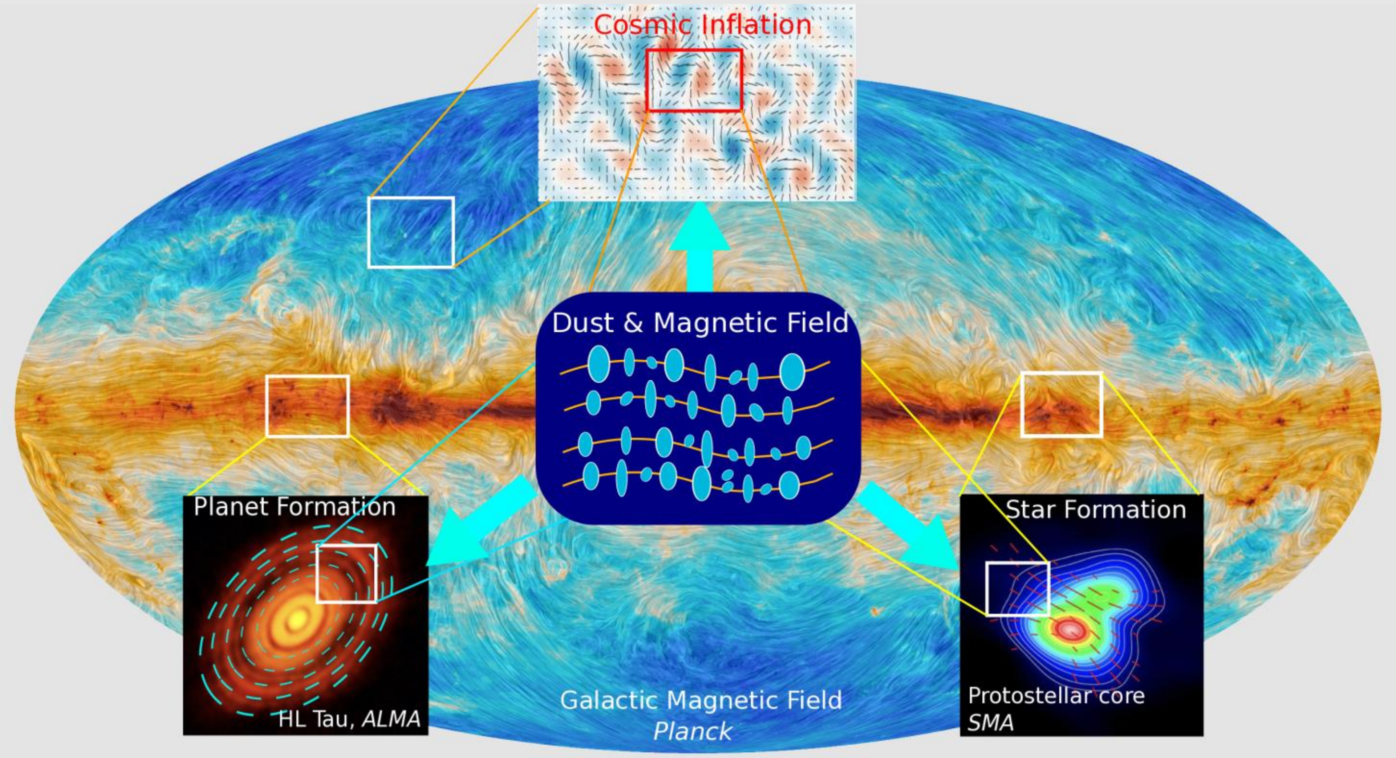
1st TagKASI International Conference:

Cosmic Dust & Magnetism

Korea Astronomy & Space Science Institute, Daejeon, Korea

Oct 30 – Nov 2, 2018



Theoretical Astrophysics Group
(TAG)

KASI 한국천문연구원
Korea Astronomy & Space Science Institute

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PROGRAM — Cosmic Dust and Magnetism

Wednesday, Oct 31, 2018

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12:15 – 12:30	Yusuke Tsukamoto	The impact of non-ideal MHD effects on the protostar formation and their observational signatures
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14:00 – 19:00	**Excursion**	
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PROGRAM **Cosmic Dust and Magnetism**

Thursday, Nov 1, 2018

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10:00 – 10:15	Hongli Liu	Velocity Anisotropy in Self-Gravitating Molecular Clouds
10:15 – 10:30	Tie Liu	A Holistic Perspective on the Dynamics of G035.39-00.33: The Interplay between Gas and Magnetic Fields
10:30 – 11:00	**Coffee Break**	
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11:45 – 12:00	Aris Tritsis	The Musa Molecular Cloud: An Interstellar Symphony
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What can we learn from ALMA disk polarization?		
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15:00 – 15:15	Chin-Fei Lee	ALMA Dust Polarization observations of Nearly Edgeon Protostellar disks
15:15 – 15:30	Satoshi Ohashi	Different Polarization Mechanisms in Protoplanetary Disks
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16:00 – 16:30	**Coffee Break**	
Related important issues: turbulence, shocks, and filaments		
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PROGRAM **Cosmic Dust and Magnetism**

Friday, Nov 2, 2018

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09:30 – 10:00	**Alex Lazarian**	Changing the Landscape: New Ways of Tracing and Probing Magnetic fields with Velocity and Synchrotron Gradients
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10:15 – 10:30	Yue Hu	Surveying Magnetic Fields Morphology with Velocity Gradient Technique in Molecular Clouds
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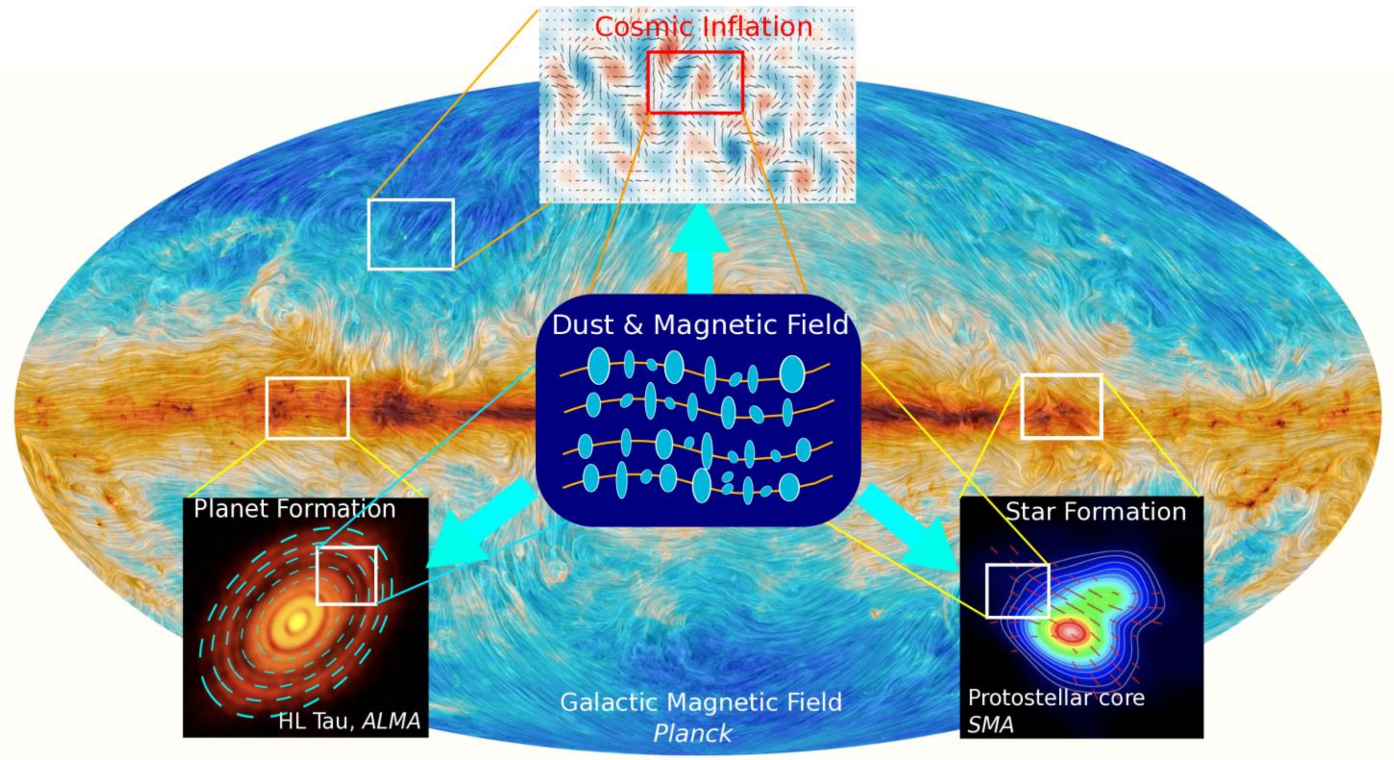
Abstract Day 1

Tuesday, October 30, 2018

Session 1: Dust Properties and Dust Evolution

Session 2: Pysics of Dust Polarization: grain alignment, scattering, and tests

Session 3: PHA & Nanodust



[Session 1: Dust Properties and Dust Evolution]

Electromagnetic Properties of Interstellar Dust

Bruce T Draine

Princeton University, USA

ABSTRACT: Much of what we know about interstellar dust is based on observations of extinction, scattering, and emission. Polarization-dependent extinction of starlight, and polarization of the far-infrared and submm emission place constraints on the geometry (shape and porosity) of dust, on the degree of alignment with the interstellar magnetic field, and possibly also on the degree to which grains may emit magnetic dipole radiation at very long wavelengths. The observational constraints will be briefly summarized, and current efforts to develop viable grain models will be described.

Dust evolution and growth in the interstellar medium

Hiroyuki Hirashita

ASIAA, Taiwan

ABSTRACT: We review the current theoretical understanding of dust evolution in the interstellar medium (ISM), focusing on the interstellar processing of dust. The evolutions of dust amount and grain size distribution are greatly governed by interstellar processing. Especially, shattering and accretion enhance the abundance of small grains while coagulation pushes those created small grains to large sizes. We show that these dust evolution processes have a variety of impacts on some observable quantities such as extinction curves and polarization curves. In the second half of the talk, we focus on grain growth (coagulation) in dense clouds. There are some pieces of observational evidence that dust grains grow in dense molecular cores up to micron sizes (coreshine; excess of scattering at micron wavelengths) and mm sizes (excess of dust emissivity at mm wavelengths). We discuss our theoretical efforts of explaining grain growth up to those sizes in dense molecular cores and protostellar envelopes. We show that it is possible to form micron-sized grains in dense molecular cores by coagulation if such dense clouds are sustained for several free-fall times. However, it is extremely difficult to coagulate grains up to mm sizes in dense cores and protostellar envelopes. Therefore, we propose a scenario in which mm-sized grains are supplied from the inner dense part of the protostellar environment. We also mention the effect of grain growth on chemical reactions.

Planck data challenge current dust models and alignment mechanism

Vincent Guillet

IAS, CNRS, University of Paris-Sud, University of Paris-Saclay, France

ABSTRACT: The Planck mission has brought unprecedented constraints on the submm polarization properties of dust grains, challenging dust models. The combination of Planck data with extinction data has revealed that diffuse dust grains are on average more emissive than we thought, by a factor larger than 2, both in total and polarized intensity. I will detail how these new constraints were obtained, and how we have adapted the Compiegne et al. (2011) dust model to account for this discrepancy. Another great surprise was the observation by Planck of polarization fractions as high as P/I = 20% in the diffuse ISM, much higher than expected based on the commonly admitted upper limit p/EBV ~ 9% observed in the optical. I will show how these observations are actually compatible with a larger set of polarization observations in the optical, without the need for any new physics. Finally, I will present a new statistical tool designed to interpret the variations of the polarization fraction, in a new attempt to disentangle between what can, on one side, be attributed to the depolarization by the magnetic field structure and, on the other side, to the variations in the grain alignment and optical properties. Applying this method to Planck data, I will show that the decrease of the grain alignment efficiency cannot exceed 25% on diffuse lines of sight with 10^{20} cm^{-2} < N_H < 2.10^{22} cm^{-2}.

The Synthetic ALMA Multiband Analysis of the Dust Properties of the TW Hya Protoplanetary Disk

Seongjoong Kim

Tokyo Institute of Technology, Japan

ABSTRACT: Analyzing multiband observations of dust continuum emission is one of the useful tools to constrain dust properties which help us to understand the physical properties of the disks. We perform the synthetic ALMA multiband analysis to find the best ALMA band set for constraining the dust properties of the TW Hya proto- planetary disk. We find that the Band [10,6,3] set is the best one among the possible combinations of ALMA Band 3 to 10. We also find two conditions for the good ALMA band sets providing narrow constraint ranges on dust properties; 1) Band 9 or 10 is included in the band set and 2) Enough frequency intervals between the bands. These are related with the conditions which give good constraints on dust properties: the combination of optically thick and thin bands, large β (β is the power-law index of dust opacity, $\kappa_\nu \propto \nu^\beta$), and low dust temperature at high-frequency bands. To examine our synthetic analysis results, we apply the multiband analysis to ALMA archival data of the TW Hya disk at Band 4, 6, 7, and 9. Band [9,6,4] set provides the dust properties close to the model profile, while Band [7,6,4] set gives the dust properties deviating from the model at all radius with too broad constraint range to specify the accurate values of dust temperature, optical depth, and β. Since these features are expected by the synthetic multiband analysis, we confirm that the synthetic multiband analysis is well consistent with the results derived from real data.

Dust along type Ia supernova sightlines

Aleksandar Cikota

Lawrence Berkeley National Laboratory, USA

ABSTRACT: SNe Ia with low total-to-selective extinction ratio values, Rv, also show peculiar continuum polarization wavelength dependencies, raising towards blue, with polarization peaks at short wavelengths (λmax $\leq$ 0.4 µm, Serkowski et al. 1975), while for comparison, normal sight lines in the Milky Way have polarization peaks at λmax ~ 0.55 µm. It is not well understood why SNe Ia sight lines display such different polarization profiles compared to what we observe in the Milky Way. Possible explanations are that the composition of interstellar dust in SNe Ia host galaxies is different from the dust in our Galaxy, or that there is circumstellar dust with an enhanced abundance of small grains, which was ejected from the progenitor system before the explosion, causing such peculiar polarization profiles. I will discuss dust properties observed along SNe Ia, their similarities to Milky Way objects (Cikota et al. 2017, Cikota et al. 2018), and possible explanations (e.g. Hoang 2017) and implication on the SN Ia progenitor systems (e.g. Cikota et al. 2017).

[Session 2: Physics of Dust Polarization: grain alignment, scattering,

Observational test of Radiative Torque Grain Alignment

B-G Andersson

NASA Ames, USA

ABSTRACT: To reliably interpret polarimetric observation in terms of magnetic field characteristics the physics of the grain alignment mechanism needs to be quantitatively understood. Modern Radiative Torque Alignment (RAT) theory provides the tools for this analysis. I will discuss the observational evidence for RAT and some of the tools for the enhance understanding the interstellar environment and grain physics possible with a well established and understood grain alignment mechanism.

Background Starlight Polarimetry in the Age of SOFIA and Gaia

Dan Clemens

Boston University, USA

ABSTRACT: Optical wavelength stellar polarimetry reveals magnetic (B-) field orientations in the plane of the sky for low extinction lines of sight and near-infrared (NIR) stellar polarimetry has excelled at probing into more opaque dark clouds. Combining data from the new HAWC+ far-infrared imaging polarimeter on SOFIA with deep near-infrared polarimetry obtained with Mimir enables tracing B-field orientations from the close environs of young stellar objects out to the kpc-scale Galactic B-field. Newly available Gaia DR2 data, in the form of stellar parallaxes and proper motions, greatly enhances our knowledge regarding the stars being observed polarimetrically. In some cases, the assumption of the stars being located behind the B-field zone being characterized is correct, while in others that assumption is grossly wrong. Combining Gaia DR2 with NIR polarimetry is particularly powerful for determining dark cloud distances and the nature of B-field orientation changes along lines of sight to 10 kpc or more. Recent findings based on the combination of SOFIA/HAWC+ with Mimir data and from Gaia DR2 with Mimir data offer new paths to greater understanding of the characteristics of B-fields and the roles they play in many phases of cloud and star formation.

A Unified Theory of Grain Alignment and Application

Thiem Hoang

KASI, Republic of Korea

ABSTRACT: Grain alignment is an important problem in dust astrophysics. In this talk, I will first review our quantitative theory of radiative torque (RAT) alignment for ordinary paramagnetic grains and unified alignment theory for grains with superparamagnetic grains. I then introduce a new effect of radiative torques in strong radiative fields, namely rotational disruption, which is termed Radiative Rotational Disruption (RRD) mechanism. We will discuss observational evidence supporting the RRD mechanism from supernovae, starburst galaxies, and young massive star clusters.

The radiative transfer code POLARIS

Robert Brauer

CEA Saclay (DRF/IRFU/SAP), France

ABSTRACT: We present the radiative transfer (RT) code POLARIS (Reissl et al., 2016; Brauer et al., 2017b) that is able to perform a broad range of RT simulations from dust grain emission to spectral lines. Moreover, based on the magnetic field distribution of MHD simulations or analytical models, POLARIS can be used to simulate the imperfect alignment and polarized emission of non-spherical dust grains as well as the Zeeman splitting of spectral lines. In this talk, we provide an overview of POLARIS capabilities and briefly present the results of selected studies.

Interstellar dust dynamics across timescales from scattering to alignment

Joonas Herranen

University of Helsinki, Finland

ABSTRACT: In this work, we extend a previously developed dynamical integrator to take into account effects of interstellar environment on dust particles. Then, we evaluate some previously applied approximations about the dynamics of spinning dust particles and the limits of the precise dynamical integration under the extreme timescale differences between scattering and magnetic field coupling effects. From this analysis, a new integration scheme is implemented and presented for the full cosmic timescale alignment problem. The dynamics and alignment of an ensemble of Gaussian random ellipsoids modeling interstellar dust and the effects on polarization are presented.

[Session 3: PHA & Nanodust]

Using 10-micron Polarimetry at the 10-m GTC to Explore Cosmic Magnetic Fields and Dust Properties

Charles Telesco

University of Florida, USA

ABSTRACT: The polarimetric and spectroscopic modes of CanariCam, the facility multi-mode mid-IR camera operating since 2012 at or near the 0.3” diffraction limit on the 10-m GTC on La Palma, are outstanding probes of cosmic magnetic fields and dust properties. CanariCam is currently being upgraded and should become operational again and available to the community shortly after this workshop takes place. We highlight CanariCam’s key performance characteristics, and we show how CanariCam will powerfully complement ALMA, SOFIA, and JWST in the ongoing exploration of cosmic dust and magnetic fields in our own and other galaxies. In this era of an explosion of pan-chromatic astronomy, we also comment on how CanariCam’s mid-IR capabilities might bear on the broader attack on problems associated with the structure and evolution of the universe by shedding some light on the origin of the Anomalous Microwave Emission. This research has been supported in part by NSF grants AST-0908624, AST-0903672, and AST-1515331 to CMT.

Formation and processing of organic and ice dust

Takashi Onaka

University of Tokyo, Japan

ABSTRACT: Formation and processing of dust in the interstellar space are important for the understanding of the lifecycle of interstellar matter. The advent of the recent cooled space telescopes, Spitzer and AKARI, has given us a large amount of data to study these processes in detail. Spitzer has provided mid-infrared spectra (5-36um) of diverse objects, which are dominated by emission from polycyclic aromatic hydrocarbons (PAHs) and thus are significant for the study of variations of PAHs. AKARI has obtained spectra in 2.5-5um for various regions in our Galaxy as well as nearby galaxies, whose range includes the emission bands from aromatic and aliphatic C-H bonds in the smallest organic dust and the absorption features of major ice species, such as H_2O, CO_2, CO, and XCN. They have provided us with an opportunity to study the variation in the abundance of aromatic-to aliphatic C-H bonds and the relative abundance of CO_2 to H_2O ice and to gain a new insight into the processing of organic and ice dust species in interstellar environments. I will give an overview of dust processing revealed by these studies, including some of the recent results obtained with AKARI and Spitzer observations.

A high angular resolution study of spinning dust in NGC2023

Matias Vidal Navarro

Universidad de Chile, Chile

ABSTRACT: Anomalous microwave emission (AME) is thought to originate from small dust grains spinning at GHz frequencies. It has been observed in different Galactic environments but the carriers of this emission mechanism remain unidentified. Until now, most of the observations of AME on the diffuse ISM have been performed at moderate angular resolution (> arcmin) which do not allow for a clear identification of the AME emitters. We have detected for the first time AME at high (~2 arcsec) angular resolution using VLA at 27 GHz in the reflection nebula NGC 2023. These observations show a strong morphological correlation with filamentary PAH emission at 8um. Using 3GHz data from the VLA we have ruled out a free-free or synchrotron origin for the 27 GHz emission. We also measured the spectrum between 18 and 37 GHz. The filaments that correlate with the 8um emission show a rising spectra, which could correspond to the rising part of the spinning dust spectrum. I will also discuss a strong correlation between the VLA maps and H2 infrared emission which might imply that in-situ H2 formation is an important spin-up process for the grains in this cloud.

Dust radio continuum components at 1cm in protoplanetary disks

Simon Casassus

Universidad de Chile, Chile

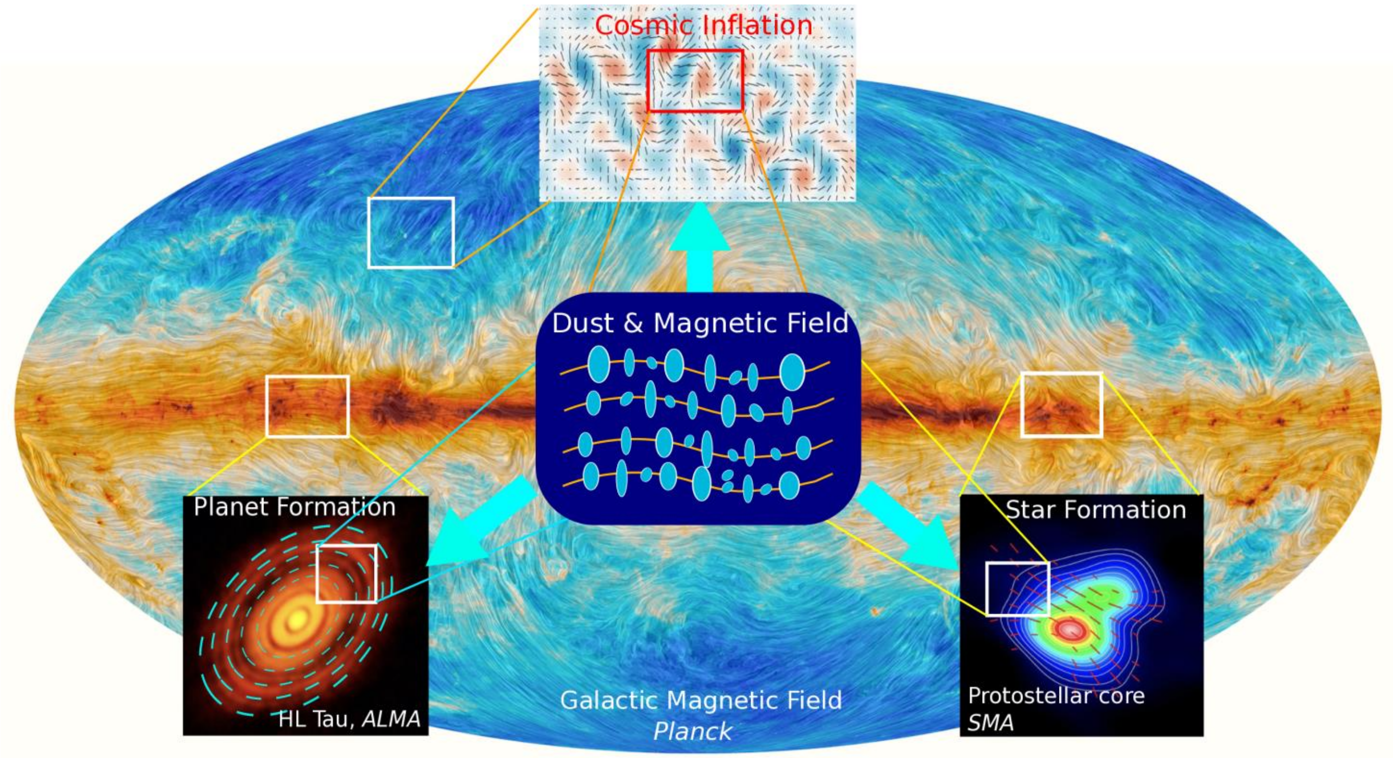
ABSTRACT: In the context of protoplanetary disk evolution, the aerodynamic coupling of dust and gas predicts the accumulation of the larger dust grains in local pressure maxima. The MWC758 disk is indeed one of the best examples for dust trapping in anticyclonic vortices, where the pile up of dust may lead to grain growth. Long wavelengths observations should thus trace clumpy distributions of the larger grains. Yet, new VLA observations (Casassus+ 2018) reveal a faint and extended component at 1cm, without counterparts in the ALMA continuum at 1mm. We suggest that this radio continuum component may be related to the excess microwave emission (EME) proposed by Hoang+ (2017), which stems from spinning dust radiation. This identification may open a new window on the very small grain population in protoplanetary disks, and is important to separate emission from the larger grains.

Abstract Day 2

Wednesday, October 31, 2018

Session 4: PHA & Nanodust (continued)

Session 5: What is the role of magnetic fields on star and planet formation?



[Session 4: PHA & Nanodust]

Organic Dust in Space

Sun Kwok

University of British Columbia, Canada

ABSTRACT: Recent solar system explorations and astronomical infrared spectroscopic observations from space have identified complex organics with aromatic and aliphatic structures in comets, meteorites, interplanetary dust particles, as well as in circumstellar environment, the interstellar medium, and distant external galaxies. A number of unexplained phenomena including the extended red emission, the 220 nm extinction feature, the 21 micron emission feature, and the diffuse interstellar bands could also be manifestations of organic dust in space. The possible relationships between stellar and solar system organics will be discussed.

On the possible detection of C60+ in the interstellar medium

Gazinur Galazutdinov

Catholic University of the North, Chile

ABSTRACT: Detection of C60+ is widely announced as an accomplished fact. However, measurements of near-infrared diffuse interstellar bands (DIB) attributed to C60+ is a challenge. There are very important issues need to be addressed: (I) the wavelength range of interest is polluted by strong telluric lines sometimes reaching the saturation level; (II) some diffuse bands are blended with stellar lines: e.g. DIB 9633 \AA, attributed to the second strong C60+ line, is blended with a stellar MgII line affected by non-LTE effects; We present the most recent results concerning the relations between "C60+" near-infrared diffuse bands and other interstellar features observed in the optical range.

[Session 5: What is the role of magnetic fields on star and planet

Star formation, polarization, and magnetic fields in the ALMA era

Chat Hull

NAOJ/ALMA, Japan

ABSTRACT: The results from the ALMA polarization system have begun both to expand and to confound our understanding of the role of the magnetic field in low-mass star formation. After a brief motivation via CARMA, SMA, and other polarization observations from the prior decade, I will discuss new ALMA results addressing the role of magnetic fields in the formation of low-mass stars. I will begin with observations of two young, Class 0 protostars in the Serpens Main region: Serpens SMM1, whose outflow appears to be shaping the surrounding magnetic field; and Ser-emb 8, whose magnetic field appears to be dominated by turbulence and infall. I will also show very new results of the magnetic field toward BHR 71, a bright pair of Class 0 sources that comprise a wide binary. After summarizing the aforementioned results in the context of a recent review article on interferometric observations of magnetic fields in forming stars, I will close with a brief summary of recently published observations of polarization toward IM Lup, a much more evolved, Class II protoplanetary disk. In the case of IM Lup, consistent with previous observations of other disks, the polarization appears to be due to scattering by dust grains, thus complicating the search for magnetic fields in disks, but opening up a new window into dust grain growth and evolution.

The Formation of Dense Gas within Magnetized Molecular Clouds

Laura Fissel

NRAO, USA

ABSTRACT: I will show comparisons between the magnetic field morphology of the young giant molecular cloud Vela C, as traced by the BLASTPol balloon-borne sub-mm polarimeter, and the orientation of elongated molecular gas structures, as traced by molecular line maps from the Mopra telescope. We find that low-density tracers 12CO and 13CO are statistically more likely to align parallel to the magnetic field, while intermediate or high density tracers show either no preferential alignment or a tendency for alignment perpendicular to the magnetic field. The transition from parallel to perpendicular orientation occurs at a molecular hydrogen number density of approximately 103 cm-3, though there are indications that this transition density may be much lower for the Centre-Ridge cloud sub-region, which harbours the highest column density filaments in Vela C and has already formed several high mass stars. Our observations suggest that the magnetic field in Vela C is strong enough to have influenced the formation of dense cloud sub-structures on much smaller scales, and also imply that the magnetic field may have affected the efficiency with which dense gravitationally unstable molecular gas was formed in the cloud sub-regions. With a new generation of large detector array polarimeters (e.g. BLAST-TNG, TolTEC) we will soon be able to apply the same analysis techniques to a much larger sample of clouds at even higher resolution, bridging the current gap in spatial scales covered by Planck and ALMA polarimetry.

Millimeter-wave polarization of protoplanetary disks: alignment or scattering?

Akimasa Kataoka

NAOJ, Japan

ABSTRACT: Millimeter-wave polarization of protoplanetary disks has been dramatically developing in both theory and observation. The mechanisms of polarization in star-forming regions have been thought to be the grain alignment with magnetic fields. In protoplanetary disks, however, the self-scattering of thermal dust emission may dominate the polarization because of the grain growth. Moreover, the grains may be aligned not with magnetic fields but with radiation gradients. ALMA has contributed a lot to understand the polarization mechanisms. Several protoplanetary disks show polarization-induced feature but there are some disks which emits alignment-induced pattern. In this talk, I briefly summarize the recent millimeter-wave polarization observations and discuss the mechanism itself as well as what we can learn from the polarization observations.

Anchoring Magnetic Fields in Turbulent Molecular Clouds II - from 0.1 to 0.01 parsec

Yapeng Zhang

The Chinese University of Hong Kong (CUHK), Hong Kong

ABSTRACT: We (Li et al. 2009; Paper-I) compared the magnetic field directions inferred from polarimetry data obtained from 100-pc scale inter-cloud media (ICM) and from sub-pc scale molecular cloud cores. The highly correlated result led us to conclude that cloud turbulence must be sub-Alfvenic. Here we extend the study with 0.01-pc cores observed by interferometers. The inferred field directions at this scale significantly deviate from that of the surrounding ICM. An apparent question to ask is whether this high-resolution result contradicts the sub-Alfvenic picture concluded earlier. We performed MHD simulations of clouds with sub-Alfvenic turbulence (MA = 0.84) and slightly super-critical mass (criticality = 2), which can reproduce the Paper-I results, and observed the development towards smaller scales. Interestingly, all subregions hosting cores with nH > 10^5/cc (the typical density observed by interferometers) appear slightly super-Alfvenic (MA ≈ 3) at 0.1 pc. Not too surprisingly, these super-Alfvenic cores result in B-field orientation offsets comparable to the interferometer observations. The result suggests that gravity can concentrate (and maybe also contribute to, which takes more study to confirm) turbulent energy and create super-Alfvenic cores out from sub-Alfvenic clouds.

The impact of non-ideal MHD effects on the protostar formation and their observational signatures

Yusuke Tsukamoto

Kagoshima University, Japan

ABSTRACT: In this talk, we discuss the impact of non-ideal effects on the protostar formation, and the observational signatures created by them. It has been recognized that non-ideal MHD effects (Ohmic diffusion, Hall effect, ambipolar diffusion) play crucial roles for the protostar and circumstellar disk formation and evolution. the Hall effect notably changes the magnetic torques in the envelope around the disk, and strengthens or weakens the magnetic braking depending on the relative orientation of magnetic field and angular momentum (Tsukamoto+15b, Tsukamoto+17). This suggests that the bimodal evolution of the disk size occurs in the early disk evolutionary phase, which is suggested by the recent disk observation of Class 0 YSOs (e.g., Yen+17). Ohmic and ambipolar diffusion decouple the gas and the magnetic field, and significantly reduces the magnetic torque in the disk, which enables the formation of the circumstellar disk. Ambipolar diffusion set an upper limit to the magnetic field strength of ~ 10-100 mu G around the disk. Hall effect and ambipolar diffusion may imprint the observable characteristic velocity structures in the envelope of Class 0/I YSOs. Hall effect forms a counter-rotating envelope around the disk. Our simulations show that counter rotating envelope has the size of 100-1000 AU Ambipolar diffusion causes the significant ion-neutral drift in the envelopes. Our simulations show that the drift velocity of ion could become 100-1000 m/s and it would be observable.

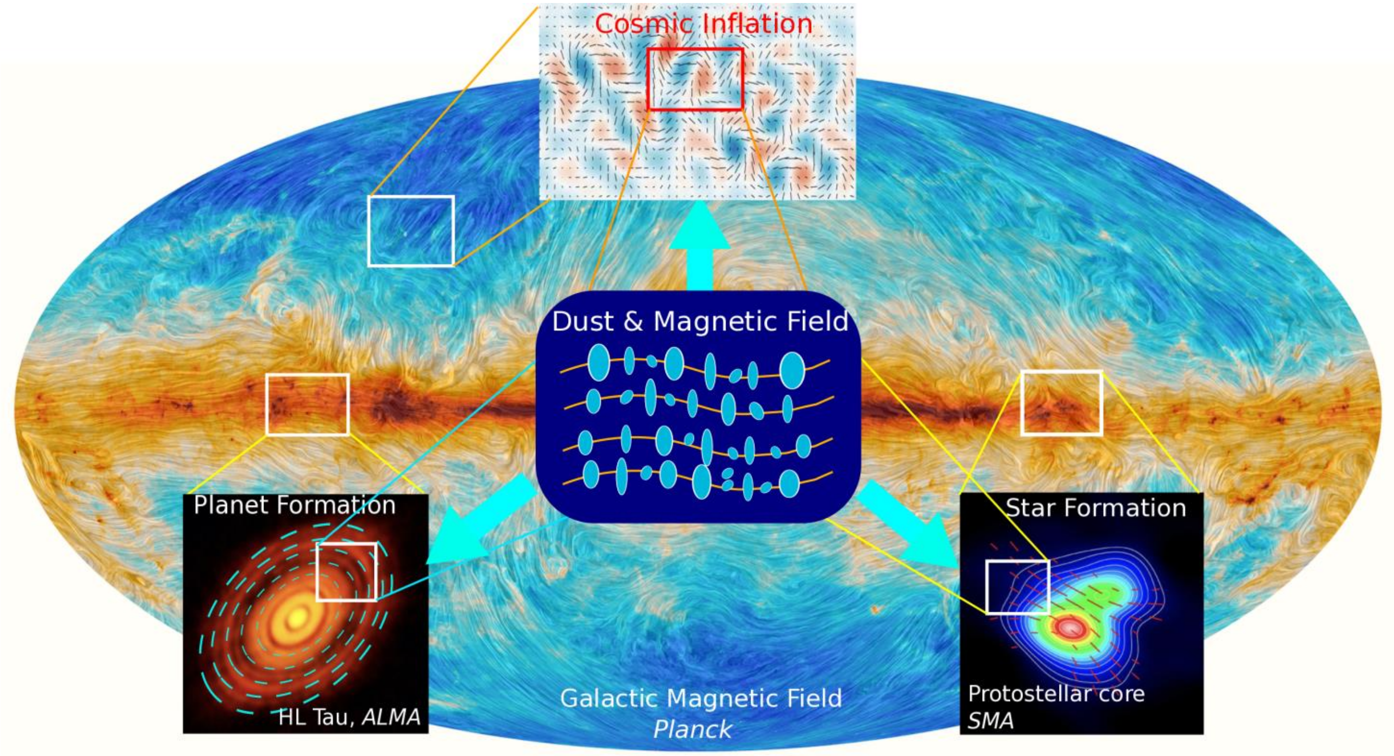
Abstract Day 3

Thursday, November 1, 2018

Session 6: What is the role of magnetic fields on star and planet formation? (continued)

Session 7: What can we learn from ALMA disk polarization?

Session 8: Related important issues: turbulence, shocks, and filaments



[Session 6: What is the role of magnetic fields on star and planet

Magnetic Fields of Star Formation on Intermediate and Small Scales

Woojin Kwon

KASI, Republic of Korea

ABSTRACT: Stars are formed in cold and dense molecular clouds by gravitational collapse. This big picture has well been drawn in the last few decades. However, many details are little known. One of long-standing, fundamental questions in star formation is what the roles of magnetic fields are. Recent theoretical and observational studies have suggested that magnetic fields largely affect star formation in broad ranges of scales and evolutionary stages: e.g., filamentary structure formation of molecular clouds on > 1000 au scales and early disk formation of young stellar objects on < 100 au scales. In this talk, the large program of the James Clerk Maxwell Telescope named B-fields in star-forming region observations (BISTRO) is introduced with some recent results on magnetic fields of filamentary structures in molecular clouds on a few thousand au scales. In addition, early disk formation of the youngest protostellar systems would be discussed with polarimetric observations using the Atacama Large Millimeter/submillimeter Array.

The Formation of Magnetized Molecular Clouds and Subsequent Star Formation

Shu-ichiro Inutsuka

Nagoya University, Japan

ABSTRACT: Recent high-resolution magneto-hydrodynamical simulations of two-fluid dynamics with cooling/heating and thermal conduction have shown that the formation of magnetized molecular clouds requires multiple episodes of supersonic compression. This finding enables us to create a new scenario of molecular cloud formation as the interacting shells or bubbles in galactic scale. We estimate the ensemble-averaged growth rate of individual molecular clouds, and predict the associated cloud mass function. This picture naturally explains the accelerated star formation over many million years that was previously reported by stellar age determination in nearby star forming regions. The recent claim of cloud-cloud collisions as a mechanism for forming massive stars and star clusters can be naturally accommodated in this scenario. This explains why massive stars formed in cloud-cloud collisions follows the power-law slope of the mass function of molecular cloud cores repeatedly found in low-mass star forming regions.

VELOCITY ANISOTROPY IN SELF-GRAVITATING MOLECULAR CLOUDS

Hongli Liu

CUHK/CASSACA, Hong Kong/Chile

ABSTRACT: Strong magnetic fields are accepted to cause the anisotropy of velocity fields in the interstellar medium (Goldreich & Sridhar 1995). Velocity anisotropy here can be understood in terms of the difference in directional power spectra or structure functions of the velocity fields along two orthogonal directions, parallel or perpendicular to the magnetic fields. Such magnetically-induced anisotropy of the velocity fields has been detected for the first time in the diffuse regions of the Taurus molecular cloud (Heyer et al. 2008, 2012) but not been recovered in the relatively high density regions. To figure out what are the possible reasons behind the loss of the velocity anisotropy in high density regions, we have carried out 3D hydrodynamical simulations with the inclusion of B-fields, gravity, and so on (Otto et al. 2017). Our simulation results not only have confirmed magnetically induced velocity anisotropy, but also found that velocity anisotropy may be destroyed or even reoriented to align with the gravitationally-formed high-density structures. So, our ongoing project is aimed to confirm our new finding from the observational point of view by investigating the velocity field of a molecular cloud. Our analysis results show that velocity anisotropy can be caused both by magnetic fields and self gravity of the cloud.

A Holistic Perspective on the Dynamics of G035.39-00.33: The Interplay between Gas and Magnetic Fields

Tie Liu

KASI, Republic of Korea

ABSTRACT: Magnetic field plays a crucial role in shaping molecular clouds and regulating star formation, yet the complete information on the magnetic field is not well constrained owing to the limitations in observations. We study the magnetic field in the massive infrared dark cloud G035.39-00.33 from dust continuum polarization observations at 850 μm with SCUBA-2/POL-2 at JCMT for the first time. The magnetic field tends to be perpendicular to the densest part of the main filament (F_M), whereas it has a less defined relative orientation in the rest of the structure, where it tends to be parallel to some diffuse regions. A mean plane-of-the-sky magnetic field strength of ~50 μG for F_M is obtained using the Davis-Chandrasekhar-Fermi method. Based on 13CO (1-0) line observations, we suggest a formation scenario of F_M due to large-scale (~10 pc) cloud-cloud collision. Using additional NH3 line data, we estimate that F_M will be gravitationally unstable if it is only supported by thermal pressure and turbulence. The northern part of F_M, however, can be stabilized by a modest additional support from the local magnetic field. The middle and southern parts of FM are likely unstable even if the magnetic field support is taken into account. We claim that the clumps in FM may be supported by turbulence and magnetic fields against gravitational collapse. Finally, we identified for the first time a massive (~200 $M_\odot$), collapsing starless clump candidate, "c8", in G035.39-00.33. The magnetic field surrounding "c8" is likely pinched, hinting at an accretion flow along the filament.

The role of turbulence and magnetic fields for filament and star formation

Christoph Federrath

Australian National University, Australia

ABSTRACT: Turbulence and magnetic fields determine the structure of the interstellar medium. In recent years we have developed a theoretical model of how this turbulence and the magnetic fields control the star formation rate. A critical step towards this theory is to understand the filamentary structure of molecular clouds and which physical processes give rise to the dense filaments within them. Here we show that the transition from supersonic to subsonic turbulence — the sonic scale — may determine crucial properties of the filaments, such as their widths, and how the sonic scale enters our derivation of star formation rates. I will also present results from the world's largest supersonic turbulence simulation, in which we measure the sonic scale, from which the filament width and critical density for star formation is derived.

Disk formation with ambipolar diffusion from low- to high-mass star formation

Commercon Benoit

Centre de Recherche Astrophysique de Lyon, France

ABSTRACT: I will present the results of 3D protostellar collapse calculations covering a wide range of initial mass (from 0.5 to 100 solar mass), magnetisation and turbulent/rotational support. The calculations were performed using the RAMSES code, including the effect of non-ideal MHD with ambipolar diffusion and radiative transfer. I will show how ambipolar diffusion is regulating the disk and outflow formation. I will discuss the disk properties: magnetisation level, magnetic field lines topology, stability. I will finally present preliminary results from protostellar collapse models which include dust dynamics.

The Musca molecular cloud: An interstellar symphony

Aris Tritsis

Research School of Astronomy and Astrophysics, Australia

ABSTRACT: Molecular clouds are the birthplaces of stars. Their structure and evolution hold the key to understanding the initial conditions of star and planet formation, and the physics that sets the distribution of masses and multiplicities of newborn stars. However, their complexity, their typically turbulent, filamentary, disordered appearance, and ubiquitous projection effects hinder all efforts to model them in detail. An exception to this messy picture is found in a recently discovered class of structures, molecular cloud striations: ordered, low-column-density, quasi-periodic, elongated structures parallel to the magnetic field. The physics that drives the formation of such striations has remained a mystery since their discovery. We have performed a comprehensive numerical experiment testing all possible driving mechanisms, and we have found that the only viable explanation for the appearance of striations is their formation by magnetohydrodynamic waves generating trapped modes, just like vibrations in a resonating chamber: they are, in every sense, a magnetohydrodynamic "song", with dense filaments being the instrument. We have additionally demonstrated that, by examining the spatial power spectrum of striations, we can find the normal modes of the "resonating chamber", and thus derive the true dimensions of dense filaments, including their previously inaccessible by any means line-of-sight dimension. We have applied such a normal mode analysis towards the Musca molecular cloud - one of the best-studied "dense filaments" in the interstellar medium and, contrary to all expectation, we have unequivocally demonstrated that the Musca filament is not, in fact, a filament: it is a sheet-like structure with comparable line-of-sight and plane-of-sky dimensions, seen edge-on. We discuss the implications of this discovery for the physics of dense molecular cloud formation.

Magnetic alignment between three distinct tracers of the local ISM

VIbor Jelic

Ruder Boskovic Institute, Croatia

ABSTRACT: Based on LOFAR (Low Frequency Array) polarimetric observations, the Faraday tomography of a field centered at 3C 196 shows an astonishing variety of structures (Jelic et al. 2015). The boundaries of observed features are clearly defined by depolarization canals. A real puzzle, however, is that most of them are extraordinary straight. During my talk I will present the results of the recent study aiming to characterize the properties of the straight depolarization canals using the rolling Hough transform (Jelic et al. 2018). I will also discuss an alignment that we found between three distinct tracers of the local ISM (of magneto-ionic structures observed in the LOFAR radio-polarimetric data, cold neutral filaments observed in the HI-EBHIS data, and the plane-of-sky magnetic field orientation probed by the Planck 353 GHz polarization data), suggesting that an ordered magnetic field plays a crucial role in confining different ISM phases.

Mapping magnetization with the Velocity Gradient Technique

Ka Wai Ho

The Chinese University of Hong Kong (CUHK), Hong Kong

ABSTRACT: Recent developments of the Velocity Gradient Technique (VGT) show that the velocity gradients provide a reliable tracing of magnetic field direction in turbulent plasmas. In this paper, we explore the ability of velocity gradients to measure the magnetization of interstellar medium. We demonstrate that the distribution of velocity gradient orientations provides a reliable estimation of the magnetization of the media. In particular, we determine the relation between Alfvenic Mach number M_A in the range of M_A in [0.2,1.7] and properties of the velocity gradient distribution, namely, with the dispersion of velocity gradient orientation as well as with the peak to base ratio of the amplitudes. We apply our technique for a selected GALFA-HI region and find the results consistent with the expected behavior of M_A. Using 3D MHD simulations we successfully compare the results with our new measure of magnetization that is based on the dispersion of starlight polarization. We demonstrate that, combined with the velocity dispersion along the line of sight direction, our technique is capable to delivering the magnetic field strength. The new technique opens a way to measure magnetization using other gradient measures such as synchrotron intensity gradients (SIGs) and synchrotron polarization gradients (SPGs).

Bayesian revisit of the relationship between the total field strength and the volume density of interstellar clouds

Jiang Hangjin

The Chinese University of Hong Kong

ABSTRACT : Zeeman effect has been the only method to directly probe the magnetic field strength in molecular clouds. The Bayesian analysis of Zeeman measurements carried out by Crutcher et al. (2010) has been the only reference for cloud magnetic field strength. However, their results and interpretations are highly controversial. In this paper, we reviewed their model and checked the Bayesian analysis. We also relaxed some of their overly restricted parameters as an effort to let the data speak. Surprisingly, as shown in our analysis, none of the original and modified models can give a reliable estimation of the relation between the magnetic field and the number density. The non-identifiability is resulted from the fact that the number density data comes with uncertainty. Thus one needs to be cautious when concluding from such data.

[Session 7: What can we learn from ALMA disk polarization?]

ALMA polarization observations from core to disk scales

Josep Miquel Girart

Institute of Space Sciences (CSIC) / IEEC, Spain

ABSTRACT: Millimeter continuum polarization observations have being extensively used to trace magnetic fields threading star forming regions from cloud to core scales. With the advent of ALMA, these type of observations can reach disk scales. These has allowed to trace physical regimes where other mechanism can yield to significant polarization of the dust emission. In this talk I will review what ALMA has shown so far regarding the polarization properties from core to disk scales in low and high mass star forming regions.

ALMA Dust Polarization Observations of Nearly Edge-On Protostellar disks

Chin-Fei Lee

ASIAA, Taiwan

ABSTRACT: Polarized emission is detected in two young nearly edge-on protostellar disks in 343 GHz continuum at ~20 au resolution with Atacama Large Millimeter/submillimeter Array. In both disks, the polarization orientations in the nearside are almost perpendicular to the disk major axis, suggesting a presence of toroidal field around the outer edges of the disks. In the more resolved disk, the farside of the disk is also seen, the polarization orientations there are bended around the jet axis. These orientations, when rotated by 90 degree, become parallel to the jet axis and thus may suggest a presence of poloidal field in the disk. I will discuss these results in the talk. If time permitted, I will talk about polarization results of an additional edge-on disk, which shows polarization orientation neither parallel nor perpendicular to the disk major axis.

Different polarization mechanisms in protoplanetary disks

Satoshi Ohashi

RIKEN, Japan

ABSTRACT: The origin of polarized emission from protoplanetary disks is uncertain. Three mechanisms have been proposed for such polarized emission: grain alignment with magnetic fields, grain alignment with radiation gradients, and self-scattering of thermal dust emission. Aiming to observationally identify the polarization mechanisms, we analyzed ALMA polarization data of the 0.87 mm dust continuum emission toward the circumstellar disk around HD 142527 with high spatial resolution. We find that the polarization vectors in the northern region are consistent with self-scattering, and those in the southern region are consistent with grain alignment by magnetic fields. To understand the differences between the polarization mechanisms, we propose a simple grain size segregation model: small dust grains are dominant and aligned with magnetic fields in the southern region, and middle-sized (~ 100 microns) grains emit self-scattered polarized emission in the northern region. This model is consistent with theories where smaller dust grains are aligned with magnetic fields. The magnetic fields are toroidal, at least in the southern region.

ALMA Observations of Dust Polarization and Molecular Line Emission from the Three Class 0 Protostellar Source Serpens SMM1, Emb 8 and Emb 8(N)

Valentin Le Gouellec

ISAE-Supaero, France

ABSTRACT: We present high angular resolution ALMA dust polarization data of the three young protostars Serpens SMM1, Emb 8, and Emb 8(N). Recently, ALMA has been unveiling the role of the magnetic field in star formation processes in such Class 0 low-mass protostars. With spatial resolutions up to 40 au at 870 μm, we expose unpredicted very high polarization fractions along the outflow cavities in Serpens Emb 8(N) and SMM1, allowing us to investigate the physical processes involved in the radiative alignment of dust grains by UV radiation along the outflow cavity walls. The polarized dust emission results presented here are from three different datasets that have been combined together to emphasize different morphology by recovering different spatial scales. The continuum emission toward Serpens Emb (8)N is clearly enhanced along the outflow cavity walls, where the polarization fraction is highest. Some questions now arise concerning the asymmetrical nature of this polarized intensity, which might be due to projection effects, or possibly interaction of the jet with the cavity wall. Accompanying these continuum and polarization maps are 3mm and 1mm molecular tracers, which we use to investigate outflow and dense gas properties and their correlation with the polarized emission. These observations allow us to constrain crucial phenomena occurring in young star forming sources.

Observational signatures of misaligned magnetic fields in early disk formation

Miikka Vaisalsa

ASIAA, Taiwan

ABSTRACT: We have used radiative transfer code Perspective to explore observational signatures of misaligned magnetic field (initial rotation axis perpendicular to the field) in disk formation, using data from the set of MHD models by Li, Krasnopolsky & Shang (2013). Perspective calculates radiative transfer of continuum emission with ray tracing; with simple magnetic field dependent polarization included. Due to its effectiveness, Perspective can be used with all model frames, giving also therefore a sense of the time evolution and its effects. Based on Perspective results, I will discuss what observational implications disk formation via misaligned magnetic fields has with regards to the early disks, such as what signatures you can you infer based on both polarization (assuming that if the magnetic field dependence works) and the continuum emission. Particularly the density structure of the early disk could give indications of its origins. In addition, observational features will be connected to the disk\\'s rotation, precession, in- and outflows, and how some interpretations in terms of velocity could be deceiving.

[Session 8: Related important issues: turbulence, shocks, and

Magnetic Fields in Clusters of Galaxies: A Theorist View of the Nature and Origin

Dongsu Ryu

UNIST, Republic of Korea

ABSTRACT: Magnetic fields appear to be ubiquitous in astrophysical environments, including the large-scale structure of the universe. The existence of magnetic fields, especially in clusters of galaxies, has been well established through various observations, such as Faraday rotation and synchrotron observations. Yet, the nature and origin of the magnetic fields remains controversial and largely unknown. In this talk, I first introduce a plausible scenario, based on small-scale, turbulence dynamo, for the magnetic fields; seed fields were created in the early universe and subsequently amplified during the formation of the large-scale structure of the universe. I then discuss whether the turbulence dynamo scenario can explain the observed characteristics of magnetic fields, such as the strength and coherence length, in clusters of galaxies.

Particle scattering in MHD turbulence

Siyao Xu

University of Wisconsin-Madison, USA

ABSTRACT: The scattering and acceleration of particles are the central ingredients of space physics and astrophysics. The pitch-angle diffusion coefficient is conventionally calculated using the quasi-linear theory. The turbulence nature of magnetic fields entails the broadening of quasi-linear resonances. I will present a general theory of resonance broadening arising in MHD turbulence, which is applicable to both high-energy cosmic rays and low-energy dust grains. The parameter space for the importance of slow modes in scattering will also be addressed.

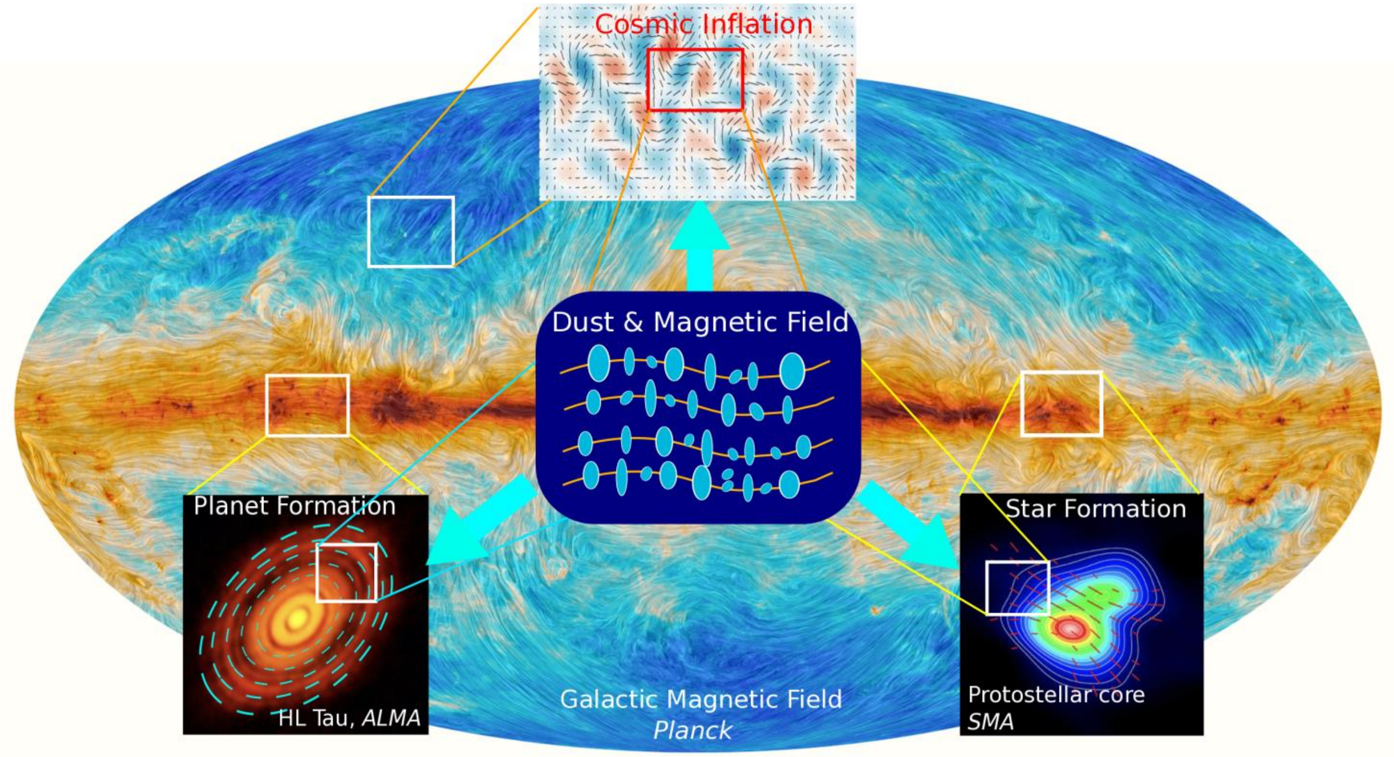
Abstract Day 4

Friday, November 2, 2018

Session 9: Alternative ways to trace magnetic fields as a synergy dust polarization

Session 10: Related important issues: turbulence, shocks, and filaments (continued)

Session 11: What dust astrophysics and magnetic fields required for accurate modeling of CMB B-mode foregrounds?



[Session 9: Alternative ways to trace magnetic fields as a synergy dust

Non-Zeeman Circular Polarization of Rotational Molecular Spectral Lines

Martin Houde

University of Western Ontario, Canada

ABSTRACT: In this presentation I will discuss the recent discovery of circular polarization signals in the rotational line profiles of molecules that are negligibly sensitive to the Zeeman effect. Our initial findings obtained for CO in the Orion KL star-forming region with the Caltech Submillimeter Observatory were followed with similar detections for two transitions of CO in an exhaustive study of the supernova remnant IC 443 (G), obtained with the IRAM 30m. These new results have clearly established that circular polarization arises, as predicted, from the conversion of linear polarization signals incident on the molecules responsible for the detected radiation. I will show how the anisotropic resonant scattering model developed to explain these observations directly involves the ambient magnetic field. These results, and new ones using SMA archival data, suggest the possibility of starting a whole new subfield of more incisive studies of magnetic fields in the interstellar medium.

Changing the Landscape: New Ways of Tracing and Probing Magnetic fields with Velocity and Synchrotron Gradients

Alex Lazarian

University of Wisconsin-Madison, USA

ABSTRACT: Modern understanding of MHD turbulence suggests that this type of turbulence is strongly anisotropic at small scales. This entails a conclusion that gradients of velocity and magnetic field are perpendicular to the local direction of the magnetic field. Guided by this fact we proposed, developed and successfully tested with observational data a set of new techniques for studying interstellar magnetic fields. I shall demonstrate how the velocity gradients can be measured using either velocity centroids of thin channel spectroscopic maps, while magnetic field gradients can be measured using synchrotron intensity or synchrotron polarization. I shall present 3D maps of galactic magnetic fields obtained with the new technique, demonstrate that gradients can provide both magnetic field tracing and identify the regions of graviational collapse. I shall discuss new ways of obtaining magnetic field strength using the gradients. I shall show how to use different types of gradients to map the structure of the magnetic web within the multiphase interstellar media.

Gradients of Synchrotron Polarization: Tracing 3D distribution of magnetic fields

Ka Ho Yuen

University of Wisconsin-Madison, USA

ABSTRACT: We describe a new technique for probing galactic and extragalactic 2D and 3D magnetic field distribution using gradients of polarized synchrotron emission. The fluctuations of magnetic field are elongated along the ambient magnetic field. Therefore, the field variations are maximal perpendicular to the B-field. This allows tracing B-field with synchrotron polarization gradients (SPGs). We demonstrate that the Faraday depolarization allows to map 3D B-field structure by. The depolarization ensures that the polarization gradients sample the regions close to the observer with the sampling depth controlled by the frequency of radiation. We also analyze the B-field properties along the line-of-sight by applying the gradient technique to the wavelength derivative of synchrotron polarization. This Synchrotron Derivative Polarization Gradients (SDPGs) technique can recover the 3D vectors of the underlying B-fields. The new techniques are different from the Faraday tomography as they provide a way to map the 3D distribution of B-fields components perpendicular to the line of sight. In addition, we find that the alignment of gradients of polarization with the synchrotron polarization can be used to separate the contribution of the foreground from the polarization of cosmological origin. We notice that the same alignment is also present for the dust polarization.

Surveying Magnetic Field Morphology with Velocity Gradient Technique in Molecular Clouds

Yue Hu

University of Wisconsin-Madison, USA

ABSTRACT: Magnetic fields are hinged to many astrophysical processes but their importance are often underestimated by the community. Probing magnetic fields through polarimetry is the most common way in providing insight of magnetic field in interstellar media. However, the inaccuracy and cost of use of interometric instruments limit the use of polarimetry especially in self-gravitating regions. The recently proposed Velocity Gradient Technique provides an alternative way in predicting magnetic field directions both in two- and three-dimensions through identifying the anisotropy of spectroscopic intensity structures. } Here we show the first magnetic field survey for five major molecular clouds (Taurus, Perseus A, Serpens, NGC1333, L1551) using publicly available spectroscopic data, which shows accurate correspondence to the PLANCK measurements in the exterior diffuse region. Surprisingly, we do not see signatures of gravitational collapse, indicating the collapsing regions constitute a small fraction of clouds.

3D magnetic tomography with atomic alignment

Huirong Yan

DESY & Uni Potsdam, Germany

ABSTRACT: It was predicted more than a decade ago that the spectropolarimetry arising from ground state alignment (GSA) traces 3D magnetic field in diffuse medium. Nonetheless, the observationally it remained unexplored territory until recently. Here I will review briefly the theory before reporting our first detection of GSA in ISM. The comparison between absorption and emission line polarimetry confirms the prediction from the GSA theory. 3D magnetic tomography reviews a dipolar structure. In addition, magnetic strength is constrained by the comparison of different lines. The applicability of GSA in various environments will be exhibited.

Identification of magnetosonic modes in Galactic turbulence with synchrotron polarization

Heshou Zhang

DESY & Uni Potsdam, Germany

ABSTRACT : We have detected the first observational evidence of magnetosonic modes in the Orion Nebulae and Cygnus X region, with our novel method, the signature from polarization analysis (SPA). Through comparison with the spectrum at other wavelengths, our results provides a new perspective in understanding star formation processes, which is intimately linked to turbulence properties as widely acknowledged. The method I am going to present, SPA, sheds light on the hitherto unknown plasma modes composition of the Galactic turbulence, and marks the onset of a new era in the study of interstellar turbulence and accordingly our understanding of star formation and cosmic ray transport.

Possible inadequacies in grain surface chemistry revealed by the first detection of H2S in protoplanetary disk

Nguyen Thi Phuong

Vietnam National Space Center, Vietnam

ABSTRACT: Dust has crucial contribution to the formation of planets in protoplanetary disks and provides conditions for surface chemistry. Recent detection of cold-gas phase methanol (CH3OH) and hydrogen sulfide (H2S) in TW Hya and GG Tau A has opened a window for studying volatile species and surface chemistry in protoplanetary disks. I will present the first detection of H2S in a cold dense disk around GG Tau A using NOEMA data. The observed column density of H2S is one order of magnitude lower than the value predicted by chemical code Nautilus. This suggests that the H2S formation process onto grain and/or desorption mechanisms are not fully understood. A hypothesis of strong sulfur depletion may be able to explain the low observed column density. I will also present the detection of HCO+, H13CO+ and DCO+ in GG Tau A.

[Session 10: Related important issues: turbulence, shocks, and

Geodesic Mesh MHD : A New Paradigm for Computational Astrophysics and Space Physics Applied to Spherical Systems

Dinshaw Balsara

University of Notre Dame, USA

ABSTRACT: A majority of astrophysical systems tend to be spherical. The same is true for problems in space physics. Even so, simulations of such systems tend to be done on logically Cartesian meshes. The r-theta-phi meshes that are often used have a few major deficiencies: a) They donít cover the sphere uniformly, b) The coordinate singularity on-axis results in a loss of accuracy, c) The timestep is seriously diminished. All these problems are associated with using an inadequate coordinate system for doing the calculation. As astrophysicists and space physicists actively take on the issues of MHD turbulence, it becomes increasingly important to have high orders of accuracy. High accuracy schemes are the only way of reducing the dissipation and dispersion that should be held down in turbulence simulations. In this work we show that an excellent alternative is available. The most isotropic covering of the sphere comes from icosahedrally generated geodesic meshes. The elements of such a mesh are inherently curved and we show that isoparametric mapping provides an extraordinarily accurate re-mapping strategy for the sphere. We show that divergence-free MHD calculations can be done on such meshes with no loss of on-core processing efficiency or parallelism. To improve accuracy we use a combination of: a) WENO methods, b) A re-formulation to support high order divergence-free reconstruction of magnetic fields, c) Multidimensional Riemann solvers, d) Higher order timestepping to match the spatial accuracy. The resulting capability achieves provably high order of accuracy and high levels of parallelism. Several stringent test problems are presented and a few frontline applications are shown to highlight the utility of our approach.

A New Analytic Model for the Star Formation Law, from Galactic Clouds to Galaxies

Blakesley Burkhart

Flatiron Institute Center for Computational Astrophysics, USA

ABSTRACT: Stars form in magnetized supersonic turbulence molecular clouds that are self-gravitating. Magnetohydrohynaic(MHD) Turbulence is expected to produce lognormal density probability distribution functions (PDFs) while gravity should form power-law density PDFs. I will present a new analytic determination of the star formation rate (SFR) and star formation efficiency in a magnetized gravoturbulent medium based on the density PDF of molecular clouds having a piecewise lognormal and power-law form. This is in contrast to previous analytic SFR models that are governed primarily by interstellar turbulence which sets purely lognormal density PDFs. The magnetic field is a critical factor for determining the critical density for the onset of collapse in this model, particularly in the sub-critical to the critical regime. When the power law self-gravitating density is included in the star formation rate calculation the star formation rate accelerates, in agreement with observations and simulations. I will demonstrate that the gravoturbulent analytic model compares well with numerical simulations and observations and discuss the exciting future avenues for the application of this theory.

Stellar magnetic fields from Main sequence to white dwarf stages: a brief review and main results.

Gennady Valyavin

Special Solar Observatory, Russia

ABSTRACT: This review discusses the history of studies of stellar magnetism, observational techniques used in these studies and basic properties of magnetic fields in stars. Some questions related to origin and evolution of stellar magnetic fields will also be touched.

[Session 11: What dust astrophysics and magnetic fields required for accurate modeling of CMB B=mode foregrounds?]

Understanding and Mitigating Polarized Dust Emission in CMB Experiments

Brandon Hensley

Princeton University, USA

ABSTRACT: Polarized emission from interstellar dust is one the principal limitations in the ongoing search for a B-mode signature from primordial gravitational waves. In this talk I will discuss the most challenging aspects of dust modeling and subtraction for CMB science, such as spatial variations in the dust SED (including along the line of sight) and polarized anomalous microwave emission. I will describe how expertise from the dust modeling and ISM communities can be leveraged to both better simulate realistic dust emission and take advantage of ancillary data (e.g., HI, starlight polarization) to perform higher fidelity component separation.

Exploring helical magnetic fields in the ISM through dust polarization power spectra

Andrea Braco

Nordita, Denmark

ABSTRACT: The full-sky Planck polarization data at 850um revealed unexpected properties of the E and B mode power spectra of dust emission in the interstellar medium (ISM). The positive cross-correlation between the total dust intensity, T, with the B modes has raised new questions about the physical mechanisms that affect dust polarization, such as the Galactic magnetic-field structure. This is key both to better understanding ISM dynamics and to accurately describing Galactic foregrounds to the polarization of the Cosmic Microwave Background (CMB). In my talk I will discuss the possibility that the observed cross-correlations in the dust polarization power spectra, and specifically between T and B, are related to a parity-odd quantity in the ISM such as the magnetic helicity. I will show synthetic dust polarization data, derived from 3D analytical toy models of density structures and helical magnetic fields, to compare with the E and B modes of observations. Focusing on the observed T-B correlation, I will propose a new line of interpretation of the Planck observations based on a large-scale helical component of the Galactic magnetic field in the solar neighborhood.

A Comparison between Magnetic Field Directions inferred from Planck and Starlight Polarimetry

Gu Qilao

The Chinese University of Hong Kong (CUHK), Hong Kong

ABSTRACT: We compare the magnetic field (B-field) orientations inferred from Planck 353 GHz thermal dust polarization and starlight polarimetry data and study the cloud-field alignment based on these two tracers within Gould Belt clouds, which shows good agreement with each other. Furthermore, we analyze two fundamentally different but confusing alignment studies: global cloud-field alignment which compares mean fields and global cloud orientations (Li et al. (2013)) and local structure-field alignment which compare this relation pixel by pixel (Planck Collaboration et al. (2016)), and find the connection between them.

Dust polarization modelling at large scale over the Northern Galactic cap using the Planck and EBHIS data

Debabrata Adak

IUCAA, India

ABSTRACT: The primary limiting factor in the quest for the primordial CMB B-mode polarization is submillimetre polarized emission from Galactic dust. We need to characterize and separate the Galactic polarized foreground accurately to search for such a faint signal. Therefore dust polarization modelling is an essential step to build a component separation method to separate CMB B-mode from polarized foreground with high accuracy. The Planck and HI emission data together show at high Galactic latitude dust and HI intensities are tightly correlated. Also, the Planck data reveals a line-of-sight depolarization arises due to the turbulent magnetic field. Our paper presents the modelling work on dust polarization over a low column density regions at the Northern Galactic cap taking into account the Planck and EBHIS data together. We provide a model which incorporates a phenomenological magnetic field model and physically motivated HI templates. This seven-parameter model can reproduce all statistical properties over 66% sky of the Northern Galactic cap integration over least number (N = 3) of HI layers along line-of-sight. Our work is an important step towards dust polarization modelling which is useful to assess the accuracy of component separation methods and to quantify the confidence level of separating Galactic polarized foreground and CMB B-mode in present and future CMB missions.

Statistical modelling of dust polarization as a CMB foreground

Francois Boulanger

ENS, France

ABSTRACT: The statistical characterization of the dust polarization foreground to the Cosmic Microwave Background (CMB) is required to optimize component separation methods and detect the cosmological signal associated with primordial gravitational waves. I will present on-going work we are carrying to simulate maps of polarized dust emission on the sphere that reproduce power spectra and the one-point statistics of the dust polarization fraction and angles. This work builds on the analysis of Planck data. It relates the dust polarization sky to the structure of the Galactic magnetic field: its ordered and turbulent components, and its coupling with interstellar matter and dust polarization properties. I will show what we have achieved so far, and will introduce on-going work and outstanding questions.

[Poster Session]

Resolved observations of the centimeter-wavelength continuum from the Rho Ophiuci molecular cloud: Local emissivity boost in the Rho Oph W photo-dissociation-region

Carla Arce-Tord

University of Chile, Chile

ABSTRACT : TBD

Bimodal cloud-field orientation at sub-cloud scales

Law, Chi Yan

The Chinese University of Hong Kong (CUHK), Hong Kong

ABSTRACT : There is an emerging interest on the effects of cloud-field orientations on both morphological and kinematics conditions in molecular clouds. Here we investigate the cloud-field orientations of sub-cloud structures in 12 molecular clouds and show that the cloud field orientations are end to be perpendicular or parallel. Hence the bimodal distribution in cloud-field-orientation preserves toward sub-cloud scale.

Infrared/X-ray properties of Nitrogen-included Carbonaceous Compounds: as a candidate of dust in classical novae

Izumi Endo

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ABSTRACT : The unidentified infrared (UIR) bands have been ubiquitously observed in various astrophysical environments and consist of a series of emission features arising from aromatic/aliphatic C-C and C-H bonds. The polycyclic aromatic hydrocarbon (PAH) hypothesis has been widely accepted to interpret the behavior of the bands. However, the true nature of the carriers of the UIR bands has not been fully understood so far. Recent observational studies have revealed the varieties in the appearance of the UIR bands in terms of the peak positions and the band profiles. In particular, the ëClass Cí UIR bands, characterized by broad 8-8.2μm feature instead of 7.7μm and 8.6μm features, have been observed in limited objects. UIR bands observed in classical novae are categorized into this class. We have synthesized Nitrogen-included Carbonaceous Compounds (NCC) via plasma chemical vapor deposition utilizing 2.45GHz microwave discharge. We have found that infrared properties of NCC exhibit an outstanding broad band structure at 8μm and are remarkably similar to the UIR bands observed around classical novae (e.g. V2361 Cyg). We have conducted various analysis to characterize the nature of the NCC. We found that N/C ratio (atom) of the NCC is 4-5% based on the measurement with EA/IRMS. X-ray Absorption Near Edge Structure (XANES) analysis of NCC indicates that amine and imine structures are contained in the NCC. We concluded that the broad feature at 8μm is arising from amine structures in addition to aromatic C-C structures. This result suggests that, in addition to the classical hydrocarbon models, nitrogen inclusion should be the key to better understanding of the carriers of the UIR bands.

DFT study of Interstellar PAH molecules with aliphatic side groups

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ABSTRACT : Polycyclic Aromatic Hydrocarbon (PAH) molecules have emerged as a potential constituent of the Interstellar Medium (ISM) that emit strong features at 3.3, 6.2, 7.7, 8.6, 11.2 and 12.7 μm with weaker and blended features distributed in the 3-20 μm region. These features are proposed to arise from the vibrational relaxation of PAH molecules on absorption of background UV photons. These IR features also known as Aromatic Infrared Bands (AIBs) have been observed towards almost all types of astronomical objects; say HII regions, photodissociation regions, reflection nebulae, planetary nebulae, young star forming regions, external galaxies, etc. Astrophysical PAHs are proposed to exist in various forms, viz, ionized, both substituted and unsubstituted. Some interstellar PAHs are also identified to carry an aliphatic component that gives rise to 3.4 μm feature near the aromatic 3.3 μm feature. The 3.3 and 3.4 μm features are characteristics of stretching of an aromatic and aliphatic C-H bond in a PAH molecule. Despite the extensive research and wide acknowledgement of PAH molecules as carriers for AIBs, the identification of exact form of carriers still faces major challenges. In this work, we consider PAH molecules with aliphatic side groups to see any spectral similarities with the observed UIR features. This work reports a Density Functional Theory calculation of PAHs with -H, -CH3, -CH2-CH3, -CH-CH2 to determine the expected region of emission features and to find an aliphatic/ aromatic ratio from moderate to large PAHs. We also include a deuterium (D) component in the aliphatic side group to see any possible consequences. We present a detailed analysis of the IR spectra of these molecules and discuss the possible astrophysical implications.

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