ALMA2019: Science Results and Cross-Facility Synergies

Report of Contributions

https://indico.ict.inaf.it/e/ALMA2019

Contribution ID: **1** Type: **not specified**

Registration

Monday, 14 October 2019 08:00 (1h 30m)

Contribution ID: **2** Type: **not specified**

Opening

Monday, 14 October 2019 09:30 (5 minutes)

Official greetings

Presenter: Dr MOLINARI, Emilio (INAF-Cagliari Astronomical Observatory)

Contribution ID: **3** Type: **not specified**

Observatory Update

Monday, 14 October 2019 09:35 (25 minutes)

Invited talk

Presenter: Dr DOUGHERTY, Sean

Contribution ID: **6** Type: **not specified**

ASPECS: Unveiling the driver of cosmic star formation history

Monday, 14 October 2019 10:00 (25 minutes)

Invited Talk

Abstract:
NGC 253 is the one of the brightest molecular emitters outside the Galaxy and therefore the more suited candidate for deep molecular surveys.
In this presentation I will summarize the current status of the ALCHEMI project which an ALMA large program consisting of an unbiased line survey from ALMA bands 3, 4, 6, and 7 (85-370 GHz), whose scope was extended this Cycle to also cover Band 5.
In particular I will focus on the first results on the low resolution data from the 7m compact array which already shows an unprecedented molecular richness as well as first
look into the chemistry revealed at the highest resolution.
Despite of being observed at every wavelengths for decades, ALMA keeps unveiling new details on its central molecular zone.
Additionally to ALCHEMI, I will present results from deep observations spin-off ALMA projects which were going in parallel to this survey which targetted isotopic ratio based on the double isotopologue 13C18O, deuteration, and vibrational emission in NGC 253.

Presenter: Dr DECARLI, Roberto

Session Classification: Cosmology

Contribution ID: **9** Type: **not specified**

An ALMA survey of CO in submillimetre galaxies

Monday, 14 October 2019 10:25 (15 minutes)

Contributed talk

Abstract:
The results of previous ALMA observations have given us many valuable constraints for theoretical models of protoplanetary disks (PPDs) and the formation of planets within them. While only a few years ago such dust maps suggested the mere presence of embedded planets in PPDs, via the detection of rings and gaps in the continuum emission, I will argue in this talk that, at increased resolution, they can by now also inform us about the planet's dynamical behavior. It has been shown that a Neptune-sized planet in a disk with a low level of turbulence creates a pattern of three concentric rings in the dust components. We find from numerical simulations that the mutual separations of these three rings depend critically on if and how the planet is radially migrating. Inward or outward migration, as well as different migration speeds all leave characteristic signatures on the structure of the dust in the PPD. By presenting synthetic images of the executed theoretical studies, I will highlight that these structures are in principle observable (as shown by Pérez et al. 2019) when pushing ALMA to its highest resolution. The importance of the understanding of migration for our picture of planet formation cannot be overestimated, since it links the planet's final location to its original birth place.
Collaborators: Sebastián Pérez, Simon Cassassus, Oliver Gressel, Pablo Benitez-Llambay, Leonardo Krapp

Presenter: Dr WARDLOW, Julie

Session Classification: Cosmology

Contribution ID: **10** Type: **not specified**

A mm-wave view of the hot and ionised gas in galaxy clusters

Monday, 14 October 2019 10:40 (15 minutes)

Contributed talk

Abstract:
"We present ALMA and MUSTANG2 observations of the Sunyaev-Zeldovich effect from massive galaxy clusters, revealing pressure substructure due to mergers and feedback that can only be inferred in X-ray."

Presenter: Dr MROCKZKOWSKI, Tony

Session Classification: Cosmology

Contribution ID: **11** Type: **not specified**

Poster session I

Monday, 14 October 2019 16:10 (1 hour)

Contribution ID: **12** Type: **not specified**

”Interpreting the (sub)millimeter extragalactic sky: implications for obscured star-formation in the first few Gyr after the Big Bang”

Monday, 14 October 2019 11:40 (25 minutes)

Invited talk

Abstract:
I will present recent modeling and observational work aimed at understanding the prevalence of dust-obscured star-formation in the first few Gyrs of the Universe’s history. Despite great effort to map the star-formation rate density in the rest-frame UV out to z~11, similar efforts to map rest-frame FIR have not kept apace. ALMA has begun to provide hints of the cosmic density of obscured galaxies during this epoch and will, no doubt, make tremendous strides over the next decade

Presenter: Dr CASEY, Caitlin

Session Classification: Cosmology

Contribution ID: **13** Type: **not specified**

Caught in the act - massive cluster formation at z=3-7 witnessed by APEX/ALMA

Monday, 14 October 2019 12:05 (15 minutes)

Contributed Talk

Abstract:
Finding and tracing the progenitors of today's massive clusters is challenging but observations of these rare systems are rich in information on cluster assembly, including brightest cluster galaxy formation, the build up of the red sequence and intra-cluster light, heating and metal-enrichment in the forming intra-cluster medium, the triggering and quenching of both star-formation and of active galactic nuclei, and the in-fall of matter along filaments of the cosmic web.
In a multi-band survey over 2500 deg2, the South Pole Telescope discovered a population of rare, extremely bright (S1.4 mm > 20 mJy) millimetre-selected sources. Our ALMA 870μm imaging showed that ~ 90% of these sources are gravitationally lensed DSFGs at z ~ 4. However, ~ 10% of the SPT sources show no evidence for lensing but break-up into individual galaxies with ALMA and thus show all expected properties of the most active phase of early cluster formation predicted by cosmological simulations. The most spectacular example for this process identified in the SPT survey so far is SPT2349-56 at z = 4.3. This source is spatially well resolved at 870μm even with LABOCA/APEX and breaks up into 30 proto-cluster members with confirmed redshifts from ALMA. The entire system as a stunning SFR of 16500 $M_{\odot}$ yr^{-1} and contains 15 (U)LIRGs at its core within a projected radius equal to the MW-LMC distance!
In this talk I will present the latest result of our coordinated attempt to characterise all porto-cluster candidates discovered in the SPT survey.

Presenter: Dr WEISS, Axel

Session Classification: Cosmology

Contribution ID: **14** Type: **not specified**

ALMA unveils massive galaxies at z>3 that are hidden from Hubble

Monday, 14 October 2019 12:20 (15 minutes)

Contributed Talk

Abstract:
"Our current knowledge on the cosmic star formation history at z > 3 is mainly based on galaxies identified in the ultraviolet (UV) light. However, such galaxies are known to be biased against massive galaxies, most of which are dim in the UV due to dust obscuration and/or old stellar populations. This raises important questions as to what is the true abundance of massive galaxies and star formation rate density in the early universe. While a few massive UV-faint galaxies have been identified at early cosmic times2–5, most of them are extreme starbursts, which unlikely represent the bulk population of massive galaxies. Here we report ALMA-870um detections of ~40 massive star-forming galaxies at z>3 that are undetected even in the
deepest near-infrared imaging with HST. With a space density of n ~ 2 × 10−5 Mpc−3 and star formation rates of ~200Msun/yr, these galaxies are representative of normal massive galaxies and contribute a total star formation rate density ten times larger than that from equivalently massive UV-bright galaxies (LBGs) at z > 3. Residing in the most massive halos at their redshifts, they are likely the progenitors of present-day largest galaxies in massive groups and clusters. Such a high abundance of massive and dusty systems in the early universe is unexpected in current models, and challenges our understanding of massive galaxy formation."

Presenter: Dr WANG, Tao

Session Classification: Cosmology

Contribution ID: **15** Type: **not specified**

Chemical Diversity and Evolution toward Protoplanetary Disks

Friday, 18 October 2019 09:00 (25 minutes)

Invited talk

Abstract:
Star and planet formation is one of the most fundamental structure-formation processes in the Universe. Physical processes of star and planet formation have widely been investigated as one of the major targets of observational astronomy and astrophysics during the last few decades. Meanwhile, star and planet formation is inevitably accompanied with the evolution of interstellar matter. Increasing sensitivity of various telescopes allows us to identify about 200 interstellar molecules so far. This indicates high chemical complexity of interstellar clouds despite their extreme physical condition of low temperature (10-100 K) and low density (102-107 cm-3), which would ultimately be related to an origin of rich substances in the Solar System.
In the last two decades, it is clearly demonstrated that envelopes as well as protostellar disks around solar-type protostars have significant chemical diversity: some sources harbor various saturated- "complex-" organic molecules (COMs), whereas some others harbor unsaturated species instead. The chemical diversity would originate from different history of the physical environment, such as duration time of the starless core phase of each protostar. In fact, sources showing intermediate-type of chemistry, different type of chemical diversity have also been found. Thus, chemical evolution during formation of protoplanetary disk is one of the most important targets to be explored, because it tells us initial chemical compositions of the disks, which can be different depending on the source. Furthermore, physical processes of the disk formation will significantly affect an initial chemical composition of a protoplanetary disk. Thus, both physical and chemical approaches are indispensable. In this talk, I will summarize such efforts and will introduce recent progress of observational studies with ALMA. I will also discuss some prospects toward future studies.

Presenter: Dr SAKAI, Nami

Session Classification: ISM, SF

Contribution ID: **16** Type: **not specified**

ALMA observations of the DG Tau B Class I protostar disk and CO outflow

Friday, 18 October 2019 09:25 (15 minutes)

Contributed talk

Abstract:
Powerful atomic jets and molecular outflows are observed in young protostars at all stages of active accretion, from the young embedded Class 0 and Class 1 phases to the later optically revealed T Tauri or Class 2 phase. The origin of the ejection, its role in angular momentum extraction and impact on protoplanetary disk evolution remain as fundamental open questions in star formation. Studies at high angular and spectral resolution of molecular outflows are now providing important new clues to these questions. Our recent study with ALMA of the CO cavity/outflow in the prototypical edge-on HH 30 T Tauri star (Louvet et al. 2018) challenges the traditional interpretation of molecular outflows as swept-up material. Instead our ALMA observations suggest a magneto-thermal disk wind origin for the low velocity CO outflow in HH 30. We will report recent band 6 (continuum and 12CO) ALMA observations of the Class I disk/outflow source DG Tau B. We reconstruct the full 3D geometry and kinematics (including rotation) of the CO outflow. We will discuss the implications brought by these observations for the origin of the CO cavities/outflows and their potential impact on the disk evolution.

Presenter: Dr DE VALON, Aloïs

Session Classification: ISM, SF

Contribution ID: **17** Type: **not specified**

Chronology of Episodic Accretion in Protostars - an ALMA survey of the CO and H2O snow lines

Friday, 18 October 2019 09:40 (15 minutes)

Contributed talk

Abstract:
Episodic accretion is nowadays a well accepted process in low-mass star formation, but its origin and influence on star forming process are not yet fully understood. We present an ALMA survey of N2H+ (1 − 0) and HCO+ (3 − 2) toward 39 Class 0 and Class I sources in the Perseus molecular cloud. N2H+ and HCO+ are destroyed via gas-phase reactions with CO and H2O, respectively, and are thus used to trace the CO and H2O snowline locations. If the snowline location is at a much larger radius than that expected from the current luminosity, then a past accretion burst has likely occurred that has shifted the snowline outward. Among our sample, we find that ~96% of the sources are post-burst sources from N2H+, and 7/17 Class 0 sources and 1/10 Class I sources are post-burst sources from HCO+. Assuming that the refreeze-out timescales are 1000 yr for H2O and 10,000 yr for CO, respectively, we derive the intervals between the burst episodes to be ~2400 yr and ~10,000 yr for the Class 0 and Class I stages. The median mass-accretion rate during the burst is found to be ~ (1.8–4.2)×10^5 Msun/yr, which, together with the burst frequency, enable us to construct a mass accumulation history. We suggest that episodic accretion could start from the earliest evolutionary stage and that the burst frequency decreases with time from the Class 0 to Class I stages. If an accretion burst is triggered by an infalling fragment, this result suggests that fragmentation is prone to occur at the earlier evolutionary stage or that the fragments tend to fall more often onto the central source.

Presenter: Dr HSIEH, Tien-Hao

Session Classification: ISM, SF

Contribution ID: **18** Type: **not specified**

Probing fragmentation and velocity sub-structure in the massive NGC 6334 filament with ALMA.

Friday, 18 October 2019 09:55 (15 minutes)

Contributed talk

Abstract:
"Herschel imaging surveys of Galactic interstellar clouds support a paradigm for low-mass star formation in which dense molecular filaments play a crucial role. The detailed fragmentation properties of star-forming filaments remain poorly understood, however, and the validity of the filament paradigm in the high-mass regime is still unclear. Here, we investigate the detailed density and velocity structure of the main filament in the high-mass star-forming region NGC6334. We conducted ALMA observations in the 3mm continuum and the N2H+(1-0), HC5N(36-35), HNC(1-0), HC3N(10-9), CH3CCH(6-5), H2CS(3-2) lines at an angular resolution of ~3"(~0.025 pc at d=1.7kpc). The NGC 6334 filament was detected in both the 3mm continuum and the N2H+, HC3N, HC5N, CH3CCH, and H2CS lines with ALMA. With the help of the getsources and getfilaments algorithms, we identified 21 compact (~0.03 pc) dense cores at 3mm and 5 velocity-coherent fiber-like sub-structures in N2H+, within the main filament. The 3mm continuum sources have a median mass of ~9 Msun and can be divided into 7 groups of cores, closely associated with dense clumps seen in the ArTeMiS 350um data. The projected separation between ALMA dense cores (0.03−0.1pc) and the projected spacing between ArTeMiS clumps (0.2−0.3pc) are roughly consistent with the effective Jeans length (0.08pc) in the filament and a physical scale −0.03pc of about four times the filament width, respectively, if the inclination angle of the filament to line of sight is ~30deg.

Presenter: Dr SHIMAJIRI, Yoshito

Session Classification: ISM, SF

Contribution ID: **19** Type: **not specified**

Sounding diffuse molecular gas with ALMA as a mean to prove that the CO-dark gas is molecular

Friday, 18 October 2019 10:10 (15 minutes)

Contributed talk

Abstract:
Studies of the dust continuum emission and extinction, and of the gamma ray emission show that a fraction of the interstellar gas is not traced by the combination of HI 21 cm and CO J=1-0 emission lines. The nature and physical conditions of this so called CO-dark gas are debated. We have used ALMA to search for molecular absorption towards distant quasars in the field of view of molecular clouds (Chamaelon, Taurus-Auriga, Galactic Bulge). We show that HCO+ absorption, tracing the presence of diffuse molecular hydrogen, is detected down to reddening values approaching the threshold for H2 formation (E(B-V) ~ 0.1 mag), and that the detected amount of molecular gas explains the presence of CO-dark gas. CO is detected toward a subset of sources with column densities at the same level as those
derived from FUV spectra, that are too low to produce a detectable J=1-0 emission. The CO-dark gas is dynamically active with complex HCO+, HCN, CCH and CO line profiles. The CO line profiles are narrower that those from HCO+ , providing further support for a tight coupling of the gas dynamics and chemistry. This work also confirms that HCO+ is the most sensitive tracer of diffuse molecular gas at millimeter wavelengths, with a mean abundance relative to H2 of 3x10-9, firmly established by several comparisons with other, independent column density determinations.

Presenter: Dr GERIN, Maryvonne

Session Classification: ISM, SF

Contribution ID: **21** Type: **not specified**

Molecular clouds in a Milky Way progenitor observed 8 billion years ago

Friday, 18 October 2019 11:10 (25 minutes)

Invited talk

Abstract:
Thanks to the remarkable ALMA capabilities and the unique configuration of the Cosmic Snake galaxy behind a massive galaxy cluster, we could, for the first time, resolve molecular clouds down to 30 pc linear physical scales in a typical Milky Way progenitor at z=1.036 through CO(4-3) observations performed at 0.2" angular resolution. We identify 17 individual giant molecular clouds (GMCs) that occupy the 1.7 kpc central region of the Cosmic Snake galaxy. These high-redshift molecular clouds are clearly different from their local analogues: with radii between 30 to 210 pc, they are two orders of magnitude more massive (8x10^6-1x10^9 Msun), one order of magnitude denser (with a median molecular gas mass surface density of 2600 Msun/pc2), and on average more turbulent (with internal velocity dispersions of 9-33 km/s). They thus are offset from the Larson scaling relations, well established for the local GMCs, and challenge the universality of molecular clouds. We argue that GMC physical properties are dependent on the galactic environment: GMCs must inherit their physical properties from the ambient ISM particular to the host galaxy. We find these high-redshift GMCs in virial equilibrium, and derive, for the first time, the CO-to-H2 conversion factor from the kinematics of independent GMCs at z~1. The measured large clouds gas masses demonstrate the existence of parent gas clouds with masses high enough to allow the in-situ formation of similarly massive stellar clumps seen in the Cosmic Snake galaxy in a comparable number to the GMCs. The comparison of the GMC masses and star cluster masses suggests a high efficiency of star formation, which anchors at z~1 the recently proposed scaling of the star formation efficiency with gas mass surface density. Our results corroborate the formation of GMCs by fragmentation of distant turbulent galactic gas disks, which then turn into the stellar clumps ubiquitously observed in galaxies at cosmic noon.

Presenter: Dr DESSAUGES-ZAVADSKY, Miroslava

Session Classification: Cosmology

Contribution ID: **22** Type: **not specified**

High-resolution studies of the SZ effect

Monday, 14 October 2019 12:35 (15 minutes)

Contributed talk

Abstract:
"In recent years, ALMA has allowed for probing the the Sunyaev-Zeldovich (SZ) effect at unprecedented sensitivity and angular resolution, thus opening a millimetre-wave window – complementary to X-ray observations – on the evolution of galaxy clusters and the physics of the intracluster medium. I will present recent results from high-resolution ALMA studies of the SZ effect from two of the most well-known galaxy clusters.
First, I will discuss the analysis of the renowned galaxy cluster RX J1347.5-1145. We performed the reconstruction of the pressure distribution by jointly analysing a combination of ALMA, Bolocam, and Planck data. This offered the opportunity to test the power of a joint image-visibility analysis, as well as opening a new path for interpreting the cluster morphology and merger history. In particular, the combination with results from X-ray image arithmetic has shown that the excess observed southeast of the cluster cool core in X-ray surface brightness map may not be entirely due to adiabatically-compressed gas. Thus, the possibility of a merger scenario less dramatic or at a later merger stage than what has previously been derived is suggested.
Then, I will present new results from the study of the ALMA observation of the shock front in the Bullet cluster. In particular, along with an independent view of X-ray observations on the basic shock properties, ALMA angular resolution is allowing for gaining fundamental insights into deviations from the ion-electron Coulomb equilibration."

Presenter: Dr DI MASCOLO, Luca

Session Classification: Cosmology

Contribution ID: **23** Type: **not specified**

First Identification of 10-kpc Scale [CII] 158um Halos around Star-Forming Galaxies at z=5-7

Friday, 18 October 2019 11:35 (15 minutes)

Contributed talk

Abstract:
We report the discovery of 10-kpc scale [CII] 158um halos surrounding star-forming galaxies in the early Universe. We choose deep ALMA data of 18 galaxies each with a star-formation rate of ~ 10-70 Msun with no signature of AGN whose [CII] lines are individually detected at z=5.153-7.142, and conduct stacking of the [CII] lines and dust-continuum in the uv-visibility plane. The radial profiles of the surface brightnesses show a 10-kpc scale [CII] halo at the 9.2sigma level significantly extended more than the HST stellar continuum data by a factor of ~5 on the exponential-profile scale length basis, as well as the dust continuum. We also compare the radial profiles of [CII] and Lya halos universally found in star-forming galaxies at this epoch, and find that the scale lengths agree within the 1sigma level. The existence of the extended [CII] halo is the evidence of outflow remnants in the early galaxies and suggest that the outflows may be dominated by cold-mode outflows, which challenges current galaxy evolution models.

Presenter: Dr FUJIMOTO, Seiji

Session Classification: Cosmology

Contribution ID: **24** Type: **not specified**

ALMA-IMF Large program, toward the understanding of the origin of the IMF

Monday, 14 October 2019 15:00 (25 minutes)

Invited talk

Abstract:
"Understanding the processes that determine the stellar Initial Mass Function (IMF) is a critical unsolved problem, with profound implications for many areas of astrophysics (Offner et al. 2014). In molecular clouds, stars are formed in cores, gas condensations which are sufficiently dense so that gravitational collapse converts most of their mass into a star or a small clutch of stars. In nearby star-formation regions, the core mass function (CMF) is strikingly similar to the IMF, suggesting that the shape of the IMF may simply be inherited from the CMF (e.g. Testi & Sargent 1998).
Studying extreme protoclusters is necessary to test if the IMF is universal - emerging naturally from any initial conditions in molecular clouds. During cycle 2 of ALMA, we mapped the W43-MM1 hypermassive molecular cloud. This structure, being extreme in terms of cloud concentration and star formation activity, is a case-study to confront models up to their limits. The 1 mm image reveals a rich cluster of about 300 cores with 2000 AU sizes and masses ranging from 1.6 to 100 Msun.
The resulting core mass function (CMF) is 'top-heavy', meaning that there is an important deficit in low/intermediate mass cores despite our excellent detection threshold of 1.6 Msun. This was the first measure of divergence between CMF and IMF. This result motivated the proposition of the Large-Program ALMA-IMF that was accepted in cycle 5. I will describe the strategy we adopted within the ALMA-IMF large program and present its first results."

Presenter: Dr LOUVET, Fabien

Session Classification: ISM, SF

Contribution ID: **25** Type: **not specified**

The ALMA lensing cluster survey: initial outcomes

Friday, 18 October 2019 11:50 (15 minutes)

Cotributed talk

Abstract:
The ALMA lensing cluster survey (ALCS) is an on-going cycle-6 large program to observe high magnification regions of 33 lensing clusters to expand the surveyed volume of high-redshift dust-continuum-selected and line-emitting galaxies. The ALCS covers 88 arcmin^2 in total, to a depth of 80 uJy (1.2 mm, 1 sigma), achieved by using a 15-GHz-wide spectral scan. The sample comes from the best-studied massive clusters also imaged in HST programs, i.e., CLASH, HFF, and RELICS. In this presentation, we will describe the survey design, the current status of the survey, and highlights of some selected initial outcomes. Emphasis will be placed on magnified ALMA continuum sources without HST counterparts, i.e., intrinsically-faint, HST-dark ALMA sources. These sources have faint IRAC counterparts, and the measured 1.2-mm to IRAC flux ratios suggest these are very distant (z>4-6) galaxies or forming massive galaxies at z~4, which are often completely invisible even in the deepest WFC3/HST images.

Presenter: Dr KOHNO, Kotaro

Session Classification: Cosmology

Contribution ID: **26** Type: **not specified**

Probing with ALMA the evolution of cores on the cusp of star formation

Monday, 14 October 2019 15:25 (15 minutes)

Contributed talk

Abstract:
"While clearly a vital step in the process of star formation, the transition from prestellar core to first hydrostatic core (FHSC) or protostar has not been well studied observationally. Even with ALMA, dense condensations within starless cores are very rarely detected in large surveys. Here, we present Atacama Large Millimeter/submillimeter Array (ALMA) observations from Cycles 0, 2 and 6 toward two highly evolved dense cores, Oph A SM1N and N6, within the Ophiuchus molecular cloud. Although apparently starless based on Spitzer and Herschels surveys, and despite a lack of outflow signatures in CO data in single-dish and ALMA observations, we detect compact continuum structures toward both SM1N and N6. These sources are candidates for the youngest protostars or FHSCs in the Ophiuchus molecular cloud. In particular, N6 contains a clear, low-luminosity point source embedded within extended dense gas. With matched resolution and sensitivity to large-scale structure from 850 micron to 3 mm, we model directly the SEDs of both the extended and compact features of both sources, and investigate the variation in dust emissivity and temperature at small radii. We furthermore confirm the first (and thus far only) H2D+ detection with ALMA toward SM1N, and along with observations of additional deuterated species (NH2D, N2D+), discuss the implications for chemical models of highly evolved starless and extremely young protostellar cores."

Presenter: Dr FRIESEN, Rachel

Session Classification: ISM, SF

Contribution ID: **27** Type: **not specified**

ALMA observations of extremely young star-forming cores

Monday, 14 October 2019 15:40 (15 minutes)

Contributed Talk

Presenter: Dr MAUREIRA, Maria Jose

Session Classification: ISM, SF

Contribution ID: **28** Type: **not specified**

Massive Galaxy Formation in the Reionization Era

Friday, 18 October 2019 12:05 (15 minutes)

Contributed talk

Abstract:
SPT0311-58 is a system of interacting galaxies at z=6.9, found via its millimeter-wave dust emission in the South Pole Telescope sky survey. Unlike most galaxies known in this era, which are relatively low-mass and dust-poor star forming galaxies, the constituents of this system are massive objects with significiant dust and gas content. ALMA has provided an exquisitely detailed picture of this system, revealing two main galaxies separated by just 8kpc and 500 km/s. These measurements have shown that the most massive galaxy in SPT0311-58 has the highest dust, gas, and dynamical masses of any galaxy known at z>6, including quasar hosts, and the pair resides in one of the largest halos that can exist at z~7. I will present an overview of our imaging of this system in dust continuum, atomic, and molecular lines, as well as rest-UV imaging, which reveal the complex process of galaxy assembly at this early point of cosmic history in great detail.

Presenter: Dr MARRONE, Daniel

Session Classification: Cosmology

Contribution ID: **29** Type: **not specified**

Converging filaments and the formation of a super star cluster in SgrB2

Monday, 14 October 2019 15:55 (15 minutes)

Contributed talk

Abstract:
"The star formation process is intimately related to the existence of disks, which mediate the accretion onto the star, and energetic outflows, which help to remove angular momentum from the system. Over the last years, this paradigm has been widely favoured for stars of all masses: from low-mass through B-type stars up to the most massive O-type stars. However, for O-type stars (L > 10^5 Lsun, M_star > 20 Msun) there is still less than a handful clear cut cases of detected disks. We have used ALMA to search for disk candidates around O-type protostars. Observations of six regions at a resolution of 0.2 arcsec provided us with evidence of three possible rotating disks. In this poster we present the results for G29.96-0.02, a well-known high-mass star-forming region for which rotating structures were claimed in the past. Our 0.2-arcsec resolution ALMA observations reveal a new and interesting scenario where the disk is not what it was thought to be, and an energetic and collimated outflow plays a dominant role. The observational findings are consistent with the existence of non-isotropic and non-steady accretion as seen in numerical simulations. This irregular accretion onto the massive disk has a profound impact by changing the disk plane orientation. This, in turn, modifies the orientation of the outflow which disrupts the outer parts of the disk. Under these circumstances, dense gas originally associated with the disk is pushed away by the outflow. This is observed in G29.96-0.02, where the spatial distribution and velocity field of complex organic molecules such as CH3CN or CH3CH2CN - typically found tracing the dense gas disk in massive stars - appear tracing the base of the outflow. Complementing this, we find evidence for a possible compact disk (600 au in size) perpendicular to the current outflow axis. All together, G29.96-0.02 seems to constitute a unique case of a (truncated) disk around an O-type protostar, caught in the act of being disrupted by anisotropic accretion."

Presenter: Dr SANCHEZ-MONGE, Alvaro

Session Classification: ISM, SF

Contribution ID: **30** Type: **not specified**

Solar Astronomy with ALMA

Monday, 14 October 2019 17:55 (25 minutes)

Invited Talk

Abstract:
"Solar observing with ALMA is offered as a non-standard mode since Cycle 4. The requirements for such observations are different from many other observations with ALMA in the sense that the mapped atmospheric layers of the Sun evolve on very short timescales and the primary beam being filled with complex emission. High-cadence (snapshot) imaging is needed for such a dynamic target but is very challenging. The effort and time that went into developing the observing mode seems well justified given that ALMA provides a new complementary view at a part of the solar atmosphere that is still elusive in many aspects. The solar observing campaigns with ALMA are co-ordinated with a number of space-borne and ground-based telescopes covering the UV to IR range. Co-ordinating such strictly simultaneous multi-telescope observations adds another layer of complexity but results in rich data sets covering all layers of the solar atmosphere while probing different properties of the atmospheric gas. Since Cycle 4, the imaging procedures for solar ALMA observations have been significantly improved and science-ready data are being produced. I will give a brief overview over ALMA's diagnostic potential for the Sun and challenges with carrying out solar observations and post-processing the data. First examples for Band 3 and Band 6 data are presented and illustrate the dynamic nature of the solar atmosphere, featuring, among other things, the imprint of magnetic fields and propagating shock waves."

Presenter: Dr WEDEMEYER, Sven

Session Classification: Stellar Evolution

Contribution ID: **31** Type: **not specified**

”Probing the thermal structure of the solar chromosphere with ALMA and optical/NIR observations ”

Monday, 14 October 2019 18:20 (15 minutes)

Contributed talk

Abstract:
“ALMA is a powerful new instrument that allows an unambiguous determination of the solar chromospheric temperature, and its rapid evolution. When combined with multiwavelength observations in other diagnostics, most notably strong optical/NIR spectral lines, this allows us to probe the highly structured atmosphere throughout much of its height and with high spatial and temporal resolution.
We will discuss several unique datasets that combine solar ALMA observations in Bands 3 and 6 with simultaneous imaging spectroscopy from the Interferometric Bidimensional Spectrometer (IBIS) operating at the Dunn Solar Telescope/NSO. We find that parameters of “”classical”” chromospheric spectral lines of H-alpha and Ca II are in some cases closely correlated with the ALMA brightness temperatures, posing strong constraints to interpretation of the observed spectral intensities in terms of dynamical properties.
We will also present information on the temporal evolution of dynamic events as seen by ALMA, comparing those with the shocks and small-scale impulsive events seen in the co-temporal ground-based optical data.
Finally, we will describe the opportunities and advantages of joint observations between ALMA and the soon-to-be-operational, four-meter DKI Solar Telescope (DKIST).”

Presenter: Dr GARY, Dale

Session Classification: Stellar Evolution

Contribution ID: **32** Type: **not specified**

A cool puzzle in the solar atmosphere

Monday, 14 October 2019 18:35 (15 minutes)

Contributed talk

Abstract:
While the nature of the heating mechanism that produces a rise in temperature just above the solar surface is a critical unsolved problem in astrophysics, the fact that the heated chromosphere contains pockets of material much cooler than their surroundings is also puzzling.
ALMA observations of the solar chromosphere are unique in providing direct electron temperature measurements, and are confirming that indeed there is significant cool material in the chromosphere. This paper discusses ALMA detections of strikingly cold material in both a quiet Sun region at Band 3 and in active-region plage at Band 6 that have no counterparts in observations at UV wavelengths or in magnetic field measurements. Such observations constrain radiative-MHD models of the chromosphere.

Presenter: Dr WHITE, Stephen

Session Classification: Stellar Evolution

Contribution ID: **33** Type: **not specified**

Star formation and magnetic fields in the ALMA era

Tuesday, 15 October 2019 09:00 (25 minutes)

Invited talk

Abstract:
"New ALMA polarization observations continue to both expand and confound our understanding of the role played by the magnetic field in low-mass star formation. The sample of very young, Class 0 protostellar sources observed with high resolution and high sensitivity with ALMA is now large enough that we are beginning to see the same surprising features in multiple sources. The first of these are magnetic field morphologies that beautifully trace the outflow cavity walls in several objects, indicating that the outflow has shaped the magnetic field. The polarization along the cavities is strongly enhanced, and in some cases is co-located with emission from UV-tracing molecules, suggesting that the origin of the enhanced polarization is the strong irradiation of the outflow cavities. The second, more puzzling set of features are thin structures with well organized magnetic fields that are not associated with outflow cavity walls, and yet have high polarization fractions in spite of being deeply embedded and far from any obvious source of the photons necessary to align the grains. These results challenge our understanding of both magnetic grain-alignment and grain growth in the earliest stages of star formation."

Presenter: Dr HULL, Chat

Session Classification: ISM, SF

Contribution ID: **34** Type: **not specified**

Dissipation Scale of Turbulence Cascade Revealed by ALMA

Tuesday, 15 October 2019 09:25 (15 minutes)

Contributed talk

Presenter: Dr KODA, Jin

Session Classification: ISM, SF

Contribution ID: **35** Type: **not specified**

Conference Summary

Friday, 18 October 2019 12:50 (25 minutes)

Presenter: Dr MISATO, Fukagawa

Session Classification: Conference Summary

Contribution ID: **36** Type: **not specified**

ALMA Detection of a Linearly Polarised Reverse Shock in GRB 190114C

Tuesday, 15 October 2019 09:40 (15 minutes)

Contributed talk

Abstract:
"We present the earliest observation and first detection of polarized millimeter emission in a γ-ray burst with ALMA Cycle 7 Band 3 (97.5 GHz) observations of GRB 190114C. With observations spanning 2.2 to 5.2 hours after the burst, we detect linear polarization in the GRB afterglow at ~ 5σ, decreasing from Π=(0.87±0.13)% to (0.60±0.19)%, and evolving in polarization position angle from (10±5) degrees to (−44±12) degrees. We show that the optical and X-ray observations between 0.03 days and ~0.3
days are consistent with a fast cooling forward shock expanding into a wind environment. However, the optical observations at ⊠0.03 days, as well as the radio and millimeter observations arise from a separate component, which we interpret as emission from the reverse-shocked jet. Using the measured linear polarization, we constrain the coherence scale of tangled magnetic fields in the GRB jet to an angular size of θ ≈0.001 radian, while the rotation of the polarization angle rules out the presence of large scale, ordered axisymmetric magnetic fields, and in particular the popular toroidal magnetic field model for GRBs outflows. "

Presenter: Dr LASKAR, Tanmoy

Session Classification: ISM, SF

Contribution ID: **37** Type: **not specified**

ALMA reveals a magnetically-regulated scenario for protostellar collapse: B335 & future perspectives.

Tuesday, 15 October 2019 09:55 (15 minutes)

Contributed talk

Abstract:
"Understanding the first steps in the formation of stars and protoplanetary disks is a great unsolved problem of modern astrophysics. Observationally, the key to constraining theoretical models lies in high-resolution studies of the youngest protostars. I will show our SMA and ALMA observations of the magnetic field topology in a sample of young protostars, and especially in the nearby B335 protostar where our ALMA observations have allowed to identify for the first time a scenario of magnetically-regulated collapse (Maury+ 2018). I will show how ALMA observations of the youngest, Class 0, disks confirm our early results (Maury+ 2019) that most young protostellar disks (>75%) are only found at very small radii <60 au, which may suggest magnetically-regulated models need to be considered for protostellar disk formation beyond the B335 case. I will also present our ALMA observations of the molecular line emission in a very young solar-type protostar suggesting a disk is currently forming in counter-rotation with respect to the protostellar core rotation, and discuss potential scenarii to understand this oddity (Maury+ in prep). I will argue that our ALMA observations of small disks, counter-rotating disks and organized magnetic fields in the youngest star-forming cores question the established paradigm of disk formation as a simple consequence of angular momentum conservation during the main accretion phase. They instead highlight the need to investigate magnetized models in order to unveil the mechanisms responsible, during the main accretion phase, for the pristine protoplanetary disk properties."

Presenter: Dr MAURY, Anaëlle

Session Classification: ISM, SF

Contribution ID: **38** Type: **not specified**

Tracing B-fields in protostellar targets across spatial scales with ALMA, SOFIA, BLAST, and APEX.

Tuesday, 15 October 2019 10:10 (15 minutes)

Contributed talk

Abstract:
"To understand the formation of stars and protoplanetarydisks in magnetized molecular clouds we require both (a) polarization maps of B-fields in protostellar infall envelopes, from ALMA, and (b) larger-scale B-field maps that serve to reveal the linkages - if any - between these envelope fields and the fields of the parent clouds. We will present new results from two ongoing programs in this area. First, in the densest portion of the South Ridge of the Vela C molecular cloud (d = 900 pc), we have traced magnetic fields nearly continuously from the 30 pc scale to the 1500 AU scale, via the combination of stratospheric polarimetry from BLAST, new APEX/PolKa polarimetry, and our very new ALMA Band 4 polarimetry results (PI: L. Fissel, NRAO) released to us in Spring 2019. We find a surprising agreement between the B-field orientations across three orders of magnitude in spatial scale, suggesting a relatively strong magnetic field that guides the collapse. Secondly, in the nearby stellar nurseries in Ophiuchus (d = 140 pc), the initial result from our program of synergistic polarimetric observations with ALMA and SOFIA reveals a more disordered field with only tenuous links across scales. This initial result is for the binary protostar IRAS 16293-2422 (lead on SOFIA polarimetry: F. Encalada, U. of Illinois). With these two ongoing research programs, we aim to determine the importance of magnetic fields for guiding infall and braking protoplanetary disk rotation across a range of star forming environments. Additional targets in Ophiuchus are scheduled to be observed with SOFIA's polarimeter in July of this year, and the upgraded version of BLAST is scheduled for launch in December of this year. "

Presenter: Dr NOVAK, Giles

Session Classification: ISM, SF

Contribution ID: **39** Type: **not specified**

The puzzle of protoplanetary disk masses

Tuesday, 15 October 2019 11:30 (25 minutes)

Invited talk

Abstract:
"Thanks to the advent of the Atacama Large Millimeter/submillimeter Array (ALMA), large surveys of protoplanetary disks in different star forming regions have been carried out to study the gas and dust components simultaneously. Carbon monoxide (CO) and its less abundant isotopologues have been observed to trace the bulk of the gas, while the dust was traced by the (sub-)mm continuum. A result that is common to these surveys is that CO emission from disks is fainter than expected. As a consequence, the overall CO-based gas-masses are very low, often smaller than one Jupiter mass and global gas/dust mass ratios are much lower than the expected interstellar-medium value of 100. This may be interpreted as lack of gas due to fast disk dispersal, or as lack of volatile carbon that leads to faint CO lines. After summarizing the results from different ALMA disk surveys and their implications, I will present alternative observational strategies which may help us to disentangle between the gas dispersal scenario and the chemical evolution hypothesis. More specifically I will show ALMA C2H observations that allow us to constrain the C/O ratio and to confirm that chemical evolution is at play in disks with faint CO lines."

Presenter: Dr MIOTELLO, Anna

Session Classification: Circumstellar Disks

Contribution ID: **40** Type: **not specified**

Revolutionizing Our View of Protostellar Disk and Multiplicity: The VLA/ALMA Nascent Disk and Multiplicity Survey"

Contributed talk

Abstract:
"We have conducted a large survey of 328 protostars in the Orion star forming regions at ~40 AU (0.1"") resolution, using ALMA (0.87 mm) and the VLA (9 mm). This large sample was derived from Spitzer and Herschel surveys and constitutes the majority of the protostars in Orion, providing a statistical characterization of the protostellar disk and multiplicity properties. We are characterizing the size, masses, and physical density structure of disks throughout the protostellar phase, and the same data enable us to examine the distribution of companion separations both as a whole and with evolution. We find that the disks toward protostars are significantly more massive than the proto-planetary disks around more evolved young stars, having a median mass of ~0.02 M_sun. There is a systematic decrease in protostellar disk mass with increasing evolutionary state, but with significant scatter in each evolutionary Class.

Thus, the planet formation process may be well-underway by the end of the protostellar phase. For disk radii, we find a systematic decrease from Class 0 to Flat spectrum and a median disk radius is ~30 AU. The largest disks, however, are found in the Class I and Flat spectrum systems. The longer wavelength data are crucial to enabling us to further assess the planet formation dust evolution toward these systems in terms of grain growth and the radial distribution of dust grain sizes. The distribution of companion separations is found to be bi-modal. This bimodal distribution may be indicative of multiple routes of binary/multiple star formation. The longer wavelengths of the VLA enabled us to detect companions that could not be resolved by ALMA due to optical depth of dust emission at the shorter wavelengths.

Thus, the combined strength of ALMA and the VLA at have been essential to revolutionizing our understanding of protostellar disks and multiple star formation."

Presenter: Dr TOBIN, John

Session Classification: Circumstellar Disks

Contribution ID: **41** Type: **not specified**

The demographical properties of brown dwarf disks

Tuesday, 15 October 2019 11:55 (15 minutes)

Contributed talk

Abstract:
"The study of the properties of disks around young brown dwarfs can provide important clues on the formation of these very low-mass objects and on the possibility of forming planetary systems around them. We will report on the systematic ALMA search for cold dust around extinction limited samples of young brown dwarfs with infrared excess in the Lupus, Ophiuchus and Chamaeleon I star forming regions. Combined with previous ALMA surveys of protoplanetary disks around young stars, our surveys allow us to extend to the substellar domain the demographical studies of disk properties.
We present the results of the disk mass vs central object mass, mass accretion rate vs disk mass and disk size vs disk mass correlation. The extension to the substellar domain of these populations studies allow us to constrain the formation mechanism of substellar objects and to put on firmer grounds the scaling laws of protoplanetary disk properties. We will also discuss the current evidence for du st evolution in disks around BDs and we will highlight the open questions related to dust and gas evolution and planet formation in the substellar domain."

Presenter: Dr TESTI, Leonardo

Session Classification: Circumstellar Disks

Contribution ID: **42** Type: **not specified**

Time-Domain Astrochemistry During Planet Formation

Tuesday, 15 October 2019 12:10 (15 minutes)

Invited talk

Abstract:
"The chemistry of protoplanetary disks sets the initial composition of newly formed planets and may regulate the efficiency by which planets form. Disk chemical abundances typically evolve over timescales spanning thousands if not millions of years. Consequently, it was a surprise when ALMA observations taken over the course of a single year showed significantly variable emission in H13CO+ relative to the otherwise constant thermal dust emission in the IM Lup protoplanetary disk. HCO+ is a known X-ray sensitive molecule, and one possible explanation is that stellar activity is perturbing the chemical ""steady state"" of the disk. If confirmed, simultaneous observations may provide a new tool to measure (and potentially map) fundamental disk parameters, such as electron density, as the light from X-ray flares propagates across the disk."

Presenter: Dr CLEEVES, Ilse

Session Classification: Circumstellar Disks

Contribution ID: **43** Type: **not specified**

Probing Snow Surfaces/Lines in Protoplanetary Disks

Tuesday, 15 October 2019 12:25 (15 minutes)

Contributed talk

Abstract:
"Protoplanetary disk radial and vertical thermal temperature gradients result in 2D snow surfaces, or condensation fronts. These are analogous to 1D snowlines, which are located where snow surfaces intersect with the disk midplane. CO and N2 are two of the most abundant disk molecules, and their snow surface locations could provide disk temperature structure diagnostics, while their snowline locations regulate the C/N/O ratios of outer Solar System planets and planetesimals. N2H+ is expected to only be abundant between the CO and N2 snow surfaces because it is destroyed by CO and formed from N2, and could therefore be used to probe the snow surfaces of both molecules in disks. Here we present Atacama Large Millimeter/submillimeter Array (ALMA) observations of N2H+ 3-2 at 0.2"-0.4" resolution in a sample of protoplanetary disks. We find two distinctive emission morphologies: N2H+ is either present in a bright narrow ring surrounded by the extended tenuous emission or in a single broad ring. These emission patterns can be explained by two different kinds of vertical temperature structures. Bright narrow N2H+ rings are expected in disks with vertical isothermal disk midplanes, where vertical snow surfaces at the midplane CO and N2 snow line locations produce a N2H+ emission peak defined by the CO and N2 snowline locations. Broad N2H+ rings are expected in disks that lack vertical isothermal midplanes and therefore present little exce ss N2H+ emission between the two snowline radii. For the first group, we use the inner and outer edges of the bright N2H+ ring to constrain a first set of CO and N2 snowline pairs in the disks. "

Presenter: Dr QI, Chunhua

Session Classification: Circumstellar Disks

Contribution ID: **44** Type: **not specified**

Chemistry in luminous galaxies.

Tuesday, 15 October 2019 15:00 (25 minutes)

Invited talk

Abstract:
"The chemical composition is a sensitive probe of physical condition in molecular clouds. With ALMA, astrochemical studies are possible in external galaxies. There are galaxies whose chemical composition is likely affected by starburst or AGN activities, rapid gas inflow and outflow, and shocks. I will discuss the case of the infrared luminous galaxy NGC 3256, the AGN-containing galaxy NGC 1068, and the ultra-luminous infrared galaxy Arp 220."

Presenter: Dr HARADA, Nanase

Session Classification: Galaxies

Contribution ID: **45** Type: **not specified**

Sub-mm Water Vapor Megamasers in Nearby AGNs

Tuesday, 15 October 2019 15:25 (15 minutes)

Contributed talk

Abstract:
"Water vapor megamasers in the accretion disks of active galactic nuclei uniquely probe sub-pc scale geometry and kinematics of nuclear molecular gas, provide gold-standard masses of supermassive black holes, and in some cases give geometric distances to the host galaxies, enabling a one-step measurement of the Hubble constant. Most previous observational work on water vapor megamasers has focused on the 22 GHz line, where masers in these circumnuclear disks can trace precise Keplerian rotation about the central black hole. Recent observations with ALMA have demonstrated for the first time that sub-mm lines, as well, can be detected in circumnuclear disks. Initial programs have targeted galaxies already known to host 22 GHz masers. We will discuss recent megamaser detections of the 321 GHz and 325 GHz water transitions, and then focus on the 183 GHz line. The 183 GHz transition is widely detected in known 22 GHz megamasers with peak line intensities typically a few tim es smaller than the 22 GHz lines. In some cases the sub-mm masers originate in the same thin, edge-on disk delineated by the 22 GHz lines, with sub-mm emission lines detected both at systemic and high rotation velocities, indicating masers on the front-side of the disk as well as on the edges, along the midline. Sub-mm masers can be used to probe temperatures and densities of gas in the accretion disk. With future observations, they also open up the opportunity to expand the number of precise, maser-determined black hole mass measurements."

Presenter: Dr BRAATZ, James

Session Classification: Galaxies

Contribution ID: **46** Type: **not specified**

Collimation of the relativistic jet in the quasar 3C273

Tuesday, 15 October 2019 15:40 (15 minutes)

Contributed talk

Abstract:
"The relativistic jet launched from the supermassive black hole at the center of active galactic nucleus (AGN) is one of the persistent highest energetic phenomena in universe. A key question to understand the nature is how the collimation occurs, enabling the central black hole to release the accretion and/or rotational energies to a larger scale structure beyond the host galaxy. Recent radio observations suggest that the collimation of the jet occurs on a wide range of scales inside the Bondi radius for some nearby low-powered radio galaxies. However, little is known for other AGNs like quasars due to the lack of the angular resolution. In this talk, we present the first VLBI observation including ALMA of the archetypical quasar 3C 273 at 86 GHz. Our observations achieve the highest angular resolution of ~70 µas, resolving the most inner part of the jet ever on scales of~ 10,000 Schwarzschild radii. Our results suggest that the jet parabolically collimates inside the Bondi radius and has a transition to the conical flow, similar to jets from LLAGNs. These indicate the universality of the collimation process for AGNs with various accretion rates from LLAGNs to active quasars."

Presenter: Dr OKINO, Hiroki

Session Classification: Galaxies

Contribution ID: **47** Type: **not specified**

Probing Feedback from Super Star Clusters in the Central Starburst of NGC253

Tuesday, 15 October 2019 15:55 (15 minutes)

Contributed talk

Abstract:
"Large-scale, multiphase outflows seen in nearby prototypical starburst galaxies, such as NGC253, are thought to be powered by feedback from massive stellar clusters.
Resolving these dusty compact structures outside the Milky Way system requires the spectral resolution and sensitivity of ALMA and future facilities such as the ngVLA. Using ALMA data at 350 GHz with 25 milliarcsecond (0.4 pc) resolution, we present direct evidence for outflows from super star clusters (SSCs) in the nuclear starburst of NGC253. We detect blue-shifted absorption and red-shifted emission towards four of the candidate SSCs in multiple lines, including HCN(4-3), H13CN(4-3), HCO+(4-3), and CS(7-6). These P-Cygni profiles are direct evidence for massive outflows from these SSCs. This is the first time outflows from stellar clusters have been identified outside the Milky Way system. The brightest SSC has an outflow velocity of ~50 km/s. We model the P-Cygni line profiles to constrain the outflow open ing angles and inclinations. These observations are the first of their kind, showing the formation and feedback of massive stellar clusters. This analysis allows us to determine the feedback SSCs exert on their environment and how the cluster-scales are related to the galaxy-scale outflow. From the high resolution dust continuum data, we identify >20 compact sources, with several of the clusters previously identified at lower resolution (1.9 pc; Leroy et al. 2018) breaking apart into multiple components. By combining this dust continuum data with 36 GHz radio continuum measurements made by the VLA (Gorski et al. 2019), we can constrain the ionizing flux, cluster spectral energy distributions (SEDs), and the cluster mass function (CMF). The CMF is related to the stellar initial mass function (IMF), and these SSCs provide a unique test in a region where a top-heavy IMF may be expected if it exists. "

Presenter: Dr LEVY, Rebecca

Session Classification: Galaxies

Contribution ID: **48** Type: **not specified**

Cold gas regulating the life-cycle of radio AGN

Tuesday, 15 October 2019 16:10 (15 minutes)

Contributed talk

Abstract:
"ALMA observations provide a unique opportunity to study at high resolution the tight interplay between the interstellar medium (ISM) of a galaxy and the nuclear activity that may be triggered at its centre. In particular, ALMA observations of the cold molecular gas in a handful of nearby active galactic nuclei (AGN) have provided new insights on the physical mechanisms that regulate the growth of the central super-massive black hole (SMBH) of a galaxy (i.e. AGN fuelling), and on the effects of AGN on the evolution of their host (i.e. AGN feedback). In this talk, I will focus on the tight interplay between the life-cycle of radio AGN and the cold neutral and molecular gas located in the innermost kilo-parsec of two nearby active nuclei, PKSB 1718-649 and Fornax A. In PKS 1718-649, multi-wavelength observations of the neutral and molecular hydrogen gave indications that a population of cold gas clouds is involved in the triggering and fuelling of the central active nucleus. ALMA CO (2-1) observations revealed that molecular gas is currently falling onto the SMBH within the innermost 75 pc, likely fuelling the recently started radio nuclear activity (t(AGN) ~10^2 years). In Fornax A, broad-band continuum observations (between 84 MHz and 217 GHz), in conjunction with ALMA-ACA observations of the innermost radio emission, have been critical to unlock the history of nuclear activity. MeerKAT observations of the neutral hydrogen and ALMA-ACA observations of the molecular counterpart allowed us to study the physical conditions of the cold gas in the centre of this early-type galaxy, where successive minor mergers likely triggered multiple episodes of nuclear activity."

Presenter: Dr MACCAGNI, Filippo

Session Classification: Galaxies

Contribution ID: **49** Type: **not specified**

Early High-Mass Star Formation: A Comprehensive ALMA ATLAS

Tuesday, 15 October 2019 17:10 (25 minutes)

Invited talk

Abstract:
I will present the results from our survey of Cold Cores with ALMA (CoCoA). Star formation research has still not revealed the initial conditions for high-mass star formation (HMSF). This is largely due to the lack of clear-cut examples of dense clumps that are bound to form stars but have not done so yet (high–mass starless clumps: HMSCs). While scattered, small sky patch searches have been made, no systematic galaxy-wide survey that can place such searches on a statistical firm footing has ever been conducted. We have now performed a systematic search for HMSCs from the ATLASGAL 870mu survey that covers the entire inner Galactic plane which are dense and devoid of infrared sources up to 70mu. Embedded star formation will manifest via outflowing, shocked, and warm gas components with little or no evidence of cold gas towards dense cores. By weeding out such masqueraders, and revealing the extent of fragmentation in all HMSCs, a feat only achievable with a survey machine like ALMA, CoCoA aims to reveal the truly massive starless cores if they exist.

Presenter: Dr PILLAI, Thushara

Session Classification: ISM, SF

Contribution ID: **50** Type: **not specified**

Sub-arcsecond (sub)millimeter imaging of the massive protostellar outburst in G358.93-0.03

Tuesday, 15 October 2019 17:35 (15 minutes)

Contributed talk

Abstract:
"The recent identification of accretion outbursts in two massive protostars, both heralded by 6.7 GHz methanol maser flares, has invigorated single-dish maser monitoring programs on a quest to find more cases. As a result, a third event was discovered on 14-Jan-2019 in a poorly-studied massive star-forming region G358.93-0.03. Since then, the global maser community has discovered 20 new torsionally-excited methanol maser transitions from 6 to 360 GHz toward this source(!), all likely powered by an ongoing accretion outburst in a massive protostar. We present (sub)millimeter imaging of the massive star-forming region G358.93-0.03 acquired in multiple epochs following the flare. Using DDT SMA and ALMA observations, we have discovered twelve new Class~II methanol lines which range in frequency from 199 to 361 GHz, and originate mostly from torsionally-excited states (vt=1 and vt=2). The positions of all of the maser lines coincide with the brightest continuum source (MM1),
which also hosts a line-rich hot core. The masers present a consistent velocity pattern that wraps around MM1. In contrast, the thermal lines exhibit a linear velocity gradient which bisects MM1 but at different position angles depending on optical depth. The maser spectral profiles evolved significantly over just a few month period, and the intensities have dropped significantly, however so far the dust continuum emission from MM1 is consistent with no change since our (sub)millimeter monitoring began at +1 month. This third massive protostellar outburst event exhibits properties quite different from either of the other two known cases (which also differed from each other significantly), highlighting the importance of further characterizing what may be an important and even essential phase in massive star formation."

Presenter: Dr BROGAN, Crystal

Session Classification: ISM, SF

Contribution ID: **51** Type: **not specified**

End of daily programme

Contribution ID: **52** Type: **not specified**

Dissecting high-mass protostars with SPARKS

Tuesday, 15 October 2019 17:50 (15 minutes)

Contributed talk

Abstract:
"The origin of the highest mass stars is still an enigma in modern astrophysics. The SPARKS project (Search for high-mass protostars with ALMA up to 5 kpc) is a high angular resolution follow-up of the complete sample of infrared quiet massive clumps selected from the ATLASGAL survey at 870 micron. ALMA confirms that deeply embedded high-mass protostars are already formed at the onset of collapse of the youngest massive clumps revealing the initial conditions of high-mass star formation. SPARKS reveals the so far largest sample of individual collapsing envelopes at 2000 au scales, with 135 protostars revealed, ~30 of them being high-mass. A case study of one of our targets revealed the so far known highest mass protostar with a stellar mass estimated between 11 and 16 Msol and an envelope mass of 130 Msol. With SPARKS we could study the physical and molecular structure of the inner envelope at size scales < 1500 au in great detail reaching a 400 au resolution. High sensitivity mapping of the same region with the ALMA-IMF large programme confirms that this object is a single collapsing envelope down to our resolution of 400 au. We discovered shocks at the centrifugal barrier implying an accretion disk. The chemical properties of the envelope show a striking dichotomy between O-bearing complex organic molecules (COMs) and COMs with a CN group. Altogether this reveals a qualitatively similar picture for a high-mass protostar in its main accretion phase, as for low-mass protostars."

Presenter: Dr CSENGERI, Timea

Session Classification: ISM, SF

Contribution ID: **53** Type: **not specified**

Exploring the Complex Chemistry of Young Solar Systems

Tuesday, 15 October 2019 18:05 (15 minutes)

Contributed talk

Abstract:
Studies of the complex organic chemistry in regions of star and planet formation have taken a tremendous step forward with data from ALMA. With its unprecedented sensitivity and angular resolution, ALMA has made it possible to zoom in on the gas surrounding deeply embedded protostars on Solar System scales. Such observations reveal the details of the rich complex organic chemistry taking place there - and, in particular, the physical and chemical evolution taking place while the young protoplanetary disks are being assembled. As part of the Protostellar Interferometric Line Survey (PILS), we have performed an unbiased spectral line survey in ALMA's Band 7 of the deeply embedded low-mass protostar IRAS 16293-2422, one of the template sources for star formation and astrochemistry. The survey has yielded a large number of new detections of molecules in the ISM, including key species in the chemical networks of prebiotic molecules. Also, the data show the presence of numerous rare isotopologues of complex organics and other species providing new constraints on their formation paths. The exact measurements of the abundances of the complex organic molecules and their isotopologues are compared to cometary measurements, i.p., from the Rosetta mission, providing the chemical link between the embedded protostellar stages and objects in our own Solar System. Finally, the PILS program outlines some of the paths forward in terms of future systematic ALMA surveys of the organic chemistry in star- and planet-forming regions.

Presenter: Dr JØRGENSEN, Jes

Session Classification: ISM, SF

Contribution ID: **54** Type: **not specified**

From the dense core edge to the disk scales

Tuesday, 15 October 2019 18:20 (15 minutes)

Contributed talk

Abstract:
"Dense cores are the places where stars are formed within the supersonic Molecular Clouds. These dense regions (n~10^5 cc) are cold (T~10 K) and display subsonic levels of turbulence (Mach ~ 0.5), and represent the initial conditions for both star and disk formation. Therefore, it is crucial to study dense cores to better understand the star and disk formation process. However, there are several important open questions regarding dense cores: Do they have an edge? How is the angular momentum distributed which controls disk formation? And, is the infalling envelope into the disk uniform or does it show strong asymmetries?
We present observations with ALMA, VLA, and NOEMA that focus on these questions. The ALMA observations (12m+ACA+Total Power) of a dense core reveal a surprising detection of SO and Methanol around the dense core, which highlights the material in the transition region between dense core and molecular cloud. This reveals a new window to study the edge of dense cores.
The VLA observations of 3 young Class 0 with NH3 enabled us to determine the specific angular momentum radial profile for the first time. We find that it is significantly different from solid body rotation (the typical initial condition for numerical simulations), and which does not present a region of conserved specific angular momentum down to 750 au scales.
This shows that the specific angular momentum in the early stages of protostellar evolution (Class 0) is dissipated efficiently and it places upper limits to the maximum possible disk size of ~60 au. This shows the power of studying the dense core kinematics to constrain the disk formation process.
Finally, we present NOEMA observations of a Class 0 object, which has been suggested to present a disk under gravitational instability (GI) (asymmetrical features in ALMA high resolution dust continuum emission). The new data reveal new large scale (~10,000 au) streamers of fresh gas from the surrounding dene core down to the disk scales. This streamer is perpendicular to the outflow, and it suggests that disk asymmetries could also be driven by large scale asymmetric flows instead of GI.
These results show the power and importance of studying dense cores with interferometers to provide a complete and proper picture of star and disk formation."

Presenter: Dr PINEDA, Jaime

Session Classification: ISM, SF

Contribution ID: **55** Type: **not specified**

The early stages at substellar formation in Lupus 1 and 3 clouds

Tuesday, 15 October 2019 18:35 (15 minutes)

Contributed talk

Abstract:
"The formation of brown dwarfs is still under debate. While the latest discoveries point towards a scaled-down version of the star formation process, other models, such as embryo ejection or stellar disk fragmentation, may not be discarded. Here we present our latest ALMA cycle 3 (band 6) continuum observations of Lupus 1 and 3 star formation regions based on previous ASTE/AzTEC observations and a set of previously known class II substellar objects from the literature. We classify these sources using the spectral energy distribution obtained from archival data. We report nine new sources that could be classified as either prestellar cores or deeply embedded protostar candidates, three new class I objects, and one new class II. Additionally we also detected six previously known class II systems, some of them in the boundary between brown dwars and very low mass stars. We probe the turbulent fragmentation and core collapse formation scenarios for the prestellar cores or deeply embedded protostar candidates and we compare the dust masses of the disk for the class II objects with previous studies. We also present ALMA cycle 5 band 7 data of Par-Lup3-4 where we witness for first time the presence of the base of a compact bipolar molecular cavity in radio and an optical jet in a very low mass star, close to the boundary to brown dwarfs, suggesting a scale down version of low mass star formation."

Presenter: Dr SANTAMARÍA-MIRANDA, Alejandro

Session Classification: ISM, SF

Contribution ID: **56** Type: **not specified**

The star formation process on cloud-scales in nearby galaxies

Thursday, 17 October 2019 09:00 (25 minutes)

Invited talk

Abstract:
Where do stars form and how is their formation regulated across galactic disks are two critical questions for our understanding of the star formation process. High angular observations of nearby galaxies allow us to sample the star formation process across entire galactic disks reaching now regularly the scales of the star-forming units, namely Giant Molecular Clouds (GMCs) and HII regions.
These data provide new insights on the molecular gas reservoir and its role in the star formation process as well as information on the importance of galactic components such as bulges, stellar bars, spiral arms and active galactic nuclei (AGN) in the conversion of cold (molecular) gas into stars. ALMA is fundamental for studying the molecular gas properties while the optical Integral Field Unit MUSE on the VLT is providing detailed information on the ionised gas and stellar population.

Presenter: Dr SCHINNERER, Eva

Session Classification: Galaxies

Contribution ID: **57** Type: **not specified**

ALMA view of 1 pc-scale molecular-gas structures in M33: Revealing star-formation activities in mole

Thursday, 17 October 2019 09:25 (15 minutes)

Contributed talk

Abstract:
Recent mm/sub-mm observations of molecular clouds suggest that molecular gas shows highly filamentary structure from a sub-pc to ~100 pc scale and the collision/interaction of such filamentary structures may drive the massive star formation. Although some galactic studies found very long filamentary clouds with the length of 50-100 pc (e.g., the "Nessie" nebula) possibly formed by the galactic spiral shocks, the actual origin and the star formation therein remain to be unclear, and are hard to understand due to the heavy contamination on the Galactic plane observation.
In order to reveal the relation between the galactic scale kinematics and the formation of molecular filaments/high-mass stars, we performed ALMA observations in the 12CO(2-1), 13CO(2-1), C18O(2-1) lines and 1.3 mm continuum emission toward the three most massive giant molecular clouds (GMCs) in one of the nearest spiral galaxy M33 at an angular resolution of 0".37 (corresponding to 1.5 pc). We targeted three massive (~10^6 Mo) GMCs in M33: GMC-8 with inactive star formation; NGC 604, one of the most luminous giant HII regions in the Local Group with young stellar clusters (hereafter, the NGC 604 GMC); and GMC-16, associated with relatively small HII regions.
Our preliminary results in 12CO and 13CO data demonstrate that NGC 604 GMC and GMC-16 contain many filamentary structures, whereas GMC-8 shows less filamentary structures and significantly lower 13CO/12CO ratio compared to other two GMCs. These results indicate that the dense (filamentary) gas fraction in GMCs increases as the star formation progresses. The filamentary clouds in GMC16 are highly ordered along the North-South direction with a length of 50-100 pc, which agrees with the elongation of the spiral arm. We detect red/blue-shifted wing components possibly due to the molecular outflow from massive protostar(s) at the 1.3 mm continuum source embedded in the filament, suggesting that the galactic shock may interplay in forming the long filaments and in massive star formation. In contrast to GMC-16, the molecular clouds in the NGC 604 GMC show more complex distributions composed by much shorter (10-15 pc) filaments and/or shell/arc-like structures along HII regions. Since such morphologies cannot be explained by the spiral shocks alone, we suggest that the combination of the ionization by UV photons from the NGC 604 cluster and an external atomic gas flow promoted the evolution of the GMC.

Presenter: Dr NISHIMURA, Atsushi

Session Classification: Galaxies

Contribution ID: **58** Type: **not specified**

A2C2S: The ALPINE ALMA C+ survey of galaxies at 4<z<6

Wednesday, 16 October 2019 09:00 (25 minutes)

Invited talk

Abstract:
“A2C2S is a large survey of 122 normal star-forming galaxies observed in the [CII]-158μm line and continuum. It aims at understanding stars, gas and dust properties at a time of rapid galaxy maturation after the end of HI reionization, at redshifts 4<z<6. With A2C2S it becomes possible to trace the cosmic time evolution of the star formation rate from a complete census at this key epoch, as well as to conduct a detailed characterization of ISM properties using LFIR/LUV and C+/FIR diagnostics. Dynamical masses are estimated from spectrally resolved C+, openning the way to measurements of the gas fraction and its evolution. A2C2S is providing a rich Legacy in the data-rich extragalactic survey fields ECDFS and COSMOS enabling studies with future facilities like JWST or the ELT. The key results will be presented at this meeting.”

Presenter: Dr GINOLFI, Michele

Session Classification: Cosmology

Contribution ID: **59** Type: **not specified**

Early Metal Enrichment and Multiphase Interstellar Media in a Galaxy at Redshift 8.312

Wednesday, 16 October 2019 09:25 (15 minutes)

Contributed talk

Abstract:
"How and when metal/dust enrichment happened in the epoch of reionization is one of the most fundamental questions in modern astronomy. Recent Planck results suggest an instantaneous reionization redshift of z = 7.7 ± 0.8, and the latest Hubble Space Telescope surveys have revealed strong evolution of the ultraviolet luminosity function from z ~ 10 to ~ 8, implying a rapid increase of the cosmic star-formation rate density within a very short time-scale (< 200 Myr). Hence, characterizing star formation and interstellar medium of galaxies in the heart of the reionization era (z ~ 8) is an important next step to our understanding of the earliest evolution of galaxies.
We present ALMA detections of the [OIII] 88 μm, [CII] 158 μm lines and 850 μm dust continuum emission in a Y-dropout galaxy, MACS0416_Y1. The [OIII] and [CII] detections unambiguously confirm its spectroscopic redshift to be z = 8.312, making this object one of the furthest galaxies ever identified spectroscopically. The ultraviolet-to-far infrared spectral energy distribution (SED) modeling where the [OIII] emissivity model is incorporated suggests the presence of a young (age ~ 4 Myr), star-forming (SFR ~ 60 Msun/yr), moderately metal-polluted (Z ~ 0.2 Zsun) stellar component. An analytic dust mass evolution model with a single episode of star formation does not, however, reproduce the metallicity and the inferred dust mass of 4 × 10^6 Msun in the stellar age, suggesting an underlying evolved stellar component as the origin of the dust mass.
A high [OIII]-to-[CII] luminosity ratio (~ 6) implies that typical H II regions are radiation-bounded, which is consistent with the inferred zero escape fraction of Lyman continuum photons obtained in the SED fits. It also suggests that the bulk of photodissociation regions are 'truncated' and are not terminated by molecular gas, although this would contradict the presence of dust, which should be co-spatial with molecular gas. Thus, a possible explanation for the observed fact is patchy/porous geometry of dusty molecular clouds, photodissociation regions, and highly ionized gas on sub-kpc scales, which are all suggested by state-of-the-art hydrodynamic simulations of galaxy formation."

Presenter: Dr TAMURA, Yoichi

Session Classification: Cosmology

Contribution ID: **60** Type: **not specified**

The first large, unbiased ALMA survey of CO at parsec resolution in the Small Magellanic Cloud

Thursday, 17 October 2019 09:40 (15 minutes)

Contributed Talk

Abstract:
The Small Magellanic Cloud (SMC) at only 1/5 solar metallicity is the only galaxy near enough to study the effect of a low metallicity environment on the physics of star formation and the ISM on small spatial scales. Understanding the effects of low metallicity is crucial for understanding galaxies in the early universe and the evolution of galaxies over cosmic time. Initial ALMA observations in the SMC show similar compact CO clumps (Jameson et al. 2018), but only small areas targeting specific star-forming regions have been mapped to date and we lack a statistically significant sample of the CO structure throughout the galaxy. We used ALMA in ACA standalone mode to map a 1.0 deg x 0.5 deg (~1 kpc x 500 pc) area of the Southwest Bar of the SMC at ~6.5" resolution and cover an unprecedented range in size scales from ~1.5 pc to 1 kpc. Our new map shows previously undetectable small (~ pc) molecular gas clumps, similar to what is seen in WLM (Rubio et al. 2015) and NGC 6822 (Schruba et al. 2017), but across a much larger scale. I will discuss the properties of the CO-emitting gas and how it compares to the HI gas from our new ATCA HI absorption survey and GASKAP HI map and what that reveals about the atomic-to-molecular transition at low metallicity.

Presenter: Dr JAMESON, Katie

Session Classification: Galaxies

Contribution ID: **61** Type: **not specified**

Quiescent carbon in the CGM of high redshift radio galaxies

Wednesday, 16 October 2019 09:40 (15 minutes)

Contributed talk

Abstract:
"The circum-galactic medium (CGM) is the location where galaxies directly interact with their environment through accretion and feedback events. These reservoirs can cover scales of several 100s of kpc, and are mostly studied in the optical through bright emission lines such as Lyman-alpha tracing their ionized gas. However, these optical/near-IR observations are likely missing an important part of the picture. I will present ALMA observations of the atomic carbon line [CI] in a sample of nine radio galaxies at redshifts 2 to 4.5. While some of these show broad [CI] lines up to 1000 km/s likely powered by the central AGN, we also find several examples of intriguingly narrow 50-120 km/s [CI] lines in the haloes of these massive galaxies. We compare these with our VLT/MUSE observations of the same galaxies, showing that the narrow [CI] gas detected by ALMA is tracing at least as much gas the ionized gas. Our [CI] detections reach beyond the regions where the radio jets have stirred up the gas kinematics, and therefore seem to trace the elusive CGM gas reservoirs from which these massive galaxies are forming. Future ALMA observations of other redshifted fine structure lines (e.g. [CII]158um, [NII]122/205, [OI]63/145um, [OIII]52/88um) should open up a new diagnostics of the physical conditions (density, ionization, metallicity) in the CGM at their epoch of formation."

Presenter: Dr DE BREUCK, Carlos

Session Classification: Cosmology

Contribution ID: **62** Type: **not specified**

Definitive calibration of CI, CO and dust as gas mass tracers across cosmic time

Wednesday, 16 October 2019 09:55 (15 minutes)

Contributed talk

Abstract:
"Measuring molecular gas mass in galaxies relies on the use of tracers as cold H2 is invisible. Historically CO has been the workhorse tracer as it is the second most abundant molecule in the ISM. However, it is expensive to observe large samples (100,000), and at high redshift the ground state J=1-0 transition is either inaccessible or extremely challenging to detect. Two alternative tracers have recently received attention: thermal emission from cool dust traced via sub-mm radiation, and emission from atomic Carbon (CI). Both are claimed to be 'as or more reliable' than CO, both are easier to observe at high redshift and sub-mm dust emission has already been observed in very large samples of galaxies with Herschel. In this talk I present a cross-calibration of all three tracers - the first sample of normal galaxies with CO, CI and dust emission from ALMA, plus literature observations of ~300 sources which have two of the tracers. Combining them in a self-consistent manner we find that there is no requirement (or strong evidence for) a bimodal CO-H2 conversion as is commonly adopted in the literature for 'main-sequence' and 'ULIRG/SMG' type star formation. Our study shows that all types of galaxy (with high metallicity) across z=0-4 can be modelled with constant gas-to-dust, gas-to-CO and CI abundance (with intrinsic scatter but no clear trends). In order to accommodate the popular lower CO-H2 conversion in ULIRG/SMG, we have to postulate that they must also have a lower gas-to-dust ratio AND a much higher Carbon abundance. This violates Occam's razor which states that the simplest acceptable hypothesis is the most likely one to be true.
Our 'best bet' values for the conversion factors are presented, which are very close to those found in the Milky Way ISM."

Presenter: Dr DUNNE, Loretta

Session Classification: Cosmology

Contribution ID: **63** Type: **not specified**

Stacking analysis of CO emission based on optical spectroscopic redshifts from MUSE

Wednesday, 16 October 2019 10:10 (15 minutes)

Contributed talk

Abstract:
"The origin of the rise of the star formation rate density towards z~1-3, the peak of galaxy growth, could be a large supply of molecular gas for forming stars, or a mechanism which causes high efficiency in star formation, or a combination of the two of these. The ALMA Spectroscopic Survey (ASPECS) project has conducted a spectroscopic survey in the Hubble Ultra Deep Field (HUDF) to perform an unbiased, blind search for CO emission, which traces the fuel of star formation (Gonzalez-Lopez et al. 2019). In order to push the detections of CO emission further, we perform a stacking analysis of the ALMA spectra based on the optical spectroscopic redshifts from another large, unbiased, blind spectroscopic survey in the HUDF carried out by the integral field spectrograph instrument MUSE (Multi Unit Spectroscopic Explorer) on the Very Large Telescope. The wide field-of-view (1'x1'), high sensitivity, wide wavelength coverage, and high spectral resolution of MUSE facilitate spectro scopic redshift measurements without requiring any target preselection, achieving a spatially homogeneous spectroscopic completeness. The MUSE deep survey in the HUDF obtained 1338 high quality redshifts, a factor of eight increase over the previously known spectroscopic redshifts in this field (Inami et al. 2017). In this talk, I will show the results of stacking the CO(2-1) line using the MUSE spectroscopic redshifts and the estimated molecular gas content in bins of stellar mass and star formation rate. This synergy of using the two deepest ever data cubes taken in the optical and the submm/mm plays a key role in making comparisons of galaxies with and without a direct CO detection. We will discuss the detection of CO emission and how it relates to the galaxy gas reservoir and star formation efficiency along the main-sequence relationship. "

Presenter: Dr INAMI, Hanae

Session Classification: Cosmology

Contribution ID: **64** Type: **not specified**

Early Metal Enrichment and Multiphase Interstellar Media in a Galaxy at Redshift 8.312

Contributed talk

Presenter: Dr TAMURA, Yoichi

Session Classification: Cosmology

Contribution ID: **65** Type: **not specified**

Small-Scale Substructures in Protoplanetary Disks

Thursday, 17 October 2019 11:40 (25 minutes)

Invited talk

Abstract:
The Disk Substructures at High Angular Resolution Project (DSHARP) observed 20 nearby protoplanetary disks in the 240 GHz continuum and 12CO J=2-1 spectral line with the Atacama Large Millimeter/submillimeter Array (ALMA) at a resolution of 35 milli-arcseconds (5 au). This talk will describe the motivation for this project and highlight the initial DSHARP results. We find that small-scale substructures in the dust continuum emission are ubiquitous in this sample, manifesting primarily as axisymmetric, narrow rings and gaps, with a small subset showing azimuthal deviations or spiral wave patterns. These features will be compared with current models for potential origins of disk substructures, and used to highlight some important follow-up work.

Presenter: Dr ANDREWS, Sean

Session Classification: Circumstellar Disks

Contribution ID: **66** Type: **not specified**

A path to planets: youngest known ringed structures in a protostellar disk

Thursday, 17 October 2019 12:05 (15 minutes)

Contributed talk

Abstract:
Circumstellar disks are fundamental to the low-mass star and planet formation processes, yet their properties are only beginning to be unveiled in detail during the earliest Class 0 and I phases due to the dense gas and dust envelopes present at early times. ALMA observations of the older Class II protostar HL Tau exposed dark gaps and dust rings in the disk, sparking the question: can ringed substructures already be found in younger Class I disks? To determine how early ringed structures occur, we targeted the disk of the Class I protostar IRS 63 with ALMA. Since only ~14 confirmed rotationally supported disks in the young Class 0/I phases are known, previous observations with the SMA were vital in the selection of IRS 63 as a target source. Not only is it a relatively bright Class I protostar, SMA molecular line data showed rotational signatures consistent with a moderately-inclined, rotationally-supported disk with a relatively large (~160 au) radius making it an ide al target for disk substructure studies. We have used ALMA 1.3 mm long-baseline dust continuum observations to study the Class I disk IRS 63 with 7 au resolution and expose the detailed physical structure of a Class I disk. The ALMA data indicate that concentric dust rings are present in the disk, revealing IRS 63 is the youngest-known protostellar disk with ringed dust substructures and demonstrating that these features are already present in the Class I phase. The dust ring structures could arise via several mechanisms including rapid pebble growth near snowlines, magnetorotational instabilities, or planet-disk interactions carving gaps in the disk. Even if planets have not yet formed, dust rings in disks at such an early evolutionary stage could provide a stable environment for long enough time scales to grow planets, and the ringed disk of the Class I protostar IRS 63 is the earliest evidence for these planetary cradles.

Presenter: Dr SEGURA-COX, Dominique

Session Classification: Circumstellar Disks

Contribution ID: **67** Type: **not specified**

How small molecules betray dust evolution in planet forming disks

Thursday, 17 October 2019 12:20 (15 minutes)

Contributed talk

Abstract:
ALMA observations of planet forming disks over the past several years have firmly established that the grains responsible for the millimeter wavelength continuum emission have undergone a significant evolution in their radial and size distribution. Many disks show clear signs of both radial drift of grains and accumulation in rings. This grain evolution is expected to leave an imprint on both the temperature of the disk and the penetration of stellar ultraviolet, andaffect the freeze out of CO, the presence of deuterated species, and molecules that are thought to form in CO-ice mantles like H2CO and CH3OH. ALMA observations of the lines of DCO+, DCN, N2D+, H2CO, and CH3OH in the disks around HD163296 and HD169142 confirm these expectations. In many cases, a 'ring-like' distribution is found, correlated with, but not identical to, the rings seen in dust millimeter continuum. The lack of a one-to-one correspondence requires that a combination of temperature effects and photodesorption due to increased penetration of ultraviolet radiation is invoked to explain the observed distribution of molecules. These findings illustrate that these simple molecules can be used to provide constraints on the disk's dust size populations and offer critical observational tests of dust evolution models.

Presenter: Dr HOGERHEIJDE, Michiel

Session Classification: Circumstellar Disks

Contribution ID: **68** Type: **not specified**

Organic Molecules in Protoplanetary Disks

Thursday, 17 October 2019 15:00 (25 minutes)

Invited talk

Abstract:
Earth-like planets form mostly from dry refractory materials in the inner regions of protoplanetary disks; however, they might become habitable if water and organic molecules are delivered to their surfaces and atmospheres by planetesimals formed beyond the sublimation front of water. Complex organic molecules (COMs), which are the seeds of prebiotic material and precursors of amino acids and sugars, form in the icy mantles of dust grains but cannot be detected remotely unless they are heated and released to the gas phase. Around solar-mass stars, water and COMs only sublimate in the inner few AU of the disk, making them extremely difficult to spatially resolve and study. Sudden increases in the luminosity of the central star, as seen in FU Orionis objects (FUors), will quickly expand the snow line to larger radii. Therefore, we can take advantage of the rapid increase in disk temperature of FUors to detect and analyze COMs in spatially-resolved ALMA observations. I will present our recent ALMA detection of several COMs from material directly related to planet formation in an outbursting disk source, V883 Ori.

Presenter: Dr LEE, Jeong-Eun

Session Classification: Circumstellar Disks

Contribution ID: **69** Type: **not specified**

Observing the first phases of planet formation: measuring vertical dust settling in a sample of Edge

Thursday, 17 October 2019 15:25 (15 minutes)

Contributed talk

Abstract:
Planets form in Protoplanetary disks. New instruments like ALMA and VLT / SPHERE are revealing features in young disks that may be the traces of these planets: rings, gaps, spirals. The direct detection of forming planets still located inside their disk remains, however, very challenging. The consequence is that direct observational constraints on the formation mechanism are sparse. In this talk I will show the results of an on-going survey with ALMA and HST to look for a significant sample of edge-on disks. The ALMA data reveal without ambiguity that vertical dust settling has had a major impact on the dust distribution within the disk. Clearly the dust seen by ALMA is located at the disk midplane, in a very thin layer, unresolved even with ALMA's longest baselines! This is in sharp opposition from the smaller dust seen by HST in scattered light images and located at much higher altitude above the disk midplane, co-spatial with the gas. From these data sets, direct measures of the gas scale height and geometrical thickness of the dust layer can be obtained. Other important quantities like the amount of turbulence, and the gas-to-dust ratio in the disk midplane can be derived. These observational contraints are critical to inform planet formation theories and models.

Presenter: Dr MÉNARD, François

Session Classification: Circumstellar Disks

Contribution ID: **70** Type: **not specified**

Radial variations of grain sizes and dust scale heights on the protoplanetary disk of HD 163296

Thursday, 17 October 2019 15:40 (15 minutes)

Contributed talk

Abstract:
HD 163296 is one of the best examples of the ring and gap structured protoplanetary disks. In addition, this disk is the only target where the ring and gap are spatially resolved in millimeter-wave polarization as well. By performing radiative transfer calculations of self-scattering polarization, we find that grain size and the dust scale height are the key parameters to reproduce the azimuthal and radial distributions of the observed polarization signature.
Azimuthal variation in polarization fraction is enhanced if the dust scale height is increased. In contrast, radial variation is mainly determined by the grain size because a polarization fraction is high if the particle size is $\sim \lambda/2\pi$ and low if the particle size is larger or smaller than that size.
With the comparison of our detailed modeling and observation, the best model of the HD 163296 polarization is that the dust scale height is one-tenth of that of the gas inside the 70 au ring, while it is 2/3 of the gas scale height outside of the 70 au ring. The grain size is 140 micron at the gaps while it is significantly smaller or larger in the rings. Furthermore, we constrain the gas turbulent parameter at the two gaps because both of the grain size and the dust scale height is constrained. The turbulent is α ~ 1.9x10E-6 inside of the 70 au ring and α ~ 1.5x10E-4 outside of the 70 au ring, respectively.

Presenter: Dr OHASHI, Satoshi

Session Classification: Circumstellar Disks

Contribution ID: **71** Type: **not specified**

ALMA Studies the Origin and Impact of Flares in Planetary Systems

Thursday, 17 October 2019 15:55 (15 minutes)

Contributed talk

Abstract:
The unanticipated detection of mm flaring in Proxima Cen by ALMA has spurred follow-on observations to understand the origin and nature of stellar flaring and its impact in planetary systems. In April through June of 2019, a coordinated observing campaign took place to further these investigations
and learn more about the relationship between particle acceleration and plasma heating and their impacts on nearby planets. At the core of the simultaneous campaign was ALMA's superb sub-mm capabilities, supplemented by numerous ground-based radio, optical, and space-based optical, ultraviolet and high energy recordings: ALMA, TESS, HST, Swift, Chandra, the DuPont Echelle, Evryscope, LCOGT, ANU 2.3m, Parkes, and the MWA. We report on initial results from the campaign and use this as a means to discuss the synergies of ALMA in multi-wavelength time-domain science.

Presenter: Dr OSTEN, Rachel

Session Classification: Circumstellar Disks

Contribution ID: **72** Type: **not specified**

The Event "Horizon Telescope: Imaging a Black Hole"

Wednesday, 16 October 2019 11:10 (25 minutes)

Invited talk

Abstract:
The Event Horizon Telescope (EHT) is a Very Long Baseline Interferometry (VLBI) array operating at the shortest possible wavelengths, which can resolve the event horizons of the nearest supermassive black holes. Observing at mm radio wavelengths, enables detection of photons that originate from deep within the gravitational potential well of the black hole, and travel unimpeded to telescopes on the Earth. The primary goal of the EHT is to resolve and image the predicted ring of emission formed by the photon orbit of a black hole. A sustained program of improvements to VLBI instrumentation and the addition of new sites through an international collaborative effort led to Global observations in April 2017: the first campaign with the potential for horizon imaging. After 1.5 years of data reduction and analysis we report success: we have imaged a black hole. The resulting image is an an irregular but clear bright ring, whose size and shape agree closely with the expected lensed photon orbit of a 6.5 billion solar mass black hole. This talk will cover the project and first results as well as future directions.

Presenter: Dr DOELEMAN, Shep

Session Classification: Galaxies

Contribution ID: **73** Type: **not specified**

The Size, Shape, and Scattering of Sagittarius A* at 86 GHz

Wednesday, 16 October 2019 11:35 (15 minutes)

Contributed talk

Abstract:
"High-frequency very-long-baseline Interferometric (VLBI) observations of the Galactic Center supermassive black hole, Sagittarius A*(Sgr A*) have sufficient angular resolution to probe black hole accretion and outflow on event-horizon scales. We present the first unscattered image of Sgr A*taken at 86 GHz (3.5-mm) using the Global Millimeter VLBI Array (GMVA) joined for the first time by ALMA operating as a phased array in April 2017. The network reaches an angular resolution of 87 micro-arcseconds, improving upon previous experiments by a factor of two, and revealing a nearly isotropic intrinsic source. I will discuss the consequences for underlying accretion and emission models of Sgr A*, as well as new constraints on the properties of interstellar scattering using baselines to ALMA."

Presenter: Dr BLACKBURN, Lindy

Session Classification: Galaxies

Contribution ID: **74** Type: **not specified**

Hydrogen Radio Recombination Line Masers observed with ALMA: Imaging of Warped Disks and Photo-evapo

Thursday, 17 October 2019 16:10 (15 minutes)

Contributed talk

Abstract:
Hydrogen radio recombination lines (or RRLs) are excellent probes of the kinematics and physical conditions of the ionised gas in the ISM. The lines at sub-/millimeter wavelengths are particularly especial since they may present maser amplification. This is a rare effect that has been observed only toward a handful of objects. However, in the cases where maser RRLs have been found (as e.g. in the emission line star MWC349A or in the planetary nebula MWC922), their large amplification has allowed to study with exquisite detail the kinematics and physical structure of the innermost ionised regions close to the central stars.
Massive stars are also known to strongly ionise their surroundings forming ultracompact (UC) HII regions. Recently, we have carried out very high-angular resolution images of the emission of the H21alpha RRL toward the UC HII region MonR2-IRS2, using the Band 9 of ALMA. Our images, obtained at an unprecedented angular resolution of 50 au (~60 mas at a distance of 830 pc), resolve for the first time the ionised gas around the central massive protostar into a high-velocity wind and an ionised disk. The high-velocity wind is found to be launched from the disk at a radius of 12 au from the central protostar, as if it were photo-evaporating and favouring the disk wind formation scenario for the wind. For the ionised disk, clear deviations are observed for the peak emission of the H21alpha line above and below the disk mid-plane, characteristic of a warped disk. This disk warped morphology could be due either to a companion that remains undetected, or to strong accretion processes onto the central protostar.

Presenter: Dr JIMENEZ-SERRA, Izaskun

Session Classification: Circumstellar Disks

Contribution ID: **75** Type: **not specified**

The ALMA Galactic Center Molecular Cloud Survey

Wednesday, 16 October 2019 11:50 (15 minutes)

Contributed talk

Abstract:
"Recent research has delivered fascinating insights into the physics of the Central Molecular Zone (CMZ; inner ~100 pc) of the Milky Way. The molecular clouds in the CMZ, though turbulent on large spatial scales (~5 pc), contain dense cores of 0.1 pc size that are not more turbulent than what is typically found closer to the Sun. Also, while these clouds are of a high average density on large spatial scales, the embedded cores are of a rather modest density.
In brief, this means that the gas in the CMZ on spatial scales immediately related to star formation "does not know" about the extreme physical conditions prevailing on large spatial scales. This finding has profound implications for ALMA-based studies of star formation under extreme environmental conditions, such as those that prevailed in the early cosmos and in starbursts.
But what causes these surprising trends in cloud structure? Are they, for example, consequences of cloud-cloud collisions or of the extreme magnetic field strength prevailing in the CMZ? The ALMA observations of the Galactic Center Molecular Cloud Survey (GCMS), a massive (i.e., ~25h) survey of major clouds in the CMZ, were tailored to deliver answers. This in particular includes imaging of key diagnostic molecules (e.g., H2CO and SiO) for clouds throughout the CMZ. This unique and comprehensive data set now allows us to understand the physics of the CMZ based on detailed modeling of the numerous processes affecting the molecular clouds in the Galactic Center."

Presenter: Dr KAUFMANN, Jens

Session Classification: Galaxies

Contribution ID: **76** Type: **not specified**

”ALCHEMI: The ALMA Comprehensive High-resolution Extragalactic Molecular Inventory”

Wednesday, 16 October 2019 12:05 (25 minutes)

Invited talk

Abstract:
NGC 253 is the one of the brightest molecular emitters outside the Galaxy and therefore the more suited candidate for deep molecular surveys. In this presentatio i will summarize the current status of the ALCHEMI project which an ALMA large program consisting of an unbiased line survey from ALMA bands 3, 4, 6, and 7 (85-370 GHz), whose scope was extended this Cycle to also cover Band 5. In particular i will focus on the first results on the low resolution data from the 7m compact array which already shows an unprecedented molecular richness as well as first
look into the chemistry revealed at the highest resolution.
Despite of being observed at every wavelengths for decades, ALMA keeps unveiling new details on its central molecular zone. Additionally to ALCHEMI, I will present results from deep observations spin-off ALMA projects which were going in parallel to this survey which targetted isotopic ratio based on the double isotopologue 13C18O, deuteration, and vibrational emission in NGC 253.

Presenter: Dr MARTÍN, Sergio

Session Classification: Galaxies

Contribution ID: **77** Type: **not specified**

The molecular torus of NGC1068

Wednesday, 16 October 2019 12:30 (15 minutes)

Contributed talk

Abstract:
I will present results obtained with ALMA on the prototypical Seyfert 2 nucleus in NGC 1068. Previous CO (6-5) observation already showed evidence for a high-velocity outflow at a resolution of ~ 0.04" resolution. We have now obtained data with a factor ~ 2 better resolution (~1 pc-scale) with the most extended ALMA configurations. We observed HCN J=3-2 to reveal aline profile against the radio nucleus which is consistent with the outflow observed in CO. The projected radial velocity of this molecular outflow is ~170 km/s with high velocity wings ranging up to 400 km/s. The nuclear spectrum also shows a narrow, redshifted absorption component at infall speed ~40 km/s. Analysis of the position-velocity diagram and the morphology of the integrated line flux map reveals two nested, rotating disk components. The inner disk, inside ~ 1.5 pc, has kinematics consistent with the edge-on, geometrically thin H2O water megamaser disk. The outer disk, which extends to 7 pc, is also geometrically thin but inclined. The outer disk counter-rotates relative to the inner, water megamaser disk. I will conclude with a picture in which the torus consists of two geometrically thin, counter-rotating disks, and the nuclear obscuration occurs in outflowing molecular clouds whose origin is likely a hydromagnetic wind driven off of the inner disk.

Presenter: Dr IMPELLIZZERI, Violette

Session Classification: Galaxies

Contribution ID: **78** Type: **not specified**

ALMA observes the aftermath of mergers of non-compact stars

Thursday, 17 October 2019 17:10 (25 minutes)

Invited talk

Abstract:
Red novae, a newly-recognized group of eruptive variable objects, are optical manifestations of merging non-compact stars than may be observed in real time. They represent transients erupting at luminosities intermediate between those of classical novae and supernovae. In red nova eruptions, stellar coalescence produces circumstellar environments very rich in molecular gas and dust. ALMA, NOEMA, and SMA have recently revealed the complexity of the cool remnants of such events, including their spatio-kinematic structure and a rich molecular inventory of peculiar molecular and isotopologic composition. The submillimeter observations have provided, for the first time, the masses dispersed during the merger events and revealed bipolar outflows, which strongly constrains hydrodynamic models of progenitor common-envelope systems and violent stellar mergers. Additionally, detailed studies of chemical composition of red-nova remnants have yielded many surprises and include the detection of complex organic molecules and the first observation in space of a "radioactive molecule", 26AlF. There are numerous similarities between the merger remnants and some pre-planetary nebulae (PPNe) and it is possible that some objects classified as PPNe are indeed old merger remnants. The superb angular resolution and sensitivity of ALMA has helped to establish red novae as a new type of submillimeter source and allows detailed studies of the structure and the highly unusual chemistry of material in the aftermath of an explosion. Future observations will utilize ALMA to identify new Galactic objects of this type, catching their explosions "in the act" and to search for remnants of overlooked historic red novae.

Presenter: Dr KAMINSKI, Tomasz

Session Classification: Stellar Evolution

Contribution ID: **79** Type: **not specified**

Galactic Dynamics and Dark Matter Profile of NGC1380 with ALMA and VLT/MUSE

Wednesday, 16 October 2019 12:45 (15 minutes)

Contributed talk

Abstract:
ALMA's high resolution and high sensitivity enable us to obtain kinematics of molecular gas in the center of early-type galaxies (~1kpc) complementarily to the stellar kinematics obtained with optical IFU instrument. The molecular gas kinematics is a powerful tracer of mass distribution of galaxies because the velocity dispersion is low(~10km/s) and the simple rotational model is applicable. To understand the interaction between dark matter and baryonic matter in the galaxy evolution history, it is fundamental to measure dark matter distribution in galaxies. However, it was difficult to derive the dark matter profile in the central region of early-type galaxies because of the lack of neutral hydrogen gas and the degeneracy between dynamical stellar M/L and dark matter distribution. To overcome this difficulty, we conducted a combined analysis of ALMA data and MUSE data of early-type fast rotator galaxy NGC1380. Our strategy is to measure BH mass and stellar mass well in the central region (~radius of 6", 500pc) with the cold gas kinematics. Then we derive dark matter profile with the stellar kinematics which is available in a wide field of view(~radius of 120'', 10kpc) with the help of information of the central cold gas modeling. Dynamical measurement of stellar M/L and BH mass is conducted with ALMA high angular resolution data (0.24"×0.18" ~ 21pc×16pc where BH sphere of influence of the resulted BH mass is 0.37"~ 33pc). Simple gas rotational disk model reproduce observed data cube well. The obtained BH mass of 3.38×10^8^{+0.30}*{-0.24} solar masses. With Jeans Anisotropic Models (JAM; Cappellari 2008) of stellar kinematics, we found that the substantial amount of dark matter halo is needed to maintain flat velocity profile at large radius. However, the mass model obtained with ALMA cold gas modeling cannot reproduce the central high-velocity dispersion peak in the stellar kinematics data (~10" 900pc). We obtained dark matter profile by using information from the central gas rotational disk model as a prior knowledge with Bayesian inference. The Obtained inner slope of the dark matter was gamma=0.45^{+0.11}*{-0.10} which is lower than 1.0 NFW profile predict, which indicate that this galaxy experienced some process modifying dark matter shape to shallower profile. Our developed method will enable us to increase the number of measured central slope of dark matter profile in a wide range of galaxies to explore this mechanism.

Presenter: Dr TSUKUI, Takafumi

Session Classification: Galaxies

Contribution ID: **80** Type: **not specified**

Shaping of the stellar wind of evolved red giants and their successors by (sub-)stellar binary companions

Thursday, 17 October 2019 17:35 (15 minutes)

Contributed talk

Abstract:
Planetary nebulae (PNe) reveal a wide range of morphologies. Bipolarity is the main characteristic, but jets and tori are also detected. Several contending theories of the evolution from a (roughly) spherically symmetric Asymptotic Giant Branch (AGB) stellar wind to a very non-spherical PN have emerged. Here, we present the first high-spatial resolution observational campaign of a large sample of oxygen-rich AGB stellar winds obtained in the ALMA Large Program ATOMIUM ('ALMA Tracing the Origins of Molecules formIng dUst in oxygen-rich M-type stars'). The data constitute the first observational proof that (sub-)stellar binary activity is the dominant shaping mechanism of AGB stellar winds, and their successors the PNe. We show that low mass-loss rate oxygen-rich AGB winds are more readily prone to complex structural deformations owing to their slow wind acceleration, whereas a binary-induced spiral structure is more prevalent in other classes of AGB stellar winds. These results resolve several previously unexplained phenomena — including the absence of detached shells around oxygen-rich AGB stars and disks around carbon-rich PNe — and have critical implications for the formation of type Ia supernovae.

Presenter: Dr DECIN, Leen

Session Classification: Stellar Evolution

Contribution ID: **81** Type: **not specified**

ALMA unveils highly collimated jets in evolved stars

Thursday, 17 October 2019 17:50 (15 minutes)

Contributed talk

Abstract:
The mass-loss processes that occur during final stages of the evolution of low and intermediate-mass stars are of great relevance because they determine the ultimate fate of these stars, as well as the amount of mass and chemical composition of the material that will end up replenishing the interstellar medium. Thus, the study of these processes is important to understand not only the stellar evolution but also the chemical evolution of galaxies. Particularly, in the last decades there has been mounting observational evidence that after the Asymptotic Giant Branch (AGB) phase, low and intermediate-mass stars may develop powerful highly collimated outflows that have a strong impact on the circumstellar envelope (CSE) that formed in previous mass-loss episodes. One important effect of the activity of such collimated outflows is the modification of the shape of the roughly spherical CSE. According to an increasingly popular model that explains the formation of asymmetric planetary nebulae, a fast collimated outflows carve cavities within the spherical CSE, which are eventually seen as bright lobes and bubble-like morphologies in the subsequent planetary nebula phase when the star becomes hot enough to ionise the CSE. This process occurs in a very short time-scale (a few hundred years) during which the star becomes enshrouded by gas and dust that render it invisible at optical wavelengths. As a result, it is difficult to find objects undergoing this ephemeral phase. Nonetheless, there is a particular group, containing 15 known sources in our Galaxy, of oxygen-rich post-AGB objects that exhibit high-velocity water masers tracing high-velocity (>100 km/s) collimated structures and/or bow-shocks. These objects are referred to as "water fountains" (WF) and they are thought to be undergoing the earliest manifestation of collimated mass-loss after the AGB phase. Thus, the study of WF is of great importance to understand the evolution of low and intermediate-mass stars since they hold key information to understand the launching and collimation of collimated outflows, as well as their interaction with the CSE. In this talk I will present novel results of recent observations with ALMA toward two WF for which we have traced for the first time the collimated jets proposed to be creating the seen bipolar structures. The observations reveal that the jets extend beyond the regions traced by the water masers and they exhibit deceleration as they interact with the CSE.

Presenter: Dr TAFOYA, Daniel

Session Classification: Stellar Evolution

Contribution ID: **82** Type: **not specified**

HCN laser lines in carbon-rich evolved stars

Thursday, 17 October 2019 18:05 (15 minutes)

Contributed talk

Abstract:
HCN is one of the most abundant molecules in the circumstellar envelopes of carbon-rich AGB stars. Recent APEX surveys have revealed widespread presence of HCN maser emission in the innermost regions of these envelopes at millimetre wavelengths. Besides millimetre-range masers, HCN is also known to exhibit two intense lasers in the submillimetre frequencies near 805 and 891 GHz, whose frequencies are in the highest frequency band of ALMA. Previous single-dish observations with the CSO and Herschel have detected these laser lines at extraordinarily high flux densities of a few thousand Jansky in carbon-rich stars. In Cycle 6, we have carried out a pilot imaging survey of HCN lasers for several carbon-rich evolved stars in ALMA Band 10 with the intermediate (~1 km) baselines. Among the targets that have been observed, we have invariably detected intense emission of the two HCN laser lines in the innermost circumstellar envelopes. Due to the lack of nearby, bright quasars at high ALMA frequencies, calibration of the rapidly varying interferometric phases is very challenging. The bright and compact nature of the laser-emitting regions in carbon-rich evolved stars makes it possible to self-calibrate the data and improve the dynamic ranges of the images. We will present the first results from Cycle 6, which demonstrate that self-calibration with HCN lasers can drastically improve the dynamic range by two orders of magnitude to about ~2000 in Band 10. This can yield high-fidelity detailed images of the stars' radio photospheres with high-frequency, long-baseline observations in the future.

Presenter: Dr WONG, Ka Tat

Session Classification: Stellar Evolution

Contribution ID: **83** Type: **not specified**

Tracing the mass loss history of WX Psc with ALMA and KVN

Thursday, 17 October 2019 18:20 (15 minutes)

Contributed talk

Abstract:
We present the combined results of ALMA and KVN (Korean VLBI Network) observations toward WX Psc (IRC+10011) which is a long-period variable OH/IR star. The SiO masers of v=1 and v=2, J=5-4, and the SiO thermal emission of v=0, J=5-4 were observed together with the H2O v2=1, 5(5,0)-6(4,3) and continuum emission at ALMA Band 6 in October 2017 (Cycle 5). This ALMA observation aims to study the development of asymmetric outward motions during the evolutionary phases from the asymptotic giant branch (AGB) stars to the planetary nebulae (PNe), which are closely related to the conspicuous phenomena of the mass loss at the late stage of AGBs. The strong SiO and H2O maser features are detected around the continuum emission peak, which imply the asymmetric morphology of the high density regions of the inner circumstellar envelope (CSE) swept by the stellar winds. The clumpy structures of the CSE of this source are also clearly shown by SiO v=0, J=5-4 thermal components, which are very similar to the detached shell found in many carbon-rich evolved stars. The size of this detached shell-like structure is about 100 mas that corresponds to the dust layer around this object. The detached shell-like structures are known to be developed either through the interaction of distinct wind phases or an episodic mass loss eruption associated with a thermal pulse, thus they give a crucial information related to the mass loss history of late AGB stars. While the spatial resolution 20 mas of this ALMA observation cannot clearly resolve the detailed characteristics of the inner part of the CSE, the KVN observations show in detail the spatial distributions of the v=1 J=1-0, J=2-1, J=3-2 SiO masers emitted from the inner regions of CSE. Therefore, the monitoring VLBI observations of KVN for this source help us to trace the mass loss history combining the ALMA results, which can connect the stellar evolution to the wind and mass loss. The bipolar outflow feature is also found from the KVN results of 22 GHz H2O maser and the direction of the outflow axis, NW-SE, seems to be strongly related to the void regions of the SiO v=0 thermal shell structure found in this ALMA observation. These results show the power of the cross-facility synergies between ALMA and KVN for the study of stellar evolution.

Presenter: Dr YUN, Youngjoo

Session Classification: Stellar Evolution