International Workshop on "Exoplanets and Disks: Their Formation and Diversity III"

ABSTRACT Booklet

Date:
Sunday, 21 February 2016 – Wednesday, 24 February 2016

Venue:
Hotel Nikko Yaeyama (1F Yaeyama)
559 Aza-ohkawa, Ishigaki-shi, Okinawa 907-0022

Sponsorship:
Grant-in-Aid for Scientific Research by the Ministry of Education, Culture, Sports, Science and Technology: Scientific Research on Innovative Areas (Research in a Proposed Research Area) 2011-2015 "New Frontiers of Extrasolar Planets: Exploring Terrestrial Planets"

Program

Oral Presentations

Sunday, 21 February 2016

10:00-15:00 ***Tour to Ishigakijima Astronomical Observatory, NAOJ*** *(optional)*

16:00-18:00 ***Registration*** *(Hotel Nikko Yaeyama, 2F room "Iriomote")*

18:00-19:00 ***Welcome reception*** *(1F room "Yaeyama")*

Note: posters are presented in the lobby of room "Yaeyama" (from 17:00-)

Monday, 22 February 2016

8:30-8:40 ***Opening Remark***
Masahiko Hayashi (NAOJ)

Session 1 : Observations and Theories on Protoplanetary Disks

8:40-9:00 Motohide Tamura (University of Tokyo/Astrobiology Center/NAOJ)
"Five Years of the Subaru SEEDS Direct Imaging Survey and Next Steps"

9:00-9:15 Munetake Momose (Ibaraki University)
"Observations of protoplanetary disks with the ALMA"

9:15-9:40 Ya-Wen Tang (ASIAA)
"Mapping of CO gas in the GG Tauri A Triple System with 50 AU Spatial Resolution"

9:40-9:55 Tomohiro Ono (Kyoto University)
"New Condition for the Rossby Wave Instability"

9:55-10:10 Hideko Nomura (Tokyo Institute of Technology)
"ALMA Observations of the Protoplanetary Disk around TW Hya"

10:10-10:25 Yuri Aikawa (University of Tsukuba)
"Molecular ions and COMs in protoplanetary disks"

10:25-10:40 Ryou Ohsawa (University of Tokyo)
"Impact of the initial disk mass function on the disk fraction"

10:40-11:00 *Coffee break*

Session 2 : Planetary Dust and Planets in Disks I

11:00-11:25 Wladimir Lyra (California State University)
"How shocks driven by high-mass planets can explain the spirals seen in transition disks"

11:25-11:40 Tazaki Ryo (Kyoto University)
"Diagnosing fluffy dust aggregates in protoplanetary disks"

11:40-12:05 Masahiko Arakawa (Kobe University)
"High velocity impact experiments on oblique impacts of planetary bodies and impact cratering on frozen sand"

12:05-12:20 Hiroshi Kimura (Kobe University)
"Cohesion of amorphous silica spheres: Toward a better understanding of the coagulation growth of silicate dust aggregates"

12:30-13:30 *Lunch*

13:30-14:00 ***Poster session***

Session 3 : Planet Formation Theory I

14:00-14:15 Shigeru Ida (ELSI/Tokyo Institute of Technology)
"Problems and new ideas in planet formation theory"

14:15-14:40 Shu-ichiro Inutsuka (Nagoya University)
"The Origin and Fate of Rings in HL-Tau: Diversity of Planet Formation Mechanisms"

14:40-14:55 Satoshi Okuzumi (Tokyo Institute of Technology)
"Sintering-induced multiple ring formation in protoplanetary disks"

14:55-15:10 Sin-iti Sirono (Nagoya University)
"Collisional outcomes of sintered icy grain aggregates"

15:10-15:35 Triston Guillot (Observatoire de la Cote d'Azur)
"Internal structures and compositions of giant (exo)planets"

15:35-15:50 Masahiro Ikoma (University of Tokyo)
"Effects of Snow on Giant Planet Formation"

15:50-16:05 Masanobu Kunitomo (Nagoya University)
"On the consequences of planet formation on stellar surface composition"

16:05-16:20 *Coffee break*

Session 4 : Planet Formation Theory II

16:20-16:35 Yasunori Hori (Astrobiology Center)
"“Deep Impact” on a Super-Earth in the Vicinity of a Central Star"

16:35-17:10 Jack Lissauer (NASA/AMES)
"Kepler's Multiple Planet Systems"

17:10-17:25 Makiko Nagasawa (Kurume University)
"Planet-Planet Scattering and Binary Planets"

17:25-17:40 Hiroshi Kobayashi (Nagoya University)
"From Planetesimals to Planets in Turbulent Protoplanetary Disks I. Onset of Runaway Growth"

17:40-18:30 ***1min short presentation (poster presenters)***

Tuesday, 23 February 2016

Session 5 : Theory and Modelling of Exoplanet Atmospheres I

8:30-8:45 Kiyoshi Kuramoto (Hokkaido University)
"Theoretical and numerical studies on exoplanet atmospheres in the research group A02"

8:45-9:10 Keiko Hamano (University of Tokyo)
"Thermal history and atmospheric evolution of terrestrial planets after giant impacts"

9:10-9:25 Saito Hiroaki (Hokkaido University)
"Hybrid-Type Proto-Atmosphere on Accreting Rocky Protoplanets"

9:25-9:40 Masanori Onishi (Kobe University)
"Two humidity regimes of stratosphere on a moist atmosphere"

9:40-9:55 Kiyoe Kawauchi (Tokyo Institute of Technology)
"The variation of transmission spectra occurred by the altitude changes of Earth atmospheric components"

9:55-10:20 Yoshiyuki O. Takahashi (Kobe University)
"Development of a general circulation model for shallow planetary atmospheres"

10:20-10:40 *Coffee break*

Session 6: Theory and Modelling of Exoplanet Atmospheres II

10:40-10:55 Masaki Ishiwatari (Hokkaido University)
"GCM experiments on the occurrence condition of the runaway greenhousestate on Earth-like exoplanets"

10:55-11:10 Kazuki Narita (Hokkaido University)
"An Estimation of Chemical Weathering Rate and Timescale for Nightside Cold Trap on Synchronously Rotating Exoplanet GJ667Cc with a General Circulation Model"

11:10-11:25 Kenji Kurosaki (University of Tokyo)
"The thermal evolution of ice giants with the effect of the condensation of water, ammonia, and methane in the atmosphere"

11:25-11:40 Yasuto Takahashi (Hokkaido University)
"Determinants of the atmospheric radiative cooling of Jupiter"

11:40-11:55 Yuki Tanaka (Nagoya University)
"Mass loss driven by magnetohydrodynamic waves in extrasolar gaseous planets and its detectability"

11:55-12:10 Shin-ichi Takehiro (Kyoto University)
"Diversity of atmospheric circulations of tidally locked gas giant planets -- dependence on the intrinsic heat flux strength"

12:10-13:30 *Lunch*

Session 7: Imaging, Spectroscopy, and Statistics of Exoplanets I

13:30-13:55 Masayuki Kuzuhara (Tokyo Institute of Technology)
"Individual SEEDS Findings and SCExAO Commissioning as Precursors to the Next Generation Direct Imaging Explorations for Exoplanets"

13:55-14:20 Timothy D. Brandt (Institute for Advanced Study)
"Discovering and Characterizing Exoplanets with CHARIS, a High-Contrast Spectrograph for the Subaru Telescope"

14:20-14:35 Johnny Greco (Prinston University)
"Spectral Covariance in Integral-Field Spectrograph Data"

14:35-14:50 Yasushi Suto (University of Tokyo)
"Hot Jupiters from Near-Coplanar Hierarchical Triple Systems"

14:50-15:10 *Coffee break*

Session 8: Imaging, Spectroscopy, and Statistics of Exoplanets II

15:10-15:35 Satoko Sorahana (University of Tokyo)
"Substellar Spectroscopy"

15:35-16:00 Takahiro Sumi (Osaka University)
"Microlensing exoplanet search toward the solar system analog"

16:00-16:15 Daisuke Suzuki (University of Notre Dame/GSFC)
"Discovery of A Break in the Exoplanet Mass Ratio Function beyond the Snow Line"

16:15-16:30 Bun'ei Sato (Tokyo Institute of Technology)
"A pair of giant planets around the evolved intermediate-mass star HD 47366: multiple circular orbits or a mutually retrograde configuration"

16:30-16:45 Teruyuki Hirano (Tokyo Institute of Technology)
"A New Search for Smaller Transiting Planets Unveiled by K2"

16:45-17:00 Masashi Omiya (NAOJ)
"Subaru/IRD planet search for Earth-mass planets around Late-M dwarfs"

17:00-18:00 ***Poster session / Business session***

18:00-21:00 ***Banquet*** *(room "Yaeyama")*

Wednesday, 24 February 2016

Session 9: Observations and Theories on Disks and Exoplanets

9:00-9:15 Masataka Aizawa (University of Tokyo)
"Search for planetary rings around long-period planets in Kepler photometric data"

9:15-9:30 Carol A. Grady (Eureka Scientific and GSFC)
"What HST Deep Coronagraphic Imaging Tells Us About Debris Disks"

9:30-9:45 Mitsuhiko Honda (Kurume University)
"Mid-IR studies of disks around Herbig Ae/Be stars"

9:45-10:00 Cassandra Hall (University of Edinburgh)
"Directly observing continuum emission in self-gravitating spiral waves in protostellar discs"

10:00-10:15 Kazuhiro Kanagawa (University of Szczecin)
"Estimate of a planet mass in protoplanetary disk from the gap shape"

10:15-10:30 Chikako Yasui (University of Tokyo)
"Metallicity dependence of protoplanetary disk lifetime"

10:30-10:45 *Coffee break*

Session 10: Planetary Dust and Planets in Disks II

10:45-11:00 Mari Isoe (NAOJ)
"Exoplanetary System Dynamics: Planetary Multiplicity and Mass Effects"

10:00-11:15 Eiichiro Kokubo (NAOJ)
"Orbital Structure of Planetary Systems Formed by Giant Impacts"

11:15-11:30 Yuri I. Fujii (Niels Bohr International Academy)
"Non-ideal MHD simulations in Protoplanetary Disks with Time-dependent Ionization Calculation"

11:30-11:45 Shota Notsu (Kyoto University)
"How to measure C/O ratio distributions in protoplanetary disks using infrared spectroscopic observations"

11:45-11:50 ***Closing remarks***

Poster Presentations

[P01] Yuhiko Aoyama (The University of Tokyo)
"Theoretical estimates of intensity of hydrogen line emission from accreting gas giants: Interpretation of the observed Hα intensity from LkCa15b"

[P02] Sota Arakawa (Tokyo Institute of Technology)
"A New Scenario for Compound Chondrule Formation: Crystallization from Supercooled Droplets"

[P03] Aaron C. Bell (The University of Tokyo)
"Features of the Circumstellar Medium: An Investigation of the 8.9 micron Feature Towards IRAS18434-242 and other Regions"

[P04] Mamoru Doi (The University of Tokyo)
"The first trial of transit observations with a very low resolution slit spectroscopy with LISS"

[P05] Hiroki Harakawa (NAOJ)
"Search for Exoplanets around Metal-Rich FGK Stars"

[P06] Norifumi Hasegawa (The University of Tokyo)
"Planet Engulfment by Intermediate-mass Red Giants Revisited"

[P07] Arika Higuchi (Tokyo Institute of Technology)
"Temporary Capture of Asteroids by a Planet"

[P08] Yusuke Imaeda (Kougakuin University)
"Dust coagulation in viscous accretion disk"

[P09] Daiki Ishimoto (Kyoto University)
"Velocity difference due to the disk wind in TW Hya by ALMA observations"

[P10] Masato Ishizuka (The University of Tokyo)
"Fiber Mode Scrambler Test for the Subaru Infra-Red Doppler Instrument (IRD)"

[P11] Masanori Kanamaru (Osaka University)
"Surface gravity and topography on Itokawa"

[P12] Yuta Kawai (Kobe University)
"Development of a coupled atmosphere-ocean-sea ice model to explore aquaplanet climates"

[P13] Yui Kawashima (The University of Tokyo)
"Transmission spectrum models of exoplanet atmospheres with haze: Effect of growth and settling of haze particles"

[P14] Patrick Koch (ASIAA)
"Stacking Spectra in Protoplanetary Disks: Detecting Intensity Profiles from Hidden Molecular Lines in HD 163296"

[P15] John H. Livingston (The University of Tokyo)
"Spitzer Confirmation and Characterization of K2 Exoplanets"

[P16] Yuji Matsumoto (NAOJ)
"In Situ Accretion of Close-in Super-Earths: Effects of Initial Eccentricities and Inclinations of Protoplanets"

[P17] Mede Kyle (The University of Tokyo)
"The Exoplanet Simple Orbit Fitting Toolbox (ExoSOFT), and its solution for the V450~And System"

[P18] Shugo Michikoshi (NAOJ)
"Multi-component analysis of secular gravitational instability with stochastic turbulence model"

[P19] Toshiyuki Mizuki (Tohoku University)
"Orbital characterization of a young companion to FP Cnc and constraints on properties of the system"

[P20] Shoji Mori (Tokyo Institute of Technology)
"Suppression of Magnetic Turbulence by Electron Heating in Protoplanetary Disks "

[P21] Takayuki Muto (Kogakuin University)
"Significant Variations of Gas-to-Dust Ratio of the Disk around HD 142527"

[P22] Kensuke Nakajima (Kyushu University)
"Heat transport associated with gravitational sedimentation of condensed particles in cloud layers where convection is suppressed"

[P23] Taishi Nakamoto (Tokyo Institute of Technology)
"Homogeneization of Isotopic Ratio in Early Solar Nebula"

[P24] Kazumasa Ohno (Tokyo Institute of Technology)
"A New Cloud Model for Exoplanets: Formulation and Test Calculations"

[P25] Shoichi Oshino (NAOJ)
"Terrestrial Planet Formation around Low-Mass Stars: Effect of the Mass of Central Stars"

[P26] Soonyoung Roh (Ibaraki University)
"The Propagation of Cosmic Ray Protons in Protoplanetary Disks"

[P27] Itsuki Sakon (The University of Tokyo)
"Infrared Properties of Nitrogen-bearing Carbonaceous Composite"

[P28] Matthias Samland (Max-Planck-Institute for Astronomy)
"SOURCE-CODE: Utilities for Detection and Characterization of Point Sources"

[P29] Yuhito Shibaike (Tokyo Institute of Technology)
"Formation of Galilean Satellites via Pebble Accretion"

[P30] Takashi Shibata (The University of Tokyo)
"Spin of Protoplanets by Planetesimal Accretion"

[P31] Yosuke Shirai (The University of Tokyo)
"Late Stage Capture of Solids by Accreting Proto-Gas-Giant Planets"

[P32] Stevanus K. Nugroho (Tohoku University)
""Detail Characterization of Directly Imaged Exoplanet in Subaru Telescope using High Contrast and High Dispersion Spectroscopy Instrument (IRCS+AO188)"

[P33] Keisuke Sugiura (Nagoya University)
"An Extension of Godunov SPH to Elastic Dynamics and Numerical Simulation for Collisional Growth and Destruction of Ptoroplanets"

[P34] Ko-ichiro Sugiyama (ISAS/JAXA)
"Numerical Modeling of Moist Convection in Saturn's and Uranus' atmospheres"

[P35] Takashi Mikami (Hokkaido University)
"A massive primordial-atmosphere on proto-Titan formed in a cold circum-planetary disk"

[P36] Tetsuo Taki (Tokyo Institute of Technology)
"Coagulation of Rocky Dust Particles at the Radial Pressure Bump in Protoplanetary Disks"

[P37] Shuya Tan (Osaka University)
"Stability of Titan's atmosphere and surface"

[P38] Takayuki Tanigawa (University of Occupational and Environmental Health)
"Final Masses of Giant Planets II: Jupiter Formation in a Gas-Depleted Disk"

[P39] Takashi Tsukagoshi (Ibaraki University)
"ALMA Observations for Revealing the Detailed Structure and Kinematics of the Transitional Disk around Sz 91"

[P40] Takahiro Ueda (The University of Tokyo)
"The origin and physical properties of interplanetary dust particles estimated from AKARI observations"

[P41] Taichi Uyama (The University of Tokyo)
"Search for Companions around Young Stellar Objects "

[P42] Kensuke Watanabe (Hokkaido University)
"Atmospheric evolution of GJ 1214b by hydrodynamic escape"

[P43] Akihisa Yamakawa (Tokyo Institute of Technology)
"An implementation of particle-particle particle-tree scheme for N-Body simulations including fragmentation"

[P44] Tetsuo Yamamoto (Hokkaido University)
"Chemical desorption of molecules formed on dust surface"

[P45] Yi Yang (GUAS/NAOJ)
"Near-infrared imaging of the inner region of GG Tau A disk"

[P46] Naoki Koshimoto (Osaka University)
"OGLE-2012-BLG-0950Lb: The Possible First Planet Mass Measurement from Only Microlens Parallax and Lens Flux"

[P47] Akifumi Nakayama (The University of Tokyo)
"Effects of Water Amount on the Surface Environment of Terrestrial Planets: High Pressure Ice and Carbon Cycle on Ocean Planets"

Abstract

(Oral presentations)

Monday, 22 February 8:40-9:00

"Five Years of the Subaru SEEDS Direct Imaging Survey and Next Steps"

Motohide Tamura (University of Tokyo/Astrobiology Center/NAOJ)

The SEEDS survey of exoplanets and disks is the first Subaru Strategic Program, whose aim is to conduct a direct imaging survey for giant planets as well as protoplanetary/debris disks at a few to a few tens of AU region around 500 nearby solar-type or more massive young stars. Our team composed of ~120 members at maximum has successfully completed 120-night observations during 2009 and 2015. The targets are categorized into five categories spanning the ages of ~1 Myr to ~1 Gyr (YSOs, Moving Groups, Open Clusters, Nearby stars. Debris Disks). Some RV-planet targets with older ages are also observed. We have discovered a few exoplanets and candidates via direct imaging and uncovered detailed Solar-system-scale structures such as gaps and spirals around many protoplanetary disks. We highlight the main results from this survey on both planets/companions and disks, and then introduce the next-generation instruments for exoplanet studies for Subaru.

Monday, 22 February 9:00-9:15

"Observations of protoplanetary disks with the ALMA"

Munetake Momose (Ibaraki University)

In this talk, I will introduce recent studies of protoplanetary disks that are related to the observations with the ALMA. Two topics are mainly discussed. The first topic is the detailed structure of transitional disks. It has been revealed that these disks are commonly show not only the asymmetric structure but also the remarkable spatial variation of gas-to-dust. The second topic is a series of follow-up studies related to the long-baseline campaign observations of HL Tau. The possible formation mechanisms of gaps are divided into two categories: (1) gaps carved by planets, and (2) gaps formed by a mechanism without planet, including sintering-induced ring formation. I will also comment on the future prospects of polarization observations to constrain the size of dust particles inside the disks. Schedule Request: Please schedule my presentation on Feb. 22nd. Unfortunately, I have to leave the conference in the Tuesday's morning.

Monday, 22 February　9:15-9:40

"Mapping of CO gas in the GG Tauri A Triple System with 50 AU Spatial Resolution"

Ya-Wen Tang (ASIAA)

We aim to unveil the observational imprint of physical mechanisms that govern planetary formation in the young, multiple system GG Tau A. We present ALMA observations of ^{12}CO and ^{13}CO 3-2 and 0.9 mm continuum emission with 0.35 resolution. The ^{12}CO 3-2 emission, found within the cavity of the circumternary dust ring (at radius < 180 au) where no ^{13}CO emission is detected, confirms the presence of CO gas near the circumstellar disk of GG Tau Aa. The outer disk and the recently detected hot spot lying at the outer edge of the dust ring are mapped both in ^{12}CO and ^{13}CO. The gas emission in the outer disk can be radially decomposed as a series of slightly overlapping Gaussian rings, suggesting the presence of unresolved gaps or dips. The dip closest to the disk center lies at a radius very close to the hot spot location at $\sim250-260$~au. The CO excitation conditions indicate that the outer disk remains in the shadow of the ring. The hot spot probably results from local heating processes. The two latter points reinforce the hypothesis that the hot spot is created by an embedded proto-planet shepherding the outer disk.

Monday, 22 February　9:40-9:55

"New Condition for the Rossby Wave Instability"

Tomohiro Ono (Kyoto University)

Recent observations have revealed the protoplanetary disks having non-axisymmetric structures, but the origin is still unknown. The Rossby wave instability (RWI) is one of the candidates of the origin. The RWI is the hydrodynamic instability, which forms non-axisymmetric large-scale vortices when disk profiles have steep radial gradient. Previous works show each of the necessary condition and the sufficient condition for the RWI. However, any necessary and sufficient condition has not been investigated. In this work, we perform linear stability analyses of the RWI in barotropic fluid with a wide parameter range. We calculate parameters for marginally stable states and check the necessity and sufficiency of known conditions. We find that a co-rotation radius for marginally stable states can be obtained analytically from only unperturbed profiles, and derive a new necessary and sufficient condition for the RWI in a semi-analytic form. We investigate a scope of application of the new condition. The new condition is available when vortensity has an isolated minimum. We also present a method to check stability for the RWI even when the new condition is not available. The new condition and method will be useful for interpretations of observations and non-linear numerical simulations.

Monday, 22 February　9:55-10:10

"ALMA Observations of the Protoplanetary Disk around TW Hya"

Hideko Nomura (Tokyo Institute of Technology)

We report the first detection of a gap and a ring in 336GHz dust continuum emission from the protoplanetary disk around TW Hya, using the ALMA. The gap and ring are located at 25 and 41 AU from the central star, respectively, and are associated with the CO snowline at ~30AU. The gap has a radial width of less than 15 AU and a mass deficit of more than 23%, taking it into account that the observations are limited to an angular resolution of ~15AU. In addition, we observe the 13CO and C18O J=3-2 lines to detect a decrement in CO column density down to ~10AU, indicating freeze-out of gas-phase CO onto grain surfaces and possible subsequent surface reactions to form larger molecules. According to theoretical studies, the gap could be caused by gravitational interaction between the disk gas and a planet with a mass less than super-Neptune, or result from destruction of large dust aggregates due to the sintering of CO ice.

Monday, 22 February 10:10-10:25

"Molecular ions and COMs in protoplanetary disks"

Yuri Aikawa (University of Tsukuba)

In recent years, ALMA started to reveal the radial distribution of molecular ions in protoplanetary disks (e.g. Qi et al. 2013; Oberg et al. 2015). Molecular ions tend to reach their steady-state abundances in a relatively short timescale. Their abundances can thus be described by analytical formulas, which are useful to probe the physical conditions, such as temperature in the disk (Aikawa et al. 2015). Another progress in disk observation is the detection of complex organic molecules (COMs) (Obser et al. 2015). COMs are formed by a combination of gas and grain-surface reactions and tend to be more abundant on grain surfaces than in the gas-phase in cold regions. Vertical diffusion, i.e. the interaction of cold midplane and warm molecular layer, could thus affect the gaseous abundances of COMs (Furuya & Aikawa 2014). Since COMs in ice are hard to observe directly, a comparison of disk chemistry model with gas-phase observation is important to fully understand the molecular evolution in the disk.

Monday, 22 February　10:25-10:40

“Impact of the initial disk mass function on the disk fraction”

Ryou Ohsawa (University of Tokyo)

The disk fraction, the percentage of stars with a disk in a young cluster, is widely used to investigate the lifetime of the protoplanetary disk, which can impose an important constraint on the planet formation mechanism. The relationship between the decay timescale of the disk fraction and the mass dissipation timescale of individual disks, however, remains unclear. We investigate the effect of the disk mass function (DMF) on the evolution of the disk fraction. We show that the time variation in the disk fraction depends on the spread of the DMF and the detection threshold of the disk. In general, the disk fraction decreases more slowly than the disk mass if a typical initial DMF and a detection threshold are assumed. We find that, if the disk mass decreases exponentially, the mass dissipation timescale of the disk can be as short as 1 Myr even when the disk fraction decreases with a time constant of ~2.5 Myr. The difference between the mass dissipation of individual disks and the decrease in the disk fraction should be properly appreciated to estimate the timescale of the disk mass dissipation.

Monday, 22 February 11:00-11:25

"How shocks driven by high-mass planets can explain the spirals seen in transition disks"

Wladimir Lyra (California State University)

Recent high resolution near-infrared images of protoplanetary disks have shown that these disks often present spiral features. Spiral arms are among the structures predicted decades ago by numerical simulations of disk-planet interaction and thus it is tempting to suspect of planetary perturbers as responsible for the observed signatures. However, such interpretation is not free of problems. The spirals are seen to be too wide, and in at least one case the spiral feature is seen effectively unpolarized, which implies thermal emission at roughly 1000 K. While the wide spiral problem can be understood in the context of high-mass planets launching shock waves, the high temperature implied by the lack of polarization should be physical. We have recently shown in two-dimensional models that shock dissipation in the supersonic wake of high-mass planets can become a significant source of energy for disk heating if the disk is sufficiently adiabatic. Here we extend this analysis to three dimensions in thermodynamically evolving disks. We employ the PENCIL CODE in spherical coordinates for our models, with a self-consistent prescription for thermal cooling based on the optical depth of the local vertical gas column. We use a 5MJ planet, and show that the Lindblad lobes around the planet develop substantially higher temperatures than the disk gas around it. The gas is accelerated above the midplane by these shocks, forming shock bores, and the gas returning to the disk midplane generates breaking waves in the form of a turbulent surf in the radial location of the Lindblad resonances. This turbulence, although localized, has high α values, 0.05 in the inner Lindblad resonance, and 0.1 in the outer one. We also find evidence that the material heated up by the planetary shocks becomes superadiabatic, generating convection far from the planet's orbit

Monday, 22 February　11:25-11:40

“Diagnosing fluffy dust aggregates in protoplanetary disks”

Tazaki Ryo (Kyoto University)

Micron-sized dust grains coagulate to form fluffy dust aggregates in protoplanetary disks. Observationally, fluffy dust aggregates are expected to contribute especially to observed image of scattered light, since they are easily stirred up to the surfaces of protoplanetary disks. We construct a light scattering model of fluffy dust aggregates by using the Rayleigh-Gans-Debye theory, whose validity is tested by using the rigorous method, T-Matrix method. We investigate how the presence of fluffy dust aggregates alters the interpretation with compact grains. Firstly, we show that the angular dependence of scattered intensity reflects the hierarchy structure of dust aggregates when the aggregates size is larger than the wavelength. Secondly, we show that the degree of polarization of fluffy dust aggregates of sub-micron sized monomer tends to yields that of Rayleigh scattering. For large compact grain, the degree of polarization is different from that of Rayleigh scattering depending on its size and complex refractive indices. As a result, a presence of fluffy dust aggregates could be tested by observations of asymmetry in the intensity as well as the polarization degree of forward and backward scattering light from inclined disks.

Monday, 22 February　11:40-12:05

“High velocity impact experiments on oblique impacts of planetary bodies and impact cratering on frozen sand”

Masahiko Arakawa (Kobe University)

We studied effects of an oblique impact on catastrophic disruption for planetary bodies with different porosities, and also studied effects of water ice contents on impact cratering process for a regolith layer on icy bodies. For the oblique impact experiments, we used a quartz glass sphere and a porous gypsum sphere simulating rocky and porous bodies, respectively, and made impact experiments at the impact angle from 90 (a normal impact) to 15degree (a glancing impact) using a polycarbonate projectile launching from 2 to 7km/s. Then, we found that the degree of impact disruption was well scaled by the specific energy calculated by the velocity component normal to the impact surface in both the quartz glass and the porous gypsum target. We also conducted the cratering experiments on a frozen sand with the water ice contents from 2.5 to 20 wt.%, at the impact velocity from 2 to 6km/s, and studied the crater scaling law applicable on icy bodies in the strength regime. Then, we found that the crater size gradually increased with the decrease of the water contents because the mechanical strength weakened with the decrease of the water content.

Monday, 22 February 12:05-12:20

"Cohesion of amorphous silica spheres: Toward a better understanding of the coagulation growth of silicate dust aggregates"

Hiroshi Kimura (Kobe University)

Adhesion forces between submicrometer-sized silicate grains play a crucial role in the formation of silicate dust agglomerates, rocky planetesimals, and terrestrial planets. The surface energy of silicate dust particles is the key to their adhesion and rolling forces in a theoretical model based on contact mechanics. Here we revisit the cohesion of amorphous silica spheres by compiling available data on the surface energy for hydrophilic amorphous silica in various circumstances. It turned out that the surface energy for hydrophilic amorphous silica in a vacuum is a factor of 10 higher than previously assumed. Therefore, the previous theoretical models underestimated the critical velocity for the sticking of amorphous silica spheres, as well as the rolling friction forces between them. With the most plausible value of the surface energy for amorphous silica spheres, theoretical models based on the contact mechanics are in harmony with laboratory experiments. Consequently, we conclude that silicate grains of 0.1 μm radius could grow to planetesimals via coagulation in a protoplanetary disk. We argue that the coagulation growth of silicate grains in a molecular cloud is advanced either by organic mantles rather than icy mantles or, if there are no mantles, by nanometer-sized grain radius.

Monday, 22 February　14:00-14:15

"Problems and new ideas in planet formation theory"

Shigeru Ida (ELSI/Tokyo Institute of Technology)

Planet population synthesis simulations succeeded to explain overall distributions of exoplanets, but some trends cannot be explained within reasonable ranges of parameters. I will discuss problems in type I and II migrations and results based on Grand Tack model. Pebble accretion is one of promising new ideas. I will also discuss pebble accretion in connection of structure and evolution of protoplanetary disks.

Monday, 22 February 14:15-14:40

"The Origin and Fate of Rings in HL-Tau: Diversity of Planet Formation Mechanisms"

Shu-ichiro Inutsuka (Nagoya University)

Protoplanetary disks are supposed to be the sites of planet formation, and thus, understanding of the evolution of the disk is crucial in understanding of the planet formation. Recent ALMA observation revealed a remarkable multiple ring structure in a protoplanetary disk around HL Tau. Prior to this observation, Takahashi & Inutsuka (2014) proposed a possible formation of multiple ring structures by secular gravitational instability in the case of weak turbulent diffusion. This talk describes the condition for this to occur in detail and discuss the further evolution of the rings. A possible scenario for the formation of rocky objects at outer regions of the disks is outlined and contrasted with the other formation scenarios.

[Reference] "Two-component Secular Gravitational Instability in a Protoplanetary Disk: A Possible Mechanism for Creating Ring-like Structures" Sanemichi Z. Takahashi & Shu-ichiro Inutsuka (2014) The Astrophysical Journal Vol. 794, 55 (arXiv:1312.6870)

Monday, 22 February 14:40-14:55

"Sintering-induced multiple ring formation in protoplanetary disks"

Satoshi Okuzumi (Tokyo Institute of Technology)

The latest observation of HL Tau by ALMA revealed spectacular concentric dust rings in its circumstellar disk. We propose that the multiple rings are formed by icy dust aggregates that experienced sintering. Sintering is a process that reduces the sticking efficiency of dust aggregates, and takes place where the temperature is slightly below the sublimation point of some constituent material. We here present a dust growth model that incorporates sintering, and use it to simulate global dust evolution in a modeled HL Tau disk taking into account coagulation, fragmentation, and radial inward drift. We show that the aggregates collisionally disrupt and pile up at multiple locations where different volatiles cause sintering. At millimeter wavelengths, these sintering zones appear as bright, optically thick rings, whereas the non-sintering zones as darker, optically thinner rings. Our model simultaneously reproduces the brightness temperatures and spectral slopes of the HL Tau rings. The ring patterns diminish with time as dust is depleted from the disk, consistent with the idea that HL Tau is a young object.

Monday, 22 February　14:55-15:10

“Collisional outcomes of sintered icy grain aggregates”

Sin-iti Sirono (Nagoya University)

We performed 2-D numerical simulations of collisions between sintered grain aggregates and found that collisional outcome is basically bouncing, not sticking as observed for non-sintered aggregates. Moreover, fragments are produced during a collision and fragment mass increases as collision velocity increases. It is expected that there are distinct zones where fragments are preferentially produced in a protoplanetary nebula.

Monday, 22 February 15:10-15:35

"Internal structures and compositions of giant (exo)planets"

Triston Guillot (Observatoire de la Cote d'Azur)

One can now attempt to determine the abundances of key species in the atmospheres of exoplanets, in particular hot Jupiters. In parallel, the knowledge of the densities of these exoplanets informs us on their bulk composition in terms of amounts of dense material (rocks and ices) compared to light ones (hydrogen and helium). Linking these constraints seems natural and, intuitively, one would expect dense planets to contain more heavy elements in their atmospheres. However, several physical processes, in particular the formation of a central core, its gradual erosion and the growth of a deep outer radiative zone, could decouple partially or even completely interior and atmospheric composition. The latter will also depend on how heavy elements were delivered to the planet. Close to us, measurements performed in the atmosphere of Jupiter (and to some extent in Saturn) already provide us with important clues: The high enrichment in carbon coupled to a more modest but significant enrichment in noble gases indicates that solids and gas-species followed different routes. Jupiter obtained its solids probably as a core and via pebble accretion and captured disk gas that had lost part of its hydrogen and helium. The elements originally solid in the disk but fluid in the planetary interior were at least partially mixed upward to account for the present day atmospheric composition. This simple scenario can be tested. The comparison of bulk and atmospheric compositions of hot Jupiters of different masses will tell us the importance of mixing. Measurements by the Juno spacecraft at Jupiter starting in July 2016 will help us constrain the abundance of water, a key element to understand how the solids were captured.

Monday, 22 February 15:35-15:50

"Effects of Snow on Giant Planet Formation"

Masahiro Ikoma (University of Tokyo)

Recent theories of planet formation suggest that small bodies such as fragments and pebbles are likely to make a great contribution to the formation of giant planet cores. Such small bodies, in particular, icy bodies are subject to evaporation in the planet envelope on the way toward the core, which results in polluting the H2/He envelope with evaporated materials such as H2O. In this study, we quantify the effect of condensation and chemical reactions of the evaporated materials on the structure of the accreting envelopes of gas and ice giant planets. We then demonstrate that the latent heat for condensation of H2O is large enough that the snowy envelope is much denser than that with the solar composition. This is so effective in reducing the critical core mass and enhancing the collisional cross section of the core significantly that gas and ice giant planets would be formed much more rapidly beyond the snowline than previously thought.

Monday, 22 February 15:50-16:05

"On the consequences of planet formation on stellar surface composition"

Masanobu Kunitomo (Nagoya University)

Recent spectroscopic observations indicate that there exist subtle differences between the surface composition of the Sun and the average obtained from an ensemble of stars of the same mass and metallicity (solar twins). One possible scenario is that the formation of rocky planetesimals removes refractory elements from the nebula gas and its accretion changes the solar surface composition. In this scenario, the surface convective zone has to be small. Otherwise, the accreted materials are diluted over a large mass and departures from the primordial composition would remain negligible. We investigated the formation and the pre-main sequence evolution of solar-mass stars and found that the evolution strongly depends on the entropy of accreting materials. Solutions in which the solar surface convective zone is small already after 10 million years (instead of about ~40 million years in standard models) are possible but only when considering that most of the entropy of the material accreted onto the protostar is lost. The observation of young clusters shows that this solution may explain a small fraction of stars with anomalously low luminosities. The difference in composition between our Sun and solar twins may therefore be explained by planet formation and a low-entropy accretion.

Monday, 22 February 16:20-16:35

“"Deep Impact" on a Super-Earth in the Vicinity of a Central Star”

Yasunori Hori (Astrobiology Center)

The Kepler mission has revealed the prevalence of volatile-rich/poor low-mass planets in the proximity of host stars. Several post-formation processes have been proposed for explaining volatile inventory of those planets: mass loss via stellar XUV irradiation and Parker wind, degassing of accreted material, and in-situ accumulation of the disk gas. However, the compositional dissimilarity between neighboring planets in multiple-planet systems is puzzling for the three processes. We consider the possibility of a collisional origin for the compositional diversity of close-in super-Earths. We performed three-dimensional hydrodynamic simulations of giant impacts on a super-Earth with a H/He atmosphere. A high-speed collision can strip off most of the original H/He atmosphere. ?A hot and inflated planet after the giant impact cools down so slowly that a prolonged lifetime of the extended atmosphere enhances mass loss via a Parker wind and subsequent hydrodynamic escape driven by stellar XUV irradiation. We also found that a low-speed collision results in the appearance of a positive-compositional gradient deep inside the planet which leads to an inefficient heat transport, whereas a high-speed one homogenizes a distribution of heavy elements above the core.

Monday, 22 February　16:35-17:10

"Kepler's Multiple Planet Systems"

Jack Lissauer (NASA/AMES)

More than one-third of the 4700 planet candidates found by NASA's Kepler spacecraft are associated with target stars that have more than one planet candidate, and such "multis" account for the vast majority of candidates that have been verified as true planets. The large number of multis tells us that flat multiplanet systems like our Solar System are common. Virtually all of the candidate planetary systems are stable, as tested by numerical integrations that assume a physically motivated mass-radius relationship. Statistical studies performed on these candidate systems reveal a great deal about thearchitecture of planetary systems, including the typical spacing of orbits and flatness. The characteristics of some of the most interesting confirmed Kepler multi-planet systems will also be discussed.

Monday, 22 February 17:10-17:25

"Planet-Planet Scattering and Binary Planets"

Makiko Nagasawa (Kurume University)

The gravitational scatterings of Jovian planets can lead to formation of hot Jupiters, formation of binary planets (gravitationally bounded pairs of gas-giant planets), collisions, and ejections. We carried out N-body simulations of planet-planet scattering in systems consisting of three Jovian planets and study formation rate of binary planets. The binary planets are formed when two planets almost graze in the early stage of orbital instability. The formation rate of the binary planets is about 10% and the likely binary separations are comparable to the stellar diameter. Although the frequencies of collision and ejection depend on distance from the central star, the formation rates of binary planets and hot Jupiter are less dependent on the distance, since they are determined by the encounter distances of two objects. If a pair of binary planets rotates around a star, the shape of the transit light curve shows a dip and bump and it would be different from transit to transit.

Monday, 22 February 17:25-17:40

"From Planetesimals to Planets in Turbulent Protoplanetary Disks I. Onset of Runaway Growth"

Hiroshi Kobayashi (Nagoya University)

When planetesimals grow via collisions in a turbulent disk, stirring through density fluctuation caused by turbulence effectively increases the relative velocities between planetesimals, which suppresses the onset of runaway growth. We investigate the onset of runaway growth in a turbulent disk through simulations that calculate the mass and velocity evolution of planetesimals. When planetesimals are small, the average relative velocity between planetesimals is much greater than their surface escape velocity, so that runaway growth does not occur. As planetesimals become large via collisional growth, the relative velocity approaches the escape velocity. When the relative velocity becomes approximately 1.5 times larger than the escape velocity, runaway growth of the planetesimals occurs. During the oligarchic growth subsequent to runaway growth, a small number of planetary embryos produced via runaway growth become massive through collisions with planetesimals with radii of that at the onset of runaway growth. We analytically derive the runaway radius as a function of the turbulent strength. Using the analytic solution, we give a constraint on the radial profile of turbulent strength in the solar nebula.

Tuesday, 23 February 8:30-8:45

“Theoretical and numerical studies on exoplanet atmospheres in the research group A02”

Kiyoshi Kuramoto (Hokkaido University)

The progress of theoretical and numerical modeling of exoplanet atmospheres in our research group will be introduced. It includes the following topics: 1) conditions for water retention or loss on terrestrial planets through planetary growth and early evolution, 2) GCM development and applied studies on climate with focusing on stability of surface liquid water on terrestrial planets under diverse boundary conditions, 3) elementary control mechanisms of escape rate of hydrogen and water to space, 4) cloud convection and radiative transfer of Jupiter-like planet atmospheres, and 5) general circulation of giant planet atmospheres.

Tuesday, 23 February 8:45-9:10

"Thermal history and atmospheric evolution of terrestrial planets after giant impacts"

Keiko Hamano (University of Tokyo)

Theoretical studies on planet formation suggest that terrestrial planets would form as a result of giant impacts between protoplanets. In the aftermath, the planets probably start their lives in a globally molten state. In parallel with the subsequent planetary solidification, early atmosphere would form by degassing from the magma ocean. The formation of the atmosphere would greatly affect the cooling history of the magma ocean via its blanketing and greenhouse effects, and also the time of ocean formation on planets in the habitable zone. We examined thermal evolution of a magma ocean along with the formation of an H2-H2O atmosphere, taking into account the thermal interaction and volatile exchange between the magma ocean and the atmosphere. Our results suggest that the atmospheres of the solidified planets can have different characteristics in their amount and redox state, depending on the orbital distance from the host star. We also presented the time variation of emergent spectra from the solidifying terrestrial planets through their early atmosphere. Our model predicts that molten planets located inside the inner edge of the habitable zone will emit significant thermal radiation from near-infrared atmospheric windows during the entire lifetime of the magma ocean.

Tuesday, 23 February 9:10-9:25

"Hybrid-Type Proto-Atmosphere on Accreting Rocky Protoplanets"

Saito Hiroaki (Hokkaido University)

Recent meteorite chronology suggests that the growth of Mars had been almost completed within the first several Myr of the solar system, which is consistent with the theoretical estimate for the formation time of protoplanets. During such rapid accretion, a protoplanet might gravitationally keep both degassed component and the solar nebula component as a proto-atmosphere. We call this atmosphere hybrid-type proto-atmosphere. According to our numerical analysis, a protoplanet grown to Mars-size possibly has a massive and high-temperature atmosphere (more than 1000 bar), which is sufficient to form a magma ocean. The composition of the degassed component (H_2, H_2O, CH_4, and CO) is reduced due to chemical equilibrium with silicate and metal generated by impact heating. A significant amount of H_2O may also be partitioned into the planetary interior due to high H_2O solubility into silicate melt. We will discuss implications of these results for volatile retention, evolution of the proto-atmosphere and differentiation of the silicate mantle and metallic core of a protoplanet as the embryo of a larger rocky planet.

Tuesday, 23 February 9:25-9:40

“Two humidity regimes of stratosphere on a moist atmosphere”

Masanori Onishi (Kobe University)

An inner edge of habitable zone is suggested to be determined by water loss limit. There remain some unclear points on the water loss phase, including the possibility that the water loss phase is not realized virtually (Wolf & Toon, 2015). To investigate these problems, a radiative transfer model which calculates opacity of each wavelength accurately enough for estimating temperatures in lower pressure tropopause than that of Earth is required. We estimate the temperature by using such a one-dimensional, line-by-line radiative transfer model. The model atmosphere is assumed to consist of H_2O and N_2. The troposphere and stratosphere is assumed to be fully saturated and isothermal, respectively. The value of a heating rate in tropopause are calculated for various surface and tropopause temperatures. The result shows the existence of two regime: one is dry regime, and the other is wet regime. In a dry regime, the tropopause temperature is about 120 K, that is independent of surface temperature. A wet regime, in which water vapor becomes a major constituent, appears when the surface temperature is higher than 345 K. The model atmosphere does not experience a water loss phase, instead skipping directly to a runaway greenhouse.

Tuesday, 23 February 9:40-9:55

"The variation of transmission spectra occurred by the altitude changes of Earth atmospheric components"

Kiyoe Kawauchi (Tokyo Institute of Technology)

The refraction light which passed through the atmosphere of the Earth is reflected on the lunar surface during lunar eclipse. Atmospheric components can be detected by the spectroscopy of this light. This method is the same as the transmission spectroscopy which is spectroscopic observation of the exoplanet atmosphere during transits. We investigate the time variation of the individual Earth atmospheric absorption line using the data of lunar surface during lunar eclipse which observed with the High Dispersion Spectrograph (HDS) mounted on the Subaru 8.2-m telescope on HST 2011 December 9. In this observation results, the time variation of individual absorption lines of O2 and H2O were detected. This time variation is occurred by the difference of the atmosphere which the light passed, due to change of the positional relation among Sun-Earth-Moon by time. We calculated the altitude and position of the Earth's atmosphere which the light passed by each observation times, and made the theoretical spectrum. Consequently, observed spectra are consistent with our theoretical spectra, assuming that the light has transmitted through the atmosphere above 12 km. We here show this method and this results.

Tuesday, 23 February　9:55-10:20

"Development of a general circulation model for shallow planetary atmospheres"

Yoshiyuki O. Takahashi (Kobe University)

In order to understand the diversity of atmospheric circulations and surface environments of planets, we have been developing an atmospheric general circulation model (GCM), which is applicable to exoplanets as well as planets in the solar system. Targets of the model experiments in this study are shallow atmospheres, whose effective thickness of circulation is much smaller than its planetary radius. The model calculates global distributions of atmospheric wind, temperature, and densities of multiple species including water by solving hydrodynamic equations with a shallow atmosphere approximation, radiative transfer equations, and several parameterizations for turbulent mixing, cumulus convection, and cloud formation. The model has been applied to the atmospheres of Earth, Mars, Venus, and cloud layers of outer planets of our solar system. The current model represents features of atmospheric circulations of Earth's and Mars' atmospheres. It has also been applied to atmospheres with the possible parameters for those in exoplanetary systems, such as atmospheres of a hot-Jupiter (e.g., Takehiro et al., this conference), and a synchronously rotating planet (e.g., Ishiwatari et al., this conference). In the presentation, we will describe current status of our GCM, some results of its simulations, and a future view of our activity.

Tuesday, 23 February 10:40-10:55

"GCM experiments on the occurrence condition of the runaway greenhousestate on Earth-like exoplanets"

Masaki Ishiwatari (Hokkaido University)

In order to examine the occurrence condition of the runaway greenhouse state on Earth-like exoplanets, numerical experiments using ageneral circulation model are performed. We use the AGCM developed by our research group, DCPAM, to which a simple cloud model is added. We examine the response of modeled atmospheric states to the increase of solar flux considering two spatial and temporal distributions: one for synchronously rotating planets with fixed dayside and nightside (Synchronous distribution), and the other for an Earth-like, non-synchronously rotating planets with diurnal and seasonal changes (Non-synchronous distribution) . The results of the experiments show that the values of solar constant at which the runaway greenhouse state appears are larger in the cases of Synchronous distribution than in the cases of Non-synchronous distribution. Although the runaway threshold value differs among runs with different conditions, the difference of global mean outgoing longwave radiation (OLR) is much smaller. Values of OLR are about 300 W/m2 regardless of experimental condition. Based on the result, we speculate on the existence of the upper limit of radiation in cloudy atmospheres, similar to cloud free atmospheres. Further analysis on cloud behaviors is needed for examination of our speculation.

Tuesday, 23 February 10:55-11:10

"An Estimation of Chemical Weathering Rate and Timescale for Nightside Cold Trap on Synchronously Rotating Exoplanet GJ667Cc with a General Circulation Model"

Kazuki Narita (Hokkaido University)

GJ667Cc is one of the potentially habitable terrestrial exoplanet around M dwarf. In order to evaluate its possible climate states, we carried out a series of GCM (general circulation model) simulations on GJ667Cc given observed planetary properties, expected synchronous rotation state, and scaled atmospheric mass by using dcpam5 code [Takahashi et al., 2013]. Simulations supposing the present Earth were also conducted for comparison. The global mean surface temperature and precipitation are calculated to be significantly lower on GJ667Cc. However, the chemical weathering rate per unit land area of GJ667Cc is estimated to be comparable to that of the earth due to the warm and rainy dayside of GJ667Cc. This result implies a CO2 poor atmosphere on this planet. It is also suggested that a large fraction of surface water may be transported to the cold night side hemisphere and trapped as a huge ice sheet. Based on these results, we will discuss the climate variability of synchronously rotating terrestrial planets located in the habitable zones of low-mass stars.

Tuesday, 23 February 11:10-11:25

"The thermal evolution of ice giants with the effect of the condensation of water, ammonia, and methane in the atmosphere"

Kenji Kurosaki (University of Tokyo)

Progress in observational techniques enables us to discover exoplanets whose sizes are Uranus-size. If those planets were discovered in several ten AU, ice compositions such as water, ammonia, and methane in the planetary atmosphere would be condensed. Considering the effect of condensation of ice compositions in the atmosphere is important to understand the evolution of Uranus-sized, ice-rich planet (i.e. an ice giant). In this study, we quantify the impact of the condensation of ice components in the atmosphere on the thermal evolution. Since the speed of the thermal evolution is determined by how efficiently the planetary atmosphere radiates energy, the atmospheric structure is essential. We simulate the thermal cooling of the ice giants, based on three layer models with a relatively ice-component-rich, H/He-dominated envelope on top of a water mantle that surrounds a rocky core. We demonstrate that the effect of the condensation makes the timescale of the thermal cooling of the planet shorter by an order of magnitude than in the case without condensation. Our study will be useful to understand the luminosity of a long-period planet that expected to be discovered in the future.

Tuesday, 23 February 11:25-11:40

"Determinants of the atmospheric radiative cooling of Jupiter"

Yasuto Takahashi (Hokkaido University)

Atmospheric radiative cooling to space controls the atmospheric dynamics and the thermal history of gas giant planets including exoplanets. This is of course true for Jupiter which most provides us a basis for understanding the gas giants. Because the radiative cooling mostly occurs from the shallow convective layer (troposphere) that is opaqued by cloud layers, how atmospheric species distribute and control the radiative transfer in the Jovian troposphere remains an open question. Recent numerical simulations of the cloud convection elucidate the realistic distribution of condensable gas species and condensates in the Jovian troposphere, which enables us to analyze how the radiative cooling is determined by these materials. Here we have developed a radiative transfer model that describes the radiative-convective equilibrium state with the material profile imported from the latest cloud convection simulation.This model shows that the radiative cooling in the Jovian troposphere is largely determined by the net thermal emission of ammonia and hydrogen gases. Contrary to intuition, clouds made of H2O and non-H2O ice particles have little contribution to thermal radiation because they have low opacity in long wave during the quiescent phase that spends most of the time for the cloud convection cycle.

Tuesday, 23 February 11:40-11:55

"Mass loss driven by magnetohydrodynamic waves in extrasolar gaseous planets and its detectability"

Yuki Tanaka (Nagoya University)

Several transit observations in the UV band have been suggested that hot Jupiters have high-temperature hydrogen upper atmospheres, and the existence of a large amount of atmospheric escape from the upper atmospheres. It is thought that heating by the XUV radiation from central stars is the main mechanism to drive the atmospheric escape, but a driving mechanism of atmospheric escape that includes planetary magnetic fields has not been investigated so far. Here we propose a new mechanism in which the atmospheric escape is driven by the dissipation of magnetohydrodynamic (MHD) waves. We performed MHD simulations and show that the dissipation of MHD waves in the upper atmosphere can drive a large amount of atmospheric escape and also can heat up the upper atmosphere. We also discuss the detectability of the mass-loss driven by MHD waves.

Tuesday, 23 February 11:55-12:10

“Diversity of atmospheric circulations of tidally locked gas giant planets -- dependence on the intrinsic heat flux strength”

Shin-ichi Takehiro (Kyoto University)

Numerical experiments of atmospheric circulations of tidally locked gas giant planets (hot Jupiter) are performed using a three-dimensional primitive model which assumes hydrostatic balance in the radial direction. The incident radiation from the central star illuminates only the same hemisphere of the planet at all times. There is no heat flow through the bottom boundary. The parameters characterizing the planetary atmosphere in the model are based on those of the exoplanet HD209458b. Incident radiation strength is varied around the value of HD209458b. Dual band radiative transfer is adopted to express incident short wave radiation and outgoing long wave radiation. Time integrations are performed for various strength of incident radiation. When the incident radiation is as strong as that of the original HD209458b (10^6 W/m2), strong equatorial prograde jet emerges which penetrates to about 1bar level. The equatorial jet is weakened and becomes shallow as the incident radiation is decreased. Finally, when the incident radiation is as weak as 10^3 W/m2, equatorial zonal flows tend to retrograde and prograde high latitude jets become dominant. The newly found equatorial retrograde regime of tidally locked gas giants contrasts with that of equatorial prograde flow proposed so far.

Tuesday, 23 February　13:30-13:55

"Individual SEEDS Findings and SCExAO Commissioning as Precursors to the Next Generation Direct Imaging Explorations for Exoplanets"

Masayuki Kuzuhara (Tokyo Institute of Technology)

The SEEDS direct imaging campaign has provided the unique and interesting findings for exoplanetary systems, as well as their statistics. It has detected several exoplanets and brown dwarfs, and characterized those discoveries. In addition, the SEEDS has found stellar companions around stars with inner exoplanets or low-mass stellar companions previously identified via radial velocity technique, helping us reveal the origin and property of the systems. These findings are important clues that are linked to the science discoveries to be made with more advanced high-contrast direct imaging instruments such as SCExAO plus CHARIS. In this talk, we present several major discoveries and characterizations for exoplanetary systems observed in the SEEDS campaign. In addition, we highlight the SCExAO commissioning observations. We will end the talk after providing an overview of the intriguing topics that will be explored with advanced direct imaging instruments.

Tuesday, 23 February　13:55-14:20

"Discovering and Characterizing Exoplanets with CHARIS, a High-Contrast Spectrograph for the Subaru Telescope"

Timothy D. Brandt (Institute for Advanced Study)

I will present the scientific capabilities of CHARIS, a new high-contrast spectrograph for the Subaru Telescope. CHARIS is part of a new generation of experiments that combine upgraded adaptive optics with integral-field spectrographs (IFSs) to discover and characterize faint exoplanets close to their host stars. CHARIS will be the only instrument of its class in the northern hemisphere and will have the broadest spectral coverage of any high-contrast IFS; it will provide unique sensitivity to close-in exoplanets and present new data analysis challenges. CHARIS is now being built and will begin operations this summer. It will commence its first two year, 20 night survey in early 2017, taking spectra of giant exoplanets and searching about 100 stars for new companions.

Tuesday, 23 February　14:20-14:35

"Spectral Covariance in Integral-Field Spectrograph Data"

Johnny Greco (Prinston University)

The recovery of an exoplanet's atmospheric parameters from high-contrast integral-field spectrograph (IFS) observations requires accurate knowledge of the spectral errors and covariances. Unfortunately, the complicated image processing used in such observations generally produces spectral covariances that are poorly understood and often ignored. We will show how to measure the spectral errors and covariances and include them self-consistently in Bayesian parameter retrievals. By combining model exoplanet spectra with a realistic noise model generated from GPI early science data, we will show how ignoring spectral covariance in high-contrast IFS data can both bias inferred parameters and lead to unreliable confidence intervals on those parameters. The correct treatment of spectral covariance will be essential for CHARIS, a high-contrast IFS soon to be delivered to the Subaru Telescope.

Tuesday, 23 February 14:35-14:50

"Hot Jupiters from near-coplanar hierarchical triple systems"

Yasushi Suto (University of Tokyo)

We perform a series of systematic numerical simulations for near-coplanar hierarchical triple systems, with particular attention to formation of counter-orbiting Hot Jupiters. We incorporate quadrupole and octupole secular gravitational interaction between the two orbits, and also short-range forces (correction for general relativity, star and inner planetary tide and rotational distortion) simultaneously. We find that most of systems are tidally disrupted and that a small fraction of survived planets turn out to be prograde.

Tuesday, 23 February 15:10-15:35

"Substellar Spectroscopy"

Satoko Sorahana (University of Tokyo)

Substellar objects (brown dwarfs) play an important role as a bridge between stars and planets. No steady nuclear fusion takes place in their core, except for deuterium burning in the core of relatively massive and young brown dwarfs. Hence, they simply cool off after the initial heating by gravitational energy/deuterium burning, and thermonuclear processes do not dominate their evolution. By understanding brown dwarf atmospheres we will be able to investigate exoplanet atmospheres so that we can finally gain a comprehensive understanding of atmospheres from stars to planets. The physical and chemical structures of brown dwarf atmospheres are complicated and cannot be understood with a simple extension of stellar atmospheres. The atmospheres are dominated by molecules and dust. Many photometric/spectroscopic observations have been made in the near-infrared wavelength range for studying the brown dwarf photosphere. We will present the near-infrared spectra of brown dwarfs and introduce the results of our analysis with the observed spectra.

Tuesday, 23 February 15:35-16:00

"Microlensing exoplanet search toward the solar system analog"

Takahiro Sumi (Osaka University)

Although thousands of exoplanets have been found by various methods, not many solar system planets analogs have been detected. Some Jupiter and Saturn analogs and a few Earth-like plants have been found only very recently.Gravitational microlensing has an unique sensitivity to exoplanets outside the snow-line down to the Earth-mass, where the planetary formation is very active. The MOA-II and OGLE-IV carries out microlensing exoplanet search toward the Galactic Bulge in New Zealand and Chile, respectively.These surveys are detecting various kinds of systems, including the Jupiter-Saturn analog, the Neptune analog and the 2-Earth mass planet at 1AU around one of the binary stars. The Wide Field Infrared Survey Telescope (WFIRST) is the NASA's future large space mission,which is scheduled to be launched in 2024.The exoplanet microlensing program is one of the primary science of WFIRST. WFIRST will find about 3000 bound planets and 2000 unbound planets by the high precision continuous survey with 15 min. cadence, which is sensitive to all the solar system analogs except the mercury. WFIRST can complete the statistical census of planetary systems in the Galaxy, from the outer habitable zone to the outside of the snow-line and gravitationally unbound planets ? a discovery space inaccessible to other exoplanet detection techniques.

Tuesday, 23 February　16:00-16:15

"Discovery of A Break in the Exoplanet Mass Ratio Function beyond the Snow Line"

Daisuke Suzuki (University of Notre Dame/GSFC)

I present the discovery of a break in the exoplanet mass ratio function beyond the snow line from the statistical analysis of microlensing survey data. We find a break and possible peak of the mass ratio function at q ~ 1.6e-4. This corresponds to about Neptune mass for a typical 0.5 solar mass host star. Six years of MOA survey data are used to measure the planet frequency as a function of the planet/star mass ratio and separation. The MOA sample includes 1472 well characterized microlensing events, including 22 planetary events and 1 probable planetary event. We calculate the detection efficiency for each event and employ a Bayesian analysis to deal with ambiguities. The measured planet frequency with the MOA data is somewhat lower, but consistent with, previous microlensing results. The break of the mass ratio function is also confirmed with the full microlensing sample using 30 planets. This study implies that Neptunes and failed Jupiter cores are the most common type of planets beyond the snow line. We also compare our microlensing result to RV and Kepler results.

Tuesday, 23 February 16:15-16:30

“A pair of giant planets around the evolved intermediate-mass star HD 47366: multiple circular orbits or a mutually retrograde configuration”

Bun'ei Sato (Tokyo Institute of Technology)

We report the detection of a double planetary system around the evolved intermediate-mass star HD 47366 from precise radial-velocity measurements at OAO, Xinglong, and AAO. The star is a K1 giant with a mass of 1.8M_sun, a radius of 7.3R_sun, and solar metallicity. The planetary system is composed of two giant planets with minimum mass of 1.75Mjup and 1.86Mjup, orbital period of 363.3d and 684.7d,
and eccentricity of 0.089 and 0.278, respectively, which are derived by a double Keplerian orbital fit to the radial-velocity data. The system adds to the population of multi-giant-planet systems with relatively small orbital separations, which are preferentially found around evolved intermediate-mass stars. Dynamical stability analysis for the system revealed, however, that the best-fit orbits are unstable in the case of a prograde configuration. The system could be stable if the planets were in 2:1 MMR with a high eccentricity (~0.5--0.7) of the outer planet, but this is less likely considering the observed period ratio and eccentricity. A present possible scenario for the system is that both of the planets have nearly circular orbits, namely the eccentricity of the outer planet is less than ~0.15, which is just within 1.4sigma of the best-fit value, or the planets are in a mutually retrograde configuration with a mutual orbital inclination larger than 160 degree.

Tuesday, 23 February 16:30-16:45

"A New Search for Smaller Transiting Planets Unveiled by K2"

Teruyuki Hirano (Tokyo Institute of Technology)

In this poster, we present our effort, ESPRINT, to discover and characterize small transiting planets unveiled by the K2 mission. ESPRINT is an international collaboration, which aims to 1) detect planetary candidates around relatively bright stars, 2) conduct various follow-up observations to validate the candidates (e.g., reconnaissance spectroscopy, high-contrast imaging, transit photometry), and 3) characterize especially interesting targets in terms of planetary atmospheres and orbits. Exploiting various telescope and instrumental resources (e.g., Subaru, Magellan, HARPS, HARPS-N, OAO1.88m, etc), we have already validated several planets in each of the K2 campaign fields, including a disintegrating ultra-short period rocky planet, close-in super-Earth around a mid-M dwarf, and close-in super-Neptune planets in the sub-Saturn desert. We here report a summary of our campaigns in the last couple of years, focusing particularly on the discovery of small planets.

Tuesday, 23 February 16:45-17:00

“Subaru/IRD planet search for Earth-mass planets around Late-M dwarfs”

Masashi Omiya (NAOJ)

One of key ideas to search for Earth-like planets in the habitable zone is to select late-M dwarfs as sample of the planet search. For the planet search around late-M dwarfs, we have a plan to conduct a strategic precise Radial Velocity (RV) survey using a new near-infrared Doppler (IRD) instrument for the Subaru telescope. The survey aims to detect Earth-mass planets in the habitable zone and to uncover statistical properties, formation, and habitability of Earth-mass planets around low-mass stars. To achieve the goals, we produce characteristic strategies for the Doppler survey, performed detail simulations of the observation, and calculated expected numbers of detectable planets based on predicted planetary properties by theoretical simulations. In the survey, we will observe very stable late-M dwarfs and would like to make high frequency RV observations. For 5 year-long observations with the strategies, we expect to detect more than 10 Earth-like planets in the habitable zone and more than 50 planets with a planetary mass range of Earth mass - Jupiter mass. In this presentation, we discuss future plans and expected results of the Subaru/IRD planet search.

Wednesday, 24 February 9:00-9:15

"Search for planetary rings around long-period planets in Kepler photometric data"

Masataka Aizawa (University of Tokyo)

While outer planets in our Solar system often have rings, exoplanetary rings have not yet been detected, except for unusual circumplanetary rings of J1407b. A recent attempt to search for rings of short-period Kepler planets did not find any ring-like signature, which is consistent with the simple expectation that ring particles are unstable near stars. In contrast, we focus on those KOI (Kepler Object of Interest) systems that exhibit a possible transit signature of long-period planets. First, we make a list of long-period planets by naked eye selection. Then the transit-like features are checked directly using Target Pixel Files to remove the false positives. Finally, the remaining candidate is fitted to both a planet alone model and a planet + ring model. We will discuss our tentative candidate in comparison with the possible effects including an eclipse of a binary system with large star spots, plages, faculae and/or a gravity darkening.

Wednesday, 24 February 9:15-9:30

"What HST Deep Coronagraphic Imaging Tells Us About Debris Disks"

Carol A. Grady (Eureka Scientific and GSFC)

We have been carrying out a program of deep coronagraphic imaging of previously imaged debris disks with HST/STIS (broadband NUV-optical) using a multi-roll observing strategy combined with acquisition of contemporary, color-match point spread function template observations. The resultant datasets typically have at least 9.5 ks of on-target exposure time, and through mosaicing of images have outer working angles of at least 10", and inner working angles of 0.2-0.3". We present data for 3 of our program stars where we have discovered previously unknown distant structure (HR 4796), an inner disk component (HD 141569) and moving structures which may indicate how and on what timescale debris disks disperse around M stars (AU Mic). In all cases, if we were limited to the comparatively narrow fields of view of instruments like GPI, planned for WFIRST/AFTA's Coronagraphic Instrument, or for TMT, our understanding of these systems would be incomplete.

Schedule Request: My first preference would be a talk. Scope of the talk can be tailored to what other presentations are made. If Thayne Currie submits a talk abstract on HD 141569, placement of this talk immediately ahead of it would be best.

Wednesday, 24 February 9:30-9:45

“Mid-IR studies of disks around Herbig Ae/Be stars”

Mitsuhiko Honda (Kurume University)

We have been conducting mid-IR imaging studies of disks around Herbig Ae/Be stars. Our imaging survey indicated that the group I sources tend to show the extended mid-IR disk emission, and it would imply the 'transitional disk' nature of group I disk (Honda et al. 2010, 2012, 2015). Recently, we made mid-IR multi-color imaging observations of Oph IRS 48 disk sources which was not included in our previous imaging survey. We will show the obtained images and discuss the interpretations of its disk structure.

Wednesday, 24 February 9:45-10:00

"Directly observing continuum emission in self-gravitating spiral waves in protostellar discs"

Cassandra Hall (University of Edinburgh)

Recently, several transition discs have been observed which have revealed extended non-axisymmetric structure extended out to large radii. We use a simple, self-consistent analytic geometry coupled with Monte Carlo radiative transfer to generate synthesised ALMA images with parameters matching those of recently observed systems to see if their extended features can be explained by disc self-gravity. We additionally draw more general conclusions about visible spiral structure for quasi-steady, self-gravitating discs and caution against diagnosing spiral features as being due to self-gravity unless the disc exists in a very narrow region of parameter space where the amplitudes are large enough to cause detectable features but not so large as to cause the disc to fragment.

Wednesday, 24 February　10:00-10:15

"Estimate of a planet mass in protoplanetary disk from the gap shape"

Kazuhiro Kanagawa (University of Szczecin)

In a protoplanetary disk, a large planet is able to create the so-called disk gap, which is a low gas density region along the planet's orbit, due to the gravitational interaction between the disc and the planet. The gap formation induced by the giant planet is a possible mechanism to explain the formation of the so-called pre--transition disks with a ring gap structure. If the gap is created by the planet, the gap shape, i.e., the depth and width, would represent the mass and location of the planet. At the present stage, many pre--transition disks have been observed by e.g., ALMA and Subaru telescopes. It is important for us to examine what properties of the planet are constrained from the observed gap if the planet is in the gap. We derived the relation between the depth of the observed gap and the planet mass in the gap based on the analytical model (Kanagawa et al. 2015 MNRAS). We also applied this relation to the image of the HL Tau disk given by a part of the 2014 ALMA long baseline camphene and estimated the planet masses (Kanagawa et al 2015 ApJL). We also performed the numerical hydrodynamic simulation with the FARGO and found that the gap width becomes wider with a square root of the planet mass. Using this empirical relation for the gap width, we can also constrain the planet mass from the gap width (Kanagawa et al. submitted). Using this relationship, we also estimated the planet masses within the gaps in the HL Tau disk. These relationships between the gap depth, width and the planet mass are very helpful to estimate the planet mass from the direct imaging of gaps in protoplanetary disks. I'll show about the relation between the gap depth, width and the planet mass, and talk about the method for estimating the planet mass from the observed image of gaps in a disk, such as the HL Tau disk.

Wednesday, 24 February 10:15-10:30

"Metallicity dependence of protoplanetary disk lifetime"

Chikako Yasui (University of Tokyo)

Because planets are formed in protoplanetary disks, the lifetime is thought to be one of the most fundamental parameters directly connected to the planet formation probability. From the previous studies of young clusters in the solar neighborhood with the distance of <~2kpc, the lifetime has been estimated to be ~5-10Myr. However, the Galaxy has a wide variety of metallicity. In the Galaxy as well as many spiral galaxies, the metallicity gradient is well known, lower metallicity with larger Galactocentric distance (Rg). Considering that the Earth is also made of heavy elements, metallicity is one of the most important factor for its formation.We are studying young clusters in the Galaxy-wide regions by NIR observation. From our previous studies in the outer Galaxy (Rg <~ 15kpc), where the metallicity is as low as ~-1dex, shorter disk lifetime (~1Myr) was suggests (Yasui+2009), and we proposed the metallicity dependence of disk lifetime for the first time (Yasui+2010). For the next step, we are studying young clusters in the inner Galaxy (Rg of <~4kpc). Previously, most star clusters known in such regions were starburst clusters with the cluster mass (Mcl) of ~10^4M_sun. For starburst clusters, the shorter disk lifetime is suggested. Recently, however, IR surveys such as Spitzer GLIMPSE led to discover clusters with Mcl of 10^3M_sun, which is more common cluster mass in the Galaxy. Also, because our Solar System is thought to be formed in such typical clusters (Adams+2010 ARAA), we may obtain any clues to its formation. Therefore, we are focusing on young clusters (<~20Myr) with Mcl of 10^3M_sun for investigating genuine metallicity dependence. As a result of NIR imaging and spectroscopy, the disk fraction for clusters in the inner Galaxy is estimated to be higher than those for clusters with the same age in the solar metallicity, suggesting that the disk lifetime in such regions is longer (<~15Myr).

Wednesday, 24 February 10:45-11:00

“Exoplanetary System Dynamics: Planetary Multiplicity and Mass Effects”

Mari Isoe (NAOJ)

Recently numerous systems consisting of multiple exoplanets have been discovered. Using a dataset of 375 systems (500 planets) discovered by the radial velocity method and 365 systems (899 planets) containing planet candidates found by the Kepler Mission, we investigate the dependence of the dynamical structure of planetary systems on their multiplicity and the masses of the member planets. We classify the planetary system by three parameters: planetary multiplicity, planetary mass, and the evolutionary stage of the central star. We find that in all categories the system angular momentum deficit decreases with increasing multiplicity. This suggests that in order for multiple systems to be stable, each planet's orbit must be relatively circular. In addition, we find that the distribution of orbital eccentricities of the massive planets and low-mass planets differs. In particular, only high-mass planets have eccentricities larger than 0.4. In the low-mass systems around main sequence stars, we find that the orbital separation decreases with increasing multiplicity. In addition, the orbital separation around main-sequence stars is wider than that around giants. Furthermore, the minimum orbital separation is about 6.4 for non-resonant pairs. This paper presents the statistical properties of the dynamical structure of multiple planetary systems and discusses their formation.

Wednesday, 24 February 10:00-11:15

"Orbital Structure of Planetary Systems Formed by Giant Impacts"

Eiichiro Kokubo (NAOJ)

We investigate the in-situ formation of close-in terrestrial planets including super-Earths by giant impacts using N-body simulations. The goal of this study is to obtain the basic scaling laws of close-in terrestrial planet formation as a function of properties of protoplanet systems. We systematically change the system parameters of initial protoplanet systems and investigate their effects on final planetary systems. We find that in general non-resonant dynamically cold compact systems are formed. The orbits of planets are less eccentric and inclined and the orbital separations of adjacent planets are smaller, compared with those formed in the outer disk. These properties are natural outcomes of giant impacts in the inner disk. In the inner disk the ratio of the physical radius to the Hill radius is large, in other words, gravitational scattering is relatively less effective compared with that in the outer disk. Thus protoplanets are less mobile and accretion proceeds relatively locally, which leads to formation of dynamically cold compact systems. On average the system angular momentum deficit increases with the total system mass, while the mean orbital separation of adjacent planets decreases.

Wednesday, 24 February　11:15-11:30

"Non-ideal MHD simulations in Protoplanetary Disks with Time-dependent Ionization Calculation"

Yuri I. Fujii (Niels Bohr International Academy)

Ionization degree of a protoplanetary disk is important for both chemical and MHD evolution of the disk. With abundant small dust grains, in general, the timescale of chemical reactions governing MHD effects is much smaller than the dynamical timescale and thus the equilibrium ionization degree can be adopted for MHD simulations. However, the chemical timescale could be longer than the dynamical timescale in the surface layer of a disk. Therefore, it is important to consider the non-equilibrium ionization degree for realistic modeling of protoplanetary disks. We implemented our calculation scheme for time-dependent ionization degree into the Athena MHD code and performed three dimensional non-ideal MHD simulations in a shearing box. Without photoionization, we found that the magnetically-driven disk wind transfers the poorly ionized gas inside of the disk and lowers the ionization degree of the surface layer. However, inclusion of photoionization rather increases the ionization degree inside of the disk. This effect may decrease the size of the dead zone and hence changes the disk dynamics.

Wednesday, 24 February 11:30-11:45

"How to measure C/O ratio distributions in protoplanetary disks using infrared spectroscopic observations"

Shota Notsu (Kyoto University)

We have calculated the chemical structures of protoplanetary disks and radiative transfer of H2O lines, and have proposed the method of detecting H2O snowline in disks using spectroscopic observations (e.g., Notsu et al. in prep.). It is thought that difference in snowlines of oxygen- and carbon-bearing molecules, such as H2O, CO, HCN, CO2, will result in systematic variations in the C/O ratio both in the gas and ice. Recent studies (e.g., Oberg et al. 2011) show that we can confine planet formation regions through comparing the C/O ratio of disks and planetary atmospheres. In this study, we developed our calculations of disk chemical structures and investigate the abundance distributions of simple molecules. We then calculated radiative transfer of various lines of simple molecules. We found that through investigating the profiles of molecular lines with various Einstein A coefficients and excitation energies, we can detect C/O ratio distributions in disks. For example, HCN lines in 14μm band reflect gas distributions of inner disks. In contrast, HCN lines in 3μm bands reflect those of outer disks. We also discuss the possibility of detecting such molecular lines with future near- and mid-infrared spectroscopic observations.

Abstract

(Poster Presentations)

[P01]

"Theoretical estimates of intensity of hydrogen line emission from accreting gas giants: Interpretation of the observed Hα intensity from LkCa15b"

Yuhiko Aoyama (The University of Tokyo)

Young stars are known to have circumstellar gaseous disks. Planets have been thought to form there. Recently, the Hα emission from the accreting proto-gas-giant LkCa15b was observed in the disk around the young star LkCa15 (Sallum et al. 2015). It is, however, uncertain how a forming proto-gas-giant creates H line emission and how much information about the properties of the protoplanet and its surroundings we can derive from the observed emission intensity. In this study, we quantify the radiative emission from the hot gas heated at the shock wave front at which the vertically-falling gas clashes with the circumplanetary disk (i.e., a sub-nebula). To do so, we perform 1-D post-shock hydrodynamic simulations with chemical reactions and electronic transitions. We then calculate the intensity of hydrogen line emission during that process. We demonstrate that the Hα line emission from the circumplanetary-disk surface is significantly strong in some cases. We also find that the Hα intensity is proportional to the number density of the surrounding disk gas and the square of the protoplanet's mass. Comparing our theoretical estimate with the observed Hα intensity from LkCa15b, we constrain the properties of that protoplanet.

[P02]

"A New Scenario for Compound Chondrule Formation: Crystallization from Supercooled Droplets"

Sota Arakawa (Tokyo Institute of Technology)

Compound chondrules consist of two or more chondrules fused together. We focus on three features of compound chondrules; (1) most of compound chondrules are non-porphyritic chondrules that are minor components of chondrites, (2) larger ones keep spherical shapes, and smaller ones are deformed, (3) about 20% of non-porphyritic chondrules are compounds. In previous studies, these three features are remained to reproduce. We propose a new scenario for compound chondrule formation; collisions of supercooled droplets form compound chondrules. This scenario is based on crystallographic facts that completely molten dust droplets are not crystallized at their liquidus or solidus but turn into supercooled droplets, and these droplets become non-porphyritic chondrules by collisions. Larger ones are likely to be collided more than smaller ones, then we can obtain the second feature that larger ones of compound chondrules keep round shapes while smaller ones are deformed. We also calculate the duration of compound chondrule formation for reproducing the fraction and we find that the fraction of compound chondrules can be explained if the duration of supercooling is of the order of 104 seconds. These results are consistent with planetesimal bow shock model for chondrule formation.

[P03]

“Features of the Circumstellar Medium: An Investigation of the 8.9 micron Feature Towards IRAS18434-242 and other Regions”

Aaron C. Bell (The University of Tokyo)

In recent years, we have learned much about the dust grains of the universe, but even so, the web of dust-related mysteries has only expanded. With each new species of ISM material we detect, and each emission or absorption feature we observe, many more questions arise about its exact place in the ISM puzzle. We will explore a particular mystery, of the yet unidentified 8.9 um feature, first reported by Peeters et al. (2005). Although this feature falls in the wavelength domain of the "PAH emission features" (strongly linked to some aromatic material), it does not appear to be explained by PAH emission. Various non-PAH carbonaceous materials have been taken as candidates, as well as silica. However none of the proposed carriers have been solidly linked to the 8.9 um feature. We will describe the properties of this feature, as it is exhibited by a particular source, IRAS 18434-0242. We utilize ground-based spectroscopic data obtained by via the COMICS instrument, of the Subaru Telescope. COMICS is optimized for the N-band, where the 8.9 micron emission falls, and allows for a superb level of spectral feature mapping. Need for enhanced laboratory data for potential carriers of interstellar emission features is underscored.

[P04]

"The first trial of transit observations with a very low resolution slit spectroscopy with LISS"

Mamoru Doi (The University of Tokyo)

We carried out a transit observation of XO-3b with a slit spectroscopy mode using LISS (Line Imager and Slit Spectrograph) attached to the Cassegrain focus of the Nayuta 2-m telescope on Dec.13, 2015. A very low spectral resolution mode (R~80) was adopted with a slit width of 10 arcsec. The wavelength range was ~600nm < lambda < ~1um. The spectro-photometry using a reference star TYC3727-399-1 showed about 1% transit depth, although the error was very large due to the poor weather. The observation was unfortunately terminated during the transit due to cloudy weather. We briefly summarize observational results together with parameters.

[P05]

“Search for Exoplanets around Metal-Rich FGK Stars”

Hiroki Harakawa (NAOJ)

A correlation between stellar metallicities and planet properties is one of the important subjects. Especially, the distribution of giant planets along orbital period is a vital information in understanding environment of planet birthplace and subsequent evolution of planetary orbits such as migration and scattering. However, it is still unclear how the planet properties (e.g. mass-orbit distribution) correlate with stellar metallicity, while previous studies reported that the planet frequency arises as stellar metallicity increases. Recent researches have suggested that there may exist a positive correlation between host stellar metallicities and lifetimes of circumstellar disks which will strongly affect a final distribution of formed planets. In order to clarify the correlation, we have conducted a radial velocity search for exoplanets around metal-rich FGK dwarfs since 2009. By optimizing our radial-velocity analysis method to long-term observations, we have succeeded in detecting 6 new planets around 4 metal-rich stars, HD 1605, HD 1666, HD 38801, and HD 67087. In this poster, we will present the recent results and discuss statistical remarks of the current status.

[P06]

"Planet Engulfment by Intermediate-mass Red Giants Revisited"

Norifumi Hasegawa (The University of Tokyo)

No exoplanet has been detected inside about 0.5 AU around evolved intermediate-mass stars. One possibility is that short-period planets were engulfed by their inflated host star during the red-giant-branch (RGB) phase. By simulating tidal decay of planetary orbit around evolving stars, Kunitomo et al. (2011) demonstrated that the critical semimajor axis, beyond which planets survive the RGB phase of their host star, is well below the observed inner limit of exoplanets orbiting red giants of about 2 to 3 solar masses. Here we re-examine the possibility of planet engulfment with more detailed prescription of stellar tide relative to that adopted by Kunitomo et al. (2011), using an updated version of the stellar evolution code MESA. Then, we compare the theoretical critical semimajor axis with updated data of semimajor axes of exoplanets detected so far. Consequently we reconfirmed that the critical semimajor axis is well below the inner limit of exoplanets around red giants of 2-3 solar masses. This suggests that some planet formation process is responsible for the paucity of short-period planets around intermediate stars.

[P07]

"Temporary Capture of Asteroids by a Planet"

Arika Higuchi (Tokyo Institute of Technology)

We have investigated the dependence of the prograde/retrograde temporary capture of asteroids by a planet on their original heliocentric semimajor axes through analytical arguments and numerical orbital integrations in order to discuss the origins of irregular satellites of giant planets. We found that capture is mostly retrograde for the asteroids near the planetary orbit and is prograde for those from further orbits. An analytical investigation reveals the intrinsic dynamics of these dependences and gives boundary semimajor axes for the change in prograde/retrograde capture. The numerical calculations support the idea of deriving the analytical formulae and confirm their dependence. Our numerical results show that the capture probability is much higher for bodies from the inner region than for outer ones. These results imply that retrograde irregular satellites of Jupiter are most likely to be captured bodies from the nearby orbits of Jupiter that may have the same origin as Trojan asteroids, while prograde irregular satellites originate from far inner regions such as the main-belt asteroid region.

[P08]

"Dust coagulation in viscous accretion disk"

Yusuke Imaeda (Kougakuin University)

We present the mass evolution of dust particles in the viscous accretion disk, taking into account the radial drift of the dust particles. The evolution of porous internal density is considered in accordance with Okuzumi+2012 and Kataoka+2013. The mass evolution is calculated by the coagulation equation with Lagrange method instead of Euler method. Mass distribution is not considered for simplicity, thus one representative particle mass is assumed as a function of the initial dust particle location. Whether the dust particle becomes sufficiently large to decouple from the gas disk and make the dense dust disk is discussed, since such dense dust disk is a parent of the planetesimals. The importance of the duration of partial decoupling time is also discussed.

[P09]

“Velocity difference due to the disk wind in TW Hya by ALMA observations”

Daiki Ishimoto (Kyoto University)

It has not been well known about how to dissipate the gas of protoplanetary disks.Several dissipation mechanism have been proposed so far (e.g., viscous accretion, photoevaporation), and here we focus on the disk wind which is driven by magnetic field (e.g., Suzuki & Inutsuka 2009).To observe the disk wind, molecular line emissions will be useful because each molecular line can trace specific height from the midplane (e.g., CO will trace near the midplane, and CN will trace the disk surface). Since the disk wind should have non-uniform velocity structure in the vertical direction, we can detect the velocity difference by using appropriate lines.In this poster, we will compare the latest results of ALMA Cycle2 observations and simulations, and discuss the disk velocity structure and its origin.As a result of our ALMA observations, the lines of 13CO and CN have different velocity profiles, which may be due to the disk wind.

[P10]

"Fiber Mode Scrambler Test for the Subaru Infra-Red Doppler Instrument (IRD)"

Masato Ishizuka (The University of Tokyo)

We report the results of fiber mode scrambler tests for the high-precision radial-velocity (RV) instrument for the Subaru telescope. The instrument, IRD, is a fiber-fed, near-infrared spectrometer with an Echelle grating and its main purpose is to search habitable exoplanets around late-M dwarf stars. Expected accuracy of the radial velocity measurement is ~1m/s. It is mandatory to reduce the modal noise in order to achieve ~1m/s accuracy. The modal noise is an intensity instability of light which exits from a multimode fiber and is caused by interference of many propagating modes of light. Multimode fiber has many propagating modes of light and interference of these modes makes speckle pattern. This pattern is very unstable and changes temporally. This speckle pattern change is called the modal noise and produces fake signals of RV change and reduces the accuracy of RV measurements. We have systematically tested many kinds of mode scramblers to reduce the modal noise by averaging energy distribution of propagation modes at near-infrared wavelengths. We report the effect of static and dynamic scramblers with narrow and broad bandwidth light source and deformable mirror to simulate seeing condition.

[P11]

"Surface gravity and topography on Itokawa"

Masanori Kanamaru (Osaka University)

Asteroids 25143 Itokawa was visited by the spacecraft Hayabusa and its detailed surface was unveiled. Itokawa surface is divided into rough highlands and smooth low lands.

Itokawa has very steep areas especially on the neck region. "Slope" is defined as the separation angle of a gravity acceleration vector and a normal vector of a surface facet. When we calculate the surface gravity and slope of Itokawa as a polyhedron with homogeneous density and rotation period of 12.1324 hour, around 45 degrees slopes are concentrated on the neck region. Because steep slope like this might be unstable, we have to re-calculate the gravity assuming different density map (heterogeneity of internal mass structure) or rotation period.

Change of rotation period is known as YORP effect by solar radiation. Faster rotation can change surface gravity and reduce slope. One of the possible scenario of Itokawa formation is that Itokawa rotated much faster before and surface topography was formed then. After that, the spin rate may have been decelerated by YORP effect.

[P12]

"Development of a coupled atmosphere-ocean-sea ice model to explore aquaplanet climates"

Yuta Kawai (Kobe University)

In order to explore the diversity of surface environments on exoplanets, it is important to understand the role of atmospheric and oceanic heat transports on the climates. Our research group has been conducting numerical study of aquaplanet climates, without considering ocean motion so far (e.g., Ishiwatari et al., 2007). But recent studies (e.g., Rose 2015) suggested the importance of oceanic heat transport for aquaplanet climates. To investigate the climates considering both atmospheric and oceanic circulations, we are now developing a coupled atmosphere-ocean-sea ice model. The ocean model calculates the large-scale distribution of current velocity, temperature and salinity explicitly, while the effects of some sub-grid scale processes, such as small-scale eddies and convection, are parameterized. The sea ice model is a one-dimensional thermodynamic model, which calculates the thickness and temperature of sea ice. These models are coupled with atmospheric model, DCPAM (Takahashi et al, in this conference). Presently, to check the behavior of developing coupled model, we are performing aquaplanet experiments following the set-up of Marshall et al. (2007), in which planetary parameters are the same as present Earth's ones. In this presentation, we will overview our model, and describe the preliminary results of the aquaplanet experiments.

[P13]

"Transmission spectrum models of exoplanet atmospheres with haze: Effect of growth and settling of haze particles"

Yui Kawashima (The University of Tokyo)

Recently, transmission spectra of several transiting exoplanets have been obtained. Transmission spectrum provides information of absorption and scattering by molecules and small particles such as haze and clouds in the planetary atmosphere. Thus, comparison between the observational and theoretical transmission spectra can constrain the composition of the planetary atmosphere. While there are a few studies addressing theoretical modeling of transmission spectra of atmospheres, considering the effect of haze in the atmosphere, the physically-based values of the haze layer's parameters (namely, the size and number density of haze particles and the altitude and thickness of the haze layer) were not discussed sufficiently in those studies. In this study, we have developed a theoretical model for the growth and settling of haze particles in the atmosphere to derive the physically-based distribution and typical size of haze particles. Then, we have modeled theoretical transmission spectra of the atmosphere, taking into account the vertical distribution of molecular abundances and haze particles, in addition to absorption and scattering of the incident radiation from the host star by molecules and haze particles in the planetary atmosphere. Furthermore, applying the calculated spectrum models to a few exoplanets, we discuss the property of their atmospheres.

[P14]

“Stacking Spectra in Protoplanetary Disks: Detecting Intensity Profiles from Hidden Molecular Lines in HD 163296”

Patrick Koch (ASIAA)

We introduce a new stacking method in Keplerian disks that (1) enhances signal-to-noise ratios (S/N) of detected molecular lines and (2) that makes visible otherwise undetectable weak lines. Our technique takes advantage of the Keplerian rotational velocity pattern. We apply our method to ALMA archival data of the protoplanetary disk around HD 163296. The previously undetectable spectra of the H2CO lines are now materialized at more than 3σ. These dramatically enhanced S/N ratios allow us to measure radial and azimuthal intensity distributions in all lines with high significance. The principle of our method can not only be applied to Keplerian disks but also to any systems with ordered kinematic patterns.

[P15]

"Spitzer Confirmation and Characterization of K2 Exoplanets"

John H. Livingston (The University of Tokyo)

K2 is in the midst of identifying transiting exoplanet candidates around stars in the ecliptic plane. We are conducting Spitzer follow up observations for the purpose of confirming and characterizing these candidates. Spitzer's high cadence, high precision photometric capability in the near infrared make it uniquely suited to this task. The higher cadence allows for better measurement of transit timing and orbital parameters. The addition of even a single additional transit measurement can drastically reduce uncertainty in the period. This is crucial for the future study of exoplanet atmospheres by observatories such as JWST, and Spitzer's high precision photometry enables this for transits that cannot be measured from the ground. For multi-planet systems with near-resonant periods, the deviation from Keplerian orbits can be large, and Spitzer can measure transit timing variations (TTVs) which cannot be detected in the K2 data alone. The achromaticity of measured transit depth between the Kepler and Spitzer bandpasses helps to confirm the planetary nature of the transit signals in the K2 data. This study is expected to increase the total number of known exoplanets orbiting M dwarf host stars by as much as 50%, as well as constrain their orbital and physical characteristics.

[P16]

"In Situ Accretion of Close-in Super-Earths: Effects of Initial Eccentricities and Inclinations of Protoplanets"

Yuji Matsumoto (NAOJ)

Recent observations are revealing the eccentricity and inclination distributions of exoplanets. Most of the observed super-Earths have small eccentricities ~ 0.01 - 0.1 and small inclinations ~ 0.03 rad (e.g., Fabrycky et al., 2014). The eccentricity and inclination of a close-in super-Earth are determined by gravitational scattering and collisions among protoplanets. We investigate the effects of the initial eccentricities and inclinations of protoplanets on the final eccentricities and inclinations of planets. Scattering and collisions are the relaxation process of the initial eccentricity and inclination.

We find that the final eccentricity and inclination do not depend on the initial eccentricity, but depend on the initial inclination. As the initial inclination increases, the final inclination becomes larger, and this causes the final eccentricity larger. Although the final inclination of a planet decreases with increasing the initial eccentricity when the number of the initial protoplanets is small, this dependence disappears when the protoplanets experience more collisions. On the other hand, the initial inclination is not relaxed in the large number cases.

This is because when the initial inclination is small, scattering barely increases the inclination and collisional damping is relatively effective.

[P17]

"The Exoplanet Simple Orbit Fitting Toolbox (ExoSOFT), and its solution for the V450~And System"

Kyle Mede (The University of Tokyo)

I will present the new, open source Bayesian orbit fitting tool ExoSOFT. This freely compiled package can fit any combination of astrometric and radial velocity data, including the appropriate prior distributions for all orbital elements and masses. It has a simple and modular design with a full suite of post-processing and plotting functions. I will demonstrate ExoSOFT on new direct imaging data of a low-mass companion to the young star V450 And; the companion was previously identified with the radial velocity method. With a joint analysis of the direct imaging and radial velocity data sets, we have obtained the first direct constraints on the masses of the two bodies.

[P18]

"Multi-component analysis of secular gravitational instability with stochastic turbulence model"

Shugo Michikoshi (NAOJ)

The secular gravitational instability (SGI) is one of the mechanisms that form the high-density dust region in protoplanetary disks. In the high density dust region, the planetesimal formation would be enhanced. In the previous works of multi-component analyses of SGI, the basic equation for dust was introduced intuitively, which was verified only for single-component analysis with a strong coupling limit. In this work, we consider the stochastic turbulence model and derive the basic equation for multi-component analyses in a more rigorous manner as in Michikoshi et al. (2012). Using this new formulation, we reanalyze multi-component SGI.

[P19]

"Orbital characterization of a young companion to FP Cnc and constraints on properties of the system."

Toshiyuki Mizuki (Tohoku University)

Several substellar companions around young stars have been resolved with high-resolution imaging through large survey programs such as SEEDS, which enables to not only derive orbital parameters but also determine dynamical mass of each component by combining radial velocity measurements. The dynamical mass is potentially useful to constrain the age of young systems and cooling evolutionary models for young low-mass objects. In this presentation, we report the orbital characterization of a young system, FP Cnc of which companion is at 6-7AU in projected separation. The companion was firstly resolved in 2001 with Keck/NIRC2, and has been observed with HiCIAO camera and AO188 adaptive optics system as a part of SEEDS survey. We combined those multi-epoch astrometry and radial velocities obtained by Subaru/HDS and OHP/Sophie, and constrain the age of the system by using the dynamical mass, photometric properties, and cooling evolutionary models.

[P20]

“Suppression of Magnetic Turbulence by Electron Heating in Protoplanetary Disks”

Shoji Mori (Tokyo Institute of Technology)

Turbulence driven by the magnetorotational instability hinders planet formation by preventing dust settling inducing collisional disruption of solid particles. It has recently been shown that the electric field induced by the magnetic turbulence can heat up electrons (electron heating) and thereby affect the ionization balance. Our previous work showed that electron heating widely occurs in protoplanetary disks and causes an enhancement of the ohmic resistivity, which in turn might quench the magnetic turbulence. To examine this possibility, we perform magnetohydrodynamical simulations in which the effect of electron heating on the ohmic resistivity is mimicked by a simple analytic model. Our simulations confirm that electron heating suppresses magnetic turbulence. When the effect of electron heating is significant, turbulence completely dies away, leaving a steady laminar flow where the accretion stress is dominated by ordered magnetic fields. Based on the simulation results and the scaling relation between the Maxwell stress and current density, we obtain an analytic formula that successfully predicts the accretion stress in the presence of electron heating. We apply the analytic formula to dust growth in zones where electron heating occurs.

[P21]

“Significant Variations of Gas-to-Dust Ratio of the Disk around HD 142527”

Takayuki Muto (Kogakuin University)

We present a model for gas and dust structures of the disk around HD 142527 based on the ALMA Cycle 0 observations of dust continuum, 13CO(3-2), and C18O(3-2). The dust and gas emissions show very different features. The dust emission shows strong azimuthal asymmetry, with the surface brightness contrast of ~30 between the northern and southern part of the disk, while gas emission is more symmetric compared to dust. Also, the dust emission comes from narrow radial range, while gas emission is more radially extended. These indicate that gas and dust are distributed very differently in the disk. From the model calculations, it is indicated that the dust particles are concentrated in a narrow ring with the width of ~50 AU or less, while gas emission extends at least from ~100 AU from the central star to ~250 AU. Dust surface density may have the contrast of ~70 in the northern and the southern regions, and the gas-to-dust ratio may be of the order of the unity in the region where dust is most concentrated in the North Model. The overall gas-to-dust ration is inferred to be ~10-30, indicating that the gas depletion has already been started.

[P22]

“Heat transport associated with gravitational sedimentation of condensed particles in cloud layers where convection is suppressed”

Kensuke Nakajima (Kyushu University)

In Earth’s atmosphere, condensation of H2O enhances convection by the release of latent heat. However, in planetary atmospheres in general, there are cases where convection is suppressed in the condensing layer. For example, in the case when major constituent condenses, buoyancy can hardly be allowed because density of condensing parcel is constrained by the saturation relation between pressure and temperature (Colaprete et al 2003; Yamashita et al, in revision). We propose that, even where convection is suppressed in association with condensation, gravitational sedimentation of condensed phase can contribute to vertical heat transport; the combination of the downward gravitational sedimentation of lower entropy condensed phase and the mean upwelling of higher entropy gas phase can result in the net upward transport of entropy without convective motion in gas phase. In this presentation, we demonstrate the plausibility of the above mechanism in numerical experiments. Possible application of the same mechanism to H2O, NH3, or NH4 condensation layer in hydrogen rich atmospheres of gas giant planets, where convection tends to be suppressed due to heavier molecular weights of the condensible components (Guillot, 1995) will also be discussed.

[P23]

“Homogeneization of Isotopic Ratio in Early Solar Nebula”

Taishi Nakamoto (Tokyo Institute of Technology)

It is known that the isotopic compositions, except for some highly volatile elements, of solar system materials show very little variations. This implies that the isotopic ratio of solar system material was homogenized at an early stage in a course of the solar system formation. Here, we explore a possibility that all the solid material in the solar system was once evaporated and mixed well to become isotopically homogeneous in the solar nebula. To examine that, we model the gravitational collapse of a molecular cloud core and the disk accretion. If the temperature is high enough, dust particles are evaporated completely. When such a high temperature gas cools, solid dust particles, which have a common isotopic ratio, are assumed to condense. ccording to our numerical simulations, we have found that (1) almost all the materials in the disk may be once evaporated and isotopically homogenized if the rotation angular velocity of the molecular cloud core is low enough, (2) the total mass of the disk is of the order of one hundredth of the solar mass. These results seem to be consistent with observed features of our solar system.

[P24]

"A New Cloud Model for Exoplanets: Formulation and Test Calculations"

Kazumasa Ohno (Tokyo Institute of Technology)

Some exoplanets discovered recently have a flat transmission spectrum that might suggest the presence of an optically thick cloud in their atmospheres. Previous cloud models involve some free parameters whose relationship with the physics behind cloud formation is unclear. We have developed a new cloud model that is simple but based on cloud microphysics. Our model calculates the vertical structure of clouds as a function of the updraft velocity and the number density of cloud condensation nuclei (CCN). We present test calculations for cloud formation on the Earth and Jupiter. In the case of Earth, we reproduce the observed relation between the cloud optical thickness and atmospheric parameters. In the case of Jupiter, our model simultaneously reproduces the observed particle effective radius, cloud optical thickness, and cloud geometric thickness if updraft velocity and number density of CCN are assumed to be 2.0 m/s and 10^4 --10^5 m^{-3}, respectively.

[P25]

“Terrestrial Planet Formation around Low-Mass Stars: Effect of the Mass of Central Stars”

Shoichi Oshino (NAOJ)

Recently there are several survey projects for planets around M-stars such as the InfraRed Doppler (IRD) survey of the Subaru telescope. The habitable zone of M-stars is closer to the stars than that of G-stars. Therefore, the possibility of finding habitable planets around M-stars is expected to be higher. Understanding the formation of such planets is getting more and more important. Here we study the formation of close-in terrestrial planets by giant impacts of protoplanets around low-mass stars by using N-body simulations. An important parameter that controls formation processes is the ratio between the physical radius of a planet and its Hill radius, which decreases with the stellar mass. We systematically change the mass of the central stars and the surface density of protoplanetary disks to investigate these effects on terrestrial planet formation. We find that the mass of the maximum planet decreases with the stellar mass, while the number of planets in the system increases. We also find that the orbital separation of adjacent planets normalized by their Hill radius increases with the stellar mass, while the mass weighted eccentricity and inclination of the system decrease.

[P26]

"The Propagation of Cosmic Ray Protons in Protoplanetary Disks"

Soonyoung Roh (Ibaraki University)

For the development of magneto rotational instability (MRI) which drives mass accretion in protoplanetary disks, a sufficient ionization degree is needed. Cosmic rays (CRs) are believed to be one of the dominant ionization sources for protoplanetary disk gas. In previous studies, all particle trajectories are assumed to be straight line when they estimate the ionization degree. However, in reality particles may sweep up larger column density to reach the same position by the interaction with magnetic field. We investigate the propagation of CR protons in a protoplanetary disk by solving transport equations. We will discuss the change in intensity and column density of CRs due to magnetized protoplanetary disk.

[P27]

"Infrared Properties of Nitrogen-bearing Carbonaceous Composite"

Itsuki Sakon (The University of Tokyo)

The unidentified infrared (UIR) bands are distinct emission features that have been observed in the near to mid-infrared spectra of various astrophysical sources. The remarkably ubiquitous appearance characterized by major features at 3.3, 6.2, 7.7, 8.6 and 11.2 μm even among the ISM spectra of different galaxies suggests that the carriers of the UIR bands are ubiquitous members and should be playing a crucial role in the chemical evolution of the ISM. Many studies have tried to identify the carriers of the UIR bands both based on theoretical quantum chemical calculations and laboratory experiments. Polycyclic aromatic hydrocarbons (PAHs) hypothesis (Leger & Puget 1984) has been widely used to interpret the properties of UIR bands. Recently, Kwok et al. (2011) have proposed the mixed aromatic and aliphatic organic compounds as even more realistic carriers of the UIR bands seen in the infrared spectrum of circumstellar medium of evolved stars. Further studies based on observations, theoretical calculations and laboratory experiments are needed for even more precise identification of the carriers of the UIR bands.

For this purpose, we have carried out synthetic experiment of nitrogen-containing carbonaceous composites (NCCs) by exposing carbonaceous solids (e.g., C60, PAHs) to nitrogen plasma via microwave discharge method at 2.45 GHz. Infrared spectra of NCCs exhibit broad features at 6.3 and ~8 (7.4--8.3) μm, which are similar to the "Class C" UIR band. Based on the results of X-ray photoelectron spectroscopy (XPS) and N/C elemental ratio measurements of NCCs, we have concluded that the ~8 μm feature is likely to be due to aromatic C-N stretching mode.

[P28]

"SOURCE-CODE: Utilities for Detection and Characterization of Point Sources"

Matthias Samland (Max-Planck-Institute for Astronomy)

The goal of this work is to provide a modularized software framework for objective testing and comparison of different data reductions algorithms for high-contrast imaging, as well as a comprehensive suite of functions for the detection and characterization of directly imaged point sources. The pre-requisites are computational speed (parallelization) and ease of modification (object orientation). Those two demands and the fact that it should be free and easily accessible led to the choice of implementation in the Python programming language. The code for detection and characterization of point sources (SOURCE-Code, SOphisticated Utilities for the Removal of Correlated Noise Elements) is based on principal component analysis (PCA), with three different modi: 1) Quick-Look, 2) Optimized Detection, including parameter exploration for optimal PCA reduction, and 3) Optimized Characterization, including parameter exploration for local region of already detected point source and MCMC parameter space exploration of the source's photometry and astrometry by injecting negative signals into RAW data. With these three modi we enable the handling of different situations from on-the-fly data reduction to detailed analysis, as well as comparing the quality of different reduction algorithms and parameter choices.

[P29]

"Formation of Galilean Satellites via Pebble Accretion"

Yuhito Shibaike (Tokyo Institute of Technology)

It has been recently suggested that planetesimals rapidly grow to the cores of gas giants by accreting a number of cm-sized solid particles called pebbles. We investigate how this pebble accretion mechanism affects satellite formation around gas giants. We construct a simple but comprehensive model that treats 1) the growth and radial transport of pebble-sized dust particles in a protoplanetary disk and in a circumplanetary disk around a gas giant, 2) the inflow of gas and pebbles from the protoplanetary to circumplanetary disks, and 3) pebble accretion by protosatellites in the circumplanetary disk. We find that the circumplanetary disk captures about 1/5 pebbles migrating from outside the Jupiter's orbit.

[P30]

"Spin of Protoplanets by Planetesimal Accretion"

Takashi Shibata (The University of Tokyo)

We investigate the spin of protoplanets by planetesimal accretion using N-body simulation. The spin of protoplanets is important to understand the final stage of terrestrial planet formation and the origin of the Moon. We perform N-body simulations of protoplanet formation from several thousand equal-mass planetesimals around 1 AU. In our simulation, typically protoplanets with mass 10^26 g are formed through runaway and oligarchic growth. The typical spin angular velocity of the protoplanets is about 0.1 times the critical spin angular velocity for rotational instability. The spin angular velocity of protoplanets decreases as their mass increases and the obliquity obeys an isotropic distribution, which means most planetesimals and protoplanets have inclined spin axis. We check the dependence of the spin angular velocity on the bulk density and initial mass of planetesimals. The spin angular velocity increases with the bulk density. We also find that the large initial mass weakens the dependence of the spin angular velocity on the mass. We present these results and discuss their application to planet formation.

[P31]

"Late Stage Capture of Solids by Accreting Proto-Gas-Giant Planets"

Yosuke Shirai (The University of Tokyo)

It is known that the abundances of heavy elements in the envelopes of Jupiter and Saturn are significantly higher than solar. Also, warm exo-Jupiters are in general rich in heavy elements. In the core accretion scenario for the formation of gas giant planets, such large amounts of heavy element do not always accrete during early stages of accretion. Here we investigate how much solids an accreting proto-gas-giant planet captures, by simulating the dynamical evolution of particles with various sizes around a growing protoplanet. We take the effect of the envelope gas drag into account, in contrast to previous studies. Then, we demonstrate that the envelope gas drag is especially effective in capturing small-size particles of < 100 m. Applying our results to Jupiter, we have found that the total mass of captured particles is several Earth masses in the case of the minimum-mass solar nebula model, provided the particle sizes are more than about 10 m. The amount of heavy elements is larger than that predicted by previous studies, but is still smaller than observationally inferred. This suggests that some mechanism for capturing solids efficiently works in the late stages of giant planet formation.

[P32]

“Detail Characterization of Directly Imaged Exoplanet in Subaru Telescope using High Contrast and High Dispersion Spectroscopy Instrument (IRCS+AO188)”

Stevanus K. Nugroho (Tohoku University)

We simulate spectroscopic characterization of directly imaged exoplanet’s atmosphere using IRCS (R~20,000)+AO188 in 8.2 meter Subaru telescope. We took archived data from SMOKA (Subaru-Mitaka-Okayama-Kiso-Archive) in K-band (1.97-2.47 micron) as the stellar spectrum template. The exoplanet spectrum was created to mimic the thermal emission of Beta Pictoris b then Doppler shifted at 15 km/s to make sure that the exoplanet absorption lines are well separated from telluric and stellar lines. The planet to star contrast (Fp/Fs) and separation were varied to explore capability of 5 sigma detection limit of this combination of instrument. The stellar and telluric lines were removed using the help of SVD (Singular Value Decomposition) technique. The exoplanet spectrum was recovered with cross correlation method. For 9.4 hours of exposure time, the planet signal was recovered at 5 sigma for Fp/Fs as low as 2.5x10^-5 at ~0.35" from the host star and 2.5x10^-4 at ~0.15". This observation can still be improved by using coronagraph, better instruments (e.g. IRD+SCExAO), and more sophisticated telluric+starlight removal algorithm so that it will be a great companion to characterize the directly imaged exoplanets that will be found by TMT, E-ELT, TESS, WFIRST and JWST.

[P33]

"An Extension of Godunov SPH to Elastic Dynamics and Numerical Simulation for Collisional Growth and Destruction of Ptoroplanets"

Keisuke Sugiura (Nagoya University)

Rocky planets are formed via collisional coalescences of protoplanets in protoplanetary disks. The formation of planets depends on the collisional outcomes, so that it is very important to understand the collisional phenomena of protoplanets. Simulations through Smoothed Particle Hydrodynamics (SPH) method are powerful to treat planetary collisions. However, the most popular version of SPH method, the standard SPH method, cannot treat tension-dominated region due to numerical instability, which is called the tensile instability: Clustering of particles occurs in tension-dominated region. To overcome this problem, we develop a new method using the Godunov SPH method, which achieves second-order accuracy in space. Results of test calculations show that our new method successfully suppresses the tensile instability. Moreover, we simulate collisions of protoplanets using the new Godunov SPH code. Previous simulations for protoplanet collisions ignored energy dissipation by the effects of solid material, such as deviatoric stress tensor or rock fracturing, because self-gravity is dominant in collisions of protoplanets. We extend the Godunov SPH method to elastic dynamics and include the effects of fracture, plastic deformation and friction. We find that threshold velocity that discriminates merging collision and hit-and-run collision becomes several percent larger owing to the effects of solid material.

[P34]

"Numerical Modeling of Moist Convection in Saturn's and Uranus' atmospheres"

Ko-ichiro Sugiyama (ISAS/JAXA)

Numerical simulations are performed to investigate idealized characteristics of the moist convection layers in Saturn's and Uranus' atmospheres using a two-dimensional cloud resolving model that treats thermodynamics and microphysics of the possible cloud components. Although the magnitudes of cooling adopted as a substitute for radiative forcing are still larger than those expected in the real atmospheres, some robust features are obtained. In Saturn's case, the qualitative features are similar to those obtained in Jupiter's case (Sugiyama et al., 2011, 2014); the calculated cloud convection is characterized by the intermittent emergence of vigorous cumulonimbus clouds rising from the H_2O lifting condensation level (LCL) to the tropopause, and the H_2O LCL acts as a steady kinematic and compositional boundary because of strong stable layers associated with H_2O condensation. In Uranus' case, in addition to the above-mentioned features, the CH_4 LCL also acts as a steady kinematic and compositional boundary. The existence of strong stable layer associated with CH_4 condensation is consistent with the one-dimensional thermo-dynamical calculation (Sugiyama et al., 2006). In both cases, the temporal and horizontal averaged vertical profiles of cloud particles and condensible gases are distinctly different from the hitherto accepted layered structure (e.g. Weidenschilling and Lewis 1973) because of the vertical mixing due to vigorous cloud convection.

[P35]

"A massive primordial-atmosphere on proto-Titan formed in a cold circum-planetary disk"

Takashi Mikami (Hokkaido University)

Titan is a known as a satellite with a thick atmosphere (1.5 bar at the surface) mainly composed of nitrogen. Although several hypotheses about the origin of atmosphere have been proposed, it remains an open question how and when such a thick atmosphere was generated. According to the recent satellite formation theory [e.g., Canup and Ward 2002], Titan formed within low temperature and pressure disk. We numerically investigate the property of the primordial atmosphere of Titan that grew in such a circum-planetary disk, especially in terms of the atmospheric mass and the blanketing effect. In spite of such a disk condition, Titan could capture a thick atmosphere strongly bounded by gravity, which is mainly composed of nebula gas components. This would cause a significant blanketing effect inducing differentiation of this satellite, and result in keeping the surface temperature high relatively (~200 K). This suggests that an ammonia-rich proto atmosphere could be kept on Titan even after the disk was dissipated. Titan's current nitrogen would be generated from ammonia in the proto atmosphere by photochemical reaction [Atreya et al., 1978]

[P36]

"Coagulation of Rocky Dust Particles at the Radial Pressure Bump in Protoplanetary Disks"

Tetsuo Taki (Tokyo Institute of Technology)

Planetesimal formation is a key part in the planetary system formation. However, the processes where dust grains in a protoplanetary disk grow to become planetesimals are poorly understood. There are two main difficulties called "radial drift barrier" and "fragmentation barrier" in planetesimal formation. Silicate dust particles have a smaller fragmentation velocity than icy particles. Since these two barriers become more serious in the process of rocky planetesimal formation.

We focus on the local disk structure called "radial pressure bump (Whipple, 1972; Haghighipour & Boss, 2003)". In our previous studies, we found that a radial pressure bump forms a dust dense region which has the small pressure gradient and the relatively large dust-to-gas ratio ~1.

In this study, we investigate the dust and gas dynamics including the dust growth at the radial pressure bump.We confirmed that the dust dense region formed by the pressure bump promotes the dust growth. Dust particles have the small growth timescale and quickly pass through the radius corresponding to St~1 at the dust dense region.Therefore, the pressure bumps may be a favorable location for the planetesimal formation even for the rocky dust particles.

[P37]

"Stability of Titan's atmosphere and surface"

Shuya Tan (Osaka University)

Titan has liquid on the surface, and it is the only satellite which has developed atmosphere. On Titan, the liquid is methane and the condition strongly depends on characters of the atmosphere : temperature and pressure. Titan's atmosphere is the reducing condition, and has methane gas and photolysis organic haze. The haze blocks sunlight, on the other hand, thermal infrared is absorbed by gas molecules. Moreover, near the surface, convection and condensation of methane can effect temperature. On previous researches, simple equations are used to demonstrate these effects and derive temperature profile of the atmosphere from the fixed surface value. Here, we use these equations and some hypotheses to estimate the surface environment.And on this estimation, we change some parameters : gravitational acceleration, surface pressure and solar flux. According these investigations about how atmospheric characters are influenced if some parameters change, we discuss the stability of the condition. This study doesn't only discuss the range of liquid methane existence but also may be able to constrain the general icy moons'atmospheres and surface conditions.

[P38]

"Final Masses of Giant Planets II: Jupiter Formation in a Gas-Depleted Disk"

Takayuki Tanigawa (University of Occupational and Environmental Health)

Firstly, we study the final masses of giant planets growing in protoplanetary disks through capture of disk gas, by employing empirical formulas for the gas capture rate and a shallow disk gap model, which are both based on hydrodynamical simulations. We found that, for planets less massive than 10 Jupiter masses, their growth rates are mainly controlled by the gas supply through the global disk accretion, and the gap opening does not limit the accretion. The insufficient gas supply compared with the rapid gas capture causes a depletion of the gas surface density even at the outside of the gap, which can create a disk inner hole. Secondly, our findings are applied to the formation of our solar system. We found that an initially ~10AU-sized compact disk is plausible for the formation of Jupiter. Solid material grows quickly in the disk and decoupled from the gas disk, which reduces its mass gradually at the same time through the viscous evolution by the time when the rapid gas accretion onto the solid core starts. A very low-mass gas disk also provides a plausible path where type I and II planetary migrations are both suppressed significantly.

[P39]

"ALMA Observations for Revealing the Detailed Structure and Kinematics of the Transitional Disk around Sz 91"

Takashi Tsukagoshi (Ibaraki University)

We report the high-resolution ALMA observations of the dust continuum at band 7, and CO J=3-2 and HCO+ J=4-3 line emission toward a transitional disk. The target is a class III low-mass star, Sz91, which possesses the transitional disk with the larger inner hole and lower disk mass than other transitional disks. The detailed structure of the disk has been revealed with 0.14 arcsec (28 AU) resolution, which is three or more times better than the previous observations. The dust disk appears a symmetric ring with the sharp edges and is concentrated at a radius of ~130 AU. The width of the dust disk is too narrow to resolve even with ALMA, indicating that the ring is comparable to or narrower than the resolution and the ring edge should be sharpened. The dust ring is found at the outside of the scattered disk at a near-infrared wavelength, indicating that the dust size distribution strongly depends on the disk radius. The kepler rotating gas disk was clearly found in both the CO and HCO+ images. The velocity pattern was fitted by a kepler rotation around 0.49 Msun and we found that the disk is inclined by 59 deg with respect to the line-of-sight. There is no clear inner hole or gap in the gas disk, i.e., the gas emission is filled the inside of the dust ring. We consider that the distinct difference in the distributions of the dust (submm and near-infrared) and the gas is relevant to the planet formation process.

[P40]

"The origin and physical properties of interplanetary dust particles estimated from AKARI observations"

Takahiro Ueda (The University of Tokyo)

In the Solar System, interplanetary dust particles (IDPs) originating mainly from asteroid collisions, activity of comets drift to the Earth orbit due to the Poynting Robertson drag. We analyzed the thermal emission from the IDPs around the Earth observed via all sky survey by the first Japanese infrared astronomical satellite, AKARI. The observed brightness in the trailing direction of the Earth orbit is greater than that in the leading direction by 3.7% in band at 9um and 3.0% in band at 18um. In order to reveal dust properties resulting in the asymmetry of dust distribution, we numerically integrated orbits for restricted three body problem of Sun, Earth and a dust particle, including radiation from the Sun. Particles are set to be 1-100um in radius and their initial orbits are determined according to the origins of main-belt asteroids or Jupiter-family comets. The ratio of the trailing to leading brightnesses increases with the radius of dust particles and decreases with their initial orbital eccentricity. We found that the observational asymmetry can be explained by IDPs with radius s<5.7um for main-belt origins and with s<57um for cometary origins. Dust particles for cometary origins have comparable size to that expected from in-situ spacecraft measurements.

[P41]

"Search for Companions around Young Stellar Objects"

Taichi Uyama (The University of Tokyo)

SEEDS project, exploring exoplanets and protoplanetary disks with Subaru/HiCIAO and AO188, has observed about 500 stars by Direct Imaging from 2009 Dec to 2015 Apr. Among these targets we explore around Young Stellar Objects (YSOs; age $\leqq$ 10Myr) which often have the protoplanetary disks where planets are being formed, in order to detect very young exoplanets and to understand the formation process. We analyze 68 YSOs (about 100 data in total) with LOCI data reduction, the largest samples of target objects for exoplanet survey around YSOs. In other words, this research is the first large-scale statistical exploration. We will report the results (companion candidates and detection limit) of our exploration.

[P42]

"Atmospheric evolution of GJ 1214b by hydrodynamic escape"

Kensuke Watanabe (Hokkaido University)

From its observed mass and density, a super-Earth GJ1214b is speculated to have been evolved from a Neptune-like planet that has acquired a thick hydrogen envelope during its formation. On the other hand, recent transit observations suggest that GJ1214b is covered with an atmosphere dominated by high mean-molecular-weight gas. This implies that GJ1214b has experienced severe hydrogen loss through its evolution. Recently, Lammer et al. (2013) numerically investigated the EUV-driven hydrodynamic escape from GJ1214b assuming a hydrogen-rich atmosphere. The obtained escape rate is considerably below the energy limit, but its cause is unclear. Here we perform high-accuracy numerical escape simulations by using CIP schemes to resolve this issue. Given basically the same boundary conditions, we obtain escape rates approximately 6-10 times larger than the previous study. When we use the re-evaluated escape rate and the EUV flux dependent on the stellar age, the initial mass of GJ1214b is possibly as large as 1.15-1.9 times current mass. Even if GJ1214b originally had a hydrogen envelope with mass fraction similar to Neptune, almost all hydrogen may have been lost to date. This result is consistent with the observation suggesting hydrogen-depleted atmosphere.

[P43]

"An implementation of particle-particle particle-tree scheme for N-Body simulations including fragmentation"

Akihisa Yamakawa (Tokyo Institute of Technology)

To date, in almost all simulations of the final phase accretion of the terrestrial planets it is assumed that all collisions lead to perform simulations in mergers. To simulate more realistic condition, it is necessary to treat a larger number of particles and integrate them for longer time. We present the implementation and performance of the P3T (Particle-Particle Particle-Tree) scheme we developed to simulate planetary formation process. In P3T, the gravitational force between two particles is split into short-range and long-range contributions. Short-range forces are evaluated by direct summation and integrated with the fourth order Hermite scheme with the block time steps. For long-range forces, we use a combination of the Barnes-Hut tree code and the leapfrog integrator with the constant time steps. The tree part of our simulation environment is accelerated by using Framework for Developing Particle Simulator (FDPS). Using this scheme, we can calculate many N-Body problems accurately in low calculation cost. In this workshop, we show the result of test calculations.

[P44]

"Chemical desorption of molecules formed on dust surface"

Tetsuo Yamamoto (Hokkaido University)

Chemical desorption is one of the key elementary processes of release of molecules formed on dust surfaces in cold environments such as in deeply embedded protostars, dark clouds, and outer regions on protoplanetary disks. In these cold environments, molecules are expected to freeze onto the dust surfaces in time scales shorter than those of the objects. However, the observations detected molecules that would have friezed onto the dust surface in the gas phase. Recent laboratory experiment (Delieu et al., 2013) have shown that molecules formed on cold surface (10 K oxygen ice surface) are actually ejected to the ambient gas. We present a theory of explaining the experiment quantitatively and clarify what determines the desorption conditions.

[P45]

“Near-Infrared Imaging of the Inner Region of GG Tau A Disk”

Yi Yang (GUAS/NAOJ)

With the help of Subaru/HiCIAO, we have successfully detected the polarized scattered light from the inner region of the disk around the GG Tau A system in H band with a spatial resolution about 0.07". We find out that the inner disk shows signimifcant asymmetric and for both companions: GG Tau Aa and GG Tau Ab, there are some sign of the circumstellar disks around them. We report the discovery of a spiral arm extending from GG Tau Ab. After comparing with previous observations, we suggest that this spiral arm is actually a streamer transfering substances from the outer region to the circumstellar disk around GG Tau Ab. This process may help the circumstellar disk to survive longer time and planet can have enough time to form. While the asymmetric inner disk structure in the inner disk may imply the gravitational instability process, it could also lead to planet formation. Our observation shows the complicated disk structures around young binaries, it will be quite beneficial for us to learn the planet formation process around them.

[P46]

"*OGLE-2012-BLG-0950Lb: The Possible First Planet Mass Measurement from Only Microlens Parallax and Lens Flux*"

Naoki Koshimoto (Osaka University)

The gravitational microlensing is the only method that has a sensitivity to Earth mass planets beyond the H2O snowline. One of its difficulties is to determine their physical masses and distances. There are up to three observables in microlensing which can give us the mass-distance relations of the lens, i.e., the angular Einstein radius, the microlens parallax and the lens flux. The angular Einstein radius is commonly measured, while the microlens parallax can be observed only in relatively rare events and the lens flux measurements need a follow-up observation with high angular resolution. We analyze a planetary microlensing event, OGLE-2012-BLG-0950. We detect the microlens parallax effect in the light curve. We also obtain the lens flux from high resolution AO images by NIRC2 instrument on KECK II. Combining these two mass-distance relations, we find that the lens system is located at $D_L = 3.0^{+0.8}_{-1.1}$ kpc and consists of a planet with mass of $M_p = 35^{+17}_{-9}$ M_{earth} orbiting about a star with mass of $M_h = 0.56^{+0.12}_{-0.16}$ M_{sun} with a semi-major axis of $a = 3.1^{+2.0}_{-0.8}$ AU. This is the first mass and distance measurements from only microlens parallax and the lens flux if the parallax signal is real.

[P47]

"*Effects of Water Amount on the Surface Environment of Terrestrial Planets: High Pressure Ice and Carbon Cycle on Ocean Planets*"

Akifumi Nakayama (The University of Tokyo)

Terrestrial planets with several wt% of H2O in the habitable zone of extrasolar planetary systems are predicted by a recent theory of planet formation. Planets with large water amount (> 50 Earth's ocean mass) may have high-pressure (HP) ice on the seafloor. Our aim is to clarify the relationship between water amount and surface environment focusing seafloor environment.

Amount of atmospheric CO2 (PCO2) is regulated by the balance between the degassing from planetary interior and carbonate formation through chemical weathering of surface rock. When the seafloor is covered by HP ice, it has been thought that any weathering processes will not work and PCO2 will be extremely high. When plate tectonics works, HP ice near the mid-ocean ridge will be kept solid-liquid coexistent state at the melting point of HP ice because of high heat flow. The seafloor weathering under this condition efficiently works because weathering temperature is kept at the melting point regardless of the surface temperature.

We developed a carbon cycle model considering HP ice effects. The result indicated that HP ice enhanced the seafloor weathering and planets with large ocean (> 90 Earth's ocean mass) might lapse into a snowball state.

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