Vertical shear instability in dusty protoplanetary disks

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The vertical shear instability (VSI) is a hydrodynamic instability applicable irradiated parts of protoplanetary disks, where the disks's angular velocity varies with height from the mid-plane due to a radial temperature gradient. The VSI taps into this free energy and the result is hydrodynamic turbulence. This is expected to have important effects on the evolution of dust grains in the disk. However, previous analytical studies of the VSI have been restricted to purely gaseous disks. By utilizing a recently-developed framework for studying dusty gas dynamics, we generalize VSI theory to include tightly coupled dust particles. We show that dust-loading generally stabilizes the VSI. Thus VSI activity in a protoplanetary disk directly depends on the vertical dust distribution. Importantly, we show that these results can be understood by drawing on the physical analogy between dust-loading and buoyancy in an adiabatic gas.

Transit Timing Analysis of the Planet Qatar-1b

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Qatar-1b is a known extra-solar planet in the Qatar-1 system. Covion et al. (2013) and Maciejewski et al. (2015) have studied its transit timing variations (TTVs) and published thirty light curves. Due to that there is no definite conclusion among these previous results, we employ several meter-class telescopes to do further observations and obtain thirteen new light curves. We investigate possible TTVs from all these forty-three light curves and discuss mechanisms which can explain these possible TTVs.

The asymmetric structures in dust rings

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Unprecedented sensitivity and resolution achieved by ALMA has allowed us to probe deeply into compact structures, such as cavities, asymmetries and spiral patterns in protoplanetary systems. Currently, different hydrodynamical models of planet-disk interaction have proposed that vortices excited by planets might be a good explanation for these interesting structures within transitional disks.

We selected multiple observations of different transitional disks from ALMA data archive. For each objects, we divided the dust ring every 5 azimuthal angle and fit the intensity profile respectively. Detailed analysis on the returned parameters gives us hints on the underlying structures of the unresolved disk and potentially constrains the locations of embedded objects that cannot be directly observed yet. We present our work in the poster and hope to give better comparison with numerical simulations.

A New KBO Occultation Light Curve Simulator for a Diffuse Telescope Array

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TAOS II is a next generation blind occultation survey designed to measure the size distribution of small (diameter 0.5 to 30 km) Kuiper Belt Objects (KBOs). The survey will operate three telescopes at San Pedro Martir (SPM) Observatory in Mexico. The telescopes will be separated by 130 to 330 meters, which are far enough apart that different telescopes will measure different chords with different relative timings through the occultation shadows. We have developed an improved simulation of occultation event light curves to account for this separation. Additional effects must now be considered, including the two vector components of the transverse velocity (which depend on the time of year, inclination of KBO orbit, and rotation of earth), the telescope positons and elevation, and the position of the target star. In this poster, we demonstrate various effects for a survey comprising several telescopes over a large area, and show how the multi-telescope light curve measurements can help better constrain the measured size and distance of the occulting object.

Colours of the Outer Solar System Origins Survey: Classifying TNO Surfaces using z band

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Several different surface types of trans-Neptunian objects (TNOs) have been inferred from their optical and near-infrared colors. As part of the Colours of the Outer Solar System Origins Survey (Col-OSSOS), we have obtained precision *g*, *r*, *z*, and J band photometry of 26 TNOs using Subaru and Gemini Observatories. Previous color surveys have not utilized *z* band reflectance, and the inclusion of this band reveals significant surface reflectance variations between sub-populations. The colors of TNOs in *g ? r* and *r ? z* show significant structure, including the known bimodality in *g ? r*. The distribution of colors of the two dynamically excited surface types can still be explained using the two-component mixing models from Fraser & Brown (2012), and the use of an additional band makes it possible to more precisely identify the two excited surface types. In *g - r* and *r - z*, the two dynamically excited surface groups are also distinct from the cold classical TNO surfaces; the addition of *z* band makes it possible to differentiate the red excited TNOs from the red cold classical TNOs. The discovery of different *z* band reflectance for these TNO surfaces makes it possible to search for cold classical surfaces in other regions of the Kuiper belt and to more completely separate cold classical TNOs from the dynamically excited population, which overlaps in orbital parameters.

The Role of Gas Drag on Resonant Trans-Neptunian Objects

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Resonant Trans-Neptunian Objects (TNOs) are celestial objects in resonance with Neptune. The most popular mechanism is that TNOs are captured into resonance by Neptune during its outward migration. On the other hand, the drag force exerted by the gaseous disk may help these TNOs to migrate into the resonant region of Neptune, and hence be captured. In this study, we revisit the role of gas drag using a hydrodynamic code for more realistic behavior of the gaseous disk, in order to construct a general picture of the formation of resonant TNOs.

On the long-term time evolution of highly-inclined Trans-neptunian Objects

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It is known that the capture efficiency of long-period comets originated from the distant Oort cloud into short-period comets is very low. This is particularly so for those originally in high-inclination or retrograde orbits. Such paradigm has been the basis for identifying the population of small objects outside Neptune's orbit (e.g., TNOs) in low-inclination orbits to be the source of the short-period comets. The recent discovery of a "disk" of TNOs in high-inclination or retrograde orbits (cf. Chen et al., 2016; The Astrophysical Journal Letters, 827:L24) raises interesting questions on their origin, namely, at what time and under what circumstance were they injected into the current orbital configurations? Also, what are their evolutionary histories? Along the same line, we would like to attack another related problem; that is, what are the dynamical lifetimes of objects with different orbital inclinations after first injection into the trans-neptunian region. Could there still be a small population of highly-inclined/retrograde objects dated back to the phase of Oort cloud formation? To explore this issue, we examine the associated dynamical evolution by long-term orbital integration. The statistical results from this numerical exercise will be presented here.

A Study of the Seasonal Variation of the Sublimation Rate of the Sputnik Planum Ice Sheet on Pluto

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The Sputnik Planum (SP) of Pluto is one of the most important discoveries of the New Horizons spacecraft during its flyby observations of the Pluto-Charon system in July 2015. SP is located at the northern mid-latitude hemisphere in the antipodal position to Charon on the opposite side. It contains a large quantity of the nitrogen ice on Pluto, and the content of Pluto's atmosphere is likely controlled by the variable sublimation rate of the SP ice. In this work, we use a coupled treatment of the Clausius-Clapeyron equation and the surface energy balance equation to compute the variation surface temperature and the sublimation rate of SP in the different orbital phase of Pluto. Moreover, we also calculated the total amount of nitrogen gas emitted from the SP during the whole orbital period. This set of model calculations will allow us to explore the range of Pluto's atmospheric content and the corresponding escape dynamics.

Gas Tori Of The Outer Planets Including The Pluto-Charon System

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The global environments of the outer planets usually can be characterized by studying the extended structures of neutral gas clouds that originated from planetary moons and rings. For example, the neutral cloud of Io is the main supporter for the atomic sulfur and oxygen in the Jovian system. The other example is that in the Saturnian system the water-group neutral cloud is produced by the water plume of Enceladus.

The dynamical and compositional effects of these neutral gas tori in the magnetospheres have been well studied. In this study, we pay attention to the other gas tori, which is less explored so far. Our cases include the oxygen gas cloud emitted from Callisto, the Titan originated hydrogen and methane gas clouds, and the time-variable gas halo emitted from Pluto. The Callisto torus is interesting because the corresponding pickup ions could be the sources of energetic magnetospheric particles. The content of Titan's methane cloud is closely related to the atmospheric escape rate of Titan. The detection or non-detection of the methane group ions can hence be used either to test the atmospheric escape models or to probe the dynamics of Saturn's outer magnetosphere. Finally, the gas cloud model of the Pluto-Charon system could be directly compared to the observations of the X-ray emission expected from the charge-transfer mechanism of the heavy solar wind ions.

Source regions of dust jets on the comet 67P/Churyumov-Gerasimenko

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Because of the inclination of the rotational axis to the orbital plane and the orbital motion around the Sun, the sunlit regions on the nucleus surface of comet 67P/Churyumov-Gerasimenko moved from the northern hemisphere to the south hemisphere between August, 2014 and October, 2015. From the comparison of the dust jet features in images taken at successive time series, the footpoints of these jets can be identified by a projection method. The distribution of the corresponding source regions can be compared with the geomorphology of the nucleus surface from inbound to outbound. The correlation of the dust jet activity with the volatile outgassing phenomenon as monitored by different scientific instruments onboard Rosetta will provide important information on the sublimation process.

A model study of the vertical distributions and escape fluxes of the major and minor species in Titan's thermosphere under different conditions

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From the measurements of the Ion Neutral Mass Spectrometer (INMS) on the Cassini spacecraft at different close encounters with Titan, it is know that the vertical temperature profile and density distributions of N_2, CH_4, H_2 and other species could have large variations which might be driven by environmental effects such as solar radiation and magnetospheric interaction. For example, the atmospheric temperature as determined from the N2density profiles can vary between 120 K and 175 K. Following the treatment of Li et al. (PSS, 104 (2014) 48-58) by applying a non-monotonic eddy diffusivity profile, we compute the vertical distributions of different species between Titan's surface to 2000 km altitude, for a range of atmospheric temperatures. Intercomparison between the model results and observations leads to better understanding of the production mechanisms of the minor species like C_2H_2, C_2H_4, C_2H_6 and others, all important to the hydrocarbon budgets of Titan's atmosphere and surface, respectively. Furthermore, such detailed photochemical calculations will also yield accurate estimates of the escape fluxes of H, H_2 and CH_4 into the circum-planetary region.

Molecular Study of Atmospheric Compositions of Galilean Moons

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According to the Grand Tack (GT) model, Jupiter is believed to have migrated very close to the Sun. Hence atmospheres of the four Galilean moons were largely destroyed during the GT due to non-thermal XUV-driven atmospheric escape. However, scarce atmospheres remain existent on Galilean moons today. It is thus important to study the chemical compositions of these atmospheres in order to understand their origins. In particular, by probing atmospheric trace components evaporated from the surface, we may infer the likely chemical compositions of the subsurface oceans suspected to exist on the outer three Galilean moons Europa, Ganymede and Callisto. Thanks to the high sensitivity and spatial resolution of the ALMA array, we are now able to resolve the discs of Galilean moons directly. As first steps, we use the archival ALMA data to study the atmospheric compositions of Io and Callisto, respectively, the innermost and outermost Galilean moons orbiting around Jupiter.

Because of its closeness to Jupiter, Io is the most geologically active body in the solar system. Io's surface appears mainly in yellow, black, white and orange colors due to sulfide compounds ejected from volcanic eruptions. Sulfide compounds from volcanic plumes are also present in Io's atmosphere. On the other hand, Callisto is about 1,880,000 km away from Jupiter, hence it is least affected by Jupiter tidally among four Galilean moons. Unlike Io, Callisto's atmosphere is thought to be formed mainly due to sublimation of icy volatiles on its surface. Preliminary results obtained from our high spectral resolution ALMA study indicate the existence of sulfide compounds (SO, SO_2 and $^{34}SO_2$) and potassium chloride (KCl) in Io's atmosphere. A hint of likely existence of ethanol in Callisto's atmosphere is seen but it requires observations of more C_2H_5OH transitions for confirmation.

Search for extremely recent break-up events of small solar system bodies

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Break-up events of small solar system bodies are common and frequent phenomena in solar system. The power-law index of the size-frequency distribution of these bodies are found to be ~3.5 which is indicative of steady-state collisional cascade. Tidal break-up at close encounter to a planet and YORP spin-up are also considered as mechanisms for split of bodies. Although small solar system bodies are thought to be remnants of planetesimals, their surface is altered by irradiation of ultraviolet radiation and energetic particles. Thermal metamorphism is also attributed for surface alteration. Break-up events may expose unaltered sub-surface of precursor objects, and these freshly exposed area of fragmented bodies are suitable target to study primordial material of solar system. In this point of view, it is scientifically meaningful to search for extremely recent break-up events and identify very young surface on small solar system bodies. Recent cyclical sky surveys, such as Pan-STARRS, is dramatically increasing number of known objects. A trial of search for recent break-up events by backward orbital integrations of known objects is reported. Candidates of fragments are characterized by photometric measurements by Palomar Transient Factory, and photometric phase curves are also presented for some objects.

Thermophysical characteristics of the large main-belt asteroid (349) Dembowska

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(349) Dembowska, a large, unusually bright main-belt asteroid, locates within the 'buried snow line' of the solar system. We investigate Dembowska's thermophysical properties, e.g., thermal inertia, roughness fraction, geometric albedo and effective diameter. We use the so-called advanced thermophysical model and analyse three sets of thermal infrared data obtained by AKARI, WISE and Subura at different epochs. With this method, the thermal inertia, roughness fraction, geometric albedo and effective diameter of Dembowksa are constrained within 3$sigma$ uncertainty of $Gamma=25^{+10}_{-11} m~Jm^{-2}s^{-0.5}K^{-1}$, $f_{ m r}=0.25^{+0.65}_{-0.25}$, $p_{ m v}=0.311^{+0.04}_{-0.034}$, $D_{ m eff}=155.4pm9.2 m~km$. The rather low thermal inertia indicates that Dembowska may be one of the first-generation planetesimals survived since the Late Heavy Bombardment. Based on the derived surface thermophysical properties, as well as the known orbital and rotational parameters, we are able to simulate Dembowska's surface and subsurface thermal state throughout the whole orbital period. The surface temperature varies from $sim40$ K to $sim200$ K while most of the surface remains hotter than 145 K for a long time, making the existence of water ice unlikely. However, the temperature below a certain depth in the North and South pole regions remain lower than 145 K, where water ice could survive.

Rotationally Resolved Polarization Observations of the M-type Asteroid 16 Psyche

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M-type asteroid is one of asteroid taxonomies which represent a metal-rich surface. Asteroid (16) Psyche is the largest M-type asteroid and also the next space mission of the metallic world.

A photometric and polarimetric survey program on M-type asteroid has recently been established with Lulin One-meter Telescope making use of the Triple Range Imager and POLarimeter (TRIPOL) instrument. To study the surface heterogeneity, we observed the selected targets simultaneously. We will have a brief report on the phase-angle v.s. polarimetry curve, the rotationally resolved polarimetric measurements, and photo-polarimetrical light-curves of (16) Psyche and other M-type objects.

Rotational resolved spectrum of the future space mission target asteroid - (16) Psyche

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Asteroid (16) Psyche is the target of NASA's next generation solar system exploration mission. The planned launch time will be in 2021 or 2023 to discover the mystery of the largest M-type asteroid which is possibly the remnant of a metallic core from a giant dwarf planet after a cataclysmic collision event in the early solar system formation.

According to the scenario of collisional fragmentation, this object is expected to have ununiformed surface material. We use Lulin One-meter Telescope (LOT) in central Taiwan to have a series of spectroscopic observation on Psyche in early 2017 to study the surface heterogeneity by rotationally resolved spectrum. Our preliminary result shows that Psyche has a nearly featureless reflect spectrum. The mean surface reflectance is similar to a standard M-type asteroid. In our observation, weak absorption bands were detected centering at 475 and 650 nm in some specific rotational phases.

Intercomparison of the Size – Rotation Period Relations of Different Taxonomic Types of Asteroids

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The size-rotation period relation of asteroids plays a key role in probing the internal properties of these primitive bodies. The existence of a spin-cutoff at about 2.2 hours has been interpreted to be the physical consequence of gravitationally bounded rubble-pile structures of the asteroids. Because different types of asteroids should have somewhat different bulk densities and albedos, their corresponding size-dependence of the rotation period distributions could be different. Following the work of Chang et al. (ApJ Supp. Ser., 219:27, 2015), we include the X-type asteroids into this consideration by comparing the light curve data of PTF and the albedo measurements of the NEOWISE mission. We are particularly interested in the M-type objects of nickel-iron composition from this point of view.

Asteroid 9 high-precision CCD observation

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Asteroid 9 Metis were observed at the Yunnan Observatory telescope of one meter in May 29 2014 to May 31, and the observation data were processed by software Astrometrica. The results show that the accuracy of the observation is about 0.08 seconds.

Lulin Photometric Survey for Taxonomic Classifications of Near-Earth Asteroids

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The near Earth asteroids (NEAs) have close relation with the Earth and human being. At the later stage of the Earth formation, the surface of Earth was heavily affected by very large collisions of NEAs. Nowadays, hitting events by NEAs are still happening but only about 10 percent of NEAs have been investigated in detail. A systematic observations programs for physical studies of asteroids therefore is necessary. Since 2013, Lulin observatory started its ambitious work to produce a comprehensive database of NEAs. In this work, we will present the preliminary results including the taxonomy classification and spin rates estimation using the both photometric and spectroscopic observations acquired from Lulin (2015-2017) and Lijiang/Xinglong (2017) observatories, respectively.

Observations of Break-up Near-Earth Asteroid's Candidates

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Research on small solar system bodies enables us to investigate evolution of the solar system. Many asteroid families have been found in the main belt asteroids (MBAs) but none in the near-Earth asteroids (NEAs) population due to frequent planetary perturbations. Apollo type NEAs (155140) 2005 UD and 2007 MK6 have been suggested to be fragments of (3200) Phaethon and (1566) Icarus, respectively. In order to examine surface material changing as they are rotating, we conducted (multi-color photometric) lightcurve observations for 2005 UD, Icarus and 2007 MK6, and spectroscopic observations for Icarus and 2007 MK6 during 2015-2016 Earth encounters at Nayoro and Lowell observatories. The lightcurve of Icarus shows that the rotation period is 2.395±0.03408[hr], while the spectroscopic observation shows that Icarus has both S-type and Sq-type features. This paper will discuss physical evidences for the break-up Near-Earth asteroids.

Development of Lunar Impact Flash and Near-Earth Asteroid Observing Camera DELPHINUS on Deep-space 6U Spacecraft EQUULEUS

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EQUULEUS (EQUilibriUm Lunar-Earth point 6U Spacecraft) will be the world's smallest spacecraft to explore the Earth-Moon Lagrange2 point (EML2). The spacecraft will be jointly developed by the University of Tokyo and JAXA which will be launched by NASA's SLS (Space Launch System) EM-1 (Exploration Mission-1) in late-2018. The spacecraft will fly to a libration orbit around the EML2 point and demonstrate trajectory control techniques within the Sun-Earth-Moon region.

DELPHINUS (DEtection camera for Lunar impact PHenomena IN 6U Spacecraft) is one of the scientific instruments onboard EQUULEUS to observe the Lunar impact flashes and near-Earth asteroids. When a meteoroid impacts the moon at several 10s of km/s, a brilliant flash at the point of impact can be observed as a flash in visible and near-infrared light. The influx rate of interplanetary dusts onto the Earth-Moon surface are essential for understanding solar system evolution and are useful information for the future human space activities in the Cis-Lunar space that is the volume within the Moon's orbit. Thus, it is very important to investigate size distributions, influx rate and daily variation of meteoroids. Ground-based meteor observations by using all-sky cameras are limited to the roughly 10,000 km^2 of upper-atmosphere visible from their location. On the other, Lunar impact monitoring enables to monitor huge collecting area larger than 10^6 km^2. Thus, Lunar impact monitoring has a great advantage to detect large meteoroids in the mass range between 10s of grams and few kilograms corresponding to centimeters and tens of centimeters, which is as a bridge between visual meteors and small asteroids.

Since the mean distance from the lunar surface during the mission phase is approximately 40,000 km, small double-camera system (f=50mm/F1.4) can monitor the comparable magnitude range of lunar impact flashes as observed from the Earth. This paper describes newly developed DELPHINUS camera system.

Spatial density of boulders ejected from several lunar impact craters of known absolute age

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In this study, we performed boulder count on the ejected blankets of 7 lunar impact craters under 1 kilometer in size known absolute formation age, to found the relation between number density of boulders with the crater age.

The craters under study are South Ray, Unnamed A, Unnamed B, Cone, North Ray, Unnamed C and Camelot, in which 'Unnamed' indicate those without designated name. The Latitude and longitude of Unnamed A, Unnamed B and Unnamed C are (12.25, 62.24), (-3.61,336.51) and (-3.02,336.58), respectively. The LROC NAC images were employed to identify boulders larger than 3 m in any visual dimension in the concentric annulus or part of concentric annulus in the crater ejecta blanket within a crater radius away from the corresponding crater rim.

Based on size distribution of identified boulders, we concluded:

1) Spatial density of ejected boulders decrease with crater age for the craters < 1 km, which is consistent with previous studies.

2) Anomalously high spatial density of boulders for unnamed A and Unnamed B located in mare, can be attribute to higher mechanical strength for mare basalts than that for highland breccias.

3) Most of the ejecta boulders will vanish in the first 100 Ma for the craters < 1 km whatever it formed in highland or mare.

4) Flections are common in the CSFD of ejected boulders for craters < 1 km. The CFSD slopes before flection are close to parallel for our study craters which means that destruction of rocks goes in the way that the spatial density decreases but its slope keeps to be approximately the same.

5) Absence of obvious flection in the CFSD of North Ray can be explained by its large size, that penetrate deeper basement that ignore the effect of regolith thickness and upper fractured layer of basement.

Comparison of the Radio Frequency Interference (RFI) Data at Selected CALLISTO Station

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Determination of Radio Frequency Interference (RFI) is very important progress in order to discover the potential radio astronomical sources. This study is currently one of a main sub-research in radio astronomy in Malaysia. Compact Astronomical Low-Cost Instrument for Spectroscopy in Transportable Observatories (CALLISTO) is a worldwide network of spectrometer system that aims to monitor the RFI and for the solar monitoring. This paper gives an overall comparison of the RFI at the National Space Agency (ANGKASA), Banting, Selangor, Malaysia and other selected station. There are 2 stations that are used to identify type of RFI for each station. This RFI study can provide the possibility

to capture a good data for solar monitoring. CALLISTO is a global network spectrometer have been deployed around the world.

KEYWORDS: Radio Frequency Interference (RFI), solar monitoring

Contribution of Velocity Vortices and Fast Shock Reflection and Refraction to the Formation of EUV Waves in Solar Eruptions

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We numerically study the detailed evolutionary features of wave-like disturbance and its propagation in the eruption. We focus on the contribution of the velocity vortices and the fast shock reflection and refraction in the solar corona to the formation of the EUV waves. Following the catastrophe, the flux rope exhibits rapid motions and invokes the fast-mode shock at the front of the rope, which then produces a type II radio burst. The expansion of the fast shock, which is associated with outward motion, takes place in various directions, and the downward expansion shows the reflection and the refraction as a result of the non-uniform background plasma. The reflected component of the fast shock propagates upward and the refracted component propagates downward. As the refracted component reaches the boundary surface, a weak echo is excited. The Moreton wave is invoked as the fast shock touches the bottom boundary, so the Moreton wave lags the type II burst. A secondary echo occurs in the area where reflection of the fast shock encounters the slow-mode shock, and the nearby magnetic field lines are further distorted because of the interaction between the secondary echo and the velocity vortices. Our results indicate that the EUV wave may arise from various processes that are revealed in the new simulations.

Quiet Sun Radiation During Solar Cycle 23 and 24

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Radio observations are playing very important role for understanding the manner of solar atmosphere. The study of quiet sun radiation is also considerable importance since it helps to obtain the knowledge related to brightness temperature for different layers of the solar atmosphere. In this paper the quiet sun component of the solar radio emission has been investigated using the data obtained at different frequencies,410, 610, 1415, 2695, 2800, 4995, 8800, 15400 MHz. Mean flux densities of three carrington rotations at all frequencies were taken from the monthly bulletin on solar indices bulletin, national geophysical data centre, and boulder, USA. using a statistical method the quiet sun component was estimated for succesive periods containing three solar rotations and brighness temperatures of correspondind frequencies also calculated.

Photospheric Magnetic Field of Active Regions During Flare in Solar Minimum of Cycle 24

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We analyzed photospheric magnetic fields of active regions in the minimum of cycle 24 which produced strong flares. We used HMI data onboard SDO satellite, and compared the total unsigned flux, total unsigned vertical current, and total unsigned current helicity of the magnetic fields with other characteristics, i.e. the areas, McIntosh classification, and Hale's class of the active regions. The preliminary results showed that the occurrences of flare maximum were not coincided with the maximum values of the abovementioned magnetic parameters.

Keywords: photospheric magnetic fields – active region flare – SDO-HMI data

PREDICTIONS OF THE ONSET OF MINI ICE AGE IN THE 25TH SOLAR CYCLE

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Predictions of the irregularity in the 11 year heartbeat of the sun due to asynchronous of the two layered dynamo effect would result in mini ice age as in the Maunder minimum. The onset of this event is expected in the beginning of 25th solar cycle and would go to its maximum in the 26th solar cycle . The minimum temperature is expected in 2028 due to the fall of solar activity by 60 % termed as solar hibernation. The predictions are based on the observations obtained by the Royal Greenwich observatory since 1874.

Spatial variation of solar coronal rotation period by fractal analysis

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The solar coronal differential rotation is studied so far as a function of latitude and longitude. In this communication, we report the findings as a function of height above the photosphere. The solar radio flux from 245, 410, 1415, 2695, 4995, 8800 and 15400 MHz are recorded from Learmonth solar observatory, Australia, since 1988 to 2009. However, the data for 245 MHz and 15400 MHz is purturbed. Hence both of them is not considered here. As it is known that higher frequency is radiated from lower corona and lower frequency radiated from higher corona. The data were used to determine the spatial variation in solar rotation as a function of height. The fractal dimension affection with solar rotation or angular velocity of the sun at different height is reported here. The fractal analysis of the solar radio flux data shows the correlation with the solar activity. Here, the data used for fractal analysis is for 1988 to 2009. The analysed data shows clear resemblance with solar activity cycle. Lower solar activity phase affects more in lower frequencies and higher solar activity phase affects more in higher frequencies.

Key words: solar coronal differential rotation- solar radio flux- relation with height- fractal analysis- solar activity.

Study of solar Transients causing intense GMSs with Dst ≤ -100nT during the period 1999-2010

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The effect of solar features on geospheric conditions leading to geomagnetic storms(GMSs)with Dst index Dst ≤ -100nT has been investigated using interplanetary magnetic field(IMF),solar wind data(SWP) and solar geophysical data with CMEs that erupted between 1999 and 2010, we considered all 51 events .The study investigated the relationship coronal mass ejection (CME) and their influence on Earth's geomagnetic field, i.e. storms and sub storms .The study is performed mainly considering intense geomagnetic storms that occurred during Solar Cycle 23 and ascending phase of 24 Solar Cycle . It has been analysed and estimated by cross correlation method that there is a delay of 17 to 96 hours in happening GMSs on the Earth after the happening of the CME on the sun.

Formation and Evolution of Geomagnetic Field and Other Planetary Magnetic Fields as well as Geomagnetic Declination and Geomagnetic Reversal

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Although geomagnetic field has been found and utilized for a long time, and many hypotheses have been proposed about the cause of geomagnetic field, so far none of them is able to completely answer every question about the geomagnetic field. So the author has researched the formation and evolution of the geomagnetic field again, and dicovered that during an interglacial period, under the action of solar ultraviolet rays and cosmic rays,Earth's atmosphere can produce a large amount of positive ions and negative ions, then form the positive charge layer at the top of cloud and the negative charge layer at the bottom of the cloud; with the rotation of Earth, the two charge layers generate a superposition of geomagnetic fields.This kind of magnetic field conforms to all the known characteristics of geomagnetic field. It can well explain the inhomogeneity of the spatial distribution of geomagnetic field and its characteristic of constant change over time, including geomagnetic declination and geomagnetic reversal. If the Earth enters an glacial period, the land and the sea would be covered by ice, then the bottom of the clouds would touch the ground, making the charge at the bottom of clouds become 0 and the surface charge be approximately equal to 0. At this time only the positive charge layer at the top of cloud has an effect on forming geomagnetic field, therefore realizing geomagnetic reversal. The formation and reversal of other planets' magnetic fields are similar with that of geomagnetic field. Since Jupiter's surface temperature is-168°C ,it's very cold there, the bottom of Jupiter's clouds touch the ground, only the positive charge at the top of the clouds plays a major role in the formation of Jupiter's magnetic field, therefore the orientation of Jupiter's magnetic field is opposite to that of Earth's magnetic field.

An Investigation of Highly Geo-effective Solar Transients and Associated Geoeffectivness

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The solar Cycle 23 has shown peculiar features, i.e. slow and prolonged decline phase. It is when combined with the ascending phase of Cycle 24, it provides us a long phase during which the overall magnetic activity was very low. The study investigate the relationship between magnetic structure of coronal holes and CME source region and their influence on Earth's geomagnetic field. The disturbance storm time index *Dst* is taken as an indicator of geomagnetic activity by setting a value of $Dst_{min} \leq -200$ nT as threshold. By examining halo CMEs the selection of geoeffective events have been made, associated with M-class and X-class solar flares. Furthermore, as the geomagnetic field (B_{Geomag}) puts a lower cutoff rigidity (R_c) to the entry of cosmic particles in to the earth, depending upon the geomagnetic activity. Sometimes when this entry of charged particles exhibits very sudden sharp and short lived increases in cosmic ray intensities, registered by neutron monitor, it is termed as Ground-level enhancement. Utilizing the spacecraft data and those provided by Omni web and geomagnetic stations like WDC-Kyoto these events are analysed. It is observed that IMF B is highly geo-effective during the main phase of magnetic storms, while it more significant at the time of storm peak, which is further contributed by southward component of IMF Bz. The correlation between Dst and wind velocity is higher, as compared with IMF Bz and ion density. It has been verified that geomagnetic storm intensity is correlated well with the total magnetic field strength better than with its southward component.

Kagoshima Ammonia Mapping Survey of Molecular Cores with Nobeyama 45m telescope

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An ammonia molecule is a powerful tool to get physical properties of molecular cloud cores.Although many investigations have been done, mapping observations are only few.We, therefore, make a mapping survey of molecular cores in the Milky Way Galaxy using Kashima 34m and Nobeyama 45m radio telescopes since 2007. Our final goal is to understand the process of star formation through temperature distribution in each molecular cloud. Until 2014 we have made maps and published for NGC 7000, Monkey Head Nebula,NGC2264, and AFGL 333. In these days we use the CO survey with Nobeyama 45m telescope named FUGIN as a finding chart of the ammonia survey. In the last season, we successfully detected for 22 objects at the peak of FUGIN C18O map.In the last and this seasons, we chose 3 objects to map. We will talk on the current status of our survey and a short repot on a molecular cloud complex G14.47-0.11.

An exact solution for magnetogasdynamic cylindrical shock wave in a self-gravitating rotational axisymmetric perfect gas with radiation heat flux and variable density

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We present a class of exact similarity solution for magneto-radiative cylindrical shock wave in self-gravitating rotational axisymmetric perfect gas. The density and azimuthal velocity of the gas are assumed to be varying and obey power law. The physical quantities radial velocity, pressure, magnetic field, azimuthal velocity, mass and flux decrease from the highest at the shock front to zero at the symmetry axis however density tends to infinity as the symmetry axis is approached. The effects of change in values of magnetic field strength, gravitational parameter, rotational parameter and adiabatic exponent on the flow variables and shock strength are worked out in detail. Magnetic field strength, rotational parameter and adiabatic exponent affect the flow variables in the same way except pressure, however gravitational parameter has reverse behavior on these flow variables. Comparison between the solutions obtained in self-gravitating and non-gravitating medium is done. The total energy of the shock wave is non-constant and varies with time.

The Internal Structure and Dynamical State of the Filamentary Dark Cloud GF 6

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We present the results of radio mapping observations and stability analyses toward the filamentary dark cloud GF 6. We investigated the internal structures and dynamical state of a typical filamentary dark cloud GF 6 to know whether the filamentary dark cloud will form stars. We performed radio observations with both ^{12}CO (J=1–0) and ^{13}CO (J=1–0) emission lines using the 14-m radio telescope of Taeduk Radio Astronomy Observatory at Korea Astronomy and Space Science Institute, in order to examine the mass distribution and its evolutionary status. The ^{13}CO gas column density map shows eight subclumps in the GF 6 region with sizes of sub-pc scale, ranging between 2.6×10^{16} cm^{-2} and 9.1×10^{16} cm^{-2}. The resulting LTE masses of all the subclumps are too low to form stars against the turbulent dissipation. We also examined the properties of the embedded infrared point sources to investigate the dust properties of this region and to search whether GF 6 contains young stellar objects. The infrared properties also indicate that these point sources are not related to the star forming activities associated with GF 6. Both radio and infrared properties indicate that the filamentary dark cloud GF 6 is too light to contract gravitationally and will eventually be dissipated away.

DFT study of Interstellar PAH molecules with aliphatic side groups

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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 (Tielens 2006). 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 3.3 μm feature. The 3.3 and 3.4 μm features are characteristics of stretching mode of an aromatic and aliphatic C-H bond in a PAH molecule (Bernstein et al. 1996). 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 effect observed. We present a detailed analysis of the IR spectra of these molecules and discuss the possible astrophysical implications.

DETERMINING THE SYSTEMATIC ERRORS IN FITS OF DUST THERMAL EMISSION: THE ROLE OF LABORATORY DATA IN UPCOMING MODELS

Interstellar dust plays an important role the study of interstellar medium, especially since the development of far-infrared and submillimeter instruments in the last decades (e.g. IRAS, Herschel, *Planck*, ALMA) has allowed wide surveys of dust thermal emission. Using a dust emission model these observations can be converted to maps of quantities such as the dust column density and temperature, or to constrain dust masses in molecular clouds and galaxies.

Dust emission is commonly modeled as a blackbody with temperature T multiplied by an opacity κ that varies with wavelength as a power law: $\kappa \propto \lambda^{-\beta}$, usually with $\beta \sim 2$. However, we are learning from both astronomical observations and laboratory tests on dust analogues that T–β models are too simplistic. Two facts in particular emerge:

1) For most candidate dust materials the opacity $\kappa(\lambda)$ does not follow a power law: its slope decreases beyond a certain wavelength (typically around 400–700 μm);
2) The optical properties of materials often depend on temperature as well; for instance opacity often increases with T.

Our group is working on optical data on several candidate dust materials, collected by multiple laboratories, to parametrize the materials' opacities as functions of λ and T. This parametrization will be the first step in building a more physically realistic and flexible dust model. By fitting observations of molecular clouds and nearby galaxies, and by constructing synthetic observations to fit with conventional methods, the new model will allow to find potential systematics in T–β fit results. The model could also be applied to galaxies at high redshift, where recent dust mass estimates are posing a challenge to dust formation models, and understanding systematics on such measurements is essential.

Cylindrical shock wave generated by a moving piston in a rotational axisymmetric non-ideal gas with conductive and radiative heat-fluxes in the presence of azimuthal magnetic field

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The propagation of a spherical (or cylindrical) shock wave in a rotational axisymmetric non-ideal gas with heat conduction and radiation heat-flux, in the presence of a spacially decreasing azimuthal magnetic field, driven out by a moving piston is investigated. The fluid velocities and the azimuthal magnetic field in the ambient medium are assume to be varying and obeying power laws. In order to find the similarity solutions the angular velocity of the ambient medium is taken to be decreasing as the distance from the axis increases. The heat conduction is expressed in terms of Fourier's law and the radiation is considered to be of the diffusion type for an optically thick grey gas model. The thermal conductivity and the absorption coefficient are assumed to vary with temperature and density. The gas is assumed to have infinite electrical conductivity and to obey a simplified van der Waals equation of state. The shock wave moves with variable velocity and the total energy of the wave is non-constant. Similarity solutions are obtained for the flow-field behind the shock and the effects of variation of the heat transfer parameters, the parameter of the non-idealness are worked out in details. The pressure and density vanish at the inner surface (piston) and hence a vacuum is form at the centre of symmetry. A comparison between rotating and non-rotating medium is made. The shock waves in conducting rotational axisymmetric non-ideal gas with conductive and radiative heat fluxes can be important for description of shocks in supernova explosions, in the study of central part of star burst galaxies, nuclear explosion, chemical detonation, rupture of a pressurized vessels, in the analysis of data from exploding wire experiments, and cylindrically symmetric hypersonic flow problems associated with meteors or reentry vehicles, etc.

Radiative Condensation Instability of partially ionized gravitating dusty plasma with applications in star formation

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The radiative condensation instability play significant role in formation of planetary nebula, molecular clouds and stars. The cloud core collapse of matter is strongly affected by self-gravitation and electron radiative condensation. In the present problem we have discussed the radiative condensation instability in partially ionized dusty plasma considering electron radiative cooling effects, dust-neutral collisions and dust polarization force. The isobaric and isochoric radiative modes are analyzed along with Jeans (gravitational) instability of partially ionized strongly coupled dusty plasma using linear perturbation (normal mode) analysis. The Boltzmann distributed ions, dynamics of inertialess electrons, charged dust and neutral particles are considered. Using the plane wave solutions, a general dispersion relation is derived which is modified due to the presence of dust-neutral collisions, strong coupling effect, polarization force, electron radiative condensation, and Jeans dust/neutral frequencies. In the long wavelength perturbations, the Jeans instability criterion depends upon strong coupling effect, polarization interaction parameter, and thermal loss, but it is independent of dust-neutral collision frequency. The stability of the considered configuration is analysed using the Routh–Hurwitz criterion. The growth rates of Jeans instability are illustrated, and stabilizing influence of viscoelasticity and dust-neutral collision frequency while destabilizing effect of electron radiative condensation, polarization force, and Jeans dust-neutral frequency ratio is observed. This work is applied to understand the radiative cooling process in star formation, molecular clouds and in interstellar media (ISM) [1].

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Searching the First Hydrostatic Cores in the Perseus Molecular Cloud

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First Hydrostatic Cores (FHCs) are the transient phase between prestellar cores and Class 0 protostars. Therefore, FHCs are best targets for understanding the earliest stage of star formation. Several FHCs candidates were suggested, but none of them have been confirmed. Recently, some potential candidates of FHCs have been suggested based on the low temperature from the SED fitting (~10K-30K); however, theoretical models predicted that FHCs can be heated over 100K. The low temperature of FHCs derived from observation may be due to the mixing of the unresolved FHCs and the cold envelope. In this project, we produce synthesis images using CASA based on a simple self-similar collapse density model. We match the simulated images of First Core candidates in Perseus Molecular Cloud to the SMA and VLA observational results. Our simulations show that with both VLA and ALMA observations, we can decouple the FHC component from envelope with reasonable observing time. The identification of FHCs will make great strides in our understanding of star formation.

Impact of high-mass stars on the star-formation properties of the interstellar filaments - A case study on the G182.4+00.3 filamentary cloud.

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Recent Herschel observations have shown that most of the star formation occurs in filaments, yet how the fragmentation operates and how the nearby massive stars affect the star-formation properties of a filament is far from being clear. We present observations towards the G182.4+00.3 molecular cloud in the transition of ^{12}CO, ^{13}CO, and C^{18}O using the PMO 13.7 m telescope. Though the emission from three molecular lines show different emission areas with their own distinct structures, the ^{13}CO integrated intensity map clearly reveals a filamentary cloud of length ~1 degree (36 pc) with column density greater than 10^{21} cm^{-2}. The distribution of excitation temperature shows two phases: cold gas of ~ 10K across the large area filament; relatively warm gas in the range 15-25 K at the edge of the filament facing an HII region S242. Using multi-wavelength data, we find that, part of the filament is indeed heated and compressed by the stellar winds and radiation from the massive stars of S242. Our C^{18}O data reveals nine massive clumps across the filament. We compare the gas properties of the clumps with the distribution of young stellar objects obtained with CFHT and Spitzer to investigate the relationship between gas properties of the clumps, their locations with respect to the HII region and star formation activity their in. Based on our multiwavelength results, in this poster, we will discuss the star formation properties of the clumps, and the kinematics of the gas and the role of HII region's feedback on the star-formation process of the filament.

ALMA imaging of trans-cis conformers of formic acid in Orion KL

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The *trans*-conformer of formic acid has long been observed in interstellar space. However, the *cis*-HCOOH, a wobbly conformer of formic acid, was not expected to exist in the interstellar medium due to its very high *trans*-to-*cis* conversion energy barrier. Recently *cis*-HCOOH was detected in the Orion Bar PDR with the IRAM 30m and a FUV photoswitching mechanism for *trans*-to-*cis* isomerization was proposed, nevertheless, no *cis*-HCOOH was detected toward Orion KL (Cuadrado et al. 2016). Thanks to the mighty ALMA with her very high angular resolution and superb sensitivity, we are able to detect an isolated, clean line of *cis*-HCOOH in Orion KL unambiguously the first time; additionally we also detect four *trans*-HCOOH lines in Orion KL. The spectral emission of both conformers of formic acid is located in a region near the continuum sources SMA 1, HKKH 8 and HKKH 9, with the *cis*-HCOOH concentrated mainly on HKKH 9, and the *trans*-HCOOH, on SMA 1. Weaker, diffuse emission of *trans*-HCOOH encircling the region between the Compact Ridge and Southern Peak is also apparent which is consistent with previous BIMA and SMA lower angular-resolution results. Our ALMA finding of the existence of *cis*-HCOOH in the optically thick Orion KL hot molecular core presents an immediate challenge to the FUV photoswitching scenario thus may require a new *trans*-to-*cis* conversion mechanism.

Star Formation in Interstellar Medium via Thermal Instability of Radiative Plasma with Hall Effect and FLR Corrections

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Abstract: The fundamental thermal instability of an infinite homogeneous, viscous plasma incorporating the effects of finite electrical resistivity, FLR corrections, Hall current, radiative heat-loss function and thermal conductivity for star formation in interstellar medium have been investigated. In this problem a general dispersion relation is derived using the normal mode analysis technique with the help of relevant linearized perturbation equations of the problem. The wave propagation is discussed for longitudinal and transverse modes to the direction of external magnetic field, and the conditions of modified thermal instabilities and stabilities are discussed in different cases. It is found that the thermal instability criterion gets modified into radiative instability criterion. The viscosity of the medium removes the effect of FLR corrections from the condition of radiative instability. The Hall current affects only the longitudinal mode of propagation and it has no effect on the transverse mode of propagation. Numerical computation shows stabilizing effect of heat-loss function, FLR corrections and viscosity, and destabilizing effect of finite electrical resistivity on the thermal instability. The results discussed in the problem helps to understand the formation of star in the interstellar medium.

Key words: Star formation, Interstellar medium, Thermal instability, FLR corrections, Hall current.

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The visible bipolar outflow in the globule CB230

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Bipolar outflows are associated with both low- and high-mass star formation, and their interaction with quiescent cloud material is a source of turbulence. Globules present a relatively simple environment where star formation can be studied without confusion.
CB230 is a globule of size 3.4'x2.2' at a distance of about 450pc. It lies at galactic latitude of 13degs, thus there are no foreground objects towards it. Embedded in CB230 is IRAS21169+6804 (luminosity 11Lo) which is also detected in submillimeter continuum emission (Tdust ~17K) and in the near infrared where it resolves into four components.
We have used HARP at the JCMT at Mauna Kea to observe CO(3-2) towards CB230 with 14" resolution, reaching an rms of 0.1K at a spectral resolution of 0.21km/s. In addition the dense gas associated with the star-forming region was observed in C18O(1-0), CS(2-1) and CH3OH(2-1) with the IRAM 30-m and Onsala 20-m telescopes.

The quiescent CO gas shows linewidths of 0.7-0.9km/s, decreasing to 0.5km/s at the edge of the globule (mass ~10Mo). Towards the star-forming region we find line wings indicating moderate outflow velocities, with the highest red and blue outflow velocity of 12.3 and 11.0km/s, respectively. Towards a 20" region centered on the YSO we observe strong self absorption at a velocity slightly higher than that of the dense gas. The cone-shaped blue lobe of the outflow has an extent of about 4', and coincides with a cone-shaped feature seen in an optical image, presumably as scattered light. The blue outflow does not extend beyond the outer edge of the globule. The red lobe is only 1.5' in size and optically invisible, but some weak optical features appear as an extension of this outflow south of the globule. We derive physical parameters of the outflow gas and discuss its formation mechanism.

Resolving a bipolar compact jet in NGC2023 MM1

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We have observed a bipolar molecular jet in NGC 2023 MM1 with the Submillimeter Array (SMA). NGC 2023 MM1, a class 0 protostar in Orion (d~460pc) with luminosity L ~ 7Lsun, is driving a large-scale CO bipolar outflow previously observed with JCMT. With an angular resolution of 4″ and a spectral resolution of 2 km/s, our observations show a highly collimated bipolar jet close to the source in both CO (2-1) and SiO (5-4) emissions. We have resolved the jet into two compact knots, which show weak velocity gradients perpendicular to the jet axis with a specific angular momentum of approximately 160 AU km/s. Such velocity gradient may suggest tentative jet rotation.

Searching for initial stage of massive star formation around the H II region G18.2-0.3

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Sometimes the early star formation can be found in cold and dense molecular clouds, such as infrared dark cloud (IRDC). Considering star formation often occurs in clustered condition, H II regions may be triggering a new generation of star formation, so we can search for initial stage of massive star formation around H II regions. Based on that above, this work is to introduce one method of how to search for initial stage of massive star formation around H II regions. Towards one sample of the H II region G18.2-0.3, multiwavelength observations are carried out to investigate its physical condition. In contrast and analysis, we find three potential initial stages of massive star formation, suggesting that it is feasible to search for initial stage of massive star formation around H II regions.

Shock gas tracers in Galactic Massive Star Formation Regions

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We carried out a survey of SiO 5-4 and SO &SO2 lines toward a sample of more than 200 Galactic Massive Star Formation Regions with the 10 meter sub-millimeter telescope (SMT) and the CSO, to study shocked gas propeties during high mass star formation. SiO 2-1 observation for these sources with KVN telesopes is on-going to study the excitation of shocked gas.

Dynamic massive star formation in G22.04+0.22: hot core, multipolar outflow, global infall, and millimeter methanol masers

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We present a high-resolution study of EGO G22.04+0.22 based on Submillimeter Array observations at 1.3 mm. A millimeter continuum core is resolved and has a gas mass of 41 M and a density of 2.4 × 10 7 cm −3 , resembling that of high mass star-forming objects. Eleven transitions of CH 3 OH were detected toward the 1.3 mm core. A rotational temperature of 210 K was obtained based on the rotational diagram of transitions of CH 3 OH , suggestive of a molecular hot core nature. A multipolar outflow has been revealed with the CO (2-1) line. Very-high velocity gas has been detected in both red- and blue-shifted lobes. The outflow has a very young dynamical age of about several thousand years consistent with the the stellar age of the putative driving source. Millimeter methanol masers in G22 are well coincident with previously reported 44 GHz Class I methanol masers. G22.04+0.22 is one of the only two known massive star-forming regions showing maser emission in CH 3 OH (4 2,2 − 3 1,2) at 218.440 GHz.

Mass-size scaling M ~ r^1.67 of massive star-forming clumps: evidences of turbulence-regulated gravitational collapse

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We study the fragmentation of eight massive clumps using data from ATLASGAL 870 μm, PdBI 1.3 and 3.5 mm, and probe the fragmentation from 1 pc to 0.01 pc scale. We find that the masses and the sizes of our objects follow M ~ r^{1.68±0.05}. The mass-size relation can be explained if the structures undergo quasi-isolated gravitational collapse in a turbulent medium. Our observational results support a scenario where molecular gas in the Milky Way is supported by a turbulence with a constant energy dissipation rate, and gas condensations like clumps and cores are structures which are massive enough to be dynamically detached from the ambient medium.

The Class 0 Protostar BHR71: Herschel Observations and Dust Continuum Models

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We use *Herschel* spectrophotometry of BHR71, an embedded Class 0 protostar, to provide new constraints on its physical properties. We detect 645 (non-unique) spectral lines among all spatial pixels. At least 61 different spectral lines originate from the central region. A CO rotational diagram analysis shows four excitation temperature components, 43, 197, 397, and 1057 K. Low-*J* CO lines trace the outflow while the high-*J* CO lines are centered on the infrared source. The low-excitation emission lines of H_2O trace the large-scale outflow, while the high- excitation emission lines trace a small-scale distribution around the equatorial plane. We model the envelope structure using the dust radiative transfer code, HYPERION, incorporating rotational collapse, an outer static envelope, outflow cavity, and disk. The evolution of a rotating collapsing envelope can be constrained by the far-infrared/millimeter spectral energy distribution along with the azimuthally averaged radial intensity profile, and the structure of the outflow cavity plays a critical role at shorter wavelengths. Emission at 20–40 μm requires a cavity with a constant-density inner region and a power-law density outer region. The best-fit model has an envelope mass of 19 M_{sun} inside a radius of 0.315 pc and a central luminosity of 18.8 L_{sun}. The time since collapse began is 24,630–44,000 years, most likely around 36,000 years. The corresponding mass infall rate in the envelope (1.2×10^{-5} M_{sun} yr^{-1}) is comparable to the stellar mass accretion rate, while the mass-loss rate estimated from the CO outflow is 20% of the stellar mass accretion rate. We find no evidence for episodic accretion.

The mass of open star clusters from 3d kinematics data

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We analyse two old open cluster's stellar membership from Milky Way Star Cluster (MWSC) and crosscheck the members with radial velocity data from LAMOST DR2 (Czernik 23 and Berkeley 72). We redetermined the stellar membership of the star cluster by including the radial velocity data. The proper motion data were taken from PPMXL catalogue. We will estimate the mass of open clusters from the 3d kinematics data with no assumption for anisotropy. The star clusters is assumed as a spheric al system and no rotation.

Mass functions and structure of the Galactic clusters

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Open clusters (OCLs) are located in the Galactic disc. It is important to determine their properties and spatial distribution to understand the structure and evolution of the Milky Way. Therefore, investigation of the OCLs and, in particular, the estimation of their physical parameters like age, distance, reddening, size and metallicity are very valuable.

The main aim of this paper is to study the astrophysical behaviour of poorly studied open star clusters using optical and near-IR photometric data. The stellar density distributions and color-magnitude diagrams are used to estimate the geometrical structural parameters (cluster center, cluster radius, core and tidal radii, the distance from the Sun, Galactocenteric distance and the distance from the Galactic plane). The main astrophysical parameters i.e. age, color excesses (using colour-colour diagrams), total mass, relaxation time, dynamical evolution parameter, luminosity and mass function are also derived for these Galactic clusters. The detailed results will be discussed at the time of the meeting.

The Link Between the Polarization and Blueing Effect of the UXOR Type Young Star GM Cephei

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UX Orionis stars, or UXORs, are a sub-type of Herbig Ae/be or T Tauri stars exhibiting sporadic extinction of stellar light due to circumstellar dust obscuration. GM Cep is such a UXOR in the young (~4 Myr) open cluster Trumpler 37 at ~900 pc, showing prominent infrared access, H-alpha emission, and flare activity. Our multi-color photometric monitoring from 2009 to 2017 showed (i) sporadic brightening on a time scale of days due to young stellar accretion, (ii) cyclic, but not strictly periodical, occultation events, each lasting for a couple months, with a probable recurrence time about two years, (iii) normal dust reddening as the star became redder when dimmer, with unusual color behavior near the brightness minima when the star appeared bluer when dimmer (the "blueing" phenomenon), (iv) moderate polarization from 4% to 9% in *g, r,* and *i* bands, with the level of polarization anti-correlated with the brightness in the bright state. The occultation events may be caused by an orbiting dust clump, or a string of dust clumps along one of the spiral arms in the protoplanetary disk. In either case, the clumpy disk of GM Cep signifies the density inhomogeneity in a young stellar disk from grain coagulation to planetesimal formation. We will present the follow-up photometry and polarization results of GM Cep, together with the discussion of the polarization behavior in the wavelength dependence and variation during the different phase of the star.

Proper motion studies of star clusters

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We discuss the results of our ongoing project to determine proper motions of star clusters in our Galaxy. For this aim, we used ground based CCD archive data observed with wide field imager (WFI) mounted on 2.2-m ESO telescope at La Silla, Chile. Proper motions are used to decontaminate background/foreground stars from the cluster sample. This separation becomes evident in the vector-point diagrams leading us to produce cleaner color-magnitude diagrams of the star clusters. Kinematic membership probabilities of the stars are also derived using these proper motions.

Searching for Be Stars in 216 Open Clusters

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The comprehensive survey of Be stars in star clusters of different ages is crucial to understand the formation and evolution of Be stars. We used H-alpha photometry of the Palomar Transient Factory (PTF) to search for Be stars in 216 open clusters. The procedure is as follow: Firstly, H-alpha emitters are selected by using the PTF on-line (Ha656) and off-line (Ha663) photometry. Secondly, the radial density profile, the near-infrared color-magnitude diagram, and the proper motions (PMs) are adopted to identify their memberships. Thirdly, the J-H and H-Ks colors are used to determine Be candidates. In total, we identified 100 Be candidates in 38 of 216 open clusters. Our preliminary results are summarized below: (1) The Be fraction of most clusters with Be stars is below 10%; (2) The clusters with age between $10^{7.5}$ - 10^{8} years have high probability to form Be stars; (3) No mass segregation effect can be found with different ages; (4) Most Be candidates have Mid-infrared color excess, which is similar to known Be stars. We have used SED-machine, BAO 2.16m, BOAO 1.8m, NHAO 2m, YNAO 2.4m and Lulin One-meter telescopes to confirm Be candidates spectroscopically. More results will be present in the meeting.

Mock catalogs for Testing Cluster Detection Algorithm

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To study physical properties of galaxy clusters statistically, mock catalogs are an useful tool for evaluating statistical uncertainties in measurements and quantifying the observational selection bias. We present a set of mock galaxy catalogs designed by using real galaxies identified in the S16A release of Hyper Surprime-Cam (HSC) survey and a halo catalog from N-body simulation. Our mock clusters span the redshift 0.3<z<1.2 with the halo mass $M_{200c} > 10^{13} M_{\odot}$. To mimic realistic observational conditions, we make use of the HSC galaxy catalog in the COSMOS field as the field population and combine it with our mock cluster galaxies, adopting mask regions where no galaxies are in it. We run the CAMIRA cluster finding algorithm on 90 realizations of mock galaxy catalogs and investigate the purity and completeness of the CAMIRA algorithm detected mock clusters. We find that the purity is high and the completeness is correlated with redshift and halo masses.

MIRIS Paschen-α Galactic Plane Survey : Comparison with WISE H II region catalog and IPHAS Hα data in Cepheus

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MIRIS Paschen-α (Paα) Galactic Plane Survey (MIPAPS) presents the first whole Galactic plane (with the width of $-3° < b < +3°$) map for the Paα emission line. Many of Paα features have been detected more brightly than the previous observed Hα features, and they coincide with dense cloud regions. This means that MIPAPS shows H II regions attenuated by foreground dust along the plane well. To check scientific potential of MIPAPS, we have selected a portion, Galactic longitude from +96° to 116° (Cepheus), and compared Paα image with WISE H II region catalog and IPHAS Hα image. We have confirmed Paα detections from about half of the H II region candidates (unknown detections of the Hydrogen recombination lines up to now), and identified them as definite H II regions. If we extend this result to the whole plane, more than 1000 candidates are expected to be identified as H II regions. We also list 35 Paα large features and 32 Paα point-like blobs, which are shown in Cepheus, but uncataloged in the WISE catalog. Using the Paα and Hα mosaic images, we measure MIPAPS Paα fluxes and IPHAS Hα fluxes for some sources detected in Cepheus. From this, we can quantify dust extinction and spectral type of ionizing star for each H II region.

Diffuse Interstellar Bands (DIBs) in the Spectra of B-emission Stars

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A longstanding challenge in astronomical spectroscopy is to uncover the carriers of the diffuse interstellar bands (DIBs). They are broad absorption features observed in stellar spectra of background stars. Although we do not know utterly the carriers of DIBs, they can be a promising tracer of the interstellar medium (ISM). One of the interesting properties of DIBs is their correlation with interstellar extinction. These correlations have considerable dispersion and differences for each band that possibly due to the interstellar physical conditions. Some DIBs are sensitive to the stellar radiation field, and some are not. To study this effect, we measure DIBs observed in peculiar spectra (WR and Be stars) observed by using Bosscha Compact Spectrograph at the Bosscha Observatory, Lembang, Indonesia. We perform an automated fitting of a combination of a smooth stellar continuum, the DIB profile, and a synthetic telluric transmission (if necessary) to the spectrum. The DIBs measurement results will be compared to the general DIBs-extinction relationship.

B-emission stars in Southern Sky: Photometry and Spectroscopic Studies of H-alpha Spectral Lines

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We present H-alpha line variations of B-emission (Be) star candidates. The stars are part of 51 program stars in the southern hemisphere and listed in the Bright Star Catalogues, observed in 2007 – 2009 at the Bosscha Observatory, Lembang, Indonesia. They show spectral line variations, such as the phase changing, from Be double-peaked to Be single-peaked emission lines and vice-versa, and also V/R and E/C variations. The phase changing are detected from the comparison of the observed data to the current data in the BeSS database. We also present the spectral energy distributions of some Be stars observed in 2009 as preliminary works for the photometry of our program stars.

Identification of M giants in the LAMOST DR3

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M giants are red-giant-branch (RGB) stars with low surface temperature and high luminosity in the late-phase of stellar evolution. Its luminous nature allows us to use these stars as good tracers to study the outer Galactic halo and distant substructures. A well classified M-giant stars sample has important scientific values for the statistic research of Galactic structure and evolution. In this work, a set of M giant spectral templates with high signal-to-noise ratio is assembled. Then, we use the template-fit method to automatically identify and classify M giant stars in spectra from the LAMOST DR3. We present a spectroscopic catalog of 24.8 thousand M-giant stars including stellar parameters like photometry, proper motion, radial velocity, metallicity, distance, spectral type and so on. This sample is further used to study the sub-structures and tidal stream in the Galactic Anti-Center.

Superflares relationship with rotational phase of G-type stars

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Solar flare was suggested to be related to the sun-spots based on previous observation of our sun. Superflares(flares with energy > 10^{33} erg) was also observed in extrasolar system (Hiroyuki et al. 2012). To investigate the relation between superflares and the rotation phase, we selected 77 G-type stars from *Kepler* measurments with well-defined light curve periodicities from previous study (Wu et al. 2015). We use the rotation period to transform the light curve into the phase to check which phases were the flares occurred. However, no relation can be found. The flares occur in any phase on the stellar rotation.

Hyper-flares phenomena of M dwarfs

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M dwarfs are known to be magnetically active displaying impulsive energy release effects in terms of stellar flares. According to our previous study (Chang et al 2016.), flare occurrences are highly related with the stellar spin period. Fast rotators (spin period < 20 days) are often found with super-flares or even hyper-flares (> 100% stellar luminosity). To further investigate the hyper-flare phenomena, we extend our sample by selecting 4000 M dwarfs with T*eff* between 2500 to 3900 and Log(g) larger than 4. We discovered that 61 M dwarfs have hyper-flare events among 4000 M dwarfs. Particularly, 7 M dwarfs have hyper-flare events with > 1000% stellar luminosity. The total energy of the events can reach to 10^{35} ergs, which is 10000 times of the M dwarf energy at quiescent state. In this study, we will present more detail of these events.

Nearby triple star HIP 101955

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HIP 101955 with strongly inclined orbit still remains. Thus the long-term dynamical stability is discussed based on the new dynamical state parameters (component masses and kinematic parameters) derived from fitting the accurate three-body model to the radial velocity, the Hipparcos Intermediate Astrometric, and the accumulated speckle data. It is found that the three-body system remains integrated and most likely undergoes Kozai cycles. With the already accumulated high-precision data, the three-body effects cannot always be neglected in the determination of the dynamical state. And it is expected that this will be the general case under the available Gaia data.

Physical Properties of the G-type Eclipsing Binaries from the Kepler Observations

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The Kepler space telescope has observed more than 2000 eclipsing binary (EB) systems during its primary mission between 2009 and 2013. According to the effective temperatures measured by Huber et al. (2014), we have selected about 100 systems with G-type primary stars characterized by Teff ~ 5000K-6000K for statistical study. These classifications are compared to the spectral measurements of LAMOST. Many of the binaries are characterized by the EA (Algol)-type light curves of detached systems. To calculate their spectral types, mass ratio, radius, system incline angles, and orbital distance between the two components in individual EBs, we measured their primary and secondary eclipsing transit depths and effective temperature ratios according to the Kepler data. In some test cases, we can find a best fit of two spectral components from LAMOST spectra. A fraction of the EBs in this sample displayed flare activities. There is an indication that the flare frequency of the G-type EBs tend to be higher than that of the single solar-type stars while the corresponding flare energetics tends to be at lower level. At the same time, some flare effects could have been generated by the M- or K-type companion stars as demonstrated by our statistical study.

Slitless Spectroscopy of the Ultra faint dwarf satellites of the Galaxy: Probing the bright and evloved stellar populations

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According to the Hierarchical Galaxy formation models, low mass galaxies similar to Ultra Faint Dwarfs (UFD) satellites were thought to be the building blocks of the Milkyway halo.
Ultra faint dwarfs are chemically least evolved systems consisting of older stellar populations. Their low Fe abundance indicate that they hosted only one or a few star formation episodes.
So detailed chemical analysis of individual stars in these UFDs will give a unique opportunity to study the nucleosynthetic products of first stars and thereby to probe into the star formation history and chemical enrichment processes in the ealry universe.

Large photometric and spectroscopic surveys similiar to SDSS have been successful in identifying these faint galaxies around Milkyway. Most of the automated photometric searches, use over densities in the HESS diagrams, using a metal poor globular cluster color-magnitude diagrams as a representative population for the UFD stars. They also pre-select the sample using various color cuts to avoid contamination from the foreground stars. Most of these methods identify very few RGB and AGB populations. RGB and AGB members are brighter and can be studied for its detailed chemical abundances, to derive clues of the early stellar population.

We initiated a slitless spectroscopic survey of 6 satellite galaxies using 2m Himalayan Chandra Telescope, India. We detected around 15 new samples in these systems which fall in either RGB or HB group. Among them one is CEMP star another is an NEMP star.
Here we present results of analysis of these interesting candidates and discuss the evolved stellar population of the UFDs that were accessible by the observatory site.

Discovery of New Planetary Nebulae selected from LAMOST Databases

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We report a multi-wavelength study of new planetary nebula (PN) candidates selected from the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (**LAMOST**) databases. We present low/mid-resolution optical spectra of these PNs. The PN status of our sample was confirmed by optical narrow-band images and low/mid-resolution spectra. Based on the locations of these objects in the log (H-alpha/[NII]) versus log (H-alpha/[SII]) diagnostic diagram, we conclude that two of them are PNs. The optical and infrared appearances of these newly discovered PNs are discussed. Furthermore, we derive the dynamical ages and distances of these nebulae and study their spectral energy distributions (**SEDs**) with extensive infrared archival data.

Revealing the Missing Stellar Dust and Gas Masses: Rigorous Photoionization Modeling of Oxygen-rich Planetary Nebulae in the Milky Way

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Material recycling between stars and the interstellar medium (ISM) has chemically enriched galaxies. The total ISM dust and gas masses in evolved galaxies can be compared to the total ejected dust and gas masses from evolved stars. However, the analysis of the stellar dust mass yield in galaxies has uncovered discrepancies. In the Magellanic Clouds, the amount of dust produced by Asymptotic Giant Branch (AGB) stars and Supernovae (SNe) accounts for only about 2-3 % of the total ISM dust mass. However, these dust recycling studies may have some fundamental problems; as they compared the different temperature dust components and adopted unconstrained constant gas-to-dust mass ratios (GDRs). In the Large Magellanic Cloud, the hot stellar dust component (~200 K) is compared with the cold ISM dust estimated using the cold H I/H2 gas (~15 K) and unjustified GDR. Using far-IR data, Matsuura et al. (2011, Science, 333, 1258) found a warm-cold dust mass of 0.4-0.7 Msun in SN1987A, which is 400-700 times the amount of the hot dust mass previously estimated from the mid-IR data. Thus, investigating the warm-cold stellar dust using far-IR data and the GDRs is important to understand material recycling in galaxies. Planetary Nebulae (PNe) represent the next evolutionary step after the AGB phase, and we have investigated over 100 Galactic PNe to quantify the dust and gas masses by SED fitting with data from UV through far-IR. We present our results on the correlation between the GDR and metallicity in gas and dust oxygen-rich PNe.

Extended 1.644 μm emission-line sources in the UWIFE Survey

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The UKIRT Widefield Infrared Survey for Fe+ (UWIFE) is an unbiased survey of the first Galactic quadrant, with narrow-band filter centered on 1.644 μm. This survey covers $7° < l < 62°$ and $|b| < 1.5°$, where active interaction of stars and interstellar medium is expected. With median seeing of 0.8 arcsec, 5 – sigma detection limit of 18.7 mag and surface brightness limit of 8.1×10^{-20} W m^{-2} $arcsec^{-2}$, this survey gives an opportunity to statistically study Galactic [Fe II] – emitting sources for the first time. In order to identify Ionic Fe Objects (IFOs) in survey area systematically, we conducted visual inspection and automatic detection simultaneously. Total of ~300 extended IFOs are identified, most of them are found out to be part of supernova remnants (SNRs), young stellar objects, HII regions and planetary nebulae. The majority of IFOs are new discoveries which reveal shocked structures in high-extinction region. Spatial distribution of IFOs suggest that they trace Galactic structure.

As a part of spectroscopic follow-up, we observed SNR candidate IFO J183740.829-061452.41 with IGRINS (Immersion Grating Infrared Spectrograph, Yuk+2010), mounted on 2.7m Harlan Smith telescope. This unknown arc-like, 6' - long IFO is coincident with inner part of radio continuum loop G25.8+0.2, which has been known as HII region. However, interior of this radio shell is filled with extended soft X-ray emission, and possible association of hard X-ray pulsar / pulsar wind nebula makes the nature of the IFO unclear. The H and K-band 2D spectrum shows shock-ionized [Fe II] filaments, which is apart from photoionized HII filaments. In this presentation we present basic statistics of newly identified IFOs, as well as the follow-up study of IFO J183740.829-061452.41.

JVLA and Chandra Observations of SNR G16.7+0.1

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We report on the analysis of JVLA and Chandra data of
shell-type supernova remnant (SNR) G16.7+0.1 and Pulsar Wind Nebula (PWN) G16.73+0.08.
X-ray observation allows us
analyze the feature of the PWN and its possible central point source and obtain
their physical parameters (e.g. absorption column density (NH)). HI continuum and HI-
line observations bring reliable HI absorption spectrum to the SNR. OH observation to
G16.7+0.1 confirms detecting a 1720 MHz maser of v = $approx$20 km^{-1} at its
southern shell which supports exiting an interaction between SNR shock and surrounding
molecular cloud. ^{13}CO image towards SNR G16.7+0.1 reveals a broadened CO cloud at
about 25 km^{-1} which validates above claim of an SNR-cloud interaction. The HI
absorption spectrum, the 1720 MHz OH maser and the broadened CO feature all together
solid the remnant's distance of d $~$ about 13.5 kpc, i.e. the far side distance of
20 km^{-1}. The NH-d ratio constrains the NH/Av relation along the line of sight
towards G16.7+0.1

Diversities of Type Ia supernovae

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Introduce the study of SNe Ia diversity though the observation at Lijiang 2.4m telescope. Basing on the relation among SNe Ia progenitor, explosion mechanism, environment and observational diversity, we are going to find out the origination of SNe Ia diversity and reduce the systematic errors in SNe Ia cosmology.

A Study of Stellar Gyrochronology by Using the PTF and K2 Data

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Chang H.Y. et al. (ApJ, 2016) showed that flare activities of the M dwarfs correlates with their corresponding chromospheric Hα emission by analyzing the LAMOST and Kepler K1 data. Stars with rotation periods shorter than 20 hours usually exhibit enhanced Hα emission and frequent occurrence of large flare events. This is consistent with the gyrochronological relation describing the age effect of stellar magnetic activity. To further the flare phenomenon of the M dwarfs might be important to the development of biospheres of Earth-like exoplanets in the habitable zones, we have initiated a project to estimate the Hα emission strength of M dwarfs using the Palomar Transient Factory (PTF) data archive. So far, we have found a considerable amount of M dwarfs which are all included in the PTF Hα data archive and K2 catalog in just one Campaign of K2. We examine that if the PTF Hα photometric measurements can yield similar results as obtained in medium resolution spectral observations. In the future, we plan to apply this method to M dwarfs in open clusters from which age dependence of the gyrochronological relation can be better understood.

Keywords: Stellar Gyrochronology, H-alpha, M dwarfs, Kepler K2, PTF, Exoplanets, Habitable zones

Study Orbital Period Change and Physical Property of Eclipsing Binary Syatem W Ursa Majorit-Type V1853 Ori.

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V1853 Ori is a W Ursa Majoris type eclipsing binary system. Observations were done at Regional Observatory for the Public Chachoengsao, using a 0.7 Telescope mounted with CCD photometric system in b, v and r in March, 2017. MaxIm DL5 Program was used for photometry measure, PHOEBE 0.31a Program was used to calculate parameter and build the model. The result from light curve to this binary star was a period orbital of 0.382999411 day. The value of time its light minima, were used with the previously published times of minima to get O-C diagram of V1853 Ori. The new linear ephemeris equation. Conclusion, from the analysis of physical parameters and model, V1853 Ori were a contact binary star with incllnation (i) = 84.026269±0.621122 and mass ralio (q) = 0.227449±0.003038 . This would be the evolution of V1853 Ori would be a single star due to mass transfer of the system.

Variable stars in the region of open cluster NGC 457

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Through time-series BV CCD photometry of the open cluster NGC 457 region, I have detected above 60 variable stars including 14 members of NGC 457. They are a beta Cep, 5 SPBs, 14 delta Sct variables, 16 binaries, 25 semi-long periodic or slow irregular variables and an RR Lyrea variable star. I have performed multiple-frequency analysis to determine pulsation frequencies for the delta Sct variables and SPBs, and phase fitting process to obtain periods for the binaries and semi-long periodic or slow irregular variables. I present the results, and observing and reducing processes.

On the dust-production rates of AGB stars in the Solar Neighbourhood

Alfonso Trejo, Ciska Kemper, Sundar Srinivasan, Peter Scicluna

Asymptotic Giant Branch (AGB) stars are a very important contributor to the total dust mass injected into the ISM in galaxies.
Good estimations of the dust mass injection by AGB stars in the Magellanic Clouds have been achieved using Spitzer data (Srinivasan et al, 2016). However, the last estimate of the dust injection rate in the Milky Way was done in the late '80s for a non-all sky sample (Jura & Kleinmann 1989).
In this work we revise the total dust mass-loss rate from AGB stars in the Solar neighborhood using a distance-limited sample.
It remains especially hard to evaluate precise distances to dusty AGB stars in the Milky Way, as the highest mass-loss rate objects have not been included in the Hipparcos catalogue, due to circumstellar extinction.
Using present-day all-sky infrared facilities (WISE, 2MASS, AKARI), we have constructed spectral energy distributions for all AGB stars within 1 kpc from the Sun. We make use of the GRAMS model grid to estimate the dust production for this sample of AGB stars.
Preliminary results show an increase in the number of known dusty objects within 1 kpc. An integrated dust production rate of ~ 10^-5 Msun/year or an average of ~ 10^-7 Msun/year per object is obtained, which does not seem to change for several sub-samples covering different distances. The result for the Solar Neighborhood will be extrapolated for the entire Milky Way, using a suitable stellar distribution function.
This work is a step towards more reliable determinations of the mass loss of AGB stars, and it aims to provide new insight on the discrepancy between the dust mass produced by AGB stars and that estimated to be present in the ISM.

H-BAND TIME-SERIES OBSERVATIONS OF CLASSICAL CEPHEIDS IN M33

Chien-De Lee[1]; Chow-Choong Ngeow[1]
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Cepheid variables are crucial standard candles for distance estimation from intragalactic to intergalactic scale. A precise and accurate measurement of distance beyond our Milky Way narrows down the error budget of Hubble constant determination and better constraining the properties of dark energy. M33 is the second nearest major galaxy harboring at least several hundreds Cepheids with plentiful observation in optical wavelengths. Therefore, M33 deserves to be on the list of the primary anchoring galaxies. However, the near-infrared observation is very sparse, despite it provides advantages including less effect of extinction and small-amplitude light curve making mean magnitude estimation easier. Here, we present a preliminar result of the long period Cepheids in M33 and their mean magnitude in H-band WIRcam on the CFHT.

THE LAMOST SPECTROSCOPIC SURVEY OF SUPERGIANTS IN M31 AND M33

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We present systematic identifications of supergiant of M31/M33 in LAMOST spectroscopic survey. Radial velocities of nearly 1500 individual photometric candidates were derived from the spectra with signal-to-noise ratio greater than 5 observed by LAMOST in its past three years spectroscopic survey. By comparing the radial velocities of the ~1200 targets and those expected from M31/M33's rotation curves, we identify 96 rank-1 (near certain; 55 for blue supergiants, BSGs; 38 for yellow supergiants, YSGs; 3 for red supergiants RSGs), 62 rank-2 (probable; 16 for BSGs; 45 for YSGs; 1 for RSGs) supergiant members of M31 and 33 rank-1 (15 for BSGs; 16 for YSGs; 2 for RSGs), 74 rank-2 (18 for BSGs; 55 for YSGs; 1 for RSGs) supergiant members of M33. So far, this is the largest supergiant sample of M31/M33 with spectra covered the full optical range (e.g. $3700<\lambda<9100$Å). These optical spectra will allow us to derive detail physical properties of those supergiant members and thus to constrain the stellar evolution model of massive stars.

Refining period of a Mira in M33 with multi-band analysis.

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[HBS 2006] 40671 is a confirmed long period Mira found in M33. Using observed light curves from Hartmann et al (2006) data, Barsukova et al. (2011) found a period of 665 day for this Mira. In addition to Hartmann's data (2005~2006), we also collected PTF (Palomar Transient Factory) data taken from 2009 to 2016. Combining these two datasets that spanned ~10 years we can refine the period of this Mira. The preliminary results show that the period of [HBS 2006] 40671 could be 503 days. In addition to Hartmann's data and PTF data in R band, several nights of LOT data were collected in R band and I band. We combined these datasets spanned in different bands and refine the period further using the multi-band Lomb-Scargle method and the method proposed in He et al. (2016). We also collected a number of confirmed Miras in I band with periods similar to our target in LMC and SMC from OGLE database to compare to our target. According the Mira of OGLE database we found majority of Miras are multi-periodic, hence we also tried to find out the additional periods with our method. In this poster, we present our lasted investigation on the period refinement of this Mira.

Investigations of warm-cold dust mass and gas-to-dust mass ratio in Large Magellanic Cloud Planetary Nebulae

Masaaki Otsuka[1]; You-Hua Chu[1]
[1]*ASIAA*

Material recycling between stars and the interstellar medium (ISM) has chemically enriched galaxies. The total ISM dust and gas masses in evolved galaxies can be provided by total ejected dust and gas masses from evolved stars. However, this view has been recently questioned by analyzing the stellar dust mass yield in the Magellanic Clouds (MCs); the amount of dust mass produced by asymptotic giant branch (AGB) stars and supernovae can account for only about 2-3 % of the total ISM dust mass in the MCs. Investigation of the cold stellar warm-cold dust component using the far-IR data and the gas-to-dust mass ratio (GDRs) would be necessary to understanding material recycling in galaxies. By taking several advantages of PNe, we started a pilot study on the warm-cold masses and the GDRs in LMC PNe, which are detected in far-IR Herschel/PACS and/or Spitzer/MIPS bands. In this presentation, we quantify the dust and gas masses by SED fittings with UV through far-IR data, characterize PNe and their central stars' evolution using metal abundances and central stars' parameters, compare the dust masses with/without far-IR data, and investigate the correlations amongst the dust masses, GDRs, and the metallicities. This work is supported by the research fund 104-2811-M-001-138 and 104-2112-M-001-041-MY3 from the Ministry of Science and Technology (MOST), R.O.C.

New orbit and physical parameters of RX Hydrae binary system

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We present new medium and high-resolution spectroscopies of RX Hya – a bright (B = 9.78), Algol-type system with a pulsating component. eShel spectroscopies were obtained using 2.4m telescope at the Thai National Observatory (TNO), Thailand and 1.8m telescope at the Bohyunsan Optical Astronomy Observatory, Korea. Photometric observations were acquired using Thai Southern Hemisphere Telescope (TST, PROMPT-8) at Cerro Tololo Inter-American Observatory (CTIO) in Chile. Least-Squares Deconvolution (LSD) technique was used to construct high S/N profiles of components. For the first time, we detected and measured the radial velocity orbit of a weak secondary component. We found the basic parameters of the binary system and components using the simultaneous solution of the radial velocity and light curves.

EVOLUTIONARY STATUS OF β AURIGAE

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β Aurigae (β Aur) is a well-known detached binary which is a double-lined spectroscopic binary and also an eclipsing binary. A spectroscopic observation were carried out in order to analyze the chemical abundances of β Aur. The spectra were obtained using 1.5 m telescope and Gunma Astronomical Observatory Echelle Spectrograph (GAOES) with a spectral resolution of 75,000 at Gunma Astronomical Observatory, Japan. Using these echellogram data combining with some photometric results from previous authors, we present the evolutionary status of the two components of β Aur which have been calculated using our parameters and we also compare a several numerical simulations of the conservative and the non-conservative models. Mass transfer is also included in the simulations. The non-conservative model considered the mass and angular momentum losses from the system via a stellar wind. At the end, we discuss the compatibility between our model and the observational data.

Key words: binaries: eclipsing – binaries: spectroscopic – stars: evolution – stars: individual: β Aurigae – stars: mass-loss – techniques: spectroscopic

The THASSOS survey on oEA stars

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We present the THASSOS (THAi Sky Survey for oEA Stars) survey project status report on discoveries of new pulsating components in Algol-type systems (oEA stars). Analyses of 10 systems with their primaries ranging between A-F spectral types revealed pulsations occurrence in two of them, namely VY Hya and GQ TrA. GQ TrA has a rich oscillation spectrum that consists of 13 frequencies and is a very promising target for further asteroseismic studies. We present also a detailed study of the oscillation properties of other known oEA stars, namely AS Eri, VV UMa, Y Leo, and LT Her. Current results suggest that the portion of oEA stars among the Algols with A-type components is about 20%.

Study of Embedded X-ray Brown Dwarfs in the Young Star Cluster IC 348

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Brown dwarfs have masses (15-80 M_{Jup}) below that required to maintain core hydrogen fusion. Such a substellar population in star-forming regions is the critical first step to understand their formation mechanism (do they form like stars, or like planets?). The sample also serves to bridge the knowledge of free-floating planets versus exoplanets. We have identified brown dwarf candidates via imaging detection of possible water absorption, one of the characteristics of cool atmospheres, in the young (3-Myr) star cluster IC 348. Some of these are matched with X-ray sources and also with JCMT 850-micron emissions, thus are magnetically active brown dwarfs in their infancy. These embedded X-ray brown dwarfs have $Lx/Lbol \geq 10^{-5}$-10^{-4}, to be compared with other young stellar populations such as 10^{-4} for typical T Tauri stars, and 10^{-4}-10^{-6} for Herbig Ae/Be stars, or with 10^{-7} for OB stars. While late-M dwarfs are expected to be fully convective, as is the case in dMe stars, to be X-ray emitters, even cooler L and T type brown dwarfs and planet-mass objects may have largely neutral atmospheres, hence unlikely to activate magnetic dynamos. Our brown dwarf sample is the most comprehensive a young star cluster, and we present their spectral typing, X-ray and submillimeter properties.

Keywords: brown dwarfs, open clusters and associations: individual (IC 348), X-rays.

[2017 APRIM abstract]

The Centroid Shift of Sgr A*

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Abstract Topic
Galactic Center; Sgr A*; Supermassive Black Hole; Jet;
VLBI; Core shift; Astrometry

Abstract
The Galactic center, Sagittarius A* (Sgr A*), is the closest supermassive black hole (SMBH) and emits synchrotron radiation. It provides great opportunity to study the origin of mm/sub-mm emission. Currently, two competing models have been suggested as a jet base and a radiatively inefficient accretion flow (RIAF). To unveil the properties, the extremely high resolution (~10 μas) corresponding to the projected Schwarzschild radius of ~0.1 AU is necessary. The very-long-baseline-interferometry (VLBI) allows us to reach such an innermost region of SMBH. At the same time, a jet model can be tested by multi-frequency observations because the optically thick surface in a jet (i. e. radio core) moves toward the center at a higher frequency. The Korean VLBI Network (KVN) is one of the best VLBI arrays to study the core shift, thanks to its quasi-optics system at four frequencies (i. e. 22 ,43, 86 and 129 GHz). It enables to calibrate the phase of target source at higher frequencies using the solution of bright/compact calibrator at lower frequency (so called, source frequency phase referencing (SFPR) technique), so that the precise astrometric studies are available. Therefore, we conducted several observations for Sgr A* using KVN and found the positional shift of its center at different frequencies. We present our recent results of the Sgr A* centroid shift measurements and discussions to remove the residual positional (i. e. phase) uncertainties.

Millimeter VLBI observations of Sgr A* with KaVA and EAVN

Guang-Yao Zhao and EAVN AGN science work group
East Asia VLBI workshop

Abstract: We present recent observation results of Sgr A* at millimeter obtained with VLBI arrays in East Asia.
7 mm monitoring of Sgr A* is part of the KaVA AGN large project. The results at 10 epochs during 2013-2015, including high resolution maps, flux density and two-dimensional size measurements will presented. The source shows no significant variation in flux and structure related to the G2 encounter in 2014. According to recent MHD simulations by kawashima et al., flux and magnetic field energy can be expected to increase several years after the encounter; Our monitoring will be continued in order to test this prediction.
In 2017, this program has been upgraded into East Asian VLBI Network monitoring program. The sensitivity of EAVN will be at least 3 time higher than KaVA. We will be able to detect faint refractive substructures and possibly a magnetar very close to the central SMBH. Details of the new observations and preliminary results will be presented.

Radiative mechanism for hard X-ray emissions of high synchrotron peak blazars

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The x-ray emissions of low synchrotron peaked BL Lacs is dominated by inverse Compton emissions, while the that of high synchrotron peaked BL Lacs is dominated by sychrotron emissions. Therefore, there is an apparent sequence that the X-ray spectra becomes softer from LBL to HBL. For some BL Lacs, the X-ray spectra presents a concave shape which is believed to be combined emissions from sychrotron and SSC emissions. In this talk, we presents a detailed study on the radiative mechanism of X-ray emissions of HBL to see does this consist with that sequence.

Propagation of exponential shock wave in an axisymmetric rotating non-ideal dusty gas

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One-dimensional unsteady isothermal and adiabatic flow behind a strong exponential shock wave propagating in a rotational axisymmetric mixture of non-ideal gas and small solid particles, which has variable azimuthal and axial fluid velocities, is analyzed. The shock wave is driven out by a piston moving with time according to exponential law. The azimuthal and axial components of the fluid velocity in the ambient medium are assumed to be varying and obeying exponential laws. In the present work, small solid particles are considered as pseudo-fluid with the assumption that the equilibrium flow-conditions are maintained in the flow-field, and the viscous-stress and heat conduction of the mixture are negligible. Solutions are obtained in both the cases, when the flow between the shock and the piston is isothermal or adiabatic by taking into account the components of vorticity vector and compressibility. It is found that the assumption of zero temperature gradient brings a profound change in the density, axial component of vorticity vector and compressibility distributions as compare to that of the adiabatic case. The effect of the parameter of non-idealness of the gas in the mixture, the mass concentration of solid particles in the mixture and the ratio of the density of solid particles to the initial density of the gas are worked out in detail. Also, a comparison between the solutions in the cases of isothermal and adiabatic flows is made. The shock waves in non-ideal rotating dusty gas can be important for description of shocks in supernova explosions, in the study of a flare produced shock in solar wind, central part of star burst galaxies, nuclear explosion, rupture of pressurized vessel, in the analysis of data from exploding wire experiments, and cylindrically symmetric hypersonic flow problems associated with meteors or reentry vehicles, etc.

Time-dependent Pattern Speeds in Double-barred Galaxies

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With high resolution N-body simulations, we explore the formation and evolution of these systems based on initial galaxy models dependent on the disk thickness and disk kinematics. We show that for suitable initial conditions the lifetime of double-barred galaxies can exceed 3.5 Gyr, which is compatible with the high frequency of double-bar galaxies. We study their dynamics and determine the evolution of their respective pattern speeds. It is found that the pattern speeds and the effective potential neighboring the corotation resonance region are strongly time-dependent in any rotating frame.

Gauss‘s Law of Gravity With Anisotropic Field Flux Distribution to Interpret the Rotation Curves of Disk Galaxies

Te Chun Wang[1]
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The flat rotation curve of disk galaxies has long been considered as one of the key observations to support the dark matter model. The velocity of many outskirt stars orbiting the center of the disk galaxies were found to keep nearly unchanged as the orbit radius increases. This report shows that a Gauss’s law of gravity with an anisotropic flux distribution on a non-spherical Gaussian surface, in which the luminous disk is enclosed, may well describe such flat rotation curves of disk galaxies. It is pointed out that a disk-shaped, or a shallow columnar symmetric gravitatioinal flux distribution, with a fraction of the total gravitational flux of the galaxy being located on the side wall belt surface of the disk, may convert the inverse square radius dependence of the Newtonian gravitational field into a direct inverse radius dependence along with an inverse disk thickness dependence. The flat rotation curve condition corresponds to a limiting case that the gravitational flux per unit length of the Gaussian disk thickness keeps constant as the orbit radius increases.

On Anisotropic Gravitational Field Flux Distribution and a Possible New Role of Thickness in Disk Galaxies

Te Chun Wang[1]
[1]*Chung Shan Industrial and Commercial School*

It is shown that the Newtonian gravitational field with inverse square distance dependence can be altered into a simple inverse distance dependence by using Gauss's law of gravity with a disk shape Gaussian surface in which the galaxy disk is enclosed. The flat rotation curves of disk galaxies may be explained by this anisotropic gravitational flux distribution model without the need for dark mass. The galactic disk thickness variation may cause rotation velocity to vary correspondly. The disk thickness dependent variation of rotation curve is discussed as an example for low surface brightness galaxies within this Gauss's law framework. Other possible consequences induced by the anisotropic gravitational flux distribution are examined.

On the Distinct Mass-size Relations between Normal and Dwarf Early-type Galaxies

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The mass–size scaling relation of galaxies is a crucial product of their formation histories. The distinct sequences defined by 'normal' (steep relation) and 'dwarf' (shallow) early-type galaxies (ETGs) has raised an intriguing question of how different their growth histories are. Here we explore the evolutionary pathways of the two types of ETGs by utilizing the mock galaxy database from the Illustris cosmological hydrodynamic simulation. We find that, in the past at $z \sim 2$ the normal ETGs used to populate along a shallow sequence that is remarkably similar to the dwarf-ETG sequence at $z \sim 0$. The fast growth afterward, however, has created the current steep mass–size relation of the normal ETGs. We show that such fast growth is most likely involved with the dry merger, by which galaxies grow in size more effectively than the wet merger. The steep sequence of the normal ETGs on the mass–size plane implies that the dry merger has been more important than previously thought in the histories of massive galaxies.

The Physical Characteristics of Interstellar Medium in NGC 3665 with Herschel Observation

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abstract:

We present Herschel PACS and SPIRE photometry and spectroscopy to study physical characteristics of the interstellar medium (ISM) in NGC 3665. The photometric observations are obtained at 100, 160, 250, 350 and 500 μm, and the far-infrared (FIR) spectroscopic observations are focused on the five fine-structure lines of [N II] 122 and 205 μm, [C II] 158 μm, [O I] 63 μm, and [C I] 370 μm, which are important coolants in the thermal balance of gas in the ISM. We use spectral energy distribution (SED) model to determine the NGC 3665 containing high stellar mass and rich dust, with the dust mass ($M_{dust}/M_* \sim 1.2 \times 10^{-4}$) nearly two orders of magnitude larger than local ETGs at fixed stellar mass. The heating efficiency of the gas in PDRs, diagnosticated by the ([C II]+[O I]63)/F_{TIR} line ratio, is $(1.03 \pm 0.06) \times 10^{-3}$, which is relatively lower than the previous studies. We conclude the dust-rich disk is the root cause of the lower heating efficiency. Based on the [N II] 122/[N II] 205 ratio, the electron density (n_e) in H II regions is 49.5 ± 11.9 cm^{-3}. Using the [C II]/[N II] 205 ratio, we calculate that ~43% of observed [C II] emission originates from ionized gas region. Compared the observed FIR emission line ratios with a theoretical model, we derive two physical parameters in the photodissociation regions (PDRs): the hydrogen nucleus density, $n \sim 10^{3.75}$ cm^{-3}, and the strength of FUV radiation field, $G_0 \sim 10^{-0.25}$. The result is reasonable for the effect of strong dust extinction, although NGC 3665 contains a certain amount of young stars with a week AGN. The star formation rate (SFR) is 1.73 ± 0.09 $M_\odot$ yr^{-1}.

The effect of environment on the evolution of galaxies as traced through neutral hydrogen observations

Virginia Kilborn[1]
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There are many indications in the local universe that the local environment within which a galaxy lives affects its evolutionary path. For example galaxy morphology, star formation, and gas richness are all observed to vary according to environmental parameters. Neutral atomic hydrogen (HI) is an excellent tracer of interactions and physical processes occurring in galaxies, enabling us to observe first-hand events such as gas-stripping, tidal interactions, and hydro-dynamical processes that are acting on the gas. When combined with other indicators such as star formation rate, this can elucidate how galaxies are transformed in dense environments. Next generation telescopes such as the Australian SKA Pathfinder will provide thousands of resolved maps of the HI distribution galaxies in the local universe. I will outline the state of the art research in this area, and how next generation telescopes will help us to untangle the physical processes acting on galaxies in the local universe.

A unified model for the spatial and mass distribution of subhaloes

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N-body simulations suggest that the substructures that survive inside dark matter haloes follow universal distributions in mass and radial number density. We demonstrate that a simple analytical model can explain these subhalo distributions as resulting from tidal stripping which increasingly reduces the mass of subhaloes with decreasing halo-centric distance. As a starting point, the spatial distribution of subhaloes of any given infall mass is shown to be largely indistinguishable from the overall mass distribution of the host halo. Using a physically motivated statistical description of the amount of mass stripped from individual subhaloes, the model fully describes the joint distribution of subhaloes in final mass, infall mass and radius. As a result, it can be used to predict several derived distributions involving combinations of these quantities including, but not limited to, the universal subhalo mass function, the subhalo spatial distribution, the gravitational lensing profile, the dark matter annihilation radiation profile and boost factor. This model clarifies a common confusion when comparing the spatial distributions of galaxies and subhaloes, the so called “anti-bias”, as a simple selection effect.

THE VIRUS-P EXPLORATION OF NEARBY GALAXIES (VENGA): POSSIBLE EXCITATION SOURCES OF DIFFUSE IONIZED GAS IN EDGE-ON GALAXY NGC4013

Man I Lam[1]; Lei Hao[1]; Rongxin Luo[1]; Weizhe Liu[1]; Ramya Sethuram[1]
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NGC4013 is a notable HI warped galaxy with extraplanar ionized gas layer away from the stellar disk. In the previous study of Miller & Veilleux (2003), they found the excitation sources of eDIG are quite complicated in this galaxy. In this paper, we present the integral-field-spectroscopy (IFU) studies of this galaxy, by using the data from VIRUS-P Exploration of Nearby Galaxies Survey (VENGA). In the nucleus region, we find the wide opening angle bipolar structures of [N II]/Hα and [OIII]/Hβ ratio extended to 2.3 kpc, indicated the high enhancement of ionization state in galaxy center. In contrast, the [SII]/Hα ratio shows the blob structure parallel to the galaxy mid-plane. This may revealed that the intrinsic
excitation differences between [NII] and [SII]. By the map of Hα/[NII] and Hα/[SII], the eDIG regions fall
into supernovae remnant region, however, eDIG of center partially moves to the pAGB region. By using the
MAPPINGS model, we find the higher [NII]/[SII] can be explained as the shock heated region, which located
in the galaxy center and spread to the halo. Combined to morphology and excitation states in the galaxy disk, the shock from supernovae may be the most possibly excitation object of the galaxy eDIG, however, the
contribution of pAGB stars should be considered in bulges or early-type galaxies

The Effects of Ram Pressure by Intergalactic Gas on Dwarf Galaxies

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Ram-pressure stripping (RPS) is a well observed phenomenon of massive spiral galaxies passing through the hot inter-galactic medium (IGM) of galaxy clusters. Since the dominant morphological type of galaxies in clusters are gas-free early-type dwarf galaxies (DGs), these must have suffered gas evacuation during their lives for which gas stripping by ram pressure of the IGM is most favorable. RPS of DGs can, however, not be observed at the same regions as for massive spirals, because for low-mass DGs it must happen already in the outskirts of clusters. In fact, since the last decade a few DGs in ram-pressure transformation are observed.

Although this RPS process sounds analytically simple, various structures are observed in DGs allowing for total gas evacuation but also partial gas stripping only. Surprisingly, in contrast to spirals DGs show star formation (SF) in stripped gas clouds. In addition, SF seems to be partially enhanced and centrally concentrated by the ram pressure as witnessed by blue cores in some early-type DGs. RPS seems also to act in the field, visible as cometary DGs.

From these observational facts a bunch of questions must be addressed to the theoretical understanding, as e.g. when, where, and how the gas is stripped-off from DGs, how the interstellar medium in DGs is affected by the ram pressure, how gas-rich DGs are already influenced when they move through low-density IGM, etc.

We tackle these questions by means of numerical simulations of the RPS acting on DGs, applying the massively parallel AMR code FLASH. Exciting results are obtained regarding SF triggering and the survival of interstellar gas of which the physical causes must be discussed.

The baryonic mass-size relation of late-type galaxies

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Disk galaxies exhibit tight scaling relations among their mass, size, and rotation speed. These observed scaling relations put stringent constraints on theories of galaxy fomation and evolution. Studies on the relation between stellar mass and size of late-type galaxies found the slope of the stellar mass-size relation depends on stellar mass. At low-mass end, the size only weakly depends on stellar mass, $R \sim M_{star}^{0.1-0.2}$. The slope steepens at high-mass end, reaches $R \sim M_{star}^{0.3-0.4}$. The slope also depends on the morphological type, where galaxies of later morphological types have shallower slope in the stellar mass-size relation. The scatter in R at fixed M_{star} is also mass-dependent; the scatter increases at low-mass end.

Using the 3-micron images from the Wide-field Infrared Survey Explorer (WISE) and the Spitzer space telescope, and the HI 21 cm line emission from the Arecibo Legacy Fast ALFA (ALFALFA) survey, I derive the stellar and gas mass, and disk size of ~1,000 late-type galaxies in the local Universe. I demonstrate that the stellar-mass size relation is an incomplete representation of a more fundamental, underlying baryonic mass-size relation. Once the gas mass is taken into account, the relation between baryonic mass and size of late-type galaxies is a single power law across ~4 orders of magnitudes in mass. The scatter in R at fix baryonic mass M_b is constant at all M_b. The varying slope and scatter in the stellar mass-size relation is naturally explained by the gas fraction as a function of stellar mass and morphological type.

Slightly Deformed Spherical Systems in Modified Newtonian Dynamics

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Modified Newtonian dynamics (MOND) is very competitive to dark matter theory in explaining the missing mass problem in astronomy. As a modified gravity theory MONDian potential satisfies a nonlinear Poisson equation which is hard to analyse except for some highly symmetric cases. Here we put forward a scheme to solve slightly deformed spherical systems. The scheme is based on a compatibility condition derived from the curl free condition on the Newtonian and MONDian fields.

Studying Sersic indexes and effective radii of galaxies with Lulin One-meter Telescope (LOT)

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Sersic index and effective radius of a galaxy reflect its structure and light profile. They are important parameters for the study and classification of galaxies, e.g., some studies found that there is a relation between the Sersic index and the central black hole mass of galaxies. We observe hundreds of nearby galaxies using Lulin One-meter Telescope. The profile of each galaxy is analyzed by *GALFIT*. Result on the Sersic indexes and effective radii of these galaxies will be presented.

HI and optical properties of Low Surface Brightness galaxies : Spirals, dwarfs and Irregulars

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We present a study of the HI and optical properties of nearby Low Surface Brightness (LSB) galaxies. We have derived a large sample of 898 LSB galaxies from the literature and divided it into the morphological typesof spirals, dwarfs and Irregulars. Our aim is to understand how different these galaxies are from normal, High Surface Brightness (HSB) galaxies in terms of their HI gas properties, stellar discs and environments and whether among the LSBs, spirals are distinct from dwarfs and Irregulars. We have compared , e.g. their total HI masses, stellar masses,optical colors and color magnitude plot with those of HSB galaxies, and explored whether they are located in more isolated environments. Our results indicate that LSB dwarfs and irregulars are generally distinct from LSB spirals, both in terms of gas to stellar mass ratios and environment.

Spectral Analysis of SN 2011fe in M101

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We present some results of spectral analysis for Type Ia supernova SN 2011fe in M101, which was discovered by the Palomar Transient Factory on August 24 2011 UT. We performed spectroscopic observations for SN 2011fe at Bohyunsan Optical Astronomy Observatory with the high resolution echelle spectrograph BOES attached to 1.8-m reflector. Our spectra was obtained for 18 epochs from September 6 2011 to April 1 2012 UT. Along with spectral feature variations for several significant lines the interpretations will be discussed.

Statistical Analysis of Interacting Galaxy Pairs: the Spin–Orbit Alignment

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The galaxy-galaxy interaction plays a key role in galaxy evolution. Among many parameters involved, the spin–orbit orientation, the angle between the spin vector of a galaxy and the orbital angular momentum vector of an intruder, can affect the morphology and the star formation activity of the galaxies. Here, we present a statistical analysis of the gas spin–orbit orientation of interacting pairs, using the state-of-the-art cosmological hydrodynamic simulations, EAGLE and Illustris. On the one hand, we find that interactions between galaxies ($>10^9$ $h^{-1}M_{sun}$) are preferentially prograde, i.e. the vectors of spins and orbits tend to be aligned. The prograde fraction is as high as ~70 %. The prograde fraction slightly increases as either the galaxy mass or the mass ratio increases. We speculate that galaxies acquire their spin from the aligned angular momentum of the interacting neighbors. On the other, we show that the gas spin orientation strongly correlates with the star formation properties of the two involved galaxies. The spin–orbit alignment is stronger when both galaxies are star-forming, and the trend becomes more evident for closer pairs. Star-forming galaxies favor the prograde paths, while quiescent galaxies are more randomly oriented. We discuss the possible origins of the causal connection between the star forming/quenching activities and the spin–orbit orientation.

The 4th most important parameter of the fundamental metallicity relation of star-forming galaxies

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A tight relation has been observationally known among star formation rate, metallicity, and stellar mass of star-forming galaxies. The relation is among three of the most fundamental physical properties of galaxies. Thus it has been called as 'fundamental metallicity relation' (FMR), and had profound implications to galaxy formation and evolution models. However, there still remained considerable amount of dispersion around the FMR. Here we show, the 4th parameter, size of galaxy, reduces the dispersion around the FMR. Out of a principal component analysis of 27 physical parameters of 41,338 star-forming galaxies from the Sloan Digital Sky Survey ($0.04 < z < 0.1$, $8.3 < \log M_* < 11.3$, $-1.0 < \log SFR < 1.5$), the galaxy size is found to be the 4th most important parameter. The new fundamental metallicity relation including the size forms a tighter hypersurface in the 4D parameter space, reducing the metallicity dispersion to 40%. Based on the results, we suggest the size as the 4th most important property governing the physics of star-forming galaxies. A benefit of the size is that it can be easily measured from imaging data, and thus is widely available. We suggest future galaxy evolution analyses and models consider the FMR in 4D space, including the size. One possible physical explanation of the size dependence is higher star-formation efficiency in smaller galaxy at fixed stellar mass. This suggests the second-order `upsizing' effect, i.e., smaller galaxy evolved earlier than larger galaxy at the same stellar mass, could play an important role in galaxy evolution.

The SAMI Galaxy Survey: energy sources of the turbulent velocity dispersion in spatially-resolved local star-forming galaxies

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We investigate the energy sources of random turbulent motions of ionised gas from Hα emission in eight local star-forming galaxies from the Sydney-AAO Multi- object Integral field spectrograph (SAMI) Galaxy Survey. These galaxies satisfy strict pure star-forming selection criteria to avoid contamination from active galactic nuclei (AGN) or strong shocks/outflows. Using relatively high spatial and spectral resolution of SAMI, we find that, on sub-kpc scales our galaxies display a flat but elevated distribution of ionised gas velocity dispersion as a function of star formation rate (SFR) surface density, suggesting that star formation feedback is not the only source of random motions in local star-forming galaxies. Our sample shows the same positive correlation between ionised gas velocity dispersion and SFR surface density as local Hα luminous galaxies and high redshift star-forming galaxies. Our results suggest that additional sources beyond star formation feedback contribute to driving random motions of the interstellar medium (ISM) in star-forming galaxies. We speculate that gravity, galactic shear, and/or magnetorotational instability (MRI) may be additional driving sources of turbulence in these galaxies.

Herschel/SPIRE view of Dusty Star-Forming Galaxies in the North Ecliptic Pole field

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Using *Herschel* data from the SPIRE survey of the North Ecliptic Pole (NEP) field, we examine various properties of local dusty star-forming (SF) galaxies detected at 250-micron. The entire NEP-Wide field (~5.4 deg^2) surveyed by Akari space telescope was covered with all three SPIRE bands, and ~4,800 sources detected at 250-micron (PSW) are catalogued with the photometry of all three SPIRE bands. Among these sources, we identified ~300 objects having spectroscopic redshifts ($0 < z < 1$) and photometric information from u* to 24-micron band except for AGN types, which are proved to be sub-milimeter (sub-mm) counterparts of local MIR-PAH galaxies in the NEP-Wide field observed by Akari. We carried out the spectral energy distribution (SED) fit analysis based on all available data points from u* to sub-mm 500-micron band includining WISE and PACS data. Majority of the sample in this work appears to be LIRGs type population in terms of L_{IR} . To describe the dust-obscured star-forming activities of our sample, we derived various physical parameters such as star-formation rate (SFR), stellar mass (M_*), dust mass (M_d), and total infrared luminosity (L_{IR}) and so on. Due to the wide range of redshift and types, they show broad distribution in the SFR and stellar mass (M_*) space, but most of them seem to be various type of main-sequence galaxies, showing down-sizing pattern toward present epoch from the higher redshift (z~1).

Angular Clustering of Submillimeter Galaxies

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We present angular clustering measurements of submillimeter galaxies (SMGs) in the GOODS-N and ECDFS. Using SCUBA-2 data obtained by our team and public multiwavelength data in the respective fields, we employed cross-correlation measurements between the SMGs and the normal galaxies with best photometric redshifts. We then derived the linear bias and the clustering strength of the SMGs, which lead to the underlying dark matter halo mass for the SMGs. We find that the SMGs cluster strongly in these two fields, occupying a relatively high-mass dark matter halos.

SCUBA-2 Ultra Deep Imaging EAO Survey (STUDIES): Counterpart Properties

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Dust absorbs the UV/optical starlight and re-radiates it into the far infrared (FIR). Therefore, to understand the star formation history completely, we need to study the star formation that is obscured by dust, which can be traced from the ground through the submillimeter windows. To study dusty star formation in distant galaxies, we conduct an ultra deep 450μm survey, STUDIES (SCUBA-2 Ultra Deep Imaging EAO Survey), which is taken with SCUBA-2 on the 15m JCMT (James Clerk Maxwell Telescope) starting from December 2015. The STUDIES image is taken within the deep extragalactic CANDELS-COSMOS footprint under the grade-1 weather on Maunakea. The total observing time of the observations will be 330 hours. So far, 40% of the data (~140 hours) had been taken. The deepest region in our map reaches a sensitivity of ~ 0.9 mJy rms. A total of 97 sources are identified at > 4σ, and additional 40 sources are detected at 3.5-4.0σ from the regions with deep coverage (i.e. rms < 5 mJy). Furthermore, we are also conducting SED fitting on sources with multi-wavelength counterparts to estimate their photometric redshifts, infrared luminosities/star formation rates, and stellar masses. We will discuss the details about the counterparts and the multi-wavelength properties of our sample.

Spatially resolved Hα and M□ relation for MaNGA galaxies

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We repent our study on the spatially resolved Hα and M□ relation for both star-forming and quiescent galaxies taken from the MaNGA survey. Our results show that the star formation rate surface density (Σ_{SFR}), derived based on the Hα emissions, and M□ surface density (Σ□) also form a tight correlation on kpc scales for star-forming galaxies and can be directly connected to the global star-forming sequence. Our results suggest that the global main sequence may be a consequence of a more fundamental relation on small scales. On the other hand, the resolved SSFR of the quiescent galaxies is lower than that of the star-forming population. Meanwhile, we also find a tight correlation between $\Sigma_{H\alpha}$ and Σ□ for LINER regions in quiescent galaxies. This is the first time we show that the emission line fluxes are directly correlated with the underlying stellar mass surface density for quiescent galaxies. This result strongly supports the hot, evolved stars as the dominant mechanism powering the Hα emissions in quiescent galaxies.

The Relation Between Galaxies with Water Maser Emission and Their Magnitude in OIR Bands

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Water maser plays an important role on measuring geometric distance of a galaxy. However, there is no practical method to find out galaxies with water maser emission. To improve efficiency, we tried to distinguish maser galaxies from non-maser galaxies with statistical method. First, we selected data from The Megemaser Cosmology Project (MCP) survey result and collected OIR bands magnitude of maser galaxies and non-maser galaxies with Sloan Digital Sky Survey (SDSS) and Wide-field Infrared Explorer (WISE). We discover that water maser galaxies follow a tendency under some circumstances. Therefore, we could set horizontal and vertical axis parameter to separate maser galaxies and non-maser galaxies .

Gravitational Lensing in Modified Newtonian Dynamics

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The missing mass problem in astronomy can be interpreted as some matter is unaccounted for (as in dark matter theory) or as some acceleration is unaccounted for (as in modified Newtonian dynamics, MOND). MOND is very successful for galaxy scale objects, but most of the studies assume spherical symmetry. Recent development in MOND on slightly deformed spherical systems enable us to investigate phenomena related to objects such as elliptical galaxies. We study gravitational lensing by elliptical galaxies using relativistic MOND. In this contribution, we show some specific examples and compare the results of MOND and GR.

Optical Warps of Spiral Galaxies and their Environment

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We analyze disk structure of 340 edge-on galaxies of which 192 galaxies have appreciable warps. We identify warps using color images provided by the SDSS DR7 as well as the r-band isophotal maps. We derive the environmental parameters such as the local background density and the tidal strength to examine the dependence of the arp parameters on the galaxy environment. We find a clear trend that strongly warped galaxies are likely to be located in high density regions where tidal interactions are frequent. However, the correlations between the warp properties and environmental parameters are very weak for weakly warped galaxies. The cumulative distributions of weakly warped galaxies as a function of environmental parameters are not significantly different from those of galaxies with no detectable warps. This implis that weakly warped disks are caused by a variety mechanisms, including internal ones.

Impact of feedback in high-redshift galaxy formation using cosmological hydrodynamic simulations

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We present the results of high-redshift galaxy formation using cosmological hydrodynamic simulations with zoom-in initial conditions. We use the GADGET-3 SPH code with updated SPH schemes and physical models. In particular, we investigate the formation of first galaxies and their evolution from high-z to z□6. We focus on the evolution of a few massive galaxies that end up in halos with masses Mh ~ 10^10 to 10^12 Msun/h at z=6. We find that star formation occurs intermittently due to supernova (SN) feedback, and it is significantly suppressed in even massive galaxies at z>6. The SN feedback produces clumpy gas structure, and it suppresses the formation of galactic disk at z>6. The expulsion of gas at the galactic center also affects the inner dark matter density profile. One of our simulated galaxy shows resemblance to the observed properties of LAEs with □10 Msun/yr at z~6. The star formation rate (SFR) of massive galaxies in another halo becomes higher than 100 Msun/yr at z~7.5, which corresponds to the observed bright galaxies. We also discuss the results of dust and metal content of simulated galaxies, and show that the most massive galaxies at z~6 can be observed by ALMA and JWST in different wavelengths via radiative transfer calculations.

Recent tests of KaVA AGN polarimetric Observations

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I will report the current status and recent test results of KaVA AGN polarimetric observations.

Parsec-Scale Jet structure of new gamma-ray AGN candidates

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We conducted VLBI fringe detection survey for total of 850 radio sources located within the positional error of 149 out of 232 un-associated gamma-ray sources, which are located at high galactic latitude ($|b|> 5$ deg) and declination of more than -30 deg listed in Fermi-LAT second catalogue (Nolan et al. 2012) to search for new gamma-ray emitting AGN candidates with the Japanese VLBI Network (JVN) wide-band observation system in 2012 December. As the result of our survey, we succeeded to detect 28 new gamma-ray AGN candidates (15 solid detections and 13 marginal detections), of which the brightness temperature T_b is more than 8×10^7 K (for solid detections, Fujinaga et al. 2016). For six out of fifteen solid detections in our previous survey, we performed multi-wavelength (2.3, 8.4, 15.4 GHz) VLBA follow-up observations to clarify those radio spectra and parsec scale structure. We report on the result of our VLBA observations. One of six has very steep radio spectra at spectral index a of ~ 1 at between 2 - 15 GHz ($S \sim ?^{-a}$), and others have relatively flat radio spectra like blazars. Now we have attempted AGN classification of these 6 candidates by structural information and radio spectra obtained by VLBA observation.

Evidence of Suppressed Star Formation in MaNGA AGN

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In order to study the star formation properties of AGN host galaxies and search for possible signature of the AGN's feedback on host galaxies, we have selected 12 AGN with star-forming disks, i.e. central AGN plus a disk with ongoing star formation as revealed by the BPT diagram from SDSS-IV MaNGA survey. The large sample and spatially resolved spectra of individual galaxies from MaNGA help us identify star forming regions around the AGN and statistically investigate whether AGN hosts show similar levels of SFRs to normal galaxies or not. Our result points that AGN hosts have decreased SFRs as compared to normal galaxies that have similar stellar masses and morphological types to AGN hosts, implying possible negative feedback of accreting SMBHs on star formation of their host galaxies.

Galaxy Morphology Resulted from the Influence of AGNs, Star Formation, and Environments

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Galaxy morphology is mainly determined from the process of galaxy formation. Parent galaxies, formation history, environments, active galactic nuclei (ANGs), and dark matter all affect the morphology of the galaxy. In this poster, we first investigate the mutual interaction of AGNs and star formation in the host galaxies and its influence on the morphology of AGN host galaxies. We found that the morphology distributions of AGN host galaxies are different for type I and type II AGNs; this result is difficult to explain with the traditional unification model of AGNs. We will also discuss how the environment might influence the morphology and star formation of elliptical and spiral galaxies. Elliptical galaxies are found to be rounder in dense regions suggesting that the morphology of elliptical galaxies are affected by environments and the formation history of their parent galaxies. Besides, some star-forming elliptical galaxies show continuum star formation history, implying that there might be some unknown mechanisms, similar to the density waves in spiral galaxies, in maintaining the star formation in these elliptical galaxies.

Merging shock front in peculiar galaxy cluster Abell 2626

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We present result derived from the analysis of 120ks Chandra observations of a very peculiar galaxy cluster Abell 2626 (Z=0.0553) . This deep observations have revealed the presence of a weak shock front at ~37 kpc in the south-west direction having Mach number of ~1.4 . Also we detected a pair of cavities within ~15 arcsec from the center of nucleus. We confirm the excess emission detected previously in the north and south direction of the nucleus along with newly detected excess emission just below the nucleus. We found remarkable and unusual central metallicity of ~ 0.8 Msun within ~ 35 arcsec region.

The X-ray—weak non-BAL quasars from the Sloan Digital Sky Survey

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Using archival Chandra data, we study the X-ray properties of 582 SDSS DR7 quasars in the redshift range $1.7<z<2.7$, focusing on X-ray weakness in quasar sample. We extend the work of Gibson et al. 2009, who analyzed 315 SDSS DR5 quasars with Chandra X-ray observations. The fraction of radio-quiet non-BAL quasars under-luminous by a factor of 20 are constrained to be ~ 1.5%. Another ~ 3000 SDSS DR10 quasars with Chandra observations are under investigation.

A new method to select red QSOs at z = 0.3 - 1.2

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We investigated the properties of a sample of red QSOs using optical, radio, and infrared data. These QSOs were selected from the SDSS DR7 quasar catalog. We only selected sources with sky coverage of the VLA FIRST survey, and searched for sources with the WISE counterparts. We defined the spectral color of the QSOs based on the flux ratio of the rest frame 4000A to 3000A continuum emission. In accordance with this criterion, only QSOs with redshifts between 0.3 and 1.2 could be selected. We found that the red QSOs (especially for radio-loud QSOs) exhibited stronger infrared emissions than the typical QSOs did. However, the red QSOs at high redshifts had a low population than the red QSOs at low redshifts had, yet the typical QSOs showed inverse population distribution along the redshifts. Furthermore, at high redshifts, the luminosity distribution of the typical QSOs and the red QSOs seemed to exhibit similar patterns. However, at low redshifts, the red QSOs showed a different luminosity distribution than that of the typical QSOs. These findings suggest that there might have been at least two types of red QSOs in our samples.

ALMA spectroscopy of high-z quasar candidates selected from PanSTARRs1

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Quasars are usually identified based on their UV spectra and strong Lyman alpha emission line. However, UV emission of the high-redshift quasars is shifted to NIR wavelengths at which spectroscopy is difficult and highly time consuming. We propose an alternative approach for quasar identification based on the observation of their CO emission originating from quasar host galaxies. In young quasars, the CO is highly excited and can be observed in high rotational transitions. The observations of the high CO transition lines in submm with the interferometric facility, such as ALMA, require much less observing time and are more efficient than NIR spectroscopy of the UV emission lines of the high-redshift quasars. We perform spectroscopy of high-redshift quasar candidates selected from PanSTARRs1 in ALMA Band 3. In our work we present the selection criteria of the quasar candidates and first results of our observations. (The research is supported by the Ministry of Science and Technology of Taiwan, grant NOs MOST 103-2119-M-008-017-MY3 and MOST 105-2811-M-008-074.)

DRAGONS - the contribution of quasars to reionization

Yuxiang Qin[1]; Simon Mutch[1]; Gregory Poole[1]; Chuanwu Liu[1]; Alan Duffy[2]; Paul Geil[1]; Paul Angel[1]; Andrei Mesinger[3]; Stuart Wyithe[1]
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In this talk, I will present the result from an update of the Mutch et al. (2015) semi-analytic model, which tracks the growth of central supermassive black holes. I will investigate the contribution of quasars to reionization. The model is calibrated against the observed stellar mass function at z~0.6-7, the black hole mass function at z~0.5, the global ionizing emissivity at z~2-5, and the Thomson scattering optical depth. The model reproduces a Magorrian relation in agreement with observations at z<0.5. With the implementation of an opening angle for quasar radiation, which corresponds to an observable fraction of ~23.4 per cent due to obscuration by dust, the model is able to reproduce the observed quasar luminosity function at z~0.6-6. At high redshift, the model is consistent with the bright end quasar luminosity function and suggests that the recent observation by Giallongo et al. (2015) at the faint end includes a fraction of stellar light and consequently overestimates the number of ionizing photons produced by quasars by a factor of 2 at z~5. When we include quasars in reionization calculations using 21cmFAST, we do not find a significant contribution.

Cosmological simulation with Dust Formation and Destruction

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Dust plays an essential role in galaxy evolution through dust extinction, emission, and dust surface chemical reactions. In order to understand the dust enrichment in galaxies, we developed a dust evolution model and implemented it in our code, GADGET3-Osaka, and calculated the evolution of dust in each SPH particle. In this code, non-equilibrium cooling is treated with the Grackle chemistry package including molecular hydrogen cooling. For the grain size distribution, we treat small and large grains separately. The following processes are included for dust evolution: dust production, destruction and feedback of type Ia and II supernovae and AGB stars, dust growth in molecular clouds, and grain disruption by shattering in the diffuse interstellar medium.

In this presentation, we show results with cosmological simulation. First, we show the statistical properties of dust such as cosmological mass density of dust, the relation between dust mass and metal one of each galaxy and dust distribution in the relation between dust and metal abundances for individual galaxies, and spatial distribution of dust in the interstellar medium, circum-galactic medium (CGM), and intergalactic medium (IGM). We found that, not only the stellar dust production, but also interstellar processing (dust growth by accretion and coagulation, dust destruction by supernovae, and dust disruption by shattering) plays an essential role in determining the dust-to-gas mass ratio in nearby galaxies. Hence the constant dust-to-metal mass ratio approximation is not valid at low redshift. Finally we compare our results of the cosmic dust mass density, dust mass function, and the spatial distribution of dust in the CGM and IGM with observational data.

Observational consequences of ultra-light scalar field (Wave) dark matter

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The standard cold dark matter model (CDM) predictions face some long-standing discrepancies with observations in small scales, in particular regarding the central density profiles of dwarf galaxies and the predicted satellite abundance around Milky Way-like halos. One alternative to solve these issues is given by assuming the dark matter (DM) is of a very different nature. The Ultra-light scalar field (Wave) Dark Matter model could provide a solution to these discrepancies, the model assumes the DM is a very light spin-0 boson with mass of order 10^{-22} eV/c^2, such boson can form Bose-Einstein condensates of galactic scales that represent the DM halos. In this talk, I will show some observable signatures in the baryonic matter that are a direct consequence of the quantum nature of this DM. I will discuss how rings and shells in galaxies could result from the quantum DM nature and not only by tidal interactions, and show that high resolution data of galactic rotation curves provide a strong test to discriminate this model among other altenatives.

Emergent Universe with Interactive fluids and observational constraints

Bikash Chandra Paul[1]
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Emergent universe Scenario is realized in the presence of interactive fluids. The non-linear equation of state (EoS) considered in the general theory of relativity for obtaining emergent universe is effectively a cosmological model with a composition of three fluids. In this paper we considered two models to realise viable cosmological scenario: (i) A two- fluid model with interaction of a pressureless fluid and a fluid having non linear EOS needed for the emergent universe, (ii) a three- fluid model wiyh interaction among the fluids permitted by the EoS of the emergent universe. It is found that a realistic cosmological models in accordance with observations are not ruled out in the above cases. We determine the constraints of the model parameters making use of the cosmological and astrophysical observations.

Nonlinear Lorentz Models for Dark Matter and Dark Energy

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In the previous efforts, we constructed N-Body systems based on non-temporal and nonlinear extension of Lorentz transformation and defined degree of nonlinearity and normalized momentum to characterize the systems. We have explored root computation via iteration in the context of dynamical systems. The solution sets demonstrate various forms and structures, which including ensemble distributions similar to the canonical ones. In some related applications, we have also explored this construction for modelling gravitational lens limitations (image number and brightness). These efforts were recently further extended for simulating the convergence-divergence boundaries, and thereby we observed the formation of several hierarchical structures due to nonlinear coupling among linear, angular and spin momentum in the numerical simulation and analysis.

In this paper, we present linear-angular-spin momentum in conjunction with Lorentz transformation as an alternative candidate for modelling the phenomena currently claimed to be induced by dark matter and dark energy. For dark matter, we present configurations in domain of hierarchical structures, which depend on linear and angular momentums on the complex plane. The hierarchical structures include one, two, three, and five concentric-ring layers, which are hereby proposed to map to the families of elementary particles. The additional layers beyond three are hereby proposed to model dark matter. Further inclusion of spin momentum, we present several hierarchical structures in codomain for modelling stellar systems, such as galaxies and the solar system. Some of these substructures resemble canonical structures modelled by Newtonian gravity, while the others demonstrate different combinations of linear and angular momentum beyond the existing theories. These exceptional and stable results are hereby proposed to model dark energy.

Millisecond magnetars formed from super-luminous supernovae and gamma-ray bursts

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Super-luminous supernovae (SLSNe) are an unusual type of supernovae intrinsically bright with a peak absolute magnitude of M<-21. It is suggested that most SLSNe, in particular, the hydrogen-poor SLSNe I, could be powered by the spin-down of a newborn millisecond magnetar rather than by radioactivity as usual. By fitting the bolometric light curves of dozens of SLSNe with the magnetar-engine model, we obtained the magnetar parameters and the ejecta masses of these SLSNe. Meanwhile, millisecond magnetars are also usually considered to exist in gamma-ray bursts (GRBs) as central engines, which are associated with broad-lined hypernovae. By comparing the statistical properties of the model parameters of SLSNe and GRBs/hypernovae, we investigate the differences and possible connections between these two different astronomical phenomena. A united understanding of SLSNe, hpernovae, normal broad-lined supernovae, and normal supernovae are discussed in the united magnetar model.

APRIM 2017 Poster Presentation

Orbital Evolution of Millisecond Pulsar Binaries

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Abstract

Millisecond pulsars are neutron stars that spin with a period below 30 milliseconds. The reason why they can spin remarkably fast is generally believed to be explained by the "recycling" scenario: the pulsar gains angular momentum through accreting mass from its companion star. This is consistent with the observational fact that the millisecond pulsars has a much higher binary fraction ($\sim 80\%$) than the normal pulsars ($< 10\%$)[1]. The companion star, as an important source of energy and momentum of the system, will eventually come to an end under the mass accretion and evaporation by the central pulsar. Black widows and redbacks are such binary systems in which the pulsar wind is continuously irradiating on the companion, a low mass white dwarf or main sequence star, and finally evaporates it[2]. In this study, we aim to use a theoretical model to revisit the processes of mass accretion and ablation in the pulsar binary system. The mass accretion is modeled by the Roche-Lobe overflowing. The mass ablation is powered by the electromagnetic dipole radiation of the pulsar magnetosphere. We target to probe the evolution of the orbital parameters until the millisecond pulsar becomes isolated. We predict the amount of time required to completely isolate the pulsar from black widows or redback system. There is an intermediate stage in which the companion becomes a planet that is no longer capable for igniting the nuclear reaction. These pulsar-planet systems are rare. We will particularly focus on some of them to understand their history. In this study, we will mainly use the data of the millisecond pulsar binaries within the Galactic field. Those in Globular Clusters are not considered because the processes happening in Globular Clusters are much more complicated: the pulsars may have changed their companion for multiple times. On the other hand, using the current available data of the millisecond pulsars, we try to differentiate between the isolated and binary population: what makes an isolated millisecond pulsar isolated?

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Searching for strange quark stars in the Universe

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Strange quark matter (SQM) may be the true ground state of hadronic matter so that the observed pulsars may actually be SQM stars, but not neutron stars. However, it is still an unsolved difficult task to tell SQM stars from neutron stars observationally. Researchers usually resort to the different mass-radius relations or different cooling rates of these two kinds of compact objects to discriminate them. But the differences are generally subtle and no definite conclusions can be drawn yet. In our studies, we suggest that we could try to identify SQM objects by searching for SQM planets. Due to their extreme compactness, strange quark planets can spiral very close to their host SQM stars, without being tidally disrupted. These systems would serve as a new kind of sources for gravitational wave bursts and can be detected by gravitational wave detectors. We could also identify SQM planets with other methods based on their compactness. These effects provide a unique probe for SQM objects and is hopefully a powerful tool to test the SQM hypothesis.

X-ray index-luminosity relationship and radio/X-ray correlation in AGNs and X-ray binaries: theoretical interpretation

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Over the past few dacades, the AGNs and black hole X-ray binaries (BHBs) reveal numerous similarities, indicating that similar accretion physics is under action. Two important observational results are that, 1, both AGNs and BHBs, individually and collectively, show a V-shaped index-luminosity relationship in hard X-rays (2-10 keV), i.e. they behavior "softer when brighter" in their bright (X-ray luminosity L_x greater than 0.001 Eddington luminosity L_{edd}) phases, and "harder when brighter" in their less-bright phases. Moreover, when they are in their faint phases, their X-ray spectrum remains nearly un-affected by the luminosity. 2, the radio luminosity L_r follows the 2-10 keV X-ray luminosity L_x, and they form the so-called fundamental plane (FP) when black hole mass is taken into account. Apart from the "original/standard" single-power-law FP, recently a new FP was established in BHBs (and also the low-luminosity AGN NGC 7213), which are classfied as the outliers to the original FP. For these outliers, the radio/X-ray correlation slope (the p value in $L_r \sim L_x^p$) is steep, $p \approx 1.3$, at large L_x; flat, p □ 0, at moderate L_x and has the original FP slope. In this talk, we will provide comprehensive understanding on these two complex observations. It is based on the truncated accretion-jet model, where the central region is a hot accretion flow, who is responsible for the hard X-ray emission. We argue that the change in index-luminosity relationship and radio/X-ray correlation is due to the change in the accretion mode. We further examine this senario in NGC 7213, and we excellently explain its main properties.

Black hole accretion and wind

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Black hole accretion is one of the most important fundamental processes in the universe. In recent years, one of the most important findings of black hole accretion theory is the outflows/wind by observations and numerical simulations. In this report, first, I will introduce the finding history of wind in black hole accretion theory. Second, based on three-dimensional numerical simulations, the driven mechanism of outflow in black hole accretion disk is discussed. Third, I will introduce the applications of wind in the explanation of observations. Finally, I will introduce the feedback by black hole wind on the evolution of galaxies.

A new Class of Relativistic Models of anisotropic Compact Objects

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A class of new relativistic solutions with anisotropic fluid for compact stars in hydrostatic equilibrium is presented. Considering known metric for the interior space of a compact object we obtain a class of physically viable stellar models in the framework of Einstein Gravity. The parameters of the geometry are employed to obtain density, radial pressure, tangential pressure etc., for viable stellar configuration. As the EOS of matter inside a compact object is not known we predict the same here. In the paper properties of some known compact objects are also explored.

Equation of State of Quark Matter with Density Dependent B-Parameter of Anisotropic Strange Star.

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A class of relativistic solutions for compact cold stars with strange matter in a pseudo-spheroidal space-time is presented here. Considering strange matter equation of state namely, $p = frac{1}{3}(ho-4B)$, where $ ho$, p and B are energy density, pressure and MIT Bag parameter respectively, stellar models are obtained. In the presence of anisotropy with a pseudo-spheroidal geometry described by Vaidya-Tikekar metric stellar models are explored, where the Bag parameter varies with the energy density ($ ho$) inside the compact object. We determine the density dependence of B for different anisotropy including isotropic case. It is noted that although B varies with anisotropy inside the star, finally at the surface it attains a value which is independent of the anisotropy. The Bag parameter B is found to increase with an increase in anisotropy for a given compactness factor (M/b) and spheroidicity ($lambda$). It is also noted that for a star with given mass and radius, the parameter B increases with the increase of $lambda$ and finally at large value of $lambda$ it attains a constant value. We note that in this model equation of state (EoS) obtained from geometrical consideration with allowable value of 'B' is similar to that obtained by earlier investigators from consideration of micro-physics. The stability of the stellar models for compact stars with anisotropy in hydro-static equilibrium is also studied.

Using mHz QPOs to put constraints on neutron star size and equation of state

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We performed a variability study of archival XMM-Newton data of 4U 1636-536, a neutron star (NS) low mass X-ray binary, and investigated the energy dependence of its low frequency variability. Here we present the results of our waveform analysis and phase resolved spectral investigations of the mHz quasi-periodic oscillations (QPOs). Our study showed that the oscillations are not caused by variations in the blackbody temperature of the NS, but revealed a correlation between the change of the count rate during the mHz QPO pulse and the spatial extent of a region emitting blackbody emission. The maximum size of the emission area allowed us to obtain a lower limit on the size of the NS that rules out equations of state that prefer small NS radii.

A quick estimation of luminosity function based on the luminosity-distance diagram

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Based on the luminosity-distance diagram, we propose a method to quickly estimate the luminosity function for any certain astrophysical objects. Giving the mean distance between any two objects at a given luminosity range, we can find the relation between the mean distance and the luminosity, and consequently, can obtain the luminosity function. Not like the straightforward counting method, this method does not need a complete sample. The only requirement is that the object distributes uniformly in space. We apply this method to a simulated sample, and find it can produce the luminosity function properly. This method can also be used for energy function.

Accumulation of Dark Matter around Black Holes

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Dark matter is an unknown type of matter that makes up roughly 85% of all matter in our Universe. While we can observe its gravitational effects, its particle nature is still unknown. To probe this particle nature, we may look for signals of particle annihilations and collisions. Such phenomena are expected to happen in places with relativistic environments and high concentrations of dark matter. We demonstrate how adiabatically growing black holes could act as a laboratory to study dark matter in these type of relativistic environments. To this end, we have developed a fully general-relativistic simulation code MARBLE to study dark matter near rotating black holes.

On Some polarized VLBA results of a Small Sample of CSSs/GPSs at MM Wavelength

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Counter jets are detected at 3 CSSs/GPSs sources with quite high significance, previous morphology for 0046+316 shows core jet structure. 2021+614 is detected counter jet component at south-west side of the core which was not observed. The previous morphology of 2134+004 showed an obvious double structure, which is now more likely to be two sided structure with two new component detected; Two of the sources are definitely detected polarized emission; 2021+614 almost shows no polarized emission; Of the proposed 5 source, 2 other sources have not valid data, larger sample is required to obtain statistical information.

Accretion Induced Collapse of White Dwarfs as an Alternative Symbiotic Channel to Millisecond Pulsars

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The direct collapse of a white dwarf (WD) to a neutron star (NS) has been postulated by many authors in order to explain the origin of some low mass X-ray binary sources, as well as the existence of millisecond pulsars (MSPs). In this paper, we investigate the implication of accretion induced collapse (AIC) in accreting WDs for the MSPs papulation. In addition, we derive estimates for the number of AIC are believed to occur in the Galaxy. We confirm that a significant fraction of MSPs may originate from AICs, approximately 4

Compact Object with Electromagnetic field in Higher dimensions.

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A class of relativistic solutions for compact cold stars with Electromagnetic field in hydrostatic equilibrium in a Pseudo-spheroidal geometry is presented. Stellar models are constructed using the relativistic solutions. The pseudo- spheroidal geometry considered here is described by Vaidya- Tikekar metric. The central density as well as density profile is found to depend on dimension of space time and geometrical parameters. It is found that central density is independent of charge. We determine the limiting values of the parameters. The validity of SEC and WEC inside the stars are also syudied. We predict the EoS of some known stars. The stability of the stellar models for the compact stars in hydrostatic equilibrium is also explored.

Fermi Large Area Telescope Observations of the Kes 73/1E 1841-045 Region: An Attempted Search for Gamma-ray Excess from a Magnetar

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The supernova remnant Kes 73 and/or the magnetar 1E 1841-045 at its center can deposit a large amount of energy to the surroundings and is potentially responsible for particle acceleration. Using the data taken with the Fermi Large Area Telescope (LAT), we confirmed the presence of an extended source whose centroid position is highly consistent with this magnetar/supernova-remnant pair. Its emission is intense from 100 MeV to >100 GeV. Its LAT spectrum can be decoupled into two components which are respectively governed by two different mechanisms. According to the young age of this system, the magnetar is seemingly a necessary and sufficient source for the downward-curved spectrum below 10 GeV, as the observed <10 GeV flux is too high for the supernova remnant to account for. On the other hand, the supernova remnant is reasonably responsible for the hard spectrum above 10 GeV. Further studies of this region in the TeV regime is required, so that we can perform physically meaningful comparisons of the >10 GeV spectrum and the TeV spectrum.

Maximum Mass of Relativistic Anisotropic Star in Higher Dimensions

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A class of relativistic solutions of cold compact anisotropic stars in hydro-static equilibrium in the framework of higher dimensions using spheroidal geometry is investigated here. The solutions obtained with Vaidya-Tikekar metric are used to construct stellar models of compact objects and studied their physical features. The effects of anisotropy and extra dimensions on the global properties namely, compactness, mass, radius, equation of state are determined in terms of the spheroidicity parameter ($lambda$). It is noted that for a given configuration, compactness of a star is found smaller in higher dimensions compared to that in four dimensional space-time. It is also noted that the maximum mass of compact objects increases with the increase of space-time dimensions (D) which however attains a maximum value when D = 5 for any spheroidicity parameter ($lambda$), thereafter it decreases as one increases the number of extra dimensions (D). The effect of extra dimensions on anisotropy is also studied.

Dynamical cross-correlation study of a neutron star source GX 17+2

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We performed a dynamical cross-correlation function (CCF) study of a Z source GX 17+2. The RXTE PCA data for the source was used for this study. The dynamical CCF was performed when the source was in the horizontal branch where 5-60 Hz QPOs were present. We used 2-5 keV and 13-60 keV energy band light curves to cross correlate and explore the lag scale at smaller Fourier scales. We found that 5-10 s delay was present in some of the observations, which is indicative of a variable corona or inner accretion disk close to the neutron star. We discuss our results in the framework of the truncated accretion disk geometry where the role of a jet cannot be ruled out.

X-ray Spectral Analysis of 2015 outburst of V404 Cygni with the TCAF Solution

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V404 Cygni (GS 2023+338) is a Galactic X-ray binary containing a black hole candidate. It is an X-ray transient, which exhibited 3 outbursts in 1980's. After a long period of quiescence, V404 Cygni showed X-ray outburst in 2015 June. This outburst lasted for about a month, with more active in soft X-rays. Meanwhile, multi-wavelength observations of this outburst from radio to gamma-rays were conducted.

We will use the Two-Component Advective Flow (TCAF) model fits file to understand its physical accretion flow properties during the outburst by fitting spectra. The TCAF model, developed by Chakrabarti anf his collaborators in mid 90s, considers the disc accretion rate (Keplerian, high angular momentum) and the halo accretion rate (sub-Keplerian, low angular momentum) to explain both soft and hard components of the observed energy spectrum. Relevant model parameters can also describe QPO phenomena produced by the Compton cloud around the central black hole.

We will introduce the TCAF model and report the estimated mass of the black hole in V404 Cygni based on TCAF spectral fitting of data taken by Swift/XRT and BAT from 15 June to 8 July 2015.

Investigation of Short GRBs with Extended Emission using Luminosity/Spectral Lag Relations

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Gamma-Ray Bursts (GRBs) are classified into the two groups that are long GRBs (LGRBs) and short GRBs (SGRBs). Their progenitors are expected to be different because they have their own distinct observational characteristics. Occasionally, the SGRBs having faint extended emission (EEGRBs) are observed. The EEGRBs exhibit similar properties what the SGRBs have, but observed T_{90} of the EEGRBs is longer than two seconds as the LGRBs. Because the EEGRBs have characteristics of the two types of GRBs, study of the EEGRBs is important to understand origins of GRBs. In this study, we obtain the luminosity/spectral lag relations of EEGRBs observed by *Swift*/BAT. We compare these results with luminosity/spectral lag relations of LGRBs and SGRBs. We find that the EEGRBs seem to have no correlations in luminosity/spectral lag relations in contrast with the LGRBs and SGRBs. It is difficult to discuss similarities and differences between EEGRBs and LGRBs or SGRBs through the luminosity/spectral lags relations.

Observation of the Crab in the Compton Spectrometer and Imager (COSI) 2016 flight

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The Compton Spectrometer and Imager (COSI) is a balloon-borne soft gamma-ray telescope designed to study astrophysical sources in the MeV energy range and, if with good enough statistics, also the polarization of their emissions. COSI had a few balloon flights in the past. The most recent one was an ultr-long duration balloon flight with a super-pressure balloon launched from Wanaka, New Zealand, in May 2016, which lasted for 47 days. Although it was in the southern hemisphere, there was still considerable exposure on the Crab. Here we report results of Crab observation in the COSI 2016 flight.

Tracking X-ray Spectral Modulations of A 6-Hz Type-B Quasi-periodic Oscillation in GX 339-4 using Hilbert-Huang Transform

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We present the phase-resolved spectroscopy results based on the Hilbert-Huang transform (HHT) for a 6-Hz type-B quasi-periodic oscillation (QPO) in the black hole X-ray binary GX 339-4. It had been shown that type-B QPO frequencies have strong correlation with the hard X-ray flux, but the detail variations of hard X-ray spectral components during the oscillation is still not clear. To track modulations of spectral parameters, we utilized the HHT to characterize the HHT-based timing properties, extract the QPO instantaneous phases, and then construct its phase-resolved spectra. We found that the QPO is composed of a series of intermittent oscillations with a ~1 s coherence time. Furthermore, the phase-resolved spectra illustrate significant modulations of Comptonization parameters with unignorable modulations of thermal disk components. Finally, we discuss differences of the HHT-based timing property between this type-B QPO and a 4-Hz type-C from XTE J1550-564 and give possible interpretations of the spectral modulations.

Correlation between energy spectra and Quasi-Periodic Oscillation behavior in Sco X-1

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The origin of Quasi-Periodic Oscillation (QPO) in X-ray binaries is still under debate,despite of a huge volume of observation data and theoretical works.
In this paper we present the result of searching for correlation between energy spectra and Quasi-Periodic Oscillation behavior in Sco X-1 with RXTE archival data.
Sco X-1 is so bright that we are able to conduct such a study at a time scale of 16 seconds.Our results will be helpful for identifying the QPO origin in Sco X-1.

The Unified understanding of the Aquila X-1 hard-to-soft state transition and its implication of the cosmic battery effect

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Neutron-Star (NS) Low mass X-ray Binaries (LMXBs) exhibit drastic spectral changes, as they switch between the soft state with a bright soft spectrum, and the hard state with a hard continuum. Nevertheless, Sakurai et al. (2014) successfully described these two types of spectra with a single unified spectral model, consisting of a multi-color disk (MCD) emission, and Comptonization of a blackbody from the NS surface. To reinforce the reality of this novel unified view, we analyzed a hard-to-soft state transition of the LMXB Aquila X-1 fortunately caught by Suzaku.

The observation was performed on 2011 October 21, during a rising phase of an outburst. On a time scale of ~20 ksec, the spectral shape changed continuously from a typical hard-state one to that of the soft state. The inner disk radius meantime decreased from 30 km to 20 km, and so did the blackbody radius from 11 km to 7 km, suggesting that the corona shrank to the vicinity of the NS equator. The same inference was obtained from the optical depth of the corona. Thus, the unified modeling has been confirmed to be fully physical.

As another important result, we found that the radial infall velocity of the corona is rather low, ~4% of the free fall velocity, so that the motion of the flattened corona is close to Keplerian. This condition favors the operation of an interesting phenomenon, called cosmic battery effect (Contopoulos +15, Koutsantounious +14): by Comptonization, the soft photons from the NS surface will decelerate the azimuthal motion of coronal electrons, but not of protons. Thus, a global electric ring current will be generated, which in turn will produce poloidal magnetic fields. This predicts the formation of jets in the soft state, in agreement with some ratio observations.

An X-Ray Point Sources in NGC 7331

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We report on Chandra X-ray observatory ACIS-S observations on NGC 7331. There are 50 X-ray point sources, including SN 2014C, identified by combining five observations taken between 2001 and 2015 within the optical D_{25} region of NGC 7331 with a signal to noise ratio (S/N) larger than 3. The detection limit of our sample is 1.3×10^{38} ergs s^{-1} in the 0.5–7.0 keV energy. Fifteen of them are variable with luminosity variability larger than 3 sigma. The cumulative luminosity function of point sources can be fitted with a broken power-law with a luminosity break at 3.6×10^{38} ergs s^{-1} while the slope is 0.6 and 2.04 before and after the break, respectively. This may indicate a mixture of bright and young sources on the spiral arms, and older disk populations as studied in other late type galaxies. For the five sources with net counts larger than 120, the spectral model fittings are carried out with absorbed power-law, Raymond-Smith and blackbody models. The spectral fitting of SN 2014C shows a decrease of column density with time and the photon indices vary from -0.24 to 0.87. As for the other four sources, the average power-law photon index is about 1.6. By adopting the classification method proposed by Prestwich et al. (2003) according to the X-ray color-color diagram of the sources with S/N larger than 4, we find 9 sources that are likely to be low-mass X-ray binaries in addition to SN 2014C. We plan to use the observations taken with the Hubble Space Telescope (HST) Wide Field and Planetary Camera 2 (WFPC2) and Wide Field Camera 3 (WFC3) to identify optical counterparts lying in the error ellipses of X-ray sources in the future.

1.2m Wide-field Astronomical Telescope at Changchun Observatory

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1.2m wide-field astronomical telescope at Changchun Observatory is located at the south of Dasui river town, Jilin city, Jilin Province, where the mean and optimum seeing values are 1.2″ and 0.6″, respectively. The 1.2m wide-field astronomical telescope has prime focus system and Cassegrain focus system, which of FOV values are1.5°*1.5°and 11′*11′. Many astronomers will use the telescope to perform the observations for the studies on Galactic sciences (stellar parameters, extinction measurements, Galactic structures, exoplanets, etc.) and time-domain astronomy (supernovae, gamma-ray bursts, stellar tidal disruption events, and different types of variable stars), as well as space debris and objects.

The Palomar Transient Factory and RR Lyrae Program at the National Central University: Overview and Progress

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The Palomar Transient Factory (PTF) and its successor, the intermediate-PTF (iPTF), are dedicated synoptic surveying projects that utilized the 48-inch wide-field Samuel Oschin Telescope, known as P48, located at the Palomar Observatory. This telescope was equipped with a mosaic CCD that provides a field-of-view of ~7.2 degree squared, while maintaining a pixel scale of 1.01"/pixel. The PTF and iPTF surveys were mainly conducted in Mould R filter, with occasion observations done in the SDSS g filter. The large volume of time series data is not only been used for the search of transients, but also provides a valuable mine for variable stars research. At the Graduate Institution of Astronomy, National Central University (IANCU), we are interested in the investigation of RR Lyrae variable stars using the full PTF/iPTF data. This is because RR Lyrae are considered as a "Swiss Army Knife" of astronomy (Sarajedini 2011), for examples RR Lyrae are standard candles for distance measurement, they can be used to trace old stellar populations, they serve as metallicity and/or extinction indicators, and they are laboratory for stellar pulsation and evolution studies. The main goal for our PTF/iPTF-RR Lyrae program is to search, identify and characterize known and new RR Lyrae in Galactic field and halo down to R~20 mag with the combined PTF and iPTF data, which will enable a wide range of scientific investigations using RR Lyrae. In this presentation, I will briefly present an overview of our program, followed by recent progress such as the derivation of metallicity-light curve relation in the native PTF/iPTF R-band filter (Ngeow et al 2016).

Recent Meteor Observations of the Taiwan Meteor Detection System

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Taiwan Meteor Detection System is a joint platform under a collaborative development among National Dong-Hwa University (NDHU), National Central University (NCU) and Taipei Astronomical Museum (TAM). This developing system intends to scope meteor events in the sky surrounding Taiwan and subsequently analyze the data detected. At present, we have established two stations to perform observations of meteor events: One is situated at the Lulin observatory of NCU. The other is placed at Hutian Elementary school inside Yang Ming Shan National park. From 2016 to date, plentiful meteor events were successfully recorded at both observation stations. Especially, several simultaneous events are matched. We apply triangulation observation method to analyze the position and velocity information of detected meteors, moreover the meteors orbits are determined using the commercial softwares UFO Capture

detected meteors are resolved from undertaken spectroscopic analyses while retrieving the NIST atomic and molecular spectra databases [1, 2] to identify the observed spectra lines.

[1] http://physics.nist.gov/asd
[2] https://www.nist.gov/pml/molecular-spectroscopic-data

Economic Robotic Telescope System for Remote Operation

Manish Hiray[1]; Raka Dabhade[2]
[1]*Junior Research Fellow;* [2]*Associate Professor*

Development Robotic Telescope System is need of modern academic society. By blending of existing technology and custom made equipment it is possible to develop such system which is affordable by economic Countries. Observing celestial objects from different time zone demonstrated the value of autonomous robotic telescope systems. Pursuing the idea of remote control system we have come across the economical robotic system which can be installed on remote sites from different time zone. Major components of the system are Observatory Control Software, Image processing ,Optical Tube Assembly, Detectors (CCD, Photometer and DSLR), Telescope Mounting System, Robotic Enclosure (Dome) and Weather Station for local weather conditions ; well documented description of the system enables to implement it elsewhere. Each aspect of the system is explained in details to ensure that it can be reproduced easily. Major part of system is designed in such way that it can be maintained with ease and accessories can be purchased from local market. The goal of this project is develop the unique and economical system to explore the skies from different time zone with minimal use of human interference.

The conditions for optical communication at Ali observatory

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Ali observatory locates in the southwest of Tibet plateau, and many telescopes has been built here for its better astronomical observation conditions. And the cloud cover, atmospheric transmissivity, the sky radiation and the atmospheric turbulence will be discussed here to provide the atmospheric conditions for optical communication at Ali observatory.

Metrology Camera Software Development at ASIAA

Jennifer Karr[1]; Shiang-Yu Wang[1]; Chih-Yi Wen[1]; Chi-Hung Yan[1]
[1]*ASIAA*

ASIAA is a participant in an international collaboration developing the Prime Focus Spectrograph for the Subaru Telescope. As part of Taiwan's participation, ASIAA is developing the Metrology Camera System, which is instrumental for the positioning of the spectrograph fibres. I will discuss ASIAA software development for this instrument.

Early Science results from Wallaby

Lister Staveley-Smith[1,2,3,4]
[1]ICRAR; [2]UWA; [3]CAASTRO; [4]CAASTRO-3D

The Australian SKA Pathfinder (ASKAP) has been taking early science data for the key HI Wallaby survey since October 2016. I will briefly review the science drivers for Wallaby, provide an ASKAP update (if there are no other ASKAP speakers), but mainly discuss science results that are flowing from the fields chosen. Wallaby early science will cover less than one per cent of the southern sky, but gives our first insight into the phenomenal results expected when the full survey is completed in a few years. The main Wallaby goals are the discovery of new Local Group galaxies, understanding galaxies and their evolution, and providing cosmological insights.

Radio Frequency Interference Environment at the site of the Thai 40m Radio Telescope

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National Astronomy Research Institute of Thailand (NARIT) has started a 5-year project, known as the Radio Astronomy Network and Geodesy for Development (RANGD), which includes the establishment of 40-meter and 13-meter radio telescopes. To ensure best performance of the telescopes, several extensive Radio Frequency Interference (RFI) surveys have been conducted, where suitable location has been preliminary concluded to be in the Doi Saket District, Chiang Mai. In January, 2017, RFI measurements were carried out with a DC spectrum analyzer, active directional antennas and a low-loss cable from 20.0 MHz to 6.0 GHz with full azimuth scan. The antennas were raised to approximately 30-meter above ground level. The data from 3-minute pointing were recorded, for both horizontal and vertical polarizations, in maxhold and average modes. A 30dB LNA was also used at certain frequency window to increase sensitivity. The results show acceptable intensity level of mobile phone frequency, and sporadic WiFi and Bluetooth, and weak aeronautics and satellites transmission. The noise floor at the site of our equipment was approximately -130 dBm/(m^2.Hz), which was higher than International Telecommunication Union (ITU)'s recommendation by 100 dB (ITU-R RA.769-2). A permanent RFI station at the site has been planned in the future.

Keyword – astronomy radio telescope interference survey NARIT

Present status of Ibaraki station: Hitachi and Takahagi 32-m antennas

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Two 32-m antennas at Ibaraki station (Hitachi 32-m and Takahagi 32-m) are operated by Ibaraki University jointly with NAOJ. We have developed two receivers for each antenna: The low-frequency-band receiver (C/X-RX) covering 6.3-7.0 and 8.0-8.8 GHz, and the high-frequency-band receiver (K-RX) covering 20.5-25.0 GHz. Both receivers receive LHCP and RHCP simultaneously. The basic operation plan is like the following: On Hitachi antenna, the C/X-RX is mounted all year round. On Takahagi antenna, the C/X-RX is mounted in summer, and the K-RX in winter. Because it takes ~3 days to exchange the C/X-RX and K-RX, frequent exchange of the receiver must be avoided.

The VLBI (JVN and EAVN) observation mode (1 Gsps x 2 bit x 1 ch using ADS-1000+ and OCTADISK) and the single-dish observation mode (64 Msps x 2 bit x 1 ch for the observations of H2O maser at 22.235 GHz, and 16 Msps x 4 bit x 1 ch for the observations of methanol maser at 6.668 GHz using K5/VSSP32) is now available. The daily observations of the methanol masers are now conducted using Hitachi antenna (Yonekura et al. 2016).

We are now developing three new systems: One is a Hitachi-Takahagi 2-element interferometer. The correlator (OCTAD) can handle 4 IFs (LHCP and RHCP for both antennas) and correlations are calculated in real time. The sampling speed is 1 GHz, 2 GHz, or 4 GHz, and the input frequency range is from 256 MHz to 25.5 GHz. FFT points are 32 K for 1 GHz sampling, and 4 K for 1, 2, 4 GHz sampling. Second is a VLBI network with small numbers of baselines using K5/VSSP32 sampler (maximum sampling speed of 64 MHz) for the observations of maser emission. Third is a wide-band recording system using OCTAD. The maximum sampling speed is 8 GHz.

Recent Progress of the Japanese VLBI Network

Kenta Fujisawa[1]
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Japanese VLBI Network (JVN) is a VLBI network operated by six universities and the National Astronomical Observatory of Japan. The network consists of more than 10 radio telescopes with diameter of 11 m to 64 m those are owned or operated by universities and research institutes. The baseline length of JVN ranges 50 - 2500 km, and the observation frequencies are 6.7, 8 and 22 GHz. Main subjects of JVN are such as AGNs and star forming regions. Expansion of the VLBI network to the East Asia in cooperation with China and Korea has been made since 2010. A VLBI imaging survey observation of methanol maser sources was published in 2014 as the first result of East Asian VLBI Network (EAVN). On the other hand, non-imaging (fringe detection) observation with a few telescopes is considered as a new observation mode of JVN. The advantage of this mode is relatively high detection sensitivity at a few mJy, and large amount of observation time. Some scientific results will be presented in the poster.

Observational study of the change in size of an emitting region of 6.7 GHz methanol maser sources by a VLBI network with small numbers of baselines

Tagiru Saito[1]; Koichiro Sugiyama[2]; Yoshinori Yonekura[2]; Munetake Momose[1]; Kotaro Niinuma[3]; Kenta Fujisawa[4]; Kazuhiro Takefuji[5]

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6.7 GHz methanol masers are detected only in the process of the massive star formation. More than one thousand sources are discovered so far, and about forty sources show periodic intensity change. It is proposed that the change in size of the maser emitting region can cause the intensity change. The maser emitting region is considered to be consisted of the core with the size of several AU and the halo with the size of several hundred AU, and thus the VLBI observations are essential. In order to study the change in the size of the maser emitting region, observations at the quiescent period and the bursting period are necessary, and a VLBI network with a small number of baselines is suited for monitoring such a region in timely fashion.

Test observations were carried out on October 26th, 2016, by four antennas: Hitachi 32-m, Takahagi 32-m, Kashima 34-m, and Yamaguchi 32-m radio telescopes. Fifty-six 6.7 GHz methanol maser sources were observed. The bandwidth of 8 MHz (6664-6672 MHz) including the methanol maser line (~6668 MHz) were sampled at 4bit. The integration times were five minutes per source. In order to calibrate the delay and delay rate, three continuum sources (DA193, NRAO512, and 4C39.25) were also observed with the integration times of five minutes per source. Fringes with SNR greater than 7 were detected in all of 56 maser sources at ~300 m baseline, 25 sources at ~100 km baseline, and 23 sources at ~1000 km baseline. We will make further observations both at the quiescent period and the bursting period in near future.

Simultaneous Multi-Frequency VLBI Observation and its Demonstration with KaVA

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The Korean VLBI Network (KVN) has a unique receiver system that can perform simultaneous multi-frequency (i.e. 22, 43, 86 and 130 GHz) VLBI observations, which enables to calibrate tropospheric fluctuations effectively. For that, many observational demonstrations have been made by the KVN and now this system is extending to other VLBI telescopes. In 2015, two quasi optical systems for the simultaneous 22/43 GHz observations were installed at the Mizusawa and Iriki radio telescopes of VERA (VLBI Exploration of Radio Astrometry). The first fringes of two VERA telescopes at 22/43 GHz were successfully detected as well as with the KVN baselines. Here, we present the results of the first simultaneous 22/43 GHz observing campaign of KaVA (KVN and VERA Array) conducted in 2016 and discuss its future prospects.

Why VLBI sucks.

Jeffrey Hodgson[1]
[1]*Korea Astronomy and Space Science Institute*

Very Long Baseline Interferometry (VLBI) is famous amongst astronomers as being a "black-belt" observational technique that requires years of training and specialised knowledge to use. To a large extent this is true. This leads to VLBI and the science that is performed using VLBI to often be quite separated from other areas of astronomy. In recent years, there has been some effort to make VLBI easier to use for scientists, with for example pipelines available for instruments such as the Korean VLBI Network and the Very Long Baseline Array. While calibrating the raw data is becoming easier for relatively simple experiments, the imaging and analysis of VLBI data is still a time consumuing process. In this talk, I will overview the current state of VLBI as seen from the perspective of a non-VLBI astronomer and then discuss what still needs to be improved.

Yamaguchi Interferometer

Takahiro Aoki[1]
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We have constructed a two-element radio interferometer using the Yamaguchi 32 m and 34 m antennas in Japan, which we call the Yamaguchi Interferometer (YI). The 34 m antenna was used for satellite communication until 2015. After the completion of the industrial operation, we developed an antenna control system to track astronomical objects, a narrow band radio receiver using devices on hand, and a signal transmission path with the radio-frequency over fiber (RFoF). The antenna is currently used for radio astronomy and integrated as the YI narrow band system. For higher sensitivity and more effective operation, we are making a wide band (512 MHz bandwidth) receiver and a real-time software correlator. The YI has the 108 m baseline length and therefore the ~1 arcmin angular resolution and will have a detectable sensitivity of ~1 mJy at the C band (6600 – 7112 MHz) and X band (8192 – 8704 MHz). Data will be acquired at the 2 bit quantization and the 1024 MHz sampling rate. Observation targets of the YI are variables or transients such as gamma-ray bursts afterglows, gravitational wave sources, active galactic nuclei flares, and others. The YI will be a powerful contributor to time-domain radio astronomy. We also plan to establish a commensal observation system that simultaneously conducts interferometric observation and time-series pulse search such as fast radio bursts in the future.

65536 channels spectrometer for GLT

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The spectrometer is built for the Greenland telescope (GLT) single-dish observations which are expected up to 15 THz frequency for sub-millimeter astronomy. This system provides large bandwidth and frequency resolution for back-end signal processing. IF signals are digitized by the 8-bit, 5 giga samples per second (Gsps) analog-to-digital converter printed circuit board assembly (PCBA) developed by ASIAA. The digital output signals are processed with Reconfigurable Open Architecture Computing Hardware (ROACH2) field-programmable gate array (FPGA) platform developed by Collaboration for Astronomy Signal Processing and Electronics Research (CASPER) community. ROACH2 is programed with the model file to acquire the data and do the simplification. A NETGEAR M4300 12X12F 10-Gigabit Ethernet switch is adapted to do the data transmission between ROACH2 and the controlling PC. For now, the GLT spectrometer is capable of analyzing the radio frequency signals from DC to 2.048 GHz and up to 32K channels, 64 kHz frequency resolution.

Development of the Ibaraki two-element interferometer for the frequent monitoring observations of radio continuum sources

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To observe the burst phenomena of AGNs and T Tauri stars in continuum emission with high precision and high temporal resolution, the effect of amplitude fluctuations due to earth's atmosphere and the receiver systems must be minimized. When we observe radio continuum with a single dish radio telescope, we must quickly switch ON and OFF positions. Observing with an interferometer, however, it is not the case because the atmospheric and sky noises between the two elements are incoherent and are suppressed in the process of cross correlation. At Ibaraki University, we are operating two radio telescopes; Hitachi 32-m and Takahagi 32-m. We started development of the two-element interferometer with the bandwidth wider than 500 MHz.

The Ibaraki two-element interferometer consists of the hardware correlator. The correlation is processed in real time after 3 bits sampling with the bandwidth of 512, 1024 or 2048 MHz out of 6.3-7.0, 8.0-8.8, and 20.0-25.5GHz with the FFT points of 4096. The predicted values of the delay time and its first- and second-order derivatives between antennas at every second are calculated in advance of the observations from the celestial coordinates of the target, the antenna locations, and the observing date and time. The observed data are recorded after the integration of 1.024 or 0.1024 second. The sensitivity is estimated to be ~1 mJy (5-sigma) for the observations at 8 GHz with 512 MHz bandwidth and 10 min integration.

We confirmed the data can be obtained without rapid change of the amplitude and phase at the setting of 512 MHz bandwidth and 1.024 sec integration. In near future, we will observe the sources with known flux to establish the method to convert the observed amplitude to the actual flux. We plan to start the frequent monitoring observations of radio continue sources during this year.

Performance of the First Three Preproduction 35 – 50 GHz Receiver Front-ends for Atacama Large Millimeter / submillimeter Array

Yuh-Jing Hwang[1]; Chau-Ching Chiong[1]; Yau-De Huang[1]; Chi-Den Huang[2]; Ching-Tang Liu[2]; Fang-Chia Hsieh[2]; Yen-Hsiang Tseng[2]; Po-Han Chiang[1]; Chih-Cheng Chang[1]; Chin-Ting Ho[1]; Shou-Ting Jian[1]; Yi-Wei Lee[1]; Alvaro Gonzalez[3]; John Effland[4]; Kamaljeet Saini[4]; Marian Pospieszalski[4]; Ricardo Finger[5]; Valeria Tapia[5]; Nicolas Reyes[5]

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The Band-1 receiver front-end cartridges for Atacama Large Millimeter Array, which covered 35 – 50 GHz frequency range, are currently in preproduction stage. The receiver performance of the first three cartridges is presented in this paper. The measured receiver noise temperature is less than 30K for any combination of the in-band RF and LO frequency. The measured gain flatness, with the limitation of the optical window of the cryostat and the broadband matching of the cryogenic amplifier, is typically lower than 5 dB over any 2GHz window. Extracted aperture beam efficiency is higher than 80% over the full frequency range. The crosstalk over the orthogonal channel is lower than -63 dB. For the suppression of the unwanted lower sideband, the imaged band suppression is higher than 20 dB for the worst case and around 30 dB typically.

Corrugated conical Horn feed design for wideband single pixel feed (WBSPF) receiver system

Yue Ma[1]; Shenghua Yu
[1]*Corrugated conical Horn feed design for wideband single pixel feed (WBSPF) receiver system*

Corrugated conical Horn feed for receiver systems is proposed and presented. The cryogenic feed system design is considered with emphasis on its application in future wideband radio telescope systems. A great deal of simulated results are presented in this paper. Hence, the results showed that the proposed design achieved a low reflection coefficient, a main lobe with near-constant symmetrical beam width and a higher aperture efficiency across the bandwidth. Further developments needed to completely fulfill the requirements for these future wideband radio telescopes are also discussed. It is expected the present design could be a possible feed candidate that is suited for radio telescopes in SKA pre-construction phase- advanced instrumentation programs (AIP) ,especially in wideband single pixel feed (WBSPF) project.

SPICA Mid-infrared Instrument (SMI): results from conceptual design study

Takehiko Wada[1]; Hidehiro Kaneda[2]; Kentaroh Asano[1]; Misato Fukagawa[2]; Daisuke Ishihara[2]; Naoki Isobe[6]; Mitsunobu Kawada[1]; Jungmi Kwon[1]; Hideo Matsuhara[1]; Koichi Nagase[1]; Takao Nakagawa[1]; Takashi Onaka[4]; Shinki Oyabu[2]; Itsuki Sakon[4]; Hiroshi Shibai[5]; Toyoaki Suzuki[2]; Kohji Tsumura[3]; Mitsuyoshi Yamagishi[1]

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SMI (SPICA Mid-infrared Instrument) is one of the two focal-plane scientific instruments planned for SPICA. SMI covers the wavelength range of 12 to 36 microns, using three spectroscopic channels: LR (R=50-120), MR (R=1300-2300), and HR (R=28000). SMI-LRS is a multi-slit prism spectrometer with 4 long slits of 10' in length equipped with a 10' x 10' slit viewer camera (SMI/CAM). SMI/LR has a very high continuum sensitivity (~30 microJy in 1 hr, 5 sigma), and is designed to perform wide-area spectroscopic surveys in a telescope step-scan mode producing a spectral map of ~10' x 10' area as a minimum field unit. SMI/MR is a grating spectrometer with a long slit of 1' in length, and SMI/HR is an immersion grating spectrometer. Both have very high line sensitivity (~3 x 10^{-20} W/m^2, and ~2 x 10^{-20} W/m^2 in 1 hr, 5 sigma, respectively). SMI/MR and HR are operated in combination with a beam-steering mirror to perform spectral mapping of relatively small areas. Scientifically, SMI/LR enables us to study spectral bands due to dust grains such as polycyclic aromatic hydrocarbons (PAHs) from star-forming galaxies at redshifts z = 0.5-7, and silicate grains from planet-forming debris disks of mid-IR luminosities close to that of our solar system. The slit viewer camera provides deep broad-band (R = 5) imaging at 34 microns which will explore the gap between the JWST/MIRI 24 micron and the Herschel 70 micron surveys. SMI/HR enables us to perform velocity-resolved studies of fundamental molecular gases (H2, H2O, CO) such as those in the innermost regions of protoplanetary disks and in the energetic outflow of active galactic nuclei. SMI/MR provides more versatile spectroscopic functions, for example, for follow-up spectroscopy of targets detected by SMI/LR in more detail. In this presentation, we will show the result of the conceptual design study.

The Taiwanese Contribution for SPICA mission

Shiang-Yu Wang[1]; Ming-Jye Wang[1]; Ciska Kemper[1]
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The SPace Infrared telescope for Cosmology and Astrophysics, SPICA, is a joint European-Japanese project. SPICA is proposed as a the next generation space infrared observatory with a 2.5-meter primary mirror cooled to below 8 K. With a new generation of ultra-sensitive detector arrays, SPICA is proposed to offer the community a unique astronomical facility covering the rich 12 - 350 μm spectral range, capable of making deep and wide surveys to unprecedented depths in spectroscopy, photometry and polarimetry. More than 100 times of gain in sensitivity is expected for SPICA compared with Spitzer and Herschel. The Taiwanese community has agreed to join the phase A studies for SPICA through collaboration with both JAXA and ESA. On the science side, we will work with the consortium to foster the science cases and the observation plans of SPICA. On the technical side, we will develop the calibration source for the far infrared instrument SAFARI and also work on the As:Si detector module for the mid infrared instrument SMI. By contributing to the design studies of the major instruments on SPICA, SMI and SAFARI, Taiwanese astronomers will join the design of the legacy surveys of SPICA and gain guaranteed observation time of SPICA if SPICA is selected and completed in 2028. In this poster, the details of the hardware development will be presented.

Development of Carbon Fiber Reinforced Polymer for Telescope Mirrors

Young-Soo KIM[1]; Jeong Gyun Jang[1]; Jihun Kim[1]; Jeong-Yeol Han[1]; Jakyoung Nah[1]; Uk Won Nam[1]
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Glass has long been used as a mirror material for telescopes, because it can be fabricated easily. However, it is brittle needed to be carefully handled. with care as it is brittle. Other materials have been considered for telescope mirrors, such as metals like aluminum, plastics, and liquids like mercury. However glass or glass ceramic is still dominantly and commonly used.

Carbon fiber reinforced polymer (CFRP) is a new material for telescope mirrors. It is stiff, non-brittle, very low in thermal expansion, light-weight, and medium cost, which is suitable for large mirrors. However, there are technical issues in making CFRP mirrors, and attempts to solve the problems have been made. In this poster, mirror materials are reviewed and development status of a CFRP mirror is presented.

The IAU National Outreach Contacts (NOC) Network and different national challenges

Sze-leung Cheung[1]
[1]*IAU Office for Astronomy Outreach*

The IAU National Outreach Contacts (NOC) Network is a formation to implement different proposed IAU outreach initiatives at national level and for maintaining the relationship with the national communities of amateur astronomers and is managed by the IAU Office for Astronomy Outreach (OAO). Currently 69 NOCs were in place. In this presentation, the author will introduce the network system, and also introduce different national challenges. The IAU OAO has conducted a preliminary survey with different NOCs to understand the specific needs of each country and the survey reveal interesting results - the diversity of communication channels, education standard, amateur-professional relationships, media relations, geographical related reach out model etc. These area findings has shown huge potentials of different areas that IAU can work on to support the global astronomy outreach development. The author will present a summary of this preliminary study.

The East-Asia Regional Office of Astronomy for Development (EA-ROAD)

M.B.N. (Thijs) Kouwenhoven[1]
[1]*Xian Jiaotong Liverpool University (XJTLU)*

During its 2012 General Assembly in Beijing, the International Astronomical Union (IAU) ratified a visionary decadal strategic plan entitled “Astronomy for Development", which aims to use astronomy to stimulate development at all levels including primary, secondary and tertiary education, science research and the public understanding of science. At the heart of the implementation of this plan was the creation of a central coordinating “Office of Astronomy for Development” (OAD) in South Africa, accompanied by several Regional Nodes accross the world, including two in the East Asia region. The East-Asia Regional Office for Astronomy Development (EA-ROAD) entails the coordination of astronomy-for-development activities in countries within the general geographical region of East Asia, primarily focusing on China, the DPRK (North Korea), and Mongolia. The other is the Chinese Language Expertise Centre (EA-LOAD) which will deal with all aspects relating to (mainly) the Chinese language and culture. The impact of the latter may obviously spread well beyond the geographical region to other parts of the world. Here, we present the activities and opportunities of the East-Asia regional offices for Astronomy Development, and plans for the near future.

IAU SEA-ROAD Programmes for Development

Wichan Insiri[1]
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The National Astronomical Research Institute of Thailand (Public Organization) has been hosting IAU Southeast Asia Regional Office for Development since 2012. Ever since, the region has seen a dramatic development of astronomy as SEA-ROAD is seen as an inevitably imperative attribute to such development. SEA-ROAD facilitates the ongoing and emerging activities, creates better channel of communication and mobilizes the influx of knowledge transfer and human resource to the region. Furthermore, the existence of SEA-ROAD pinpoints Southeast Asia in the global community of astronomy as the region of sustainable development.

SEA-ROAD aims at 2 different programmes as follows;

Capacity Building

Knowledge Transfer

The aforementioned programmes focus on a wide range of audience ranging from school students to new PhD. Graduates to be exposed to astronomy and related sciences, engaging all related parties in the region and beyond.

Analysis of the Accounts of Daytime Appearance of Venus from the Goryeosa

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We investigate the accounts of daytime appearance of Venus recorded on the Korean *Goryeosa* (History of the Goryeo Dynasty; A.D. 919–1392). For a period of 378 years (from 1014 to 1392), we find a total of 167 accounts, including five for which the day is not specified and one for which the sexagenary cycle of the day is wrong. First, we analyze the number distribution of the accounts in intervals of 16 years, based on the synoptic period of Venus. We find that the distribution shows a minimum at around 1232, when the Goryeo dynasty moved the capital to the Ganghwa island because of the Mongol invasion, and a maximum around 1390, at about the time the dynasty fell. Next, we calculate the altitude, magnitude, and elongation of Venus at sunset on the days of the reported observations, using the DE 406 ephemeris and modern astronomical algorithms. We find that the average magnitude of Venus on the days of those reports is −4.5, whereas the minimum magnitude is −3.8. Above all, the average elongation shows good agreement with the known value at which Venus reaches its maximum brilliance, i.e., 40. We think that the results of this study are useful to estimate the practical conditions for naked-eye daylight observations of Venus, and bring additional insight into the related historical reports contained in the *Goryeosa*.

Knowledge of Comets in Ancient India

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The ancient most literature of India is Veda. The Rk Veda contains more than verse which says observation of comets. Here comets of different shapes and look are mentioned. R N Iyengar observed that the comet (dhumketu) appears seven times in Rk Veda, and that Atharvaveda contains a verse about Ursa Major (Saptarsi) beimg veiled by a comet. In an ancient epic Ramayana mentions that comets are looked by the king; similarly in Mahabharata the king was warned citing ominous signs like the star (nakshatra) ν, and θ Cancri being obscured by the comet. In Gargajyotisha, composed between 100 BCE to 100 CE, includes 77 comets that are characterized by a dark reddish hue as mentioned in Varahamihira's Brihat Samhita of 550 CE. Brihat Samhita had stated categorically that it is not possible to determine by calculation the rising and setting of the comets. It had described in detail the motion of a comet underscoring its rise on the west and increase in its size as it moved towards north, touching Ursa Major. Brihat Samhita had delineated characteristics of 1000 comets. It is remarkable that, anticipating periodic orbits, Narada had emphatically claimed – 'there is only one comet which comes time and again', while Bhadrabahu had reckoned that comets are hundreds in number, each of different period. Parashara had listed 101 comets some of which are classified by him. King of Mithila and Banga had compiled cemetery records of Parashara, Garga, Varahamihira etc. in the Adbuta Sagara. In this paper I try to explore the untold history of a few ancient Indian astronomers who had knowledge about comets.

Keywords : veda, gargajyotisha, comet, cemetery records

DIVERSITY OF ASTRONOMICAL INSTRUMENTS DEVISED IN ANCIENT INDIA

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Astronomy is an observational science. The position and movements of heavenly bodies have to be observed and recorded very accurately before a theory to explain their motions can be propounded. All theories have to be revised if their predictions are not in accordance with observational results. Also for many purposes, the time since sunrise has to be measured precisely. However, visual observations are not very accurate and it is necessary to devise instruments to ascertain the positions and motions of heavenly bodies and measure the duration of time. Ancient Indian astronomers devised a number of diverse instruments for observation. Ancient Indian astronomers had facilities for naked eye astronomical observation. This paper briefly deals with the diversity of some of the major astronomical instruments used for observation by Indian astronomers of pre-telescopic period. These instruments were used primarily for two purposes — to determine time and to fix positions of the heavenly objects. But none of the instruments described by the Indian astronomers before the time of Maharaja Jai Singh (1688 – 1743 AD) survive today. Perhaps they were made of perishable materials like wood and bamboo. Admittedly also, they were not very sophisticated. Details of some of these ancient instruments have been found out on the basis of information available in various astronomical treatises of ancient India written mainly in Sanskrit, which was the language of the then astronomers. Some of these treatises were later translated into English and are still available.

The Asiatic Society of Calcutta and a study of Science with special reference to Astronomy and Mathematics

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Set up in 1784 the Asiatic Society is not only the oldest institution of Asia but also a cultural icon of our country. Primarily a colonial construct, but the vision of the founder of Sir William Jones had a wide3 concept in building up the socirty. The society took an interest not only in languages , literature and culture, but also in the natural sciences as they were related to India. There was no idea of establishing a museum as a part of the society's activities. The museum was foumded and developed under the active care and guidence of Dr Nathaniel Wallich, a renowned Botanist. The First three galaries like archeology, zoology and geology were the starting point. Whence Sir William Jones started his journey from Englad for India, he noted down some important points to explore India where science was included. India had made notebly good knowledge of the progress in the physical science, especially astronomy, which had drawn attention of many western scientists like William Hunter, Samual Davis and John Playfair. The first European was Reuben Burrow who pointed out Mathematical sciences were highly developed in ancient India. His paper on "A proof that the Hindus had the binomial theorem" was published in the second volume of Asiatic Researches. He also tried to prove that although Newton was responsible for the application of binomial theorem to fractional indices, the Hindus understood each in whole members to the full as well as Briggs and much better than Pascal. Sir William Cecil Dampier once told that " the vast and imposing structure of modern science is perhaps the greatest triumph of human mind. But the story of its origin, its development and its achievements of least known parts of history.

Keywords : astronomy, binomial theorem, hindus, triumph

Transition of Water-Hammering Type Astronomical Clock in the Middle of the Joseon Dynasty

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The astronomical clock was produced using the water-hammering type power system that was traditionally employed in the Joseon Dynasty period. In the early years of the Joseon Dynasty, the astronomical clock was activated by supplying water constantly and controlling the water wheel using the overflow-type 2-stage or 3-stage *Pasuho* (water supply jar) and *Cheonhyeong* apparatus (escapement). However, this kind of method was not transmitted due to the Japanese Invasion of Korea in 1592 and the Manchu war of 1636. In the middle of the Joseon Dynasty, Choi Yuji (1603-1673) made an astronomical clock personally in order to study *Shang Shu*. However, there is no clear evidence showing the control of the water wheel in the literature. After that, Yi Min-cheol (1631-1715) produced the water-hammering type astronomical clock by order of King Hyeonjong (reign 1659-1674) of Joseon in 1669. Yi Min-cheol made two *Suhos* (water supply jar). The astronomical clock was activated by making one of the two *Suhos* as *Soho* and installing *Bucha* (floating waterwheel) made of copper inside the *Soho* to rotate *Giryun* (mechanical device) through a floating force. The astronomical clock was activated by supplying water constantly using *Suho* and *Bucha* and creating buoyancy. It is presumed that it had a form which was completely different from the overflow-type *Pasuho* and *Cheonhyeong* apparatus in the early years of the Joseon Dynasty. *"Jejeonggak-gi"*, "*Gyujeonggak-gi" and "Sinjo-honcheonui-yanggajeong-jingye"* that were literature materials relating to Yi Min-cheol's *Honcheoneui* (armillary sphere) were analyzed. Also, the change in the model of the water-hammering type power system in the middle of the Joseon Dynasty was presented through the conceptual design based on such contents.

An Analysis of Internal Structure of the Heumgyeonggak-nu and a Study of its Design

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The *Heumgyeonggak-nu*, which is called *Ong-nu* as well, was completed in the 20th year (1438) of King Sejong's reign. It is an automatic water clock installed inside the *Heumgyeonggak*. The Annals of the Joseon Dynasty recorded a detailed description of the outward form of *Heumgyeonggak-nu*, but omitted the description of its internal mechanism or introduced some parts only. According to the result of a careful analysis of the records of the *Heumgyeonggak-nu* that were scattered for about 180 years, the *Heumgyeonggak-nu* consisted of a three step clepsydra, had special features such as a waterfall or inclining vessel using an overflow mechanism, and told the time using beads. This study intends to restore the *Heumgyeonggak-nu*, based on the mechanism of a water-hammering-type mechanical clock which was popular around the 15th century. To this end, this study is carrying out a phased development: The first phase is the development of a power operating system and a solar drive system; the second phase is the development of a time signal management system and exhibition-oriented contents; the third phase is the development of exhibition-fusion contents of digital *Ong-nu*. This study deals with the first phase, and designs the internal structure of the *Heumgyeonggak-nu*, based on the results of a study of its mechanical and physical mechanisms. A water wheel is designed with a diameter of 120 cm, and 16 fixed-type scoops are made to work organically with a *Cheonhyeong* apparatus (an escapement system). A scoop can hold 1.25 liters and a water wheel rotates 61 times a day. So, a total of 1,220 liters is used in a day. In addition, a rotating circle of the power gear wheel is designed with 366-gears and *Cheonun-hwan* related to the movement of the sun is designed with 365-gears to realize the sun's movement along the ecliptic.

Classification and Verification of Korean Historical Astronomical Records

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This study aims to introduce the database which is to collect astronomical records among scattered in Korean history books and to translate the ancient texts into modern Korean.The ancient dynasty of Korea was commenced by the Three Kingdoms period (Goguryeo, Silla, and Baekje, B.C. 57~ A.D. 935) and continued to the Goryeo (A.D. 918~1392) and the Joseon (A.D. 1392~1910) dynasty. Over the past 2,000 years, Koreans have recorded a great deal of astronomical phenomena. In the Joseon dynasty, several literature and relics about various astronomical instruments have also been collected and reported. During the past decade, we have been working on collecting and organizing ancient materials in order to build an astronomical history museum. In our study, the first step is to convert the old dates into the modern calendar dates, the second is to collect astronomical phenomena records, and the third step is to verify its phenomena of database. We completed the first stage 10 years ago, and at present, all the astronomical data of each period are collected, and the phenomenon data of the Three Kingdoms and Goryeo period are classified by each phenomenon. Most astronomical records are listed in a one-dimensional method, i.e., in chronological order or in kind of phenomenon. However, we have integrated these two one-dimensional recording methods into a database as two-dimensional data. In the future, we plan to verify the accuracy of each astronomical phenomenon using modern astronomical calculation methods while producing the database of these astronomical records. Many studies have been proceeding to analyze the solar and lunar eclipse. We are also going to research the recorded data such as observations of the Venus, comets and planetary movements

Any Astronomical Alignment in Batujaya Temple Complexes?

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Batujaya temple complexes in Karawang, West Java, Indonesia is suspected to be a relic of civilization of Tarumanegara, the oldest Hindu Kingdom in Java Island (4th century).

These temple complexes have been studied in various fields such as culture, history, and archeology. We have conducted astronomical measurements of the temple complexes in various aspects. The purpose of these measurements is to find out whether there are astronomical alignment in the temple complexes..

A preliminary result will be presented.

Verification of the latitude of Korean Treasure No. 840, a stone horizontal sundial

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We study on the horizontal sundial which is the Korean Treasure No. 840. After the influx of the Western science from China, this sundial is said to have been made by a royal astronomers of Joseon dynasty. With its 3D Scan Data of Cultural Heritage Administration of Korea, we analyze the latitude of only 13 hour lines engrave on this horizontal sundial. We can extract a few points of the origin, because a convergent point of extension of two hour lines including the 12h-hour line can be the origin of all hour lines. The latitude of a variety of the origins is calculated as an average of 37° 15′ ± 26′. This value is very consistent with the latitude of inscription on the horizontal sundial which is 37° 39′ and 14′ more than our calculation. Our study is significant to estimate the latitude of a horizontal sundial, without its information or its gnomon, only by hour lines.

Astronomy Education Curriculum □ Initial steps towards the IAU international recommendations and guidelines

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IAU has redefined astronomy as a comprehensive science from a part of physics. It is an important message on "IAU Astronomy for Development Strategic Plan 2010-2020". Based on this recommendation, we (our team) intend to build a standared curriculum and syllabus two guidelines in astronomy that can be used around the world.With this research work,there are two goals, 1.Guideline A: course to become an astronomer. 2.Guideline B: course to all college student. Regarding guideline A, Science Council of Japan determin the quality guidelines of Japanese all universities. On the other hand, regarding the guideline B, Astronomical Society of Japan are just creating the gudeline for all universities which have astronomy class.In this talk, we first review about such recent developments in Japan. Next we will also introduce examples of advanced initiatives in foreign countries.For example, Leiden University in the Netherlands is developing guidelines for astronomyl literacy. The IAU's OAD also sets similar guidelines for developing countries and maintains online textbooks.By examining the previous research, we found that astronomy lessons at universities in each country are not comprehensive science like the IAU would like.As a next step, we will collect curriculum and syllabus from all over the world (Refer to the talk of Lina Canas). One of the goals of this educational research is to make concrete proposals to the IAU. I will report on research results to the IAU General Assembly in 2018. And we aim for a resolution at the IAU General Assembly in 2021.

Commissioning of a 4.5-m Small Radio Telescope for education

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A laboratory course module in radio astronomy has been prepared for undergraduate level study. A 4.5-m Small Radio Telescope (SRT) have been designed to operate at 1,420 MHz to detect the neutral Hydrogen spin-flip transition line, where the Doppler shift of the signal and then the rotation curve of the Milky Way can be measured. Students will also learn about radio telescope fundamentals and calibration processes. The SRT has been evaluated in both the mechanics, e.g. pointing and tracking accuracy, and RF properties, such as the beam pattern and system noise temperature. Here, we present results from the commissioning phase.

Establishment of TARA Observatory node, Fergusson College, Pune, INDIA

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Establishment of TARA Observatory node, Fergusson College, Pune, INDIA

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Fergusson College has been actively engaged in science popularization in Astronomy and Astrophysics for the past 18 years with simple and limited facilities. Recently, the Inter University Center for Astronomy and Astrophysics IUCAA, Pune has officially acknowledged us with a IUCAA Node for Astronomy and Astrophysics Development i.e. INAAD center for popularization of the subject.. The Physics Department also has Astronomy and Astrophysics as an elective subject. Presently we are involved in setting up an observatory with existing Celestron telescope with go to facility. We have procured grants for purchase of Photometer, CCD and a Solar Telescope.

The Cork Institute of Technology, Ireland, recently visited the college for possibilities of a collaborative project in setting up a Robotic Telescope using the existing facility. Their existing robotic telescope operating at Cork and California, US which are already linked. The TARA Fergusson College node will thus allow students to carry out projects and research in using the setup. The node would also let students and teachers use this telescope for live observing sessions as well as scheduled observations. Further, the difference in time zones between USA, Ireland, India is also ideal for day time astronomy – Solar studies.

An integral part of the project will also be the implementation of a public outreach scheme to allow students to utilize the robotic telescope system as a learning and inspirational tool. The TARA node will provide a unique opportunity for college students, in India, Ireland and USA to perform observations, manually as well as remotely. Further in due course of time the observatory can have more nodes which will enable different Institutions from various countries to participate in remote observations.

Surveying Astronomy Tertiary Education Curriculum: First Results

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The International Astronomical Union (IAU) has re-defined Astronomy as "Comprehensive Science", able to embrace a vast number of areas such as “Culture & Society”, “Science & Research” and “Skills & Technology”. Our goal is towards an international astronomy education curriculum that reflects this broader scope and extensive understanding of astronomy as a complete science and to support developing countries to build and/or improve their curricula in astronomy so that everyone achieves a similar baseline of topics addressed, smoothing the transitions of future exchange students - to help them have similar knowledge to start with when inserted in other academic institutions outside their country. The research here conducted intended to understand, in a first approach, up to which extend the international existing astronomy curricula and syllabus reflect these aspects. This project compiled a list of astronomy syllabus and curricula from different courses (with a particular focus on University level of Astronomy courses and General Education courses) around the world. The data was analysed in order to understand the current situation on the astronomy courses in different countries - these first results can be used to define a starting point into establishing guidelines of an astronomy curriculum that can be utilised as a reference internationally.

Applications of Internet Telescope in Astronomical Education

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Internet Telescopes are small telescopes which are installed at the various locations in Japan and other countries and are remotely controlled via the Internet. Anyone can see the night sky by using them anywhere and anytime. We are working on the project named "Keio University Internet Telescope Project". The purposes of our project are the development of Internet Telescope and the spread of astronomical education using them. In this presentation, we will introduce the system and the network of our Internet Telescopes, and ones recently installed at Yokosuka and Hiratsuka in Japan. We will also report some applications of Internet Telescope in astronomical education, specifically the results of the seminars held, as one of the extra lessons, for high school students in Japan.

History of Astronomy inspires students in primary level – A Study

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Students like to hear stories of different subjects. Educationists have tried this story-telling method to attract students in their reading materials for ages. It will be a strong educational tool to popularize astronomy among children. In this category astronomical myths and history of astronomy may be the main parts of the study. To apply this method properly teachers should be prepared as what children like. We can use some animations to attract young students in this subject as children love something colourful, big and moving. If required teachers training must be provided only to implement this method. When we applied this method in our project 'Learn Simple, Learn More', we have got good result. Our senior teacher tells stories on an astronomical subject or life sketch of an astronomer and it inspires students. They start to ask different questions. When our class ends then they demand more time or another day to come to their school premises. Since this work is being conducted on Sunday or holiday, so, there must come limitations which can be overcome if this method is implemented in primary schools on a regular basis.

Introduction to the course "Learning Japanese using Popular Science Magazine"

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I have started to offer a new course named "Learning Japanese using Popular Science Magazine" at the Language Center of National Central University in Taiwan since September 2015. The idea of this course is to provide an opportunity to Taiwanese students to learn Japanese from a native speaker and to study basic science in Japanese. The course is given purely in Japanese, and students are encouraged to have more conversations in the classroom. Every week, I pick one article from Japanese popular science magazines, such as "Newton", and read it in the classroom. Topics for this course include, but not limited to, astronomy, physics, space science, Earth science, chemistry, and biology. After reading, I have discussion about the contents of the article with students. Students are expected to understand basic scientific principles and to know outcome of recent research activities, in addition to studying Japanese grammar. The course is very unique for focusing science, with a strong preference in astronomy, as a language teaching. The design and overview of the course is presented.

Study Efficacy of Public Education Program at Bosscha Observatory

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One of public outreach program in Bosscha Observatory is public visitation program. This program become the popular public choice to learn about astronomy by listening the material and looking the astronomical instrument directly. In this project we try to build a robust efficacy evaluation program for exploring behavior change outcomes such as interest, inspiration, rawareness, and motivation about astronomy, furthermore we also evaluate the understanding level of visitors, evaluating the given material, and the way to communicate with public by questionnaire. The questionnaire is developed by highlight the goal of public observatory program, which given from management, visitor expectation and available evaluation example. Challenges are showed for defining the suitable condition and visitor culture for Bosscha Observatory program, so we should modified the source by collecting, collaborating and then eliminating factors. Data collected using verbal and written questionnaire from visitors and observatory management. To make a comparison result we collect the evaluation method that held the education for public program in the other institution in Indonesia

Our Solar Siblings: A Curriculum-based project for use with Robotic Telescopes for Student Research and Education

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Our Solar Siblings is an intervention project for high school level astronomy. It is an investigative data and inquiry driven curriculum replacement for the "astronomy out of the text book" approach commonly undertaken in high schools. It employs an embedded professional learning program for the teacher while the students undertake authentic astronomical analyses of data collected by professional grade astronomical telescopes. Thus, the personnel in the project provide teaching and learning support, access to research grade telescope instrumentation from the teacher's classroom and extensive curriculum materials who would like an opportunity to undertake authentic astronomy in their classrooms with a minimum of stress and preparation.

The core of the project revolves around the curriculum materials supplied as an interactive digital "book" with all of the software, student materials, teacher guides and explanatory movie clips supplied. These materials are updated and expanded as teachers implement the project in their classrooms and supply feedback of their experiences to us. We act on teachers' and students' feedback to improve the curriculum materials. By providing pre-prepared and coherently structured but editable and customizable curriculum materials to the teacher, as well as support via digital technologies such as email, Skype, Zoom during implementation, we minimize the teacher's own preparation time and let them focus on providing quality astronomy education in their classroom.

A Documentary Film for Greenland Telescope

homin jiang[1]
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Going to the North Pole, building up an observatory, such things seemed to be a remote and impossible dream for most Taiwanese. Mapping the direct image of a black hole is one of the highest priorities for astronomers worldwide. Documenting this scientifically and technically challenging project is the responsibility of the local video workers.

Started from 2011, collaborating with U.S. institutions, the Institute of Astronomy and Astrophysics, Academia Sinica (ASIAA) has been devoting huge resources to put the ALMA-NA prototype, a highly accurate 12-meter radio telescope whose weight is hundreds of tons, at the Summit of Greenland. In comparison with the Antarctica, where there are many scientific research camps with well-built infrastructure, there is almost nothing at the summit of Greenland. Therefore, the ASIAA team has to deploy the telescope and build up the associated infrastructure from scratch on the widely open and empty ice sheet.

It is a great challenge for Taiwan to design a precision telescope which can operate at the extremely low temperature of -65 degree C at the Summit of Greenland, the Arctic. In order to take the lead in science, all of the developed countries will invest wisely and use the latest developed technologies to make their research successful. This is a game of pursuing excellence in science and technology.

General public are always attracted by the mysterious black hole. This can be seen in the variety of imagination about black hole in people's mind and variety of fiction novels and movies that have been produced. The scientific goal of the Greenland Telescope is to image the black hole directly, and this is one of the ultimate scientific aims. Greenland Telescope will measure directly for the first time the only two properties that can be known about a black hole: its mass and its spin. It will provide scientists a new window for studying General Relativity under strong gravity field. For the general public, it will unravel the secret face of the black hole. Thus, the success of the Greenland Telescope project will be a milestone in astronomy and a big event in the human history.

This filming project will cover the whole process of upgrading and deploying the telescope. It includes transportation, assembly, testing and the actual observation. The general public would be touched by the courage and persistence of Taiwanese scientists and engineers in this film, when they see Taiwan lead the construction of the very first astronomical observatory in the Arctic. This in turn may inspire some people to enter the field of scientific research or provide support. Furthermore, this film will introduce the physics of black hole and the principle of the Very Long Baseline Interferometry (VLBI) in a simplified way so that the public can more easily understand.

Developing Tactile Models of NAOJ-related Telescopes with a 3D Printer

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Astronomy is one of the most exciting fields in science that attract many people with and without disabilities. Sighted people are fascinated by images of celestial bodies and cutting-edge telescopes taller than themselves. On the other hand, tactile resources are needed that visually impaired people can understand and enjoy. More than 30,000 people visit Visitors' Area of National Astronomical Observatory of Japan (NAOJ) Mitaka headquarters per year. However, scale models of NAOJ's cutting edge telescopes such as the Subaru Telescope, the 8.2-m optical and infrared telescope located on Maunakea, Hawai`i, are inside of a glass case and information for visually impaired people is very limited.

We have started a project to develop tactile models of NAOJ-related telescopes and astronomical objects with a commercial 3D printer. Based on the blue print of the Subaru Telescope, we made a prototype of the telescope model. We had a pilot survey for the prototype among visually impaired people and a science teacher at a blind school, and decided to make two types of the model: the simple model and the detailed model. The simple model is good for students at a blind school who are learning how to touch samples at science classes. The detailed model is good for experts of "touching culture" and for even sighted astronomy enthusiasts.

We will show the 3D model of the Subaru Telescope and present know-hows and tips to develop a tactile model that visually impaired people can understand and that is replicable among astronomy educators and enthusiasts.

Performance and Results from the Globe at Night – Sky Brightness Monitoring Network

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The Global at Night - Sky Brightness Monitoring Network (GaN-MN) is an international project for long-term monitoring of night sky conditions around the world. The network has currently 23 stations operating in 9 countries/regions in Asia, Europe, and Africa. More than 26 million individual NSB data entry had been collected up to February 2017. This huge NSB database allows for studies of temporal and geographical variations of light pollution and their correlations with various natural and artificial factors. In this presentation, preliminary analysis of the data will be presented. The analysis reveals that there exist huge variations in the night sky worldwide: urban night skies are significantly brighter than night skies in pristine national parks. In general, urban night skies get progressively darker with time over the night due to reduction in light usage. On the other hand, the rural sky brightness stays mostly steady throughout the night, reflecting minimal human influences. The NSB data will provide the scientific backbone in our efforts to contribute to dark sky conservation through education to the general public and to policy makers. Project website: http://globeatnight-network.org/

This project is partly supported by the University of Hong Kong Knowledge Exchange Impact Project Scheme.

Light pollution in Macau: assessment of night-sky brightness and potential implications

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Light pollution is a form of environmental degradation caused by increased anthropogenic activity and poor energy management. This form of pollution disrupts physiological cycles and behaviour of many species, including humans. Previous research has shown that Hong Kong represents the most light polluted city on Earth.

Macao is located near Hong Kong within Southern China, being characterized by higher population density and intense long-lasting outdoor lightening from casinos and hotels. This study represents a pioneer attempt to assess the light pollution in Macao, through measurement of the night sky brightness (NSB), and to evaluate geographical and seasonal variations. NSB data were measured using three stationary light sensing devices ("Sky Quality Meter") located in Macao peninsula (intense urban area), Cotai (high number of casinos) and Coloane (rural area). Results showed that light pollution is a severe environmental problem in all locations investigated in Macao (13 – 15 mag arcsec^{-2}), with the most polluted location in the Cotai area.

This project will be an important step towards understanding the level of light pollution in Macau and the importance of defining new strategies and regulations to protect human life quality and to preserve local ecosystems and biodiversity.

This project is partially supported by the FDCT, Macao.

Analysis of the telescope operation method using a time synchronization technique

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For the development of a telescope that is capable of precisely tracking satellites and high-speed operation, a special method of telescope operation is required. This study aims to propose a new telescope operation method and system configuration for the independent development of a mount and an operation system which includes the host computer. Considering that the tracking of a satellite is performed in real time, communication and synchronization between the two independent subsystems are important. Therefore, this study applied the concept of time synchronization, which is used in various fields of industry, to the communication between the command computer and the mount. In this case, communication delays do not need to be considered in general, and it is possible to cope with data loss. Above all, when the mount is replaced in the future, only the general communication interface needs to be modified, and thus, it is not limited by replacement in terms of the overall system management. The performance of the telescope operation method developed in this study was verified by applying to the new and precise real-time tracking system in Korea. This study is significant in that it proposed a new operation method and system configuration, to which the concept of time synchronization was applied, for the observation system that requires an optical telescope.

Trial Experiment for Mapping Relative Positions of Observation Points by Measuring Lunar Parallaxes in a Solar and a Lunar Eclipse with Commercial Digital Cameras

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Trial experiments for estimating lunar parallaxes among multiple observing positions using commercial digital cameras were carried out. Our trials were applied to the annual solar eclipse on May 21, 2012 and total lunar eclipse on October 8, 2014. These trials focused on an aspect of parallax that observing positions on the ground are projected in point-symmetric positions on a celestial sphere and it means that it is possible to estimate relative positions among each observing point from detected parallaxes. In the case of the solar eclipse, images were collected from web sites and we picked up 284 images taken at 37 observing points in Japan. There were 3 remarkable sunspots on the day and we used them as position references. The results of analysis indicate that the estimated lunar parallaxes were consistent with theoretical values within around 6.5″. This finding reveals that it is possible to detect small lunar parallaxes and relative positions among observing locations tens of kilometers apart from each other.As for the lunar eclipse, we asked citizens to take photos in various locations in Mie prefecture. Despite cloudy conditions on the day, more than 500 photos were received from citizens and 122 photos could undergo data processing. The results of analysis indicated that the estimated position of the center of the moon at three cities in Mie prefecture was consistent with theoretical values to within 5″, and we could easily distinguish the relative positions of each city.These two trials shows that it is possible to chart a map with lunar parallaxes among various observing points.
International cooperative observations are effective for science education. Solar and lunar eclipses are not so frequent occurred but can be observed over a wide area. Therefore, our method would be applied as an international cooperative project.

Production of lunar camera and the observation of the moon

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Because of the observation of the moon is relatively easy, it is a basic celestial object of astronomy education based on observation. Since moon can be observed with naked eyes, we do not need any special equipment to observe it. However, to observe the moon in special occasions such as the full moon, ingenuity is necessary to avoid the effect of the weather.

In this research, we product a lunar camera specialized for the observation of the moon. If we equip this on geographically remote places, we can observe the moon in real time without influenced by the weather. In addition, when we equip on both the northern hemisphere and the southern hemisphere, we can observe the phases of the moon with different observing points that promote the teaching effectiveness.

To product the lunar camera, we made many artifices, including being a low price and easy to operate. We here introduce the outline of the lunar camera we created. Also, we will report briefly on the moon observation by using the lunar camera.

Astronomy using a digital camera at high school

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In general, a CCD camera is used for an astronomical observation. However there are not CCD cameras at school. So my students and I tried to make photometric observations of asteroids by means of digital cameras. At first we examined whether digital cameras had competent performances (sensitivity, accuracy, etc.). As a result, we have acquired that digital cameras are inferior to CCD cameras in light curve photometry through our devising the observations many times. However we have obtained that relative light curves could be made by digital cameras, and the rotation period of the asteroid could be determined. Furthermore we might have assumed that the surface properties (geology, geomorphology) of an asteroid could be inferred from the light curve and the 3-D model. The flux (brightness) of an asteroid at the opposition ought to be proportional to the sectional area of the asteroid. It is considered that if the light curve and the sectional area indicate good agreement, the surface properties of asteroid are homogeneous, otherwise they are heterogeneous. In this way, we investigated the surface properties of some asteroids.

We have acquired some good points of digital cameras through these astronomical activities at our high school.

- Digital cameras already spread at high schools.
- Digital cameras have enough performances.
- The astronomical activities at high schools become quantitative and can be improved by using digital cameras.

Through this activity, students experienced strictness and pleasure of natural science study and some of them entered a school of higher grade to the astronomy or earth planet scientific field. We can conclude that a digital camera is extremely useful for high school astronomy.

Camera technologies overview and Applications in Astronomy imaging

Sean Chen[1]; Ricardo Covarrubias[1]
[1]*Andor Technology Ltd*

Andor Technology is a global leader in the development and manufacturing of high performance scientific imaging cameras, spectroscopy solutions and microscopy systems to match your application needs in research and OEM.

The prsentation will brief introduce current and future cameras from Andor Technology, including Electron Multiplying CCD (EMCCD) cameras, Scientific CMOS (SCMOS) cameras, Full Frame CCD cameras.We will also provide an overview of the key high-sensitivity, high-temporal-resolution detector technology types, used in astronomy applications such as adaptive optics wavefront sensing, solar exploration, high-time-resolution astrophysics, transit exoplanet discovery, gravitational lensing and even customized guide cameras. Furthermore, we will introduce Andor iKon-XL , the camera uniquely uses patent-pending 'ColdSpace™' technology to thermoelectrically cool a back-illuminated 16.8 Megapixel Very Large Area CCD sensor (e2v) down to -100 °C, circumventing the need for liquid nitrogen or cryo coolers. Extended Dynamic Range technology, facilitates lowest noise and maximum well depth within one scan, complemented by up to 18-bit digitization.

A Differential Photometry Pipeline Using Least Absolute Deviation

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We describe an IDL pipeline to compute stellar photometry using reference stars in the field of view of an image. The estimation, including an iterative derivation of the color terms, is based on differential photometry with least absolute deviation fitting. Comparison with results by the chi-squares criteron will be presented. We show a few applications of the pipeline to stellar light curves and star cluster photometry.