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SERENDIPITIES in the SOLAR SYSTEM and BEYOND

celebrating Prof. Wing-Huen Ip's 70th birthday

Abstract Book

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The Lunar-based Ultraviolet Telescope (LUT) aboard Chang'e-3

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The Lunar-based Ultraviolet Telescope (LUT) is one of the effective payloads of Chang'e-3 Lunar Lander. It was launched on 2013 December 2, got its first light on December 16, and still working well now. LUT has a diameter of 15 cm, a 1k'1k CCD detector, and a 2D rotation pointing mirror. It was designed to monitor variable stars and perform low Galactic latitude sky survey in near Ultraviolet band. This presentation will tell you the main technical characters of LUT and scientific results.

Multi-wavelength studies of stars in light of LAMOST

Jifeng Liu

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LAMOST provides an unprecedentedly large sample of stars with spectra, hence accurate spectral classification and stellar parameters. This enables studies of statistical behaviors of different stars, and also searches of exotic objects that deviate from the group statistics. We have combined LAMOST with multi-wavelength database to study stellar statistics and special objects, and here we report our preliminary results.

Spectra with H α emission lines from LAMOST Galactic survey

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Until now, the LAMOST survey has completed its pilot survey and the first four years of regular survey. About 7,000,000 stellar spectra are observed, which include a wide variety of stellar types. A considerable number of spectra exhibit H α emission lines, one outstanding feature covering early- to late-type stars, and pre-main sequence to planetary nebulae. Investigations on spectra with the H α emission from LAMOST survey are carried out in the following aspects. Emission lines mainly originate from stellar envelopes or outer stellar atmospheres in early-type stars. A catalog of early-type emission-line stars from LAMOST DR2 has been published and a preliminary analysis is made on this sample (Hou et al., 2016). Another generation mechanism for emission lines is stellar activities, often star flares due to magnetic behaviors in the case of the late-type stars (i.e., M dwarfs). Chang H.Y., et al. (2017) present a sample of flaring M dwarfs from LMAOST survey in the Kepler field. They find that M dwarfs with strong chromospheric emission in H α have large flare activity in general, and the rotational periods of M dwarfs have close correlations with magnetic activities. Besides stellar spectra with H α emission, spectra of nebulae also exhibit emission lines, mainly planetary nebulae and HII regions. 36 new planetary nebulae and 12 new HII regions are respectively discovered in the commissioning data and DR3 of LAMOST survey. More details can be found in the papers of Yuan H.B., et al.(2010) and Zhao D.W., et al.(2017).

Dark Matter

Chung-Ming Ko
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Mass of astrophysical objects can be estimated by its dynamics or its luminosity. However, for objects the size of galaxy or larger, the dynamical mass is always larger than the luminous mass, and much larger in general. The discrepancy is commonly called the "missing mass" problem. The cause is usually attributed to the existence of some unseen hidden matter, dark matter. Dark matter is ubiquitous. Modern cosmology demands dark matter, in particular non-baryonic dark matter. Here I discuss the necessity and some challenges of the dark matter paradigm.

The Story of Interstellar Pickup Ions and Their Excitation of Hydromagnetic Waves in the Solar Wind

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Based on measurements by Ulysses, Voyager and IBEX, the interaction between the solar wind and the local interstellar medium has been perhaps the most exciting theme in space physics during the last 40 years. The interstellar neutral gas flows into the heliosphere, is ionized by solar UV photons and charge-exchange with the solar wind to form interstellar pickup ions (PUIs) and a neutral solar wind. The PUIs are carried outwards with the solar wind to its termination shock, where their pressure dramatically reduces the Mach number of the shock transition and a fraction of the PUIs are accelerated to ~ 10 -100 MeV to form the anomalous cosmic ray component. An important feature of this chain of events is the excitation of hydromagnetic waves in the solar wind by the newborn PUIs as they scatter toward isotropy in the solar wind frame. Wing Ip and I (Lee and Ip, *J. Geophys. Res.*, 92, 11,041, 1987) analyzed the instability growth rate and published a prediction of the excited wave intensity in the solar wind. The predicted intensity based on pickup hydrogen was substantial and initiated a search for the PUI-excited waves at the expected frequency. The search failed initially to reveal the waves with the expected intensity and spectral signatures. It was eventually recognized that turbulent processes could obscure these signatures. However, several more recent searches have revealed many occurrences of the wave enhancements. These waves, initially predicted by Wing Ip and myself, in fact play an important role in enhancing the pitch-angle scattering of the pickup ions, contributing substantially to the hydromagnetic power in the outer heliosphere, and possibly providing a mechanism for stochastic acceleration of the PUIs.

The Importance of Pick-Up Ions in Space and Astrophysics: Some Examples

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One of Wing Ip's most important papers addressed instabilities associated with the creation of pick-up ions in the solar wind. Pick-up ions are associated with plasma mediated by cometary ions,

interstellar neutral hydrogen entering the heliosphere, and even neutral heliospheric material entering the very local interstellar medium. Pick-up ions are not typically equilibrated with the background or thermal plasma and form a distribution that is nearly isotropic and resembles some form of a shell-distribution. With this talk, we present a brief overview of some space and astrophysical problems in which pick-up ions play a central role. This includes a discussion of the contribution by pick-up ions to a plasma system's heat flux and the form of the stress tensor.

Latest results of the AMS experiment

Yuan-Hann Chang
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AMS is a particle spectrometer on board of the International Space Station. With multiple layers of different kinds of subdetectors, AMS measures the charge, energy and momentum of charged cosmic rays precisely from 1GeV to a few TeV rigidity. Here we report the latest measurements of the cosmic ray spectra of proton, antiproton, helium, and light nuclei like Li, Be, B, and C. Unexpected characteristics of the spectra are observed, which provide important input to the models of cosmic ray acceleration and propagation.

Superluminous supernovae and their host galaxies

Ting-Wan Chen
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A new class of supernovae, called superluminous supernovae, has been discovered in the past few years. They are 100 times brighter (with absolute mag -21) than normal core-collapse supernovae. This means that the standard paradigm of iron-core collapse cannot account for the origin of superluminous supernovae. An alternative mechanism is needed to power such high luminosities, such as magnetar spin down, pair-instability explosions or shell collisions. In this talk, I will present our work on superluminous supernovae, from their discovery using all-sky surveys (e.g. PanSTARRS1), to their classification with the Public ESO Spectroscopic Survey for Transient Objects (PESSTO), and their follow-up with large facilities such as the 8m VLT. We found superluminous supernovae appear to occur exclusively in metal-poor dwarf galaxies, indicating that a sub-solar metallicity is required to produce them. We also found a possible relation that, if magnetar powering is the source of the extreme luminosity, the initial magnetar spin is correlated with the metallicity of the host galaxy. If this correlation is found to hold, it represents a major step forward in our understanding of superluminous supernovae. Finally, I will discuss the ongoing and future science projects related to these explosions, in particular utilising JWST and LSST in the next era of high-redshift observations.

The New Challenges of Planetary Nebulae Research

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Space Science Institute, Macau University of Science and Technology

Although planetary nebulae (PNs) have been discovered for over 200 years, we started to understand

their origin and evolution within recent 30 years. Even today , with observations covering the entire electromagnetic spectrum from radio to X-ray, there are still many unanswered questions on their structures and morphology. In this review, I will present a summary of recent theoretical and observational researches on multipolar/bipolar PNs and their progenitors (AGBs, post-AGBs/Proto-PNs), which may be related to central binary origin plus magnetic field. The roles of PNs as organic-molecule makers in the Universe are also discussed.

PTF/iPTF: From Stars to QSO

Po-Chieh Yu

Institute of Astronomy, National Central University

The wide field of the Palomar Transient Factory (PTF) survey allow us to conduct comprehensive programs. The PTF employed g-band, R-band, and H-alpha filters with a 7.3 square-deg field of view. We initiated two large programs using PTF data, including "Searching Be Stars in Open Clusters" and "A Search for Changing-Look QSOs with PTF". In the Be star project, we conducted a program to search for Be stars in open clusters of different ages, to investigate the connection among Be star phenomena, massive stellar evolution and cluster environments. In the later mentioned QSO project, we searched for changing-look QSOs by selecting candidates from PTF light curves. Spectroscopic data are examined by comparing SDSS data with LAMOST spectra. We will present summaries of two large programs.

Investigation of magnetic field and hard X-ray signatures associated with intense solar flares

Ya-Hui Yang

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One of the key issues in solar physics is to understand the energy release and particle acceleration processes. Solar flare is one of the most explosive phenomena in the solar system that huge energy is released in a short time. It is generally believed that magnetic reconnection in the corona is responsible for the occurrence of intense solar flares. Based on the multi-wavelength observations from SDO, RHESSI, SOHO, and TRACE satellites, we examined the role of magnetic reconnection in the different phases of intense flares by estimating the electric field in the reconnection current sheet and analyzing the evolution of chromospheric double hard X-ray sources. Furthermore, we discussed the physical parameters governing the flare initiation and flare productivity of solar active regions by using photospheric vector magnetograms. We concluded that the source field strength can be regarded as the proxy of photospheric magnetic free energy, likely serving as the lowest threshold for the occurrence of intense flares.

Research on the field aligned currents in our planet Earth's magnetotail

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Some planets in the solar system are with magnetized plasmas where the Field Aligned Currents (FACs) are important to the charged particle dynamics. In this paper, the properties of the FACs in our planet Earth's magnetotail are studied. The FAC was calculated with the so called "curlometer technique" basing on the four-point magnetic field measurement by Cluster. The distribution of the FACs in the magnetotail had not only Earth-tailward asymmetry and dawn-dusk asymmetry, but also north-south hemispheric asymmetry. If mapping along the field line to the polar region, the FAC footprints also had north-south hemispheric asymmetry. The FACs distribution function, both for the tailward and the Earthward, consisted of two components, one was Gauss distribution and the other was exponent distribution. In no storm times, the FACs variation was well consistent with geomagnetic activity index Kp but not with auroral injection index AE. During the storm time, in suddenly commencement phase the variation of the FACs density inversed to the variation of AE, in main phase the FACs' variation was consistent with the AE, in recovery phase it seemed that the FACs had no correlation with the AE. The IMF cone angle and clock angle have control roles on the FACs. In the magnetotail, in a substorm time, the earthward (tailward) FACs were mainly carried by the dominant tailward (earthward) motion of electrons, and higher energy electrons (from ~0.5-26 keV) were the main carriers. However, during the substorm recovery phase, energetic keV ions also had an important role for the tailward FACs and the ions were probably originated from the ionosphere. The concerning physics mechanism of the FAC's are also discussed.

The first statistical study on pre-earthquake ionospheric anomalies (PEIAs) on the electron density and its following development

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The earthquake prediction is one of the most difficult and arguable researches. Due to intense collision between the Philippine Sea and Eurasian plates, Taiwan has been experiencing many disastrous earthquakes and inevitably will face earthquake hazards in the future. On the other hand, Taiwan is right under the EIA (equatorial ionization anomaly) zone, where the ionosphere tends daily to yield the greatest electron density of the world. These two provide an excellent opportunity to study pre-earthquake ionospheric anomalies (PEIAs). In the early morning (01:47 local time) of September 21, 1999, the largest earthquake of the 20th century in Taiwan (MW7.6, ML 7.3) struck central Taiwan near the small town of Chi-Chi. The hypocenter was located by the Central Weather Bureau Seismological Center at 23.87°N, 120.75°E, with a depth of about 7 km. There was severe destruction in the towns of central Taiwan, with over 2300 fatalities and 8700 injuries. It is found that the ionospheric electron density at the F2-peak recorded by a local ionosonde (ionospheric radar) anomalously decreases in the afternoon period on 1, 3, and 4 days before the Chi-Chi earthquake, which agrees with the statistical result of 13 $M \geq 6.0$ earthquakes in Taiwan during 1994–1999 that

the ionospheric electron density tends to reduce significantly in the afternoon period 1–5 days before the earthquakes in Taiwan. Following this first statistical finding, the ionospheric total electron content (TEC) derived by ground-based GPS receivers are introduced to detect PEIAs associated with large earthquakes. The GPS TEC allows us conducting both the temporal and the spatial PEIA analyses worldwide. Statistical results of PEIAs related to worldwide large earthquakes show that the ionospheric GPS TEC are the most credible precursor. In this paper, a story of the first statistical finding of PEIAs and Prof. Ip will be told, and the latest development toward the seismo-ionospheric precursor study will be reported.

Dusty Plasmas in the Solar System

Mihaly Horanyi
University of Colorado

Dust particles exposed to UV radiation and/or immersed in plasmas collect electrostatic charges and their motion can be influenced by electromagnetic forces, in addition to gravity, radiation pressure and drag. Comets, planetary rings, the surfaces of airless planetary bodies, or even clouds in the Earth's atmosphere are all examples where various dusty plasma phenomena have been suggested to explain unexpected observations. This talk will give a brief introduction to the physics of dusty plasmas, followed by examples throughout the solar system, and in the laboratory, where dusty plasma effects have been recognized.

Overview of Space Plasma Measurement Activities at NSSC

Ling-gao Kong
National Space Science Center, Chinese Academy of Sciences

National Space Science Center (NSSC) began the space plasma measurement on Shijian-4 satellite by a 1/2 hemisphere electrostatic analyzer in 1990s. The similar instruments were also flown on Ziyuan-1 satellite and Shenzhou-4 manned spacecraft afterwards to measure the hot plasma in magnetosphere. After that, the instrument sensor has been updated to top-hat electrostatic analyzer for TC-2 satellite, Chang'E-1/2 lunar orbiters and Fengyun-4 meteorological satellite. Recently, some new demands for space plasma measurement are emerging, for example, better ion mass discrimination and higher resolution. Based on the new requirements, NSSC is developing some advanced plasma instruments for Chinese mars mission, SMILE mission cooperated with ESA, the MIT mission and so on. Besides the missions mentioned above, NSSC extends the measurement field to cold plasma by Langmuir probe and retarding potential analyzer on sounding rocket since 2011. A cold plasma instrument package for a LEO satellite is under building in NSSC. In addition to the hardware development activities, some science achievements from the plasma measurement by NSSC will also be presented in this report.

Observation and inversion of ENA auroras

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During geomagnetic activity, NUADU (Neutral Atom Detector Unit) on board of TC-2 running around the polar region near the perigee can sometimes observed an ENA enhanced band. When the profile of the Earth, as well as the characteristic field lines, projected on the ENA images, we found that the position of the ENA enhanced band coincide with the auroral zone. The ENA enhanced band tend to occur during the field line stretched tailward and might be relate to the pitch angle diffusion of ions due to the first adiabatic invariant at the geostationary altitude, so that be called as ENA aurora. The inversion results show that the ions of the ENA aurora come from the magnetotail region beyond $L \geq 6$, around the geostationary altitude. This study was supported by the Chinese National Natural Science Foundation Committee grant 41574152

Color Systematics in the Outer Solar System

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Intense observational campaigns over the last 25 years have revealed 1) that the Kuiper belt has a complex dynamical structure and 2) that it is home to the widest range of surface types in the solar system. Fascinating but largely untestable models have been proposed to explain this complicated dynamical structure. I will describe Keck telescope measurements of the optical color systematics of the Kuiper belt objects and of related small-body populations and interpret them in terms of the relationships proposed to exist between these populations. Except for an obvious link between the Kuiper belt and the Centaurs, the physical data do not provide clear support for the dynamical models. I will discuss the meaning of this fact.

Prospects for unseen planets beyond Neptune

Renu Malhotra

Lunar and Planetary Laboratory, University of Arizona

Several recent studies have appealed to the clustering of the angular orbital elements of very distant, extreme Kuiper belt objects (KBOs) to argue for the existence of a large planet orbiting at several hundred AU heliocentric distance. We also observe that several extreme KBOs have orbital periods close to integer ratios with each other, hinting at the possibility that they are in mean motion resonances (MMRs) with a massive unseen planet. If such MMRs are true, then their resonant dynamics provide constraints on the putative planet's parameters and its current location in the sky. Additionally, we observe a marginally significant misalignment of the orbital planes of the scattered disk KBOs; this is indicative of a Mars-to-Earth mass body orbiting closer-in, about 100 AU heliocentric distance. I will review these theoretical arguments and the prospects for the existence of unseen massive bodies in the distant solar system.

Status of the Transneptunian Automated Occultation Survey (TAOS II)

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The Transneptunian Automated Occultation Survey (TAOS II) will aim to detect occultations of stars by small (~ 1 km diameter) objects in the Kuiper Belt and beyond. Such events are very rare ($< 10^{-3}$ events per star per year) and short in duration (~ 200 ms), so many stars must be monitored at a high readout cadence. TAOS II will operate three 1.3 meter telescopes at the Observatorio Astronómico Nacional at San Pedro Mártir in Baja California, México. With a 2.3 square degree field of view and a high speed camera comprising CMOS imagers, the survey will monitor 10,000 stars simultaneously with all three telescopes at a readout cadence of 20 Hz. The civil construction of the site and the enclosures has been completed and the domes are being assembled. We expect to install the telescopes this summer and start the survey in late 2017.

The Outer Solar System Origins Survey

JJ Kavelaars and the Outer Solar System Origins Collaboration
National Research Council of Canada

The last 20 years have seen a set of increasingly sophisticated observational surveys of the Kuiper Belt region. Such surveys have revealed a dynamical structure that is steadily growing in complexity as more and more details are discovered. However, both biased loss of certain dynamical classes and somewhat low orbital precision (in which orbital uncertainties are comparable to resonance widths) limit the ability to study some phenomena, like resonant trapping of transneptunian objects (TNOs) during planet migration. In this presentation I will describe the OSSOS project and current results on from the OSSOS survey and in particular the implications for the evolution of the Kuiper belt caused by the migration of the giant planets as outlined in Fernandez and Ip (1984).

Exploring the 2:1 resonance using the Outer Solar System Origin Survey

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The resonant dynamic plays a significant role in our outer Solar System. The dynamical structure and population of the resonant objects are important clues to understand the evolution of Solar System. Twotinos, objects in the 2:1 resonance with Neptune, have been shown to be tracers of the migration of Neptune. Different migration rates could produce distinct architectures which could be

detected by a large survey. The Outer Solar System Origin Survey (OSSOS) is a large program of the Canada-France-Hawaii Telescope, executed from 2012 to 2016. This survey has detected and tracked nearly 1000 TNOs in an entire region of 168 square degree both on and off ecliptic plane. With the well-designed cadence, the precise orbital parameter measurements could determine the liberation center and amplitude of objects in resonant orbits, which are the keys to estimate the total intrinsic resonant population and provide the end-state for theoretical models. Using the OSSOS twotinos and survey simulator, we constrain the possible range for the eccentricity and the slope of size distribution. We also constrain the fraction of symmetric and asymmetric twotinos, and the fraction of twotinos in the leading and trailing islands.

On the inclination distribution of Neptune Trojans

Hsing-Wen Lin

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Currently, 21 Neptune Trojans (NTs, included the not yet public OSSOS samples), the asteroids in co-orbital 1:1 mean motion resonance with Neptune, have been found. The wide orbital inclination distribution of NTs seems to imply an unusual formation/capture mechanism for NTs; the NT have to be captured from a pre-excited planetesimal disk. Recently, we used both Pan-STARRS 1 (PS1) and Outer Solar System Origin Survey (OSSOS) data to study the orbital distribution of NTs. The PS1 solar system survey was covering the whole +/- 10 degrees and part of +/- 20 degrees areas of the ecliptic plane and has limiting magnitude ~ 22.5. On the other hand, the OSSOS has only cover ~ 100 square degrees around the L4 point of Neptune, but with much deeper limiting magnitude ~ 25. In results, the PS1 and OSSOS detected six and four L4 NTs, respectively. The PS1 samples have absolute magnitude (H) range from 7.1 to 8.1, and the OSSOS samples have H range from 8.0 to 9.9. The data set yields the surprising results that the larger NTs seem to have a dynamically colder inclination distribution compared with physically smaller NTs (where the separation or large/small appears to be around $H \sim 8$, which corresponds to a diameter of 150 km); only one of the six PS1 samples has inclination larger than 15 degrees, whereas three of four OSSOS NTs have inclinations larger than 15 degrees. Therefore, we performed survey simulations of different intrinsic NT population models to determine the intrinsic inclination distribution of non-biased NT population.

Size Frequency Distributions of Jupiter Trojans, Hildas and Main Belt Asteroids

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Chiba Institute of Technology/Kobe Univ.

We performed a survey observation for L4 Jupiter Trojans (JTs) and Hilda group asteroids (Hildas) by the 8.2-m Subaru telescope equipped with the wide-field CCD camera: Hyper Suprime-Cam on March 30 2015 (UT), then detected 631 JTs and 130 Hildas. Our survey is the deepest survey for JTs and Hildas so far. The smallest size of detected objects is about 1.7 km for JTs and 1.4 km for Hildas, respectively. In the size range of detected JTs and Hildas (~1-10km) from our survey, which

is likely the size range that objects have experienced collisional evolutions, we found their size frequency distributions (SFDs) are represented by a single-slope power law (i.e., no break or roll-over) and the SFDs of the two groups are very similar with each other. Therefore, the resulting SFDs for JT and Hilda populations from our survey would suggest that the two groups have similar impact strength parameters, which means they share the composition and internal structure, possibly the same origin. According to the planetary migration models, JTs are outer objects implanted from the trans-Jupiter region 3.8 Gyr ago, the era of late heavy bombardment. The Hildas have the same origin with JTs, therefore, they are also transported objects from the outer region. We combined our results with the SFDs of larger JTs and Hildas collected from literature to obtain the entire SFDs for JTs and Hildas and then compared them with the SFDs of main belt asteroids in different regions. We noticed that the SFDs of JTs and Hildas are basically flat in the R-plot and the SFDs of MBAs has wavy structure on the R-plot. We also found that gradual change of the shape of SFDs from inner MBAs to outer MBAs, the SFDs are getting flatter to approach the shape of SFDs of JTs and Hildas. This may be an evidence the outer objects implanted into not only JT and Hilda regions but also outer main belt region at 3.8 Gyr ago.

Determinations of shape and photometric phase curve of asteroids

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The brightness of an asteroid is due to its surface reflecting to the sun light. So, the observed/or say integral brightness is related to the size of surface area illuminated and visible, the scattering property of surface, and the viewing/illumination geometry. The integral brightness at different solar phase angle is called the integrated phase curve/ function. The approximate expression of phase function can be derived assuming a spherical shape of an asteroid. Besides solar phase angle, this function contains some other quantities, such as roughness, porosity, asymmetry factor, and particle scattering albedo. Which therefore is taken as an important source to understand the surface micro-structure of asteroid. Similarly, the approximate expression of phase function of an ellipsoid asteroid may be derived by integrated the scattering light over the ellipsoid surface. Comparing to case of spherical shape, there is one more quantity-- aspect angle (between spin orientation of asteroid and line of sight) in the phase function model. For the irregular shape case, it is impossible to get such approximate expression like above two cases. For solving the shape and phase function of an irregular asteroid, in practice, some simplified phase function models are applied, i. e. H-G1-G2 system and the phase function with a exponential and linear function. In this presentation, the some phase function models based on different scattering laws are compared firstly. As the practice application, the different combinations of shape and phase function are applied for different asteroids with dense and/or spare photometric data. For example, the Lommel-Seeliger ellipsoid model is used to determine the ellipsoid shape of asteroid and its phase function from spare data. Furthermore, the model with a cellinoid shape and Lommel-Seeliger law is applied in the lightcurves with two diversity peaks. Lastly, the Kaasalainen's model, a convex shape and the phase function with a exponential and linear function is used to inverse the very irregular lightcurves of asteroid with enough aspect angle and phase angle coverage.

Cellinoid Shape Model for Asteroids

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Based on the special shape first introduced by Alberto Cellino, which consists of eight ellipsoidal octants with the constraint that adjacent octants must have two identical semi-axes, an efficient algorithm to derive the physical parameters, such as the rotational period, spin axis, and overall shape from either lightcurves or sparse photometric data of asteroids, is developed by Lu et al.[1]. They call this model 'Cellinoid' shape model. Numerical applications confirm that the cellinoid shape model could derive the best-fit rotational period for the asteroid from several lightcurves observed in one apparition. Furthermore by exploiting more lightcurves observed in various viewing circumstances, the derived spin axis could be refined [2]. Additionally the cellinoid shape model is applied to the sparse Hipparcos data with the average number of measurements being of the order of 70 per object, similar to the future catalog of the ongoing space project, Gaia [3]. The derived rotational periods from 70 sparse measurements are accurate and the spin axes are close to the known results, derived from lightcurves by other methods. With only 3 more parameters than the traditional triaxial ellipsoid, the cellinoid shape model of having the asymmetric morphology could perform efficiently and simulate the real asteroids better. That could be employed for the huge number of photometric sparse data observed by Gaia in the coming future.

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Taxonomical Survey of Dynamically Unstable Asteroid in the Near-Earth Region

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According to the numerical study, we can rule out several dynamical unstable regions in the inner solar system: the Near Earth-Asteroids (NEAs) and the Asteroid in Cometary Orbits (ACOs). They all have very chaotic orbits with a mean timescale of a few million-years (Morbidelli and Nesvorny, 1999). An interesting question comes out from such object with the unstable dynamical nature: what are the origin and the supplement of the objects? Previous studies gave some possible explanations: draft from the main asteroid belt (Wetherill, 1985); cometary origin (Fernandez and Sosa, 2015); or object kicked out from the resonance belt (Chang et al., 2016; Kim et al., 2014). To find out the object which is cometary origin, we made a general taxonomical survey on the object with a chaotic orbit which has $TJ < 3.05$, eccentricity > 0.3 , and $a < 5.2$ au. About 80 objects had been newly classified the surface taxonomy using Lulin One-meter Telescope (LOT) in the central Taiwan. The ratio between C-complex (C/X/D) and S-complex (S/Q) object amount the whole sample is about 2, but smaller objects (diameter ≤ 10 km) tend to have more C-type objects. The non-gravitation force like Yarkovsky effect may play an important role to kick out the carbon-rich object inward from a stable outer main belt. Combining with the albedo measurement by NEOWISE space mission, we have pointed out some extinct comet candidate.

Asteroid 4179 Toutatis: New observations as Closely Observed by Chang'e-2

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Toutatis, as an Apollo near-Earth asteroid in an eccentric orbit, was successfully visited by Chang'e-2 on December 13th 2012 after the spacecraft completed its lunar exploration and an extended mission of space-environment exploration at the Sun-Earth Lagrangian point. This flyby as close as a distance of 770 m away from the asteroid's surface, reveals many geological features on Toutatis' surface, like concavities, boulders, lineaments and regolith, particularly an ~ 800 m giant depression at the end of the large lobe, as well as a sharply perpendicular silhouette near the neck region, indicating that Toutatis is probably a rubble-pile asteroid (Huang et al. 2013). We further identify more than 200 boulders from the imaged area of Toutatis, and infer that most boulders cannot solely be produced by impact cratering, but probably originate from the fragments of the parent body of Toutatis (Jiang et al. 2015). Incorporation with ground-based radar observations over the last two decades, we investigate the orientation and the rotational parameters of Toutatis based on the images captured by Chang'e-2. Hence, Chang'e-2's flyby enables us to have an in-depth understanding of the formation and evolution of this asteroid.

The Asteroid Spin-Rate Study Using the Palomar Transient Factory

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Using the Palomar Transient Factory, we have carried out seven asteroid rotation period surveys in 2013 -- 2015. The total sky coverage were ~ 450 deg², and 2780 reliable rotation periods were obtained. From this data set, we consistently see the spin-barrier at 2.2 hour [1] held by most asteroids [2-3]. Moreover, we also see the C-type asteroids have lower spin-rate limit than the S-type [2]. However, three large (i.e., $D > 150$ m) super-fast rotators (SFRs) were discovered in our surveys [2-4]. These large SFRs cannot be explained by the typical rubble-pile structure. Among the six known large SFRs, none of them is C-type asteroid. If the taxonomy tendency for large SFRs is true, this might suggest that non-C-type asteroids have stronger structure to resist the exceedingly fast rotation. With this large data set, we carried out the spin-rate distributions for the asteroids with different diameters and different locations in the main belt. Regardless of their locations, we see that (a) the asteroids of $3 < D < 15$ km show a spin-rate distribution with a number decrease with increase of spin-rate; (b) the asteroids of $D < 3$ km have a number drop at $f = 5$ rev/day in their spin-rate distributions, and only a few asteroids with $f > 5$ rev/day have light-curve variations > 0.2 mag. The former case indicates the YORP effect might be comparable to the collisions between asteroids. The

latter case could suggest that the small and elongated asteroids have been span up over the spin-rate limit due to their shorter YORP effect timescale and consequently been destroyed [2].

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Recent observation on small Solar system bodies by CNEOST

Hai-Bin Zhao and Bin Li

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In this paper, the detailed information and key scientific goals of CNEOST (China Near Earth Object Survey Telescope) are introduced. As a quite large field of view telescope, CNEOST has dedicated itself to several large sky coverage survey program aimed at small Solar System Bodies detection, asteroid rotational characteristics, optical transit events, multi-color characteristics of stars in Galaxy, etc. Also, the ideal concepts of next generation Near Earth Object Survey Telescope will be discussed.

Spatial distribution of steep lunar craters

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We examine the global distribution of lunar craters larger than 8km in diameter using LU60645GT catalogue (Salamunićcar et al. 2012). We find the number density enhancement of simple craters with high depth/diameter (d/D) ratio in the leading side and the polar regions of the Moon. The apex/antapex asymmetry can be explained by the synchronous rotation of the Moon. However, the enhancement of the polar regions is in contradiction with the expected impact flux from the observed near-Earth objects.

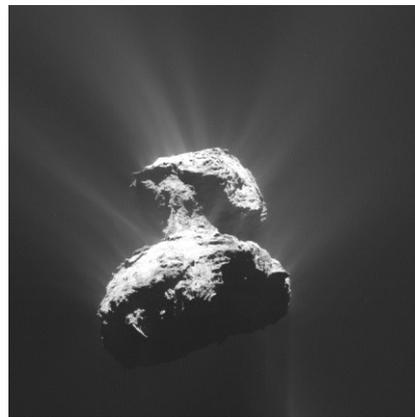
On Steep Cliffs and Fountains of Dust - The Rosetta Comet 67P/Churyumov-Gerasimenko

Holger Sierks on behalf of the OSIRIS Team
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Comets are important objects to understand the origin of our Solar System, its formation and the 'pre-solar' material it was built from. Comets are pristine and thus carry information on how they initially formed 4.5 billion years ago; they are tie-points for the formation models. 67P/Churyumov-Gerasimenko is the first comet studied in detail with a spacecraft for more than two years in the vicinity along the comet's orbit around the sun. The Rosetta mission of the European Space Agency was launched on 2 March 2004 from the CSG spaceport in French-Guyana. The spacecraft arrived on 6 August 2014, at comet 67P after 10 years of cruise. The two scientific cameras onboard Rosetta, the OSIRIS Narrow- and the Wide Angle Camera, observed the cometary nucleus, the activity, and dust and gas environment from afar and very close with image scales of up to 2 mm per pixel in final descent to the surface. The scientific results reveal a nucleus with two lobes and varied morphology. Active regions are located at steep cliffs and collapsed pits which form collimated gas jets. Dust is accelerated by the gas, forming bright jet filaments and the large scale, diffuse coma of the comet. In escort at comet 67P OSIRIS witnessed all important milestones of the mission: initial nucleus morphological characterization, Philae landing, and observing the increasing comet activity while sun was approached. The activity declined post perihelion allowing the spacecraft to go back close, identifying numerous morphological changes on the surface, which can be attributed to the strong insolation during perihelion passage.



Comet 67P/C-G as RGB color mosaic.



67P/C-G around perihel.

Investigating the Physical Properties of the Outburst of comet 67P/ChuryumovGerasmenko

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The phenomena of cometary outbursts have been observed in several comets by ground-based telescope and in situ instruments of spacecraft. However, the mechanism and physical properties for these activities are still unclear. The OSIRIS camera onboard the Rosetta spacecraft provided first-

hand information on the transient events (outbursts) of comet 67P/C-G during perihelion passage in 2015. The physical properties of the outbursts can be therefore investigated via time-series images with high-resolution images. Our analysis is given to the wide- and narrow-angle images obtained in the monitoring and outburst sequences between July and September 2015. In this work, we will present our results of the calculated excess brightness and the brightness slopes from these outburst plumes, and the ejection masses and outflow velocity during outbursts.

Retrieving spatial pattern of early activity of comet 67P/C-G from the MIRO observations and 3D radiative transfer model

Yuhui Zhao

Key Laboratory of Planetary Sciences, Purple Mountain Observatory, Chinese Academy of Sciences;

Ladislav Rezac, Paul Hartogh

Max-Planck-Institute for Solar System Research;

Jianghui Ji

Purple Mountain Observatory, Chinese Academy of Sciences

The Microwave Instrument on the Rosetta Orbiter (MIRO) has detected the first water vapour from 67P/Churyumov-Gerasimenko on 6 June 2014, when the comet had a heliocentric distance of 3.92AU. Several mapping campaigns for the spatially unresolved nucleus were followed in the June-July 2014 time interval. In this work, with the knowledge of exact shape, we want to learn which regions were responsible for the activity by studying the effects of 3D coma structure on the rotational water line transitions measured by the MIRO instrument during this period. Combined with a detailed shape model, a 3D radiative transfer model (LIME code) is applied. Armed with the MIRO observation data, we will see the inhomogeneous activity distribution on the nucleus surface.

Observing and modeling near-nucleus dust activity on 67P/Churyumov-Gerasimenko

Xian Shi, Xuanyu Hu, Holger Sierks, Carsten Guettler, and the Rosetta/OSIRIS Team

Max Planck Institute for Solar System Research

Understanding the interaction between cometary nucleus and its innermost gas and dust comae is essential for deciphering the mechanism of cometary activity, as well as physical properties of the nucleus. During over two years' long escort of Jupiter Family Comet 67P/Churyumov-Gerasimenko through its perihelion passage, Rosetta has collected a wealth of multi-instrument dataset with unprecedented spatial and temporal resolution. Imaging data acquired by OSIRIS, the science camera system onboard Rosetta, has shown the onset, evolution, and cutoff of cometary activity on both diurnal and seasonal time scales. By combining OSIRIS data with three dimensional Direct Simulation Monte Carlo modeling of volatiles, we study the link between 67P's dark, irregular nucleus and the fine structures in its inner comae. Our analysis on the observations of dust emission beyond dusk terminator has suggested that dust activity is turned off slowly after sunset due to water ice sublimation at a shallow subsurface. On the other hand, observations at the dawn terminator suggest that dust activity can be initiated instantly after sunrise, which implies water sublimation occurring much closer to or even on the nucleus surface, confirming the recondensation mechanism at work

during cometary night. Our study sheds light on the formation of dust jets, one of the most intriguing phenomena in the cometary coma whose nature is not yet fully resolved, to show how different factors shape the near-nucleus coma structures we see.

Probing Jupiter's interior via its gravitational field

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One of the most fascinating features in the solar system is the fast, alternating zonal winds on Jupiter. The winds have been measured for decades but their generation/maintenance remains highly controversial. The problem is now attracting intensive attention because of the ongoing Juno mission: launched in 2011, Juno spacecraft arrived at Jupiter in the summer of 2016 with the new observational data coming out soon. An objective of the Juno mission is to probe how far the zonal winds penetrate into the Jovian interior, a property closely associated with the origin of the winds, and how its internal convection and dynamo operate by accurately measuring their effects on Jupiter's gravitational field. The accurate gravity measurements provided by the Juno spacecraft, together with accurate theoretical and numerical modeling, may enable the resolution of this long-term scientific puzzle. We shall present/discuss the mathematical theory and numerical model for interpreting Jovian gravitational signature in connection with its non-spherical shape, interior structure and internal fluid motion.

The origin and evolution of the atmosphere of Saturn's Earth-like moon, Titan

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Three historic events led to the modern day intrigue about Saturn's moon Titan: discovery by Christiaan Huygens in 1655, limb darkening observed by Comas Solá in 1908 and the detection of methane by Gerard Kuiper in 1944. However, it was the close encounter of Voyager 1 with Titan on 12 November 1980, which revealed that the moon is unique in the solar system for having an atmosphere that is denser and thicker than our own and its surface hidden behind photochemical smog. These mysteries of Titan were some of the key drivers of the NASA-ESA-ASI Cassini-Huygens Mission to the Saturn system. Following a highly successful 13-year mission at Saturn, the spacecraft will end its mission on 15 September 2017 upon entering the planet's atmosphere. Results from Cassini-Huygens have revolutionized our understanding of the workings of Saturn's atmosphere, its moons, rings and the magnetosphere. The focus of my talk is the origin of Titan's nitrogen atmosphere and the role methane and the cycle of methane play in maintaining that atmosphere. All possible scenarios will be considered, including primary and secondary sources, along with their merits and demerits based on observational and theoretical constraints. Despite the tremendous breakthroughs in our understanding of the origin and evolution of Titan's atmosphere, unsolved mysteries remain that have led to renewed interest in return to this ocean world in the future.

Simulation of Proto-atmosphere Accretion Using FLASH

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Protoplanets are believed to form before gas dissipates in the stellar nebula and thus they are likely to capture proto-atmospheres from the nebula gas. Such hydrogen/helium-rich atmospheres have been detected and characterized in exoplanetary systems (e.g. low-density super Earths and mini Neptunes). The accretion and structure of the proto-atmosphere is subject to the evolution of the protoplanetary disk such as the evaporation of nebula gas, the XUV radiation from the central star, the potential impacts between planetoids, the shape of the protoplanet's orbit and the protoplanet mass. We have been using the hydrodynamics code FLASH to simulate the gravitational accretion of gas onto a protoplanet and its subsequent evolution. We first establish a one-dimensional stationary model assuming spherical symmetry and constant accretion luminosity (due to planetesimal impacts) to benchmark the results with Stokl et al. (2015) which used a different numerical approach. In the presentation I will introduce the series of work in progress and in plan to model the proto-atmosphere accretion in a more physically realistic sense, including implementing sophisticated treatments of planetesimal accretion rate, planet mass and atmosphere opacities, and exploring the influence from the planet traveling on an eccentric orbit.

Modeling the accretion of proto-atmospheres is essential to many scientific topics, including the nebula origin of Earth's water and other volatiles (H₂, CO/CO₂, N₂, etc.), the supply of Earth's noble gases and the role of proto-atmospheres in chondrule-forming planetary bow shocks. Understanding how the proto-atmospheres could influence or even create the current terrestrial planetary environments in the solar system also has general significance to the study of exoplanet habitability.

Far infrared observations of the solar system

Paul Hartogh

Max Planck Institute for Solar System Research

The field of the solar system studies in the far infrared (FIR) has expanded enormously since the first observations in the late 1960s. Meanwhile a large set of ground-based, airborne and space borne facilities exist and has been applied to studies of planets and small bodies. Among these Herschel, with its unprecedented sensitivity, has provided exciting new insights into solar system science addressing topics such as the origin and formation of the solar system, the water cycle of Mars, the source of water in the stratospheres of the outer planets, the isotopic ratios in cometary and planetary atmospheres and a number of new detections (possibly related to cryo-volcanic activity) including the Enceladus water torus, water atmospheres and emissions of the Galilean satellites and Ceres and the ocean like water in a Jupiter family comet. The first deep space FIR heterodyne spectrometer, the Microwave Instrument for the Rosetta Orbiter (MIRO) has acquired maps of the subsurface temperature of comet 67P/Churyumov-Gerasimenko, at 1.6 mm and 0.5 mm wavelengths, and spectra of water vapor, methanol, carbon monoxide and ammonia of the Jupiter family comet 67P/Churyumov-Gerasimenko. The analyses of the detected highly resolved spectra show some features that cannot be derived from scenarios provided by state-of-the-art coma models yet. The Submillimetre Wave Instrument (SWI) on the Jupiter ICy moons Explorer is presently in the

developing phase. After its launch (planned for 2022) and 8-years travel time to the Jupiter system it will investigate the evolution, chemistry and circulation of Jupiter's stratosphere, the surfaces of the Galilean satellites and structure, kinetics and composition of their atmospheres and exospheres.

The Scientific Achievements of the Cassini Orbiter Mission

Linda Spilker

Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA, USA

The Cassini mission's findings have revolutionized our understanding of Saturn, its complex rings, the amazing assortment of moons and the planet's dynamic magnetic environment. The robotic spacecraft arrived in 2004 after a 7-year flight from Earth, dropped a parachuted probe named Huygens to study the atmosphere and surface of Saturn's big moon Titan, and commenced making astonishing discoveries that continue today. Key discoveries include icy jets shooting from the tiny moon Enceladus from a liquid water ocean beneath its icy crust, and lakes of liquid hydrocarbons and methane rain and on Saturn's giant moon Titan. These Cassini findings have fundamentally altered many of our concepts of where life might be found in our own solar system and beyond. This flagship mission is a cooperative undertaking by NASA, ESA, and the Italian space agency (Agenzia Spaziale Italiana (ASI)). Highlights of Cassini's ambitious inquiry at Saturn and the potential for life in the Saturn system will be presented. This research was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA. Copyright 2017 California Institute of Technology. Government sponsorship is acknowledged.

Huygens Mission to Titan: a close view on a fascinating solar system body

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2. LESIA, Observatoire de Paris-Meudon, France;
3. former ESA Huygens Project Scientist and Mission Manager.

The international NASA/ESA/ASI Cassini-Huygens mission became a reality in 1990 after several years of study of Cassini that included a Titan probe from the beginning in 1983. Prof Wing Ip played a major role in the making of the mission. After a brief history of the mission development, the main scientific achievements of Huygens will be reviewed and major lessons learned for the future in situ exploration of Titan will be discussed.

Charged particle measurements in the inner Saturnian magnetosphere during the "Grand Finale" of Cassini in 2016/2017

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After 13 years in orbit around Saturn Cassini is coming to an end in September 2017. The last phase of the mission is called the “Grand Finale” and consists of high latitude orbits crossing the F-Ring 22 times between Nov 2016 and April 2017 followed by the so called proximal orbits passing the ring plane inside the D-ring. The roughly 7-day long F-ring orbits with periapsis at nearly the same local time allow to study temporal variations of the particle distributions in the inner part of Saturn’s magnetosphere. In this presentation first results of the Magnetosphere Imaging Instrument MIMI during the “Grand Finale” will be presented including the variability of Saturn’s innermost radiation belts, the first in-situ measurements of charged particles inside the D-ring, and field-aligned particle beams connecting the spacecraft with the auroral region of Saturn.

The Saturnian near-ring plasma environment

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The presence of an O₂ atmosphere over Saturn’s main rings has been confirmed by the Cassini spacecraft at Saturn Orbital Insertion in 2004 (Waite et al., 2005; Tokar et al., 2005). Saturn’s ring atmosphere is primarily generated by photolytic decomposition of water ice producing O₂ and H₂ (Johnson et al., 2006). Tseng et al. (2010) also predicted seasonal variations in the ring atmosphere and ionosphere due to the orientation of the ring plane to the sun. In addition, the O₂ molecules formed in the main rings would be scattered to the magnetosphere and become a plasma source once ionized. Therefore, the seasonal dependence of the ring atmosphere and ionosphere can also be reflected in the variations of the plasma environment in the inner region. It has been seen in the following measurements of Cassini CAPS, MIMI and RPWS (e.g., Elrod et al., 2012; 2014; Christon et al., 2013; 2014; Persoon et al., 2015). The ring atmosphere and ionosphere play an important role in the coupling dynamics between the main rings and the Saturnian system. First, they are the sources of neutrals (i.e., O₂, H₂, H; Tseng et al., 2013a) and plasma (i.e., O₂⁺ and H₂⁺; Tseng et al., 2011) in the Saturnian magnetosphere. Second, the main rings have strong interaction with Saturn’s atmosphere and ionosphere (i.e., a source of oxygen into Saturn’s upper atmosphere and/or the “ring rain” in O’Donoghue et al., 2013). Furthermore, Cassini CAPS data showed time variations in the complex plasma environment between the main rings and Enceladus (Elrod et al., 2012; 2014). The plasma environment in this interesting region is complicated by the neutrals from both the seasonally dependent ring atmosphere and Enceladus torus (Tseng et al., 2013b), and, possibly, from small grains from the main and tenuous F and G rings (Johnson et al. 2017) and the Enceladus plumes (Hill et al., 2012) which produce the extended E-ring (e.g., Kempf et al., 2010). The data now coming in from Cassini’s F-ring orbits should shed light on the dominant physics and chemistry in this region of Saturn’s magnetosphere.

Preliminary results from the Cassini Cosmic Dust Analyser during the Grand Finale Mission

H.-W. Hsu, S. Kempf, F. Postberg, M. Horanyi, M. Seiss, R. Srama

The Cassini Grand Finale Mission provides brand new opportunities to explore the environment in the vicinity of Saturn and its main rings. With periapses of around 2.5 Saturn radii during the ring grazing orbits (2016/12-2017/04), CDA found that the inner edge of the E ring vertically extends about 1 Saturn radius away from the ring plane. Another dust population concentrated near the ring plane with a scale height of $\sim 1,000$ km was measured repeatedly and is likely originated from local source(s). For the Grand Finale dives (2017/04-2017/09), one of the most important goal is to characterize the composition of the main rings. Measurements from the first few Grand Finale orbits reveals the existence of abundant nanodust population in the vicinity of Saturn and the lacking of micron-sized particles. CDA has recorded hundreds of mass spectra that will shed lights on the origin of the main rings and how they interact with the host planet.

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

Chow-Choong Ngeow
Institute of Astronomy, National Central University

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 $1.01''/\text{pixel}$. 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 $R \sim 20$ 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).

Hyper-flares phenomena of M dwarfs

Han-Yuan Chang, Wei-Jie Hou, Chia-Lung Lin, Li-Ching Huang, Wing-Huen Ip
National Central University

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 $\text{Log}(g)$ 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^{36} ergs, which is 10000 times of the M dwarf energy at quiescent state.

Super-Flares Relationship with Rotational Phase of G-Type Stars

Wei-Jie Hou
National Central University

Solar flare was suggested to be related to the sun-spots based on previous observations of our Sun. Superflares (flares with energy $> 10^{33}$ erg) was also observed in extrasolar system (Hiroyuki et al.

2012). To investigate the relationship between superflares and the rotation phase, we selected 77 G-type stars from *Kepler* measurements with well-defined light curve periodicities from previous study (Wu et al. 2015). We used the rotation period to transform the light curve into the phase to check which phases were the flares occurred. We discovered that more flares occur when spots face and back to observer.

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

Li-Ching Huang, Wing-Huen Ip, Han-Yuan Chang, Yihan Song and Ali Luo

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 131 systems with G-type primary stars characterized by $T_{\text{eff}} \sim 5000\text{K}-6000\text{K}$ 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. We found 11 systems shows flare events in their Kepler lightcurves. Then we compare the S-indices of EB systems with and without flare activities. Similar with the single stars with and without flares, systems with flare events usually have a higher S-index than those without. And the S-index differences between binary systems are larger than that of single stars. Although there are not big S-index difference between EB and single stars.

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 H α emission by analyzing the LAMOST and Kepler K1 data. Stars with rotation periods shorter than 20 hours usually exhibit enhanced H α 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 H α 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 H α data archive and K2 catalog in just one Campaign of K2. We examine that if the PTF H α 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.

Searching for Be Stars in 104 Open Clusters by Using PTF Observations.

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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 104 open clusters. The procedure is as follows: 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 96 Be candidates in 32 of 104 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 $10^{7.5}$ - $10^{8.5}$ years have high probability to contain Be stars; (3) The B-type stars with age between 10^8 - $10^{8.5}$ years will easily form as Be stars; (4) No spatial concentration of Be stars can be found with different ages; (5) Most Be candidates have Mid-infrared color excess, which is similar to known Be stars; (6) There is one Be candidate shows long-term variability which is 0.3 magnitude changes within about 2000 days.

Imaging Asteroid albedo via Matrix light-curve inversion

Tao-Luo

Space Science Institute (SSI), Macau University of Science and Technology

Matrix light-curve inversion is a powerful algorithm to dig the internal information of data. Its main objective is to mimic the appearance of the actual surface albedo map as closely as possible. In this talk, I will briefly talk about how to image Asteroid albedo via Matrix light-curve inversion algorithm. I will also talk about the work I presented in the workshop, which is about the simulation results and denoising method.

On the long-term time evolution of highly-inclined Trans-Neptunian objects

Po Yen Liu

National Central University

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 Pilot Study of Asteroid Spin Rate Using the CNEOST at Xu-Yi Observatory

Ting-Shuo Yeh
National Central University

Several important physical properties of asteroid can be derived from lightcurve, such as rotation sense (e.g., rotation period and spin pole orientation), general shape (e.g., axis ratio estimated from light curve amplitude and shape model from light curve inversion), interior structure (i.e., the 2.2 hr spin-rate limit of rubble-pile asteroids) and taxonomic type (e.g., phase-curve relation). Moreover, the statistics on asteroid spin rate and pole orientation are also important to understand how rotational status was affected by various mechanisms (e.g., mutual collision, tidal force and the YORP effect). To have a comprehensive study on the aforementioned questions, it relies on a large sample of asteroid rotation. Therefore, we initiated our cross-strait bilateral cooperation with the Purple Mountain Observatory (PMO) to collect asteroid light curves using the CNEOST (Chinese Near-Earth Object Survey Telescope) at Xu-Yi station. A pilot survey of ~ 40 square degrees using 8-min cadence had been carried out during February 27 -- March 2 2017. 1650 light curves were collected, from which 82 highly reliable rotation periods were derived. In order to collect more samples, we will continue to carry out more high-cadence observations in next two years.

Seasonal variations of the source regions of the dust jets of comet 67P/Churyumov-Gerasimenko

Ian-Lin Lai
National Central University

Because of gas drag effect, dust grains usually accompany the outgassing process of cometary nuclei. The close-up imaging observations of comet 67P/C-G showed that the dust coma was filled by numerous narrow jets emanating from the nucleus surface. This means that they can be used to trace the gas sublimation regions as the comet moved around the perihelion. Making use of the comprehensive imaging data set provided by the OSIRIS scientific camera, we show in detail how the foot points of the dust jets and hence the outgassing zone would move in consonance with the sunlit belt. Furthermore, a number of source regions characterized by repeated jet activity could be identified which might be the result of local topographical variations or chemical heterogeneities.

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

Kang-Shian Pan
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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-polarimetric light-curves of (16) Psyche and other M-type objects.

Intercomparison of the Relations of Density and Porosity of Some X-type Asteroids

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The spin-rate limit of asteroids plays a key role in probing the interior structure of asteroids. The 2.2-hour spin-barrier has been interpreted as a result of the “rubble-pile” structure of asteroids (i.e., gravitationally bounded aggregations). Because asteroids of different types should have different bulk densities, their spin-rate limits could be different. We use the asteroid rotation periods of the PTF project (Chang et al. 2015, Waszczak et al. 2015) and the NEOWISE albedos (Masiero et al. 2011; Mainzer et al. 2011) to study the spin-rate limits of X-type asteroids. In this way, we can study their bulk densities, which in turn probes asteroid interior structure. We are particularly interested in the M-type asteroid, which is mainly made of nickel-iron. We found three fast rotating asteroids classified to different chemical compositions and spectrum types: P-type asteroid, (10305) Grignard ; M-type asteroid, (34946) 2286 T-1 ; E- type asteroid, (10359) 1993 TU36. If their gravitational force and centrifugal force were in balance, we found that E-type asteroid, (10359) 1993 TU36, was probably heavily fractured; P-type asteroid, (10305) Grignard and M-type asteroid, (34946) 2286 T-1, were probably rubble-pile structures.

Geomorphology of comet 67P/Churyumov–Gerasimenko

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After ten years of interplanetary journey, Rosetta spacecraft finally reached its target, comet 67P/Churyumov-Gerasimenko in August 2014. This comet is composed of a large lobe and a small lobe, connected by a "neck" in between. The resolution of the OSIRIS camera onboard the Rosetta spacecraft is high enough for us to investigate the variegated surface morphology on this comet, including the boulders, circular depressions and the stratification, etc. At the beginning of the mission, only the northern hemisphere of the comet was visible due to the inclination of the rotational axis. In May 2015, the southern hemisphere of comet 67P/C-G became visible by the OSIRIS cameras. The surface morphology of the southern hemisphere of the comet is quite different from that of the northern one. Several contemporary works showed that fine particle deposits are the most extensive geological unit on the northern hemisphere. In contrast, the southern hemisphere is dominated by outcropping consolidated terrain. In this work, we studied the distribution of the blocks, the stratification and the geomorphological maps of the southern hemisphere by mapping the geological units and linear features. The geomorphological maps described in this study allow us to gain a better understanding of the processes shaping the comet nucleus and the distribution of primary structures such as fractures and strata.

Lightcurve analysis of 9 asteroids

Hanjie Tan (CCU), Bin Li (PMO.China), Xing Gao (Urumqi No.1 Senior High School)

The light curves of main-belt asteroids 963, 1025, 1117, 2019 and 17814, and near-Earth asteroids (NEAs) 459872, 2014 JO25, 2017 AG5 and 2017 BS32 were obtained using Xingming Observatory (Code C42) from March 2016 to March 2017. The absolute magnitudes of these nine asteroids range from $H = 11.6$ to 27.3 mag, corresponding to a diameter range of ~ 16 m – 21 km. The synodic rotation periods derived from the light curves are between 0.1 to 10 hr.

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 at 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 surface temperature and the N_2 sublimation rate of SP when Pluto revolve around the sun in its eccentric orbit and calculate the amount of nitrogen gas emitted from the SP. 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.

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 known 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 N_2 density 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.

Simulation of the Dynamics of the Jovian Atmosphere

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Jupiter is the largest giant planet in the solar system and many interesting characteristics of the Jovian atmosphere can be observed, such as the Great Red Spot and pattern of multiple parallel zonal jets. In this work, we examine the dynamics of Jovian atmospheric structure and especially focus on the upper troposphere and lower stratosphere. We perform numerical simulations with the use of the Oxford Jupiter circulation model, which is based on the MIT General Circulation Model (MITgcm) dynamical core. Two-stream radiation and a simple cloud scheme are also included in this model. We simulate the atmosphere of Jupiter using a configuration with 1.4 degrees horizontal resolution and 33 vertical levels that goes down to the 18 bar pressure level, which lies well below the water cloud base. We also consider the effect of moist convection on atmospheric circulation, which is a crucial factor to dominate the updrafts and downdrafts and other atmospheric phenomena.

Stable Bayesian generalized Lomb-Scargle periodogram by Polynomial Series

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Estimating the rotational period is generally the first step in analyzing astronomical observation data. Based on Bayesian probability theory, Bayesian generalized Lomb-Scargle periodogram (BGLS) is proposed to describe the probability distribution to present a full sine function with the specific frequency in the data. Compared with non-Bayesian method, BGLS can better recover the frequencies. However, BGLS method is not stable for searching rotational periods, especially in the case of the unevenly observation time interval. Therefore, we apply the polynomial series to fit the points folded with the possible solutions by BGLS. Subsequently, a new defined merit function, taking use of least square, is also presented for estimating the derived periods and refining the best-fit result. Finally, its application to PTF observation data confirms that the new method, extended from BGLS can perform more stably and accurately.

The whole process to search the rotational period from the time series data is shown as below.

- 1 Divide into ten parts from 0 to 10 hour, one hour per part;
- 2 Search periods using BGLS in every part;
- 3 Polynomial fitting folded points and related absolute magnitudes;
- 4 Taking use of merit function to find predict period and refine the result.