phase. We use archival ALMA observations of the resolved distribution of H_2CO emission in the disk around the young low-mass star DM Tau to assess the relative importance of these formation routes. The observed H_2CO emission has a centrally peaked and radially broad brightness profile (extending out to 500 AU). We compare these observations with disk chemistry models with and without grain-surface formation reactions and find that both gas and grain-surface chemistry are necessary to explain the spatial distribution of the emission. Gas-phase H_2CO production is responsible for the observed central peak, while grain-surface chemistry is required to reproduce the emission exterior to the CO snow line (where H_2CO mainly forms through the hydrogenation of CO ice before being non-thermally desorbed). These observations demonstrate that both gas and grain-surface pathways contribute to the observed H_2CO in disks and that their relative contributions depend strongly on distance from the host star.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/pdf/1508.07004

Discovery and spectroscopy of the young Jovian planet 51 Eri b with the Gemini Planet Imager

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Directly detecting thermal emission from young extrasolar planets allows measurement of their atmospheric composition and luminosity, which is influenced by their formation mechanism. Using the Gemini Planet Imager, we discovered a planet orbiting the ∼20 Myr-old star 51 Eridani at a projected separation of 13 astronomical units. Near-infrared observations show a spectrum with strong methane and water vapor absorption. Modeling of the spectra and photometry yields a luminosity of $L/L_\odot = 1.6$–4.0×10^{-6} and an effective temperature of 600–750 K. For this age and luminosity, "hot-start" formation models indicate a mass twice that of Jupiter. This planet also has a sufficiently low luminosity to be consistent with the "cold- start" core accretion process that may have formed Jupiter.

Accepted by Science Express

http://arxiv.org/pdf/1508.03084

A distance-limited sample of massive molecular outflows

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We have observed 99 mid-infrared-bright, massive young stellar objects and compact H II regions drawn from the

Red MSX source survey in the J = 3−2 transition of ^{12}CO and ^{13}CO, using the James Clerk Maxwell Telescope. 89 targets are within 6 kpc of the Sun, covering a representative range of luminosities and core masses. These constitute a relatively unbiased sample of bipolar molecular outflows associated with massive star formation. Of these, 59, 17 and 13 sources (66, 19 and 15 per cent) are found to have outflows, show some evidence of outflow, and have no evidence of outflow, respectively. The time-dependent parameters of the high-velocity molecular flows are calculated using a spatially variable dynamic time-scale. The canonical correlations between the outflow parameters and source luminosity are recovered and shown to scale with those of low-mass sources. For coeval star formation, we find the scaling is consistent with all the protostars in an embedded cluster providing the outflow force, with massive stars up to $\sim 30\,M_\odot$ generating outflows. Taken at face value, the results support the model of a scaled-up version of the accretion-related outflow-generation mechanism associated with discs and jets in low-mass objects with time-averaged accretion rates of $\sim 10^{?3}\,M_\odot\,yr^{-1}$ on to the cores. However, we also suggest an alternative model, in which the molecular outflow dynamics are dominated by the entrained mass and are unrelated to the details of the acceleration mechanism. We find no evidence that outflows contribute significantly to the turbulent kinetic energy of the surrounding dense cores.

Accepted by MNRAS

http://arxiv.org/pdf/1509.00199

Impact of Winds from Intermediate-Mass Stars on Molecular Cloud Structure and Turbulence

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Observations of nearby molecular clouds detect "shells", which are likely caused by winds from young main sequence stars. However, the progenitors of these observed features are not well characterized and the mass-loss rates inferred from the gas kinematics are several orders of magnitude greater than those predicted by atomic line-driven stellar wind models. We use magnetohydrodynamic simulations to model winds launching within turbulent molecular clouds and explore the impact of wind properties on cloud morphology and turbulence. We find that winds do not produce clear features in turbulent statistics such as the Fourier spectra of density and momentum but do impact the Fourier velocity spectrum. The density and velocity distribution functions, especially as probed by CO spectral lines, strongly indicate the presence and influence of winds. We show that stellar mass-loss rates for individual stars must be $\dot{m}_w \gtrsim 10^{-7}$ $M_\odot$ yr^{-1}, similar to those estimated from observations, to reproduce shell properties. Consequently, we conclude that B and A-type main sequence stars have mass-loss rates several orders of magnitude larger that those predicted by models or that young stars are more variable than expected due to magnetic activity or accretion.

Accepted by ApJ

http://arxiv.org/pdf/1508.07008

Double DCO^+ rings reveal CO ice desorption in the outer disk around IM Lup

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In a protoplanetary disk, a combination of thermal and non-thermal desorption processes regulate where volatiles are liberated from icy grain mantles into the gas phase. Non-thermal desorption should result in volatile-enriched gas in disk-regions where complete freeze-out is otherwise expected. We present ALMA observations of the disk around the young star IM Lup in 1.4 mm continuum, $C^{18}O$ 2–1, $H^{13}CO^+$ 3–2 and DCO^+ 3–2 emission at $\sim 0\farcs5$ resolution. The images of these dust and gas tracers are clearly resolved. The DCO^+ line exhibits a striking pair of concentric rings of emission that peak at radii of ∼0.″6 and 2″ (∼90 and 300 AU, respectively). Based on disk chemistry model comparison, the inner DCO^+ ring is associated with the balance of CO freeze-out and thermal desorption due to a radial decrease in disk temperature. The outer DCO^+ ring is explained by non-thermal desorption of CO ice in the low-column-density outer disk, repopulating the disk midplane with cold CO gas. The CO gas then reacts with abundant H_2D^+ to form the observed DCO^+ outer ring. These observations demonstrate that spatially resolved DCO^+ emission can be used to trace otherwise hidden cold gas reservoirs in the outmost disk regions, opening a new window onto their chemistry and kinematics.

Accepted by ApJ

http://arxiv.org/pdf/1508.07296

Herschel-HIFI observations of H_2O, NH_3 and N_2H^+ toward high-mass starless and proto-stellar clumps identified by the Hi-GAL survey

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Our present understanding of high-mass star formation still remains very schematic. In particular, it is not yet clear how much of the difference between low-mass and high-mass star formation occurs during the earliest star formation phases. The chemical characteristics of massive cold clumps, and the comparison with those of their low-mass counterparts, could provide crucial clues about the exact role that chemistry plays in differentiating the early phases of low-mass and high-mass star formation. Water, in particular, is a unique probe of physical and chemical conditions in star-forming regions. Using the HIFI instrument of Herschel we have observed the ortho-NH_3 (1_0–0_0) (572GHz), ortho-H_2O (1_{10}–1_{01}) (557GHz) and N_2H^+ (6–5) (559GHz) lines toward a sample of high-mass starless and proto-stellar clumps selected from the "Herschel Infrared Galactic Plane Survey" (Hi-GAL). We compare our results to previous studies of low-mass and high-mass proto-stellar objects. At least one of the three molecular lines was detected in 4 (out of 35) and 7 (out of 17) objects in the $l = 59°$ and $l = 30°$ galactic regions, respectively. All detected sources are proto-stellar. The water spectra are complex and consist of several kinematic components, identified through a Gaussian decomposition, and in a few sources inverse and regular P-Cygni profiles have been detected. All water line profiles of the $l = 59°$ region are dominated by a broad Gaussian emission feature, indicating that the bulk of the water emission arises in outflows. No such broad emission is detected toward the $l = 30°$ objects. The ammonia line in some cases also shows line wings and an inverse P-Cygni profile, thus confirming that NH_3 rotational transitions can be used to probe the dynamics of high-mass star forming regions. Both bolometric and water line luminosity increase with the continuum temperature.

Accepted by A&A

http://arxiv.org/pdf/1508.06417

Disentangling the excitation conditions of the dense gas in M17 SW

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We probe the chemical and energetic conditions in dense gas created by radiative feedback through observations of multiple CO, HCN and HCO^+ transitions toward the dense core of M17 SW. We used the dual band receiver GREAT on board the SOFIA airborne telescope to obtain maps of the J=16–15, J=12–11, and J=11–10 transitions of ^{12}CO.

We compare these maps with corresponding APEX and IRAM 30m telescope data for low- and mid-J CO, HCN and HCO^+ emission lines, including maps of the HCN J=8–7 and HCO^+ J=9–8 transitions. The excitation conditions of 12CO, HCO^+ and HCN are estimated with a two-phase non-LTE radiative transfer model of the line spectral energy distributions (LSEDs) at four selected positions. The energy balance at these positions is also studied. We obtained extensive LSEDs for the CO, HCN and HCO^+ molecules toward M17 SW. The LSED shape, particularly the high-J tail of the CO lines observed with SOFIA/GREAT, is distinctive for the underlying excitation conditions. The critical magnetic field criterion implies that the cold cloudlets at two positions are partially controlled by processes that create and dissipate internal motions. Supersonic but sub-Alfvénic velocities in the cold component at most selected positions indicates that internal motions are likely MHD waves. Magnetic pressure dominates thermal pressure in both gas components at all selected positions, assuming random orientation of the magnetic field. The magnetic pressure of a constant magnetic field throughout all the gas phases can support the total internal pressure of the cold components, but it cannot support the internal pressure of the warm components. If the magnetic field scales as $B \propto n^{2/3}$, then the evolution of the cold cloudlets at two selected positions, and the warm cloudlets at all selected positions, will be determined by ambipolar diffusion.

Accepted by A&A

http://arxiv.org/pdf/1508.06699

Decoupling of a giant planet from its disk in an inclined binary system

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We explore the dynamical evolution of a planet embedded in a disk surrounding a star part of a binary system where the orbital plane of the binary is significantly tilted respect to the initial disk plane. Our aim is to test whether the planet remains within the disk and continues to migrate towards the star in a Type I/II mode in spite of the secular perturbations of the companion star. This would explain observed exoplanets with significant inclination respect to the equatorial plane of their host star. We have used two different SPH codes, vine and phantom, to model the evolution of a system star+disk+planet and companion star with time. After an initial coupled evolution, the inclination of the disk and that of the planet begin to differ significantly. The period of oscillation of the disk inclination, respect to the initial plane, is shorter than that of the planet which evolves independently after about 10^4 yr following a perturbed N-body behavior. However, the planet keeps migrating towards the star because during its orbital motion it crosses the disk plane and the friction with the gas causes angular momentum loss. Disk and planet in a significantly inclined binary system are not dynamically coupled for small binary separations but evolve almost independently. The planet abandons the disk and, due to the onset of a significant mutual inclination, it interacts with the gas only when its orbit intersects the disk plane. The drift of the planet towards the star is not due to type I/II with the planet embedded in the disk but to the friction with the gas during the disk crossing.

Accepted by A&A

http://arxiv.org/pdf/1508.06198

Dust and Gas in the disc of HL Tauri: Surface density, dust settling, and dust-to-gas ratio

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The recent ALMA observations of the disc surrounding HL Tau reveal a very complex dust spatial distribution. We present a radiative transfer model accounting for the observed gaps and bright rings as well as radial changes of the emissivity index. We find that the dust density is depleted by at least a factor 10 in the main gaps compared to the surrounding rings. Ring masses range from 10–100 $M_\oplus$ in dust, and, we find that each of the deepest gaps is consistent with the removal of up to 40 $M_\oplus$ of dust. If this material has accumulated into rocky bodies, these would be close to the point of runaway gas accretion. Our model indicates that the outermost ring is depleted in millimetre grains compared to the central rings. This suggests faster grain growth in the central regions and/or radial migration of the larger grains. The morphology of the gaps observed by ALMA - well separated and showing a high degree of contrast with the bright rings over all azimuths - indicates that the millimetre dust disc is geometrically thin (scale height ≈ 1 au at 100 au) and that a large amount of settling of large grains has already occurred. Assuming a standard dust settling model, we find that the observations are consistent with a turbulent viscosity coefficient of a few 10^{-4}. We estimate the gas/dust ratio in this thin layer to be of the order of 5 if the initial ratio is 100. The HCO^+ and CO emission is consistent with gas in Keplerian motion around a 1.7 $M_\odot$ star at radii from ≤10–120au.

Accepted by ApJ

http://arxiv.org/pdf/1508.00584

A New Method for Constraining Molecular Cloud Thickness: A study of Taurus, Perseus and Ophiuchus

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The core velocity dispersion (CVD) is a potentially useful tool for studying the turbulent velocity field of molecular clouds. CVD is based on centroid velocities of dense gas clumps, thus is less prone to density fluctuation and reflects more directly the cloud velocity field. Prior work demonstrated that the Taurus molecular cloud CVD resembles the well-known Larson's linewidth-size relation of molecular clouds. In this work, we studied the dependence of the CVD on the line-of-sight thickness of molecular clouds, a quantity which cannot be measured by direct means. We produced a simple statistical model of cores within clouds and analyzed the CVD of a variety of hydrodynamical simulations. We show that the relation between the CVD and the 2D projected separation of cores (L_{2D}) is sensitive to the cloud thickness. When the cloud is thin, the index of CVD-L_{2D} relation (γ in the relation CVD$\sim L_{2D}^{\gamma}$) reflects the underlying energy spectrum ($E(k) \sim k^{-\beta}$) in that $\gamma \sim (\beta - 1)/2$. The CVD-$L_{2D}$ relation becomes flatter ($\gamma \to 0$) for thicker clouds. We used this result to constrain the thicknesses of Taurus, Perseus, and Ophiuchus. We conclude that Taurus has a ratio of cloud depth to cloud length smaller than about 1/10-1/8, i.e. it is a sheet. A simple geometric model fit to the linewidth-size relation indicates that the Taurus cloud has a ~ 0.7 pc line-of-sight dimension. In contrast, Perseus and Ophiuchus are thicker and have ratios of cloud depth to cloud length larger than about 1/10-1/8.

Accepted by ApJ

http://arxiv.org/pdf/1508.04220

Characterizing the Atmospheres of the HR8799 Planets with HST/WFC3

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We present results from a Hubble Space Telescope (HST) program characterizing the atmospheres of the outer two planets, in the HR8799 system. The images were taken over 15 orbits in three near-infrared medium-band filters - F098M, F127M and F139M - using the Wide Field Camera 3. One of the three filters is sensitive to water absorption band inaccessible from ground-based observations, providing a unique probe of the thermal emission from the atmospheres of these young giant planets. The observations were taken at 30 different spacecraft rolls to enable angular differential imaging, and the full data set was analyzed with the Karhunen-Loeve Image Projection (KLIP) routine, an advanced image processing algorithm adapted to work with HST data. To achieve the required high contrast at sub arcsecond resolution, we utilized the pointing accuracy of HST in combination with an improved pipeline designed to combine the dithered, angular differential imaging data with an algorithm designed to both improve the image resolution and accurately measure the photometry. The results include F127M (J) detections of the outer planets, HR8799 b and c and the first detection of HR8799 b in the water-band (F139M) filter. The F127M photometry for HR8799 c agrees well with fitted atmospheric models resolving a long standing difficulty to model the near-IR flux for the planet consistently.

Accepted by ApJL

http://arxiv.org/pdf/1508.02395

YSOVAR: Mid-Infrared Variability in NGC 1333

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As part of the Young Stellar Object VARiability (YSOVAR) program, we monitored NGC 1333 for ∼35 days at 3.6 and 4.5 μm using the Spitzer Space Telescope. We report here on the mid-infrared variability of the point sources in the ~ 10 *arcmin*$\times \sim 20$ *arcmin* area centered on 03:29:06, +31:19:30 (J2000). Out of 701 light curves in either channel, we find 78 variables over the YSOVAR campaign. About half of the members are variable. The variable fraction for the most embedded SEDs (Class I, flat) is higher than that for less embedded SEDs (Class II), which is in turn higher than the star-like SEDs (Class III). A few objects have amplitudes (10-90th percentile brightness) in [3.6] or [4.5]>0.2 mag; a more typical amplitude is 0.1-0.15 mag. The largest color change is >0.2 mag. There are 24 periodic objects, with 40% of them being flat SED class. This may mean that the periodic signal is primarily from the disk, not the photosphere, in those cases. We find 9 variables likely to be 'dippers', where texture in the disk occults the central star, and 11 likely to be 'bursters', where accretion instabilities create brightness bursts. There are 39 objects that have significant trends in [3.6]−[4.5] color over the campaign, about evenly divided between redder-when-fainter (consistent with extinction variations) and bluer-when-fainter. About a third of the 17 Class 0 and/or jet-driving sources from the literature are variable over the YSOVAR campaign, and a larger fraction (∼half) are variable between the YSOVAR campaign and the cryogenic-era Spitzer observations (6-7 years), perhaps because it takes time for the envelope to respond to changes in the central source. The NGC 1333 brown dwarfs do not stand out from the stellar light curves in any way except there is a much larger fraction of periodic objects (∼60% of variable brown dwarfs are periodic, compared to ∼30% of the variables overall).

Accepted by AJ

http://arxiv.org/pdf/1508.04705

Disc fragmentation rarely forms planetary-mass objects

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It is now reasonably clear that disc fragmentation can only operate in the outer parts of protostellar discs ($r > 50$ au). It is also expected that any object that forms via disc fragmentation will have an initial mass greater than that of Jupiter. However, whether or not such a process actually operates, or can play a significant role in the formation of planetary-mass objects, is still unclear. We do have a few examples of directly imaged objects that may have formed in this way, but we have yet to constrain how often disc fragmentation may actually form such objects. What we want to consider here is whether or not we can constrain the likely population of planetary-mass objects formed via disc fragmentation by considering how a population of objects at large radii ($a > 50$ au) - if they do exist - would evolve under perturbations from more distant stellar companions. We find that there is a specific region of parameter space to which such objects would be scattered and show that the known exoplanets in that region have properties more consistent with that of the bulk exoplanet population, than with having been formed via disc fragmentation at large radii. Along with the scarcity of directly-imaged objects at large radii, our results provide a similar, but independent, constraint on the frequency of objects formed via disc fragmentation.

Accepted by MNRAS

http://arxiv.org/pdf/1508.06528

No evidence for protoplanetary disk destruction by OB stars in the MYStIX sample

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HST images of proplyds in the Orion Nebula, as well as submillimeter/radio measurements, show that the dominant O7 star θ^1Ori C photoevaporates nearby disks around pre-main sequence stars. Theory predicts that massive stars photoevaporate disks within distances of order 0.1 pc. These findings suggest that young, OB-dominated massive H II regions are inhospitable to the survival of protoplanetary disks, and subsequently to the formation and evolution of planets. In the current work, we test this hypothesis using large samples of pre-main sequence stars in 20 massive star-forming regions selected with X-ray and infrared photometry in the MYStIX survey. Complete disk destruction would lead to a deficit of cluster members with excess in JHK_s and *Spitzer*/IRAC bands in the vicinity of O stars. In four MYStIX regions containing O stars and a sufficient surface density of disk-bearing sources to reliably test for spatial avoidance, we find no evidence for the depletion of inner disks around pre-main sequence stars in the vicinity of O-type stars, even very luminous O2–O5 stars. These results suggest that massive star-forming regions are not very hostile to the survival of protoplanetary disks and, presumably, to the formation of planets.

Accepted by ApJ

http://arxiv.org/pdf/1508.01338

Detection of water vapor in the terrestrial planet forming region of a transition disk

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We report a detection of water vapor in the protoplanetary disk around DoAr 44 with the Texas Echelon Cross Echelle Spectrograph — a visitor instrument on the Gemini north telescope. The DoAr 44 disk consists of an optically thick inner ring and outer disk, separated by a dust-cleared 36 AU gap, and has therefore been termed "pre-transitional". To date, this is the only disk with a large inner gap known to harbor detectable quantities of warm (T=450 K) water vapor. In this work, we detect and spectrally resolve three mid-infrared pure rotational emission lines of water vapor from this source, and use the shapes of the emission lines to constrain the location of the water vapor. We find that the emission originates near 0.3 AU — the inner disk region. This characteristic region coincides with that inferred for both optically thick and thin thermal infrared dust emission, as well as rovibrational CO emission. The presence of water in the dust-depleted region implies substantial columns of hydrogen ($>10^{22}$ cm^{-2}) as the water vapor would otherwise be destroyed by photodissociation. Combined with the dust modeling, this column implies a gas/small-dust ratio in the optically thin dusty region of >1000. These results demonstrate that DoAr 44 has maintained similar physical and chemical conditions to classical protoplanetary disks in its terrestrial-planet forming regions, in spite of having formed a large gap.

Accepted by ApJL

http://arxiv.org/pdf/1508.07483

Disentangling the jet emission from protostellar systems. The ALMA view of VLA1623

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Context. High-resolution studies of class 0 protostars represent the key to constraining protostar formation models. VLA16234−2417 represents the prototype of class 0 protostars, and it has been recently identified as a triple non-coeval system.
Aim. We aim at deriving the physical properties of the jets in VLA16234−2417 using tracers of shocked gas.
Methods. ALMA Cycle 0 Early Science observations of CO (2–1) in the extended configuration are presented in comparison with previous SMA CO (3–2) and Herschel-PACS [OI] 63 μm observations. Gas morphology and kinematics were analysed to constrain the physical structure and origin of the protostellar outflows.
Results. We reveal a collimated jet component associated with the [OI] 63 μm emission at about 8″ (about 960 AU) from source B. This newly detected jet component is inversely oriented with respect to the large-scale outflow driven by source A, and it is aligned with compact and fast jet emission very close to source B (about 0.″3) rather than with the direction perpendicular to the A disk. We also detect a cavity-like structure at low projected velocities, which surrounds the [OI] 63 μm emission and is possibly associated with the outflow driven by source A. Finally, no compact outflow emission is associated with source W.
Conclusions. Our high-resolution ALMA observations seem to suggest there is a fast and collimated jet component associated with source B. This scenario would confirm that source B is younger than A, that it is in a very early stage of evolution, and that it drives a faster, more collimated, and more compact jet with respect to the large-scale slower outflow driven by A. However, a different scenario of a precessing jet driven by A cannot be firmly excluded from the present observations.

Accepted by A&A

http://arxiv.org/pdf/1508.05022

Detection of two power-law tails in the probability distribution functions of massive GMCs

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We report the novel detection of complex high-column density tails in the probability distribution functions (PDFs) for three high-mass star-forming regions (CepOB3, MonR2, NGC6334), obtained from dust emission observed with

Herschel. The low column density range can be fit with a lognormal distribution. A first power-law tail starts above an extinction (A_V) of ∼6–14. It has a slope of α=1.3–2 for the $\rho \propto r^{-\alpha}$ profile for an equivalent density distribution (spherical or cylindrical geometry), and is thus consistent with free-fall gravitational collapse. Above A_V∼40, 60, and 140, we detect an excess that can be fitted by a flatter power law tail with α >2. It correlates with the central regions of the cloud (ridges/hubs) of size ∼1 pc and densities above 10^4 cm^{-3}. This excess may be caused by physical processes that slow down collapse and reduce the flow of mass towards higher densities. Possible are: 1. rotation, which introduces an angular momentum barrier, 2. increasing optical depth and weaker cooling, 3. magnetic fields, 4. geometrical effects, and 5. protostellar feedback. The excess/second power-law tail is closely linked to high-mass star-formation though it does not imply a universal column density threshold for the formation of (high-mass) stars.

Accepted by MNRAS letters

http://arxiv.org/pdf/1507.08869

Star-forming regions at the periphery of the supershell surrounding the Cyg OB1 association. I. The star cluster vdB 130 and its ambient gas and dust medium

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Stellar population and the interstellar gas-dust medium in the vicinity of the open star cluster vdB 130 are analysed using optical observations taken with the 6-m telescope of the SAO RAS and the 125-cm telescope of the SAI MSU along with the data of Spitzer and Herschel. Based on proper motions and BV and JHK_s 2MASS photometric data, we select additional 36 stars as probable cluster members. Some stars in vdB 130 are classified as B stars. Our estimates of minimum colour excess, apparent distance modulus and the distance are consistent with young age (from 5 to 10 Myrs) of the cluster vdB 130. We suppose the large deviations from the conventional extinction law in the cluster direction, with $R_V \sim$ 4–5. The cluster vdB 130 appears to be physically related to the supershell around Cyg OB1, a cometary CO cloud, ionized gas, and regions of infrared emission. There are a few regions of bright mid-infrared emission in the vicinity of vdB 130. The largest of them is also visible on Hα and [SII] emission maps. We suggest that the infrared blobs that coincide in projection with the head of the molecular cloud are HII regions, excited by the cluster B-stars. Some signatures of a shock front are identified between these IR-bright regions.

Accepted by MNRAS

http://arxiv.org/pdf/1508.05274

The migration of gas giant planets in gravitationally unstable discs

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Planets form in the discs of gas and dust that surround young stars. It is not known whether gas giant planets on wide orbits form the same way as Jupiter or by fragmentation of gravitationally unstable discs. Here we show that a giant planet, which has formed in the outer regions of a protostellar disc, initially migrates fast towards the central star (migration timescale $\sim 10^4$ yr) while accreting gas from the disc. However, in contrast with previous studies, we find that the planet eventually opens up a gap in the disc and the migration is essentially halted. At the same time, accretion-powered radiative feedback from the planet, significantly limits its mass growth, keeping it within the planetary mass regime (i.e. below the deuterium burning limit) at least for the initial stages of disc evolution. Giant planets may therefore be able to survive on wide orbits despite their initial fast inward migration, shaping the environment in which terrestrial planets that may harbour life form.

Accepted by ApJ Letters

http://arxiv.org/pdf/1508.01196

Grain size limits derived from 3.6 micron and 4.5 micron coreshine

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Recently discovered scattered light from molecular cloud cores in the wavelength range 3-5 micron (called "coreshine") seems to indicate the presence of grains with sizes above 0.5 micron. We aim to analyze 3.6 and 4.5 micron coreshine from molecular cloud cores to probe the largest grains in the size distribution. We analyzed dedicated deep Cycle 9 Spitzer IRAC observations in the 3.6 and 4.5 micron bands for a sample of 10 low-mass cores. We used a new modeling approach based on a combination of ratios of the two background- and foreground-subtracted surface brightnesses and observed limits of the optical depth. The dust grains were modeled as ice-coated silicate and carbonaceous spheres. We discuss the impact of local radiation fields with a spectral slope differing from what is seen in the DIRBE allsky maps. For the cores L260, ecc806, L1262, L1517A, L1512, and L1544, the model reproduces the data with maximum grain sizes around 0.9, 0.5, 0.65, 1.5, 0.6, and ¿ 1.5 micron, respectively. The maximum coreshine intensities of L1506C, L1439, and L1498 in the individual bands require smaller maximum grain sizes than derived from the observed distribution of band ratios. Additional isotropic local radiation fields with a spectral shape differing from the DIRBE map shape do not remove this discrepancy. In the case of Rho Oph 9, we were unable to reliably disentangle the coreshine emission from background variations and the strong local PAH emission. Considering surface brightness ratios in the 3.6 and 4.5 micron bands across a molecular cloud core is an effective method of disentangling the complex interplay of structure and opacities when used in combination with observed limits of the optical depth.

Accepted by A&A

http://arxiv.org/pdf/1508.04691

The Dense Filamentary Giant Molecular Cloud G23.0−0.4: Birthplace of Ongoing Massive Star Formation

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We present observations of 1.5 square degree maps of the ^{12}CO, ^{13}CO, and C^{18}O (J=1–0) emission toward the complex region of the supernova remnant (SNR) W41 and SNR G22.7−0.2. A massive ($\sim5\times10^5$ $M_\odot$), large ($\sim$84 $\times$ 15 pc), and dense ($\sim10^3$ cm^{-3}) giant molecular cloud (GMC), G23.0−0.4 with $V_{\rm LSR}\sim$ 77 km s^{-1}, is found to be adjacent to the two SNRs. The GMC displays a filamentary structure approximately along the Galactic plane. The filamentary structure of the dense molecular gas, traced by C^{18}O (J=1–0) emission, is also coincident well with the distribution of the dust-continuum emission in the direction. Two dense massive MC clumps, two 6.7 GHz methanol

masers, and one HII/SNR complex, associated with the 77 km s^{-1} GMC G23.0−0.4, are aligned along the filamentary structure, indicating the star forming activity within the GMC. These sources have periodic projected spacing of 0.°18–0.°26 along the giant filament, which is consistent well with the theoretical predictions of 0.°22. It indicates that the turbulence seems to dominate the fragmentation process of the dense gaseous filament on large scale. The established 4.4 kpc distance of the GMC and the long dense filament traced by $C^{18}O$ emission, together with the rich massive star formation groups in the nearby region, suggest that G23.0−0.4 is probably located at the near side of the Scutum-Centaurus arm in the first quadrant. Considering the large scale and the elongation structure along the Galactic plane, we speculate that the dense filamentary GMC has relation to the spiral density wave of the Milky Way.

Accepted by ApJ

http://arxiv.org/pdf/1508.07898

The RMS Survey: Ammonia mapping of the environment of massive young stellar objects

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We present the results of ammonia observations towards 66 massive star forming regions identified by the Red MSX source survey. We have used the Green Bank Telescope and the K-band focal plane array to map the ammonia (NH_3) (1,1) and (2,2) inversion emission at a resolution of 30 arcsec in 8 arcmin regions towards the positions of embedded massive star formation. We have identified a total of 115 distinct clumps, approximately two-thirds of which are associated with an embedded massive young stellar object or compact H II region, while the others are classified as quiescent. There is a strong spatial correlation between the peak NH_3 emission and the presence of embedded objects. We derive the spatial distribution of the kinetic gas temperatures, line widths, and NH_3 column densities from these maps, and by combining these data with dust emission maps we estimate clump masses, H_2 column densities and ammonia abundances. The clumps have typical masses of $\sim$1000 $M_\odot$ and radii $\sim$0.5 pc, line widths of $\sim$2 km s^{-1} and kinetic temperatures of $\sim$16-20 K. We find no significant difference between the sizes and masses of the star forming and quiescent subsamples; however, the distribution maps reveal the presence of temperature and line width gradients peaking towards the centre for the star forming clumps while the quiescent clumps show relatively uniform temperatures and line widths throughout. Virial analysis suggests that the vast majority of clumps are gravitationally bound and are likely to be in a state of global free fall in the absence of strong magnetic fields. The similarities between the properties of the two subsamples suggest that the quiescent clumps are also likely to form massive stars in the future, and therefore provide a excellent opportunity to study the initial conditions of massive pre-stellar and protostellar clumps.

Accepted by MNRAS

http://arxiv.org/pdf/1507.02187

A concentration of centimeter-sized grains in the Oph IRS 48 dust trap

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Azimuthally asymmetric dust distributions observed with ALMA in transition disks have been interpreted as dust traps. We present VLA Ka band (34 GHz or 0.9 cm) and ALMA Cycle 2 Band 9 (680 GHz or 0.45 mm) observations at 0.2" resolution of the Oph IRS 48 disk, which suggest that larger particles could be more azimuthally concentrated than smaller dust grains, assuming an axisymmetric temperature field or optically thin 680 GHz emission. Fitting an intensity model to both data demonstrates that the azimuthal extent of the millimeter emission is 2.3 0.9 times as wide as the centimeter emission, marginally consistent with the particle trapping mechanism under the above assumptions. The 34 GHz continuum image also reveals evidence for ionized gas emission from the star. Both the morphology and the spectral index variations are consistent with an increase of large particles in the center of the trap, but uncertainties remain due to the continuum optical depth at 680 GHz. Particle trapping has been proposed in planet formation models to allow dust particles to grow beyond millimeter sizes in the outer regions of protoplanetary disks. The new observations in the Oph IRS 48 disk provide support for the dust trapping mechanism for centimeter-sized grains, although additional data is required for definitive confirmation.

Accepted by ApJL

http://arxiv.org/pdf/1508.01003

The dynamical fate of planetary systems in young star clusters

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We carry out N-body simulations to examine the effects of dynamical interactions on planetary systems in young open star clusters. We explore how the planetary populations in these star clusters evolve, and how this evolution depends on the initial amount of substructure, the virial ratio, the cluster mass and density, and the initial semi-major axis of the planetary systems. The fraction of planetary systems that remains intact as a cluster member, $f_{\rm BPS}$, is generally well-described by the functional form $f_{\rm BPS} = f_0(1 + [a/a_0]^c)^{-1}$, where $(1 - f_0)$ is the fraction of stars that escapes from the cluster, a_0 the critical semi-major axis for survival, and c a measure for the width of the transition region. The effect of the initial amount of substructure over time can be quantified as $f_{\rm BPS} = A(t) + B(D)$, where $A(t)$ decreases nearly linearly with time, and $B(D)$ decreases when the clusters are initially more substructured. Provided that the orbital separation of planetary systems is smaller than the critical value a0, those in clusters with a higher initial stellar density (but identical mass) have a larger probability of escaping the cluster intact. These results help us to obtain a better understanding of the difference between the observed fractions of exoplanets-hosting stars in star clusters and in the Galactic field. It also allows us to make predictions about the free-floating planet population over time in different stellar environments.

Accepted by MNRAS

http://arxiv.org/pdf/1508.01593

Abstracts of recently accepted major reviews

The modelling of feedback in star formation simulations

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I review the current state of numerical simulations of stellar feedback in the context of star formation at scales ranging from the formation of individual stars to models of galaxy formation including cosmic reionisation. I survey the wealth of algorithms developed recently to solve the radiative transfer problem and to simulate stellar winds, supernovae and protostellar jets. I discuss the results of these simulations with regard to star formation in molecular clouds, the interaction of different feedback mechanisms with each other and with magnetic fields, and in the wider context of galactic– and cosmological–scale simulations.

Accepted by New Astronomy Reviews

http://arxiv.org/pdf/1508.06054

Protoplanetary Discussions
7th - 11th March 2016

Registration Now Open

This is the second announcement for the international conference entitled "Protoplanetary Discussions" to be held at the John McIntyre Conference Centre, Edinburgh, UK, 7th - 11th March 2016.

Abstract submission and full registration is now open, and can be completed by visiting our website:

`http://www-star.st-and.ac.uk/ppdiscs`

The deadline for abstract submission is **Friday, November 20th, 2015.**

The SOC will select contributions by the end of 2015, and registration will close in January 2016.

The number of participants will be limited to 150 people, and early bird registrations are available. In addition, a number of pre-reserved hotel rooms are bookable on a first come, first served basis.

Scientific sessions include:

1. Disc hosting stars
2. The inner disc
3. The structure of protoplanetary discs
4. Disc chemistry
5. Disc dynamics
6. The disc-planet connection

Confirmed invited speakers include Myriam Benisty (Grenoble, FR), Ilse Cleeves (Michigan, US), Kevin France (Colorado, US), Colin Johnstone (Vienna, AT), Inga Kamp (Kapteyn, NL), Quinn Konopacky (UCSD, US), Guillaume Laibe (St Andrews, UK), Geoffroy Lesur (Grenoble, FR), Richard Nelson (QMUL, UK), Sijme-Jan Paardekooper (QMUL, UK), Christophe Pinte (Santiago, CL), Klaus Pontoppidan (Baltimore, US), Catherine Walsh (Leiden, NL), Zhaohuan Zhu (Princeton, US).

In addition to invited/contributed talks and poster sessions, we will also be offering attendees the chance to propose and host their own discussion sessions. These sessions can take any form (open discussions, collaborative 'hack' sessions, or splinter-like session with self-organized talks). The selected sessions will be chaired and organised entirely by the proposer, who will then be given the chance to report back to the full conference.

Social activities will include welcome drinks on Sunday evening, a conference dinner in the historic Playfair Library Hall, a whisky tasting experience, a visit to a preserved 17th Century area of Edinburgh, and a walking trip to the famous viewpoint of Arthur's Seat.

A limited amount of financial support will be available for students and young researchers in the form of reimbursement. If you wish to apply for this, please indicate as such during the abstract submission process.

Kind Regards,
The LOC & SOC

From Stars to Massive Stars
Connecting our understanding of massive star & star cluster formation through the universe

Wed. 6th - Sat. 9th April 2016
University of Florida, Gainesville, FL, USA

http://conference.astro.ufl.edu/STARSTOMASSIVE/

This conference will bring together researchers from star formation, star cluster evolution and massive star communities to share recent research results and help motivate future projects to improve our understanding of these processes and phenomena. The meeting comes at a time when many exciting results are appearing from surveys of our Galaxy's star-forming regions along with detailed follow-up from facilities such as ALMA and SOFIA. Utilization of JWST and TMT-class telescopes is on the horizon, which, along with full-ALMA, will allow unprecedented studies of massive star and star cluster formation across a wide range of cosmic environments. Properties of individual stars and protostars can be determined to build up an accurate statistical census of the star formation activity in entire giant molecular clouds and their star-forming clumps, thus probing the questions: what drives massive star and star cluster formation and how does it proceed in different environments such as the local solar neighborhood, dwarf galaxies, dense starburst regions, around supermassive black holes such as in Galactic center region, and at the very highest redshifts? With increasing computational resources and more sophisticated numerical modeling, theoretical and numerical models are catching up to try to explain these observations.

The conference will be held at the University of Florida in Gainesville, located within 2 hours drive from Orlando, Tampa, Jacksonville, St. Augustine, and the Atlantic and Gulf Coasts. The weather in April is generally dry, sunny and warm.

If you are interested in attending the conference, abstract submission will be open after Oct. 1st 2015 - check the conference webpage at that time,

Best regards,

Jonathan Tan & the SOC

Cloudy workshop, 2016 June 20-24, Shandong University, Weihai, China

Registration is now open for the 2016 Cloudy workshop. It will be held June 20-24, Shandong University, Weihai, China

Cloudy simulates the microphysics of matter exposed to ionizing radiation. It calculates the atomic physics, chemistry, radiation transport, and dynamics problems simultaneously and self consistently, building from a foundation of individual atomic and molecular processes. The result is a prediction of the conditions in the material and its observed spectrum.

The workshop will cover observation, theory, and application of Cloudy to a wide variety of astronomical environments. This includes the theory of diffuse non-LTE matter and quantitative spectroscopy, the science of using spectra to make physical measurements. We will use Cloudy to simulate such objects as AGB stars, Active Galactic Nuclei, Starburst galaxies, and the intergalactic medium.

The sessions will consist of a mix of textbook study, using Osterbrock & Ferland, Astrophysics of Gaseous Nebulae and Active Galactic Nuclei, application of the spectral-simulation code Cloudy to a variety of astrophysical problems, and projects organized by the participants. No prior experience with Cloudy is assumed. There is no registration fee and financial support is not available.

Details about the workshop and instructions for registration are on http://cloudy2016.csp.escience.cn/dct/page/1

Shandong University (SDU) is a key comprehensive university with a long history, a variety of disciplines, strong academic strength, and distinctive characteristics. Its main body, Shandong Imperial College (Shandong Da Xue Tang) established in 1901, was the second national university in China, only after the Imperial University of Peking. Shandong University at Weihai, as one of seven campuses of SDU, was established in 1984. Weihai (??) is the easternmost prefecture-level city of Shandong province,China. Weihai is Chinas well-known coastal tourist and leisure resorts and the city of natural hot springs.

Computational Astrophysics with GANDALF
26th - 30th October 2015
Kardinal-Doepfner-Haus, Freising, Bavaria

We are happy to announce the 'Computational Astrophysics with GANDALF' school covering the new Hydrodynamics and N-body code GANDALF (https://gandalfcode.github.io). This meeting will take place in the Bildungszentrum Kardinal-Doepfner-Haus in the beautiful Bavarian town of Freising during the week of 26th - 30th October 2015. The main aims of this school are to :

- provide classes and tutorials on how to install and run GANDALF (including dependencies)
- show the internal structure of the code and demonstrate how to best add new physics modules
- discuss the main hydrodynamical, radiative transport and other physics modules and explain the physical scenarios in which to use each available option
- demonstrate the capabilities of the Python analysis tools and how to set-up initial conditions, run simulations and prepare plots from Python scripts
- discuss general issues relating to numerical methods in Astrophysics, in particular with Hydrodynamics.

The school will take the form of a series of lectures coupled with practical sessions, presented by the code's authors Dr David Hubber and Dr Giovanni Rosotti, where participants will work through a series of exercises to gain practical experience at using all aspects of the GANDALF code. The meeting will also have some slots available for contributed talks and posters.

School website : `https://gandalfcode.github.io/gandalf-school/index.html`

Code website : `https://github.com/gandalfcode/gandalf`

Contact : gandalfcode@gmail.com

Lecturers/SOC :

David Hubber, USM, LMU
Giovanni Rosotti, IOA, University of Cambridge

LOC :
Richard Booth, IoA, University of Cambridge
Jim Dale, USM, LMU
Matthias Gritschneder, USM, LMU
David Hubber, USM, LMU
Judith Ngoumou, USM, LMU
Giovanni Rosotti, IoA, University of Cambridge

Summary of Upcoming Meetings

Cloudy Workshop
21 - 26 September 2015 Pune, India
http://cloud9.pa.uky.edu/?gary/cloudy/CloudySummerSchool/

From Clouds to Protoplanetary Disks: the Astrochemical Link
5 - 8 October 2015 Berlin, Germany
https://cas-events.mpe.mpg.de/astrolink

Exchanging Mass, Momentum and Ideas: Connecting Accretion and Outflows in Young Stellar Objects
27 - 29 October 2015 Noordwijk, The Netherlands
http://www.cosmos.esa.int/web/accretion-outflow-workshop

Extreme Solar Systems III 29 November - 4 December 2015 Hawaii, USA
http://ciera.northwestern.edu/Hawaii2015.php

Protoplanetary Discussions
7 - 11 March 2016, Edinburgh, UK
http://www-star.st-and.ac.uk/ppdiscs

From Stars to Massive Stars
6 - 9 April 2016, Gainesville, Florida, USA
http://conference.astro.ufl.edu/STARSTOMASSIVE/

Resolving planet formation in the era of ALMA and extreme AO
16 - 20 May 2016, Santiago, Chile
http://www.eso.org/sci/meetings/2016/Planet-Formation2016.html

Diffuse Matter in the Galaxy, Magnetic Fields, and Star Formation - A Conference Honoring the Contributions of Richard Crutcher & Carl Heiles
23 - 26 May 2015, Madison, USA
no URL yet

The 19th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun
6 - 10 June 2016 Uppsala, Sweden
http://www.coolstars19.com

Cloudy Workshop
20 - 24 June 2016 Weihai, China
http://cloudy2016.csp.escience.cn/dct/page/1

EPoS 2016 The Early Phase of Star Formation - Progress after 10 years of EPoS
26 June - 1 July 2016, Ringberg Castle, Germany
http://www.mpia.de/homes/stein/EPoS/2016/2016.php

Star Formation in Different Environments
25 - 29 July 2016 Quy Nhon, Viet Nam
website to be announced

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

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

Short Announcements

Fizeau exchange visitors program - call for applications

Dear colleagues!

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

The deadline for applications is September 15. Fellowships can be awarded for missions starting in November 2015.

Further informations and application forms can be found at www.european-interferometry.eu and vltischool.sciencesconf.org

The program is funded by OPTICON/FP7.

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

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

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.