Research Center for the Early Universe

Graduate School of Science

University of Tokyo

Annual Report

2017

東京大学大学院理学系研究科附属

ビッグバン宇宙国際研究センター

Version November 28, 2018

Preface

I am pleased to deliver the annual report of Research Center for the Early Universe (RESCEU) for the fiscal year of 2017 (from April 2017 to March 2018).

RESCEU was founded in 1999 as an institute belonging to Faculty of Science, the University of Tokyo, led by the first director, Prof. Katsuhiko Sato of Physics Department. In 2015 we reorganized the research projects in RESCEU, and now we have three major projects including (1) Evolution of the universe and cosmic structures (led by Prof. Jun'ichi Yokoyama), (2) Gravitational-wave astrophysics and experimental gravity (led by Prof. Kipp Cannon), and (3) Formation and characterization of planetary systems (led by myself). Those projects have been supported by a variety of collaboration among our research affiliates in Departments of Physics, Astronomy, and Earth and Planetary Sciences of Faculty of Science, the University of Tokyo

During November 28 to 30, 2017, we organized and hosted the 10th RESCEU international symposium "Planet Formation around Snowline" at Koshiba Hall, the University of Tokyo. This was supported together with the JSPS Core-to-Core program, International Network of Planetary Sciences.

The visiting professors of RESCEU include Prof. Alexei Starobinskii (Landau Institute for Theoretical Physics, from December 6 to 26, 2017 and from February 27 to March 1, 2018) and Prof. Bernard Carr (Queen Mary University of London, from February 10 to March 13, 2018). Also Dr. Othman Benomar in New York University, Abu Dhabi stayed in my group as a visiting Fellow from November 3 to December 13, 2017 for collaboration on asteroseismology.

Dr. Katsumi Kashiyama and Dr. Toyokazu Sekiguchi joined RESCEU as an assistant professor starting on April 1 and October 1, 2017, respectively. The former assistant professors, Dr. Yosuke Itoh and Dr. Teruaki Suyama, were promoted to associate professors in Department of Physics, Osaka City University in October 2017, and in Tokyo Institute of Technology in March 2018, respectively. We would like to thank them for their wonderful contributions to RESCEU over years. We believe that they continue successful scientific collaboration with RESCEU.

Finally we are pleased to announce the awards for our RESCEU members. One of our research affiliates, Prof. Masahiro Ikoma, received the JpGU Nishida Prize for Promotion of Geo- and Planetary Science in May 2017. A former graduate student in my group, Dr. Kento Masuda (currently a Sagan Fellow at Princeton University), received the 34th Inoue Young Researcher prize in February 2018. We would like to congratulate them for their wonderful achievement.

September 2018

Director Yasushi Suto

Contents

1 Members

RESCEU members

Yasushi Suto [須藤靖]	Director
Jun'ichi Yokoyama [横山順一]	Professor
Toshikazu Shigeyama [茂山俊和]	Associate Professor
Kipp Cannon	Associate Professor
Masamune Oguri [大栗真宗]	Assistant Professor
Kazumi Kashiyama [樫山和己]	Assistant Professor (2017/4/1 –)
Teruaki Suyama [須山輝明]	Assistant Professor (– 2018/2/29)
Yosuke Itoh [伊藤洋介]	Assistant Professor (– 2017/9/30)
Takuma Suda [須田拓馬]	Project Assistant Professor
Toyokazu Sekiguchi [関口 豊和]	Project Assistant Professor (2017/10/1 –)
Yutaka Komiya [小宮悠]	Research Fellow
Yi-Peng Wu	Research Fellow
Ayako Ishii [石井彩子]	Research Fellow (2017/4/1 –)
Sayuri Nagano [永野早百合]	Secretary
Chiyo Ueda [上田千代]	Secretary

RESCEU affiliates

Naoki Yoshida [吉田直紀]	Professor, Dept. of Physics
Tomonori Totani [戸谷友則]	Professor, Dept. of Astronomy
Mamoru Doi [土居守]	Professor, Institute of Astronomy
Kotaro Kohno [河野孝太郎]	Professor, Institute of Astronomy
Motohide Tamura [田村元秀]	Professor, Dept. of Astronomy
Seiji Sugita [杉田精司]	Professor, Dept. of Earth and Planetary Science
Satoshi Yamamoto [山本智]	Professor, Dept. of Physics
Aya Bamba [馬場彩]	Associate Professor, Dept. of Physics
Kazuhiro Shimasaku [嶋作一大]	Associate Professor, Dept. of Astronomy
Masaki Ando [安東正樹]	Associate Professor, Dept. of Physics
Masahiro Ikoma [生駒大洋]	Associate Professor, Dept. of Earth and Planetary Science
Hajime Kawahara [河原創]	Assistant Professor, Dept. of Earth and Planetary Science

2 Projects

Project 1. Evolution of the universe and cosmic structures

Name	Research thema
Jun'ichi Yokoyama	Physics of the Early Universe
Toshikazu Shigeyama	Coevolution of galaxies and stars
Naoki Yoshida	Evolution of compact objects and time domain astronomy
Tomonori Totani	Evolution of the universe probed by gamma-ray bursts and fast radio bursts
Aya Bamba	Chemical evolution of the universe with supernova remnant study
Kazuhiro Shimasaku	Galaxy Formation and Evolution
Masamune Oguri	Unveiling the nature of dark matter and dark energy

Project 2. Gravitational-wave astrophysics and experimental gravity

Name	Research thema
Kipp Cannon	Detection and interpretation of gravitational waves emitted by the collisions of compact objects
Mamoru Doi	Identifications of gravitational-wave sources by wide-field and multi-color optical observations
Kotaro Kohno	Radio/submm follow up of candidate sources of gravitational waves
Masaki Ando	Gravitational-Wave Experiment and Astrophysics
Teruaki Suyama	Test of theories of gravity in the strong gravity regime by using the gravitational waves

Project 3. Formation and characterization of planetary systems

Name	Research thema
Yasushi Suto	Dynamical evolution of orbit and angular momentum of exoplanetary systems
Motohide Tamura	Exoplanet observations and instrumentations
Seiji Sugita	An asteroid sample-return mission and feasibility study for an exoplanet observation satellite
Satoshi Yamamoto	Physics and chemistry of protoplanetary disk formation
Masahiro Ikoma	Diversity and origins of exoplanetary atmospheres
Hajime Kawahara	Exploring instrumentation and methods for characterizing exoplanets

3 Symposia and Meetings

3.1 RESCEU Summer School

Place: Bochouen Yamaguchi city, Yamaguchi, Japan
Time: 2017/7/29 (Sat) – 2017/8/1 (Tue)

Program

7/29 (Sat)

15:25–15:30	Yasushi Suto	Opening remark
15:30–16:30	(L) Kunihito Ioka	High energy particles in the Universe: I
16:30–16:50	Kazumi Kashiyama	Electromagnetic counterparts of binary neutron star formation
16:50–17:10	Kojiro Kawana	A variety of tidal disruption events of a white dwarf by a black hole

7/30 (Sun) morning

9:00–10:00	(L) Kunihito Ioka	High energy particles in the Universe: II
10:05–11:05	(L) Kunihito Ioka	High energy particles in the Universe: III
11:05–11:15	Break (10 min)	
11:15–11:35	Yutaka Komiya	R-process element cosmic rays from coalescing neutron star binaries
11:35–11:55	Daichi Tsuna	X-ray Detectability of Accreting Isolated Black Holes in the Milky Way
11:55–12:15	Ayako Ishii	Free Neutron Ejection by Shock Breakout in Binary Neutron Star Merger

7/30 (Sun) afternoon

13:20–14:20	(L) Keiichi Maeda	Supernovae and the final Fates of Stars: I
14:20–14:30	Break (10 min)	
14:30–15:30	(L) Keiichi Maeda	Supernovae and the final Fates of Stars: II
15:30–15:40	Break (10 min)	
15:40–16:00	Conar Omand	Radio Emission from Embryonic Super-Luminous Supernova Remnants
16:00–16:20	Hiroaki Tahara	Anisotropic Universe Based on Generalized G-Inflation
16:20–16:40	Naritaka Oshita	Stochastic inflation and the second law of thermodynamics
16:40–17:00	Takahiro Hayashinaka	A non-perturbative approach to de Sitter QED
17:00–17:10	Break (10 min)	
17:10–18:10	(L) Keiichi Maeda	Supernovae and the final Fates of Stars: III

7/31 (Mon)

9:00–10:00	(L) Aaron Zimmerman	Black hole perturbation theory and gravitational waves: I
10:05–11:05	(L) Aaron Zimmerman	Black hole perturbation theory and gravitational waves: II
11:05–11:15	Break (10 min)	
11:15–11:35	Shortaro Yamasaki	Probing the Origin of Fast Radio Bursts by Simulation of Binary Neutron Star Mergers
11:35–11:55	Eisuke Sonomoto	Domain wall problem in supersymmetric axion model
11:55–12:15	Takashi Hiramatsu	Reconstruction of primordial tensor power spectrum from B-mode observations
12:15 –	Free discussion	

8/1 (Tue) morning

9:00–10:00	(L) Aaron Zimmerman	Black hole perturbation theory and gravitational waves: I
10:05–10:25	Ye-Peng Wu	Loop corrections to cosmological correlators from inflationary phase transitions
10:25–10:45	Kenta Ando	PBH formation from an axion-like curvaton model
10:45–11:05	Keisuke Inomata	30 solar mass primordial black holes and axion dark matter
11:05–11:25	Kazufumi Takahashi	Relation between field transformations and physical DOFs in scalar-tensor theories
11:25–11:45	Souichiro Morisaki	Neutron Stars in a Scalar-Tensor Theory
11:45–12:05	Leo Tsukada	Application of a Zero-latency Whitening Filter to Compact Binary Coalescence GW Searches
12:05–	Jun'ichi Yokoyama	Closing remark

3.2 The 10th RESCEU/Planet^2 Symposium Planet Formation around Snowline

Place: Koshiba Hall, University of Tokyo (Hongo Campus)
Time: 2017/11/28 (Tue) – 2017/11/30 (Thu)

Program

11/28 (Tue) morning

9:30– 9:40	Yasushi Suto (Univ. Tokyo)	Opening Address
9:40–10:10	Andrew Howard (Caltech) [I]	Precise Demographics of the Kepler Planets
10:10–10:30	Kento Masuda (Princeton Univ.) [I]	Eccentric companions to two Kepler planets: Clues to the formation of warm Jupiters
10:30–10:50	Lauren Weiss (Univ. Montreal) [I]	Multiplanet Systems as Laboratories for Planet Formation
10:50–11:20	Takahiro Sumi (Osaka Univ.) [I]	Planet distribution outside Snowline by Microlensing
11:20–11:50	Giovanna Tinetti (UCL) [I]	A chemical survey of exoplanets
11:50–12:05	Stevanus Nugroho (Tohoku Univ.) [C]	High-Resolution Spectroscopic Detection of TiO and Stratosphere in the Day-side of WASP-33b

11/28 (Tue) afternoon

13:45–14:25	Steve Desch (Arizona State Univ.) [I]	The distribution of refractory elements and inclusions in the solar nebula
14:25–14:55	Tsuyoshi Iizuka (Univ. Tokyo) [I]	U-Pb chronology of the early solar system
14:55–15:15	Yann Alibert (Univ. Bern) [I]	On the formation timescale of Jupiter
15:15–15:30	Sho Shibata (Univ. Tokyo) [C]	Capture of Solids in the Late Stage of Gas Giant Formation
15:30–15:50	coffee break	
15:50–16:20	Mitsuhiko Honda (Kurume Univ.) [I]	Toward solid observations of snow line
16:20–16:40	Hideko Nomura (TokyoTech) [I]	ALMA Observations of S-bearing Molecules in Protoplanetary Disks: a Possible Tracer of Evaporation of Icy Planetesimals
16:40–16:55	Shota Notsu (Kyoto Univ) [C]	Possibility to locate the position of the H2O snowline in protoplanetary disks through spectroscopic observations
16:55–17:15	Aya Higuchi (RIKEN) [I]	Detection of Submillimeter-wave [CI] Emission in Gaseous Debris Disks of 49 Ceti and β Pic
17:15–17:45	Misato Fukagawa (Nagoya Univ.) [I]	What do structures in protoplanetary disks tell us about planet formation?

11/29 (Wen) morning

9:00– 9:30	Satoshi Okuzumi (TokyoTech) [I]	Accretion and dust evolution in the HL Tau disk
9:30– 9:45	Hidekazu Tanaka (Tohoku Univ.) [C]	Size Distribution of Ice-mantled Grains and Its Effect on Dust Growth
9:45–10:15	Takeru Suzuki (Univ. Tokyo) [I]	Magnetic disk wind and disk dispersal
10:15–10:30	Masanobu Kunitomo (Univ. Tokyo) [C]	Evaluating the imprints of planet formation on the compositions of stars
10:30–11:00	coffee break	
11:00–11:30	Anders Johansen (Lund Obs.) [I]	The growth of pebbles and protoplanets near ice lines
11:30–12:00	Chris Ormel (Univ. Amsterdam) [I]	Pebble accretion near the snowline
12:00–12:20	Sebastiaan Krijt (Univ. Chicago) [C]	Impact of pebble formation and migration on observable gas-phase volatiles on both sides of the snowline
12:20–12:40	Shigeru Ida (ELSI) [I]	Volatile delivery to planets in habitable zones during planet formation
12:40–13:00	Hiroshi Kobayashi (Nagoya Univ.) [I]	From planetesimals to planets in a turbulent disk

11/29 (Wen) afternoon

14:20–14:50	Julia Venturini (Univ. Zurich) [I]	The formation of gas-rich planets
14:50–15:05	Masahiro Ikoma (Univ. Tokyo) [I]	Accretion limit of snowy planetary envelope
15:05–15:35	James Owen (I. C. London) [I]	Formation clues for close-in exoplanets
15:35–15:50	Yuhito Shibaike (TokyoTech) [C]	Satellitesimal formation with collisional growth and radial drift of dust particles in steady circumplanetary disks
15:50–16:20	Motohide Tamura (UTokyo/ABC) [I]	Direct Imaging Observations of Exoplanets and Disks
18:00–20:00	conference banquet	

11/30 (Thu) morning

9:00- 9:30	Joshua Winn (Princeton Univ.) [I]	Obliquities of planet-hosting stars: new clues
9:30-10:00	Othman Benomar (New York Univ.) [I]	Spin-orbit of exoplanets constrained with asteroseismology
10:00-10:20	Makiko Nagasawa (Kurume Univ.) [I]	Planetesimal migration and evaporation caused by Jovian resonances near the snowline
10:20-10:40	Yuhiko Aoyama (Univ. Tokyo) [C]	Theoretical estimate of intensity of hydrogen line emission from accreting gas giants
10:40-11:10	coffee break	
11:10-11:40	Takayuki Kotani (NAOJ) [I]	Infrared Doppler for the Subaru telescope
11:40-12:00	Elizabeth Tasker (ISAS/JAXA) [C]	Finding Patterns in Planets: A neural network approach to the exoplanet dataset
12:00-12:20	Masataka Aizawa (Univ. Tokyo)[C]	Search for ringed planets using the Kepler data
12:20-12:50	Hajime Kawahara (Univ. Tokyo) [I]	Finding transiting objects around snowline
12:50-13:00	Masahiro Ikoma (Univ.Tokyo)	Concluding Remark

4 RESCEU colloquia

- Kent Yagi(Princeton University)
  "Probing Extreme Gravity with Gravitational Waves"
  April 20, 2017, 13:00-14:00

- Misao Sasaki (Kyoto University)
  "Inflationary massive gravity"
  June 19, 2017, 16:15-17:15

- Kipp Cannon (RESCEU) and Masaomi Tanaka (NAOJ)
  "GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral"
  "Electromagnetic Wave Observations of GW170817"
  November 20, 2017, 16:30-18:30

- George Hobbs (CSIRO)
  "Pulsar and transients observations at Parkes and towards the SKA"
  January 10, 2018, 16:30-17:30

- Mark Hindmarsh (University of Sussex)
  "Gravitational waves from phase transitions in the early Universe"
  January 18, 2018, 16:00-17:00

- Aurelien Crida (Univ. Cote d'Azur/Obs. Cote d'Azur)
  "Satellite formation from rings"
  March 23, 2018, 16:00-17:00

5 Project 1. Evolution of the universe and cosmic structures

5.1 Activity Report

This project aims at clarifying the creation and evolution of the universe and its large scale structures from both theoretical and observational studies. It covers physics of the early universe including but not limited to inflation, cosmological phase transition, formation and evolution of density perturbation, as well as formation and evolution of the hierarchical structure of the universe, namely, stars, galaxies, and clusters of galaxies in terms of numerical simulations and optical and X-ray observations. These studies not only clarifies the evolution of our Universe but also provide us with invaluable informations on the nature of dark matter and dark energy. Below are some highlights of the FY2017.

5.1.1 Inflationary cosmology

The original Higgs inflation model and Starobinsky model of R^2 inflation are two inflation models whose predictions of the spectral index and the tensor-to-scalar ratio occupy the central region of the observed likelihood contours. We have analyzed the model both mechanisms are present and found a simple relation between the Higgs nonmiminal coupling parameter and the scalaron mass.

The generalized G-inflation is the most general single-field inflation model with second-order field equations. We have found that this model can naturally accommodate anisotropic inflationary solution even if the matter content is fully isotropic. (Yokoyama)

5.1.2 Quantum effects in the early universe

Stochastic inflation allow the Hubble parameter during inflation may occasionally increase by quantum effects. We have shown that even in this case, the total entropy does not decrease due to the entropy production associated with quantum decoherence.

We have proposed a new renormalization scheme appropriate in the electromagnetism in de Sitter space where we subtract all the perturbative contributions and studied its consequences. (Yokoyama)

5.1.3 Cosmic microwave background

We studied modulation of the angular power spectrum of CMB anisotropy using the Planck 2015 data and confirmed the existence of oscillatory modulation around the multipole $\ell \sim 120$ observed in WMAP data.

We studied the observability of three point function of B-mode polarization of CMB predicted in the generalized G-inflation models and found that while the general relativistic contribution is not observable, the new term associated with G_{5X} may be observed in future. (Yokoyama)

5.1.4 Statistical Computational Astrophysics

We have been developing a machine-learned classifier of supernovae (Kimura et al. 2017). The classifier has been successfully installed and applied to real data analysis of HSC transient survey started in November

2017. A number of distant Type Ia supernovae with redshifts greater than 1 were identified, several of which have been sent for follow up observations using Hubble Space Telescope. (Yoshida)

5.1.5 Gravitational lensing from HSC data

We have published various scientific results from the first year data of the Subaru Hyper Suprime-Cam (HSC) survey. For instance, we have constructed a weak lensing shear catalog from the first-year data, and conducted careful validation tests to make sure that its quality is sufficiently high for first year science. With the weak lensing shear catalog, we have constructed large mass maps and constructed a large sample of mass selected clusters. The comparison of the mass selected cluster sample with X-ray clusters revealed possible selection effects inherent to the X-ray cluster sample. Taking advantage of the photometric redshift information, we have also constructed three-dimensional mass maps, which represent the largest three-dimensional mass maps ever created. From the five band photometry of the HSC survey, we constructed an optically selected cluster catalog that extends out to the redshift of $z = 1.1$. (Oguri)

5.1.6 Highly magnified gravitational lensing event in MACS J1149+2223

From observations of the massive cluster MACS J1149+2223 with Hubble Space Telescope, we have discovered fast transient events near the critical curve of the cluster. Our careful analysis of the lightcurve as well as the spectral energy distribution of the transients indicates that these are highly magnified individual stars at redshift $z = 1.5$. For the most prominent event, which are dubbed as Icarus, we estimate that it is magnified by more than a factor of 2000 at the peak. This discovery opens up the possibility of using such highly magnified stars to study distant galaxies as well as the nature of dark matter. (Oguri)

5.1.7 High redshift galaxies from HSC data

We used data taken in the Subaru HSC Strategic Survey Program to study various properties of high-redshift galaxies. For example, we obtained the most accurate luminosity functions of bright UV-selected galaxies and bright Lyman α emitters. We also obtained the most accurate stellar-to-halo mass relations for bright UV-selected galaxies. Those studies were published in the PASJ HSC Special Issue in January, 2018. We also used wide-field Suprime-Cam data for $z \sim 2$ Lyman α emitters to derive their reliable dark halo masses for the first time and discussed their star-formation activity. We also used gravitationally lensed images of $z \sim 6 - 9$ galaxies taken in the Hubble Frontier Fields project to measure their sizes and luminosities, thus constraining the intrinsic size-luminosity relations and luminosity functions. We also studied the evolution of the angular momentum of disk galaxies over $z \sim$ 2–4. (Shimasaku)

5.1.8 Origin of r-process elements in metal-poor stars

Faint dwarf spheroidal galaxies

Faint dwarf spheroidal galaxies can be a useful probe to identify the origin of r-process elements, because some of such galaxies have hosted a single neutron star merger (NSM) in their whole histories. If r-process elements are supplied from NSMs, stars formed before the NSM do not have these elements and can be easily distinguished from younger stars formed from gas polluted by the ejecta of the NSM. Since we have identified such a signature in some faint dwarf spheroidal galaxies from already existing observational data, we have been trying to observe as many stars in such galaxies as possible with the Subaru telescope to strengthen the argument in collaboration with researchers working at NAOJ and IPMU. From such observations for Draco spheroidal galaxy, we obtained a sign of distinct multiple events to enrich the galaxy with r-process elements and published the results in the Astrophysical Journal Letters. (Shigeyama)

R-process elements in cosmic rays

We discuss the difference in the content of r-process elements in cosmic rays if these elements are supplied by supernovae or binary neutron star mergers. We have assumed some different energy distributions for accelerated r-process elements and calculated the transfer of these elements inside our galaxy. We investigate the possibility to distinguish these origins of r-process elements using some meteorites that have long exposures of the order of Myr and satellite with short exposures. The results are published in the Astrophysical Journal. (Shigeyama)

5.1.9 Early emission from binary neutron star mergers

Gravitational waves from a binary neutron star merger were detected for the first time and the optical counter part was also detected about 11 hours from the gravitational wave detection. Follow up observations with electromagnetic waves have revealed that a short gamma-ray burst originates from a binary neutron star merger and heavy elements as much as 1% of the solar mass were ejected. As future transient surveys such as Tomo-e will be able to detect earlier emission, we are investigating what kind of information the early emission carries. To this end, we calculated the shock breakout from the merging object and found that this results in ejection of matter composed of free-neutrons with a mass of about $\sim 10^{-6}\ M_\odot$ and discussed the emission from this matter. (Shigeyama)

5.1.10 Tomo-e Gozen

To search for electro-magnetic counter parts of gravitational wave sources, we are constructing a wide-field optical camera equipped with 84 CMOS sensors, which will be mounted on 1.0-m Schmidt Telescope in Kiso Observatory at the University of Tokyo. Experimental observations by its prototype composed of 21 CMOS sensors were carried out in the spring of 2017. Optical emission from the Crab pulsar was detected and the spin rate and the pulsar profile could be derived. This Tomo-e Gozen can detect any types of transient sources ranging from comets in the solar system to afterglows of gamma-ray bursts in the distant universe. (Shigeyama)

5.1.11 Observations of the early light from type Ia supernovae

Type Ia supernova is thought to be the explosion of a white dwarf in a binary system. There are two scenarios leading to type Ia supernova. One is the double-degenerate scenario in which the companion is also a white dwarf and eventually coalesces to explode without leaving no compact remnants. The other is the single-degenerate scenario in which the white dwarf accretes matter from a red-giant or main-sequence companion star. In this scenario, there remains the companion after the supernova explosion and the existence of the companion should affect the dynamics of the ejecta of the explosion. We have been investigating effects of the companion on the dynamics and the radiation by 2D numerical simulations taking into account the finite timescale of thermalization between gas and radiation and pointed out the possibility of the enhancement of blue radiation in the early phase. Our collaborators recently observed such signatures in the early emission of some supernovae. One particular supernova exhibited an enhancement in the light curve with very red color, which cannot be reconciled with the companion interactions. We found that this enhancement is due to He detonation on the surface of a massive white dwarf. We also found that this He detonation explains the observed spectral features due to absorption by Titanium ions. The results were published in Nature. This observation project is a collaboration with M. Doi, J. Jiang, at IoA, and K. Maeda at Kyoto University. (Shigeyama)

5.1.12 Influence of supernova explosions on the companion stars

Massive stars are usually formed in multiple stellar systems. Thus a supernova explosion can affect the surface layers of nearby stars. We are focusing on the change of the abundance of Li in solar type stars after the explosion of a nearby star because Li is known to exist only in the surface layer where the temperature is lower than 2.6 million K. This effect may account for the diversity of Li abundances observed in metal-poor dwarf stars. From the theoretical point of view, we are investigating the effects of a supernova on the surface layer of low mass stars by numerical simulations. This part is a collaboration with a researcher at Tokyo Institute of Technology. At the same time, we are searching binary systems composed of a massive star and a low mass star by performing spectroscopy observations for known massive stars in our galaxy using 1-m class telescopes. To investigate the population of this kind of binary systems in the current universe, we can infer the population of metal-poor counter parts in the ancient universe. (Shigeyama)

5.1.13 Emission of type IIn supernovae

Type IIn supernovae are very bright and could be a useful probe to investigate the activity of star formation in the early universe because this type of supernovae are thought to originate from massive stars. Though the emission of this supernova is believed to come from collisions between ejecta and thick circumstellar matter, there have been no quantitative models to account for spectra and their temporal evolution. This is due to the difficulty to numerically resolve the structure of the shocked matter. We are trying to resolve the structure by assuming the shocked ejecta and the shocked circumstellar matter are in stationary states in the rest frames of the shock waves and separated by a contact surface. We have succeeded in obtaining series of such solutions for about a month from the explosion and constructing light curves of some optical bands. We will compare these solutions with previous solutions based on the thin shell approximation and with some existing observational data to test our model. (Shigeyama)

5.1.14 Fast radio bursts etc

Totani and his collaborators continued to investigate the origin of mysterious fast radio bursts (FRBs). Yamasaki et al. (2018) showed that, using a numerical simulation of binary neutron star (BNS) mergers, ejecta formation is a few msec delayed compared with the merged star starts to rapidly rotate, and hence there is a time window for radio signal to escape and become a non-repeating FRB. They also proposed that a repeating FRB is produced by the massive long-lived neutron star left after the BNS merger. They also performed a follow-up observation by Subaru for a FRB, which is reported in Bhandari et al. (2018). Tsuna et al. (2018) predicted the distribution of isolated black holes emitting X-rays by accretion from interstellar medium in the Galaxy and made some predictions for future surveys. Sudoh et al. (2018) investigated the hypothesis that the IceCube neutrinos are generated in star forming galaxies using a state-of-art galaxy formation model, and showed that this population is unlikely to be the main origin of the IceCube neutrinos. (Totani)

5.1.15 X-ray and γ-ray astrophysics

The universe looks quiet and cold world at a glance, but actually it is a quite hot and energetic world. The targets of our group are such high energy phenomena in the universe. Understandings of the origin of heavy elements and cosmic rays is one of our main goals.

This year, we have made several achievements on the study of heavy element distribution in young supernova remnants, high energy particle escape from the shocks of supernova remnants, high energy phenomena on compact stars such as white dwarfs, neutron stars, and black holes. Here, we focus on the study of the expansion structure of the supernova remnant of SN1604 (Kepler remnant). The origin of type Ia SNe is one of the biggest problem, single degenerate (SD) or double degenerate (DD). In the SD case, dense CSM makes the expansion. With excellent spatial resolution and moderate energy resolution of Chandra X-ray observatory, we succeeded to make the Doppler-shift map of Fe-K lines in the Kepler. It shows highly asymmetric structure, suggesting the expansion is highly non-uniform. The central region represents largely red-shifted Fe-K lines with the moving velocity of a few thousand kilometers. Our developed method will be applied several Ia SNRs in the next year, and we will be able to judge the ratio of SD and DD in our galaxy.

For the future missions, we work on the development of the X-ray recovery mission of Hitomi (XARM), which will be launched on the Japanese fiscal year 2020. This year XARM moved to the pre-project phase and we keeps the schedule. (Bamba)

5.1.16 Observational cosmology

We used data taken in the Subaru/HSC (Hyper Suprime-Cam) Strategic Survey Program to study various properties of high-redshift galaxies. For example, we obtained the most accurate luminosity functions of bright UV-selected galaxies and bright Lyman α emitters. We also obtained the most accurate stellar-to-halo mass relations for bright UV-selected galaxies. Those studies were published in the PASJ HSC Special Issue in January, 2018. We also used wide-field Suprime-Cam data for $z \sim 2$ Lyman α emitters to derive their reliable dark halo masses for the first time and discussed their star-formation activity. We also used gravitationally lensed images of $z \sim 6-9$ galaxies taken in the Hubble Frontier Fields project to measure their sizes and luminosities, thus constraining the intrinsic size-luminosity relations and luminosity functions. We also studied the evolution of the angular momentum of disk galaxies over $z \sim 2$–4.

5.2 Publication List

[1] F. Acero, A. Bamba, et al., "Prospects for Cherenkov Telescope Array Observations of the Young Supernova Remnant RX J1713.7−3946", ApJ, 840, 74 (2017)

[2] Hitomi Collaboration, A. Bamba, K. Nakazawa, et al., "Solar abundance ratios of the iron-peak elements in the Perseus cluster", Nature, 551, 478 (2017)

[3] V. Doroshenko, V, G. Puehlhofer, A. Bamba, F. Acero, W.W. Tian, D. Klochkov, A. Santangelo, "XMM-Newton observations of the non-thermal supernova remnant HESS J1731-347 (G353.6-0.7)", A&A, 608, 23 (2017)

[4] T. Sato, S. Katsuda, M. Morii, A. Bamba, J.P.Hughes, Y. Maeda, M. Ishida, F. Fraschetti, "X-Ray Measurements of the Particle Acceleration Properties at Inward Shocks in Cassiopeia A", ApJ, 863, 46 (2017)

[5] T. Tanaka, H. Uchida, H. Nakajima, H. Tsunemi, K. Hayashida, T.G. Tsuru, T. Dotani, R. Nagino, S. Inoue, S. Katada, R. Washino, M. Ozaki, H. Tomida, C. Natsukari, S. Ueda, M. Iwai, K. Mori, M. Yamauchi, I. Hatsukade, Y. Nishioka, E. Isoda, M. Nobukawa, J.S. Hiraga, T. Kohmura, H. Murakami, K.K. Nobukawa, A. Bamba, J.P. Doty, "Soft X-ray Imager aboard Hitomi (ASTRO-H)", JATIS, 4, id. 011211 (2018)

[6] A. Bamba, Y. Ohira, R. Yamazaki, M. Sawada, Y. Terada, K. Koyama, E.D. Miller, H. Yamaguchi, S. Katsuda, M. Nobukawa, K.K. Nobukawa, "The Transition from Young to Middle-aged Supernova Remnants: Thermal and Nonthermal Aspects of SNR N132D", ApJ, 854, 71 (2018)

[7] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Atmospheric gas dynamics in the Perseus cluster observed with Hitomi", PASJ, 70, 9 (2018)

[8] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Measurements of resonant scattering in the Perseus Cluster core with Hitomi SXS", PASJ, 70, 10 (2018)

[9] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Temperature structure in the Perseus cluster core observed with Hitomi", PASJ, 70, 11 (2018)

[10] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Atomic data and spectral modeling constraints from high-resolution X-ray observations of the Perseus cluster with Hitomi", PASJ, 70, 12 (2018)

[11] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Hitomi observation of radio galaxy NGC 1275: The first X-ray microcalorimeter spectroscopy of Fe-K α line emission from an active galactic nucleus", PASJ, 70, 13 (2018)

[12] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Search for thermal X-ray features from the Crab nebula with the Hitomi soft X-ray spectrometer", PASJ, 70, 14 (2018)

[13] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Hitomi X-ray studies of giant radio pulses from the Crab pulsar", PASJ, 70, 15 (2018)

[14] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Hitomi observations of the LMC SNR N 132 D: Highly redshifted X-ray emission from iron ejecta", PASJ, 70, 16 (2018)

[15] Hitomi Collaboration, A. Bamba, K. Nakazawa et al., "Glimpse of the highly obscured HMXB IGR J16318-4848 with Hitomi", PASJ, 70, 17 (2018)

[16] H. Nakajima, Y. Maeda, H. Uchida, T. Tanaka, H. Tsunemi, K. Hayashida, T.G. Tsuru, T. Dotani, R. Nagino, S. Inoue, M. Ozaki, H. Tomida, C. Natsukari, S. Ueda, K. Mori, M. Yamauchi, I. Hatsukade, Y. Nishioka, M. Sakata, T. Beppu, D. Honda, M. Nobukawa, J.S. Hiraga, T. Kohmura, H. Murakami, K.K. Nobukawa, A.

Bamba, J.P. Doty, R. Iizuka, T. Sato, S. Kurashima, N. Nakaniwa, R. Asai, M. Ishida, H. Mori, Y. Soong, T. Okajima, P. Serlemitsos, Y. Tawara, I. Mitsuishi, K. Ishibashi, K. Tamura, T. Hayashi, A. Furuzawa, S. Sugita, T. Miyazawa, H. Awaki, E.D. Miller, H. Yamaguchi, "In-orbit performance of the soft X-ray imaging system aboard Hitomi (ASTRO-H)", PASJ, 70, 21 (2018)

[17] K. Miyaoka, et al. (incl. K. Nakazawa), " Multiwavelength study of X-ray luminous clusters in the Hyper Suprime-Cam Subaru Strategic Program S16A field " , PASJ, Volume 70, Issue SP1, id.S22 (2017)

[18] M. Itahana, K. Takizawa, H. Akamatsu, R.J. van Weeren, H. Kawahara, Y. Fukazawa, J.S. Kaastra, K. Nakazawa, T. Ohashi, N. Ota, H.J.A. Röttgering, J. Vink, F. Zandanel, "Suzaku and Chandra observations of the galaxy cluster RXC J1053.7+5453 with a radio relic", PASJ, Volume 69, Issue 6, id.88 (2017)

[19] K. Yamaoka et al., "Suzaku Wide-band All-sky Monitor (WAM) observations of GRBs and SGRs", PASJ, Volume 69, Issue 3, id.R2 (2017)

[20] K. Ono, K. Makishima, S. Sakurai, Z. Zhang, K. Yamaoka, K. Nakazawa, "A hard-to-soft state transition of Aquila X-1 observed with Suzaku", PASJ, Volume 69, Issue 2, id.23 (2917)

[21] H. Akamatsu, M. Mizuno, N. Ota, Y.Y. Zhang, R.J. van Weeren, H. Kawahara, Y. Fukazawa, J.S. Kaastra, M. Kawaharada, K. Nakazawa, T. Ohashi, H.J. Röttgering. M. Takizawa, J. Vink, F. Zandanel, "Suzaku observations of the merging galaxy cluster Abell 2255: The northeast radio relic", Astronomy & Astrophysics, Volume 600, id.A100, 12 pp. (2017)

[22] K. Nakazawa et al. "The hard X-ray imager (HXI) onboard ASTRO-H", K. Nakazawa et al., JATIS, in press (2018)

[23] K. Hagino et al. "In-orbit performance and calibration of the hard x-ray imager onboard Hitomi (ASTRO-H)", JATIS, in press (2018)

[24] H. Tajima et al. "Design and performance of Soft Gamma-ray Detector onboard the Hitomi (ASTRO-H) satellite", JATIS, in press (2018)

[25] T. Enoto, Y. Wada, Y. Furuta, K. Nakazawa, T. Yuasa, K. Okuda, K. Makishima, M. Sato, Y. Sato, T. Nakano, D. Umemoto, H. Tsuchiya, ""Photonuclear reactions triggered by lightning discharge", Nature, Volume 551, Issue 7681, pp. 481-484 (2017)

[26] Y. Wada, T. Yuasa, K. Nakazawa, K. Makishima, T. Hayashi, M.Ishida, " An estimation of the white dwarf mass in the Dwarf Nova GK Persei with NuSTAR observations of two states " , MNRAS, 474,1564-1571

[27] Masato Shirasaki, Kazumi Kashiyama, and Naoki Yoshida: Phys. Rev. D, **95** (2017) 083012

[28] Kazumi Kashiyama and Kohta Murase: ApJ, **839** (2017) L3

[29] Kazumi Kashiyama: ASSL, **446** (2017) 279

[30] Kunihito Ioka et al. (incl. Kazumi Kashiyama): MNRAS, **470** (2017) 3332

[31] Kenta Hotokezaka, Kazumi Kashiyama, and Kohta Murase: ApJ, **850** (2017) 18

[32] Murase Kohta et al. (incl. Kazumi Kashiyama): ApJ, **854** (2018) 60

[33] Conor M. B. Omand, Kazumi Kashiyama, and Kohta Murase: MNRAS, **474** (2018) 573

[34] Rodrigo Fernández, Eliot Quataert, Kazumi Kashiyama, and Eric R. Coughlin: MNRAS, **476** (2018) 2366

[35] Kenneth C. Wong et al. (incl. Masamune Oguri): ApJ, **843** (2017) L35

[36] Suzuka Koyamada et al. (incl. Masamune Oguri): ApJ, **851** (2017) 88

[37] Yen-Ting Lin et al. (incl. Masamune Oguri): ApJ, **851** (2017) 139

[38] Massimo Meneghetti et al. (incl. Masamune Oguri): MNRAS, **472** (2017) 3177-3216

[39] Satoshi Miyazaki et al. (incl. Masamune Oguri): PASJ, **70** (2018) S1

[40] Hiroaki Aihara et al. (incl. Masamune Oguri, Ken Osato, Yasushi Suto): PASJ, **70** (2018) S4

[41] Jean Coupon et al. (incl. Masamune Oguri): PASJ, **70** (2018) S7

[42] Hiroaki Aihara et al. (incl. Masamune Oguri, Yasushi Suto): PASJ, **70** (2018) S8

[43] Yoshiaki Ono, et al. (incl. Masamune Oguri): PASJ, **70** (2018) S10

[44] Akira Konno, et al. (incl. Masamune Oguri): PASJ, **70** (2018) S16

[45] Masamune Oguri et al. : PASJ, **70** (2018) S20

[46] Keita Miyaoka, et al. (incl. Masamune Oguri): PASJ, **70** (2018) S22

[47] Hung-Yu Jian et al. (incl. Masamune Oguri): PASJ, **70** (2018) S23

[48] Atsushi J. Nishizawa, Masamune Oguri, Taira Oogi, et al. : PASJ, **70** (2018) S24

[49] Rachel Mandelbaum et al. (incl. Masamune Oguri): PASJ, **70** (2018) S25

[50] Masamune Oguri et al. : PASJ, **70** (2018) S26

[51] Satoshi Miyazaki, Masamune Oguri et al. : PASJ, **70** (2018) S27

[52] Elinor Medezinski et al. (incl. Masamune Oguri): PASJ, **70** (2018) S28

[53] Alessandro Sonnenfeld et al. (incl. Masamune Oguri): PASJ, **70** (2018) S29

[54] Masafusa Onoue et al. (incl. Masamune Oguri): PASJ, **70** (2018) S31

[55] Wanqiu He et al. (incl. Masamune Oguri, Taira Oogi): PASJ, **70** (2018) S33

[56] Masayuki Akiyama et al. (incl. Masamune Oguri): PASJ, **70** (2018) S34

[57] Yoshiki Matsuoka et al. (incl. Masamune Oguri): PASJ, **70** (2018) S35

[58] Masamune Oguri, Jose M. Diego, Nick Kaiser, Patrick L. Kelly, and Tom Broadhurst: Phys. Rev. D, **97** (2018) 023518

[59] Matthew Cornachione et al. (incl. Masamune Oguri): ApJ, **853** (2018) 148

[60] Toru Misawa, Naohisa Inada, Masamune Oguri et al. : ApJ, **854** (2018) 69

[61] Masafumi Ishigaki, Ryota Kawamata, Masami Ouchi, Masamune Oguri, Kazuhiro Shimasaku, and Yoshiaki Ono: ApJ, **854** (2018) 73

[62] Ryota Kawamata, Masafumi Ishigaki, Kazuhiro Shimasaku, Masamune Oguri, Masami Ouchi, and Shingo Tanigawa: ApJ, **855** (2018) 4

[63] Matt Hilton et al. (incl. Masamune Oguri): ApJS, **235** (2018) 20

[64] Maeda, K., Jiang, J.-. an ., Shigeyama, T., et al. 2018, Astrophys. J. , 861, 78.

[65] Ishii, A., Shigeyama, T. & Tanaka, M. 2018, Astrophys. J. , 861, 25.

[66] Kamae, T., Lee, S.-H., Makishima, K., et al. 2018, Publications of the Astronomical Society of Japan, 70, 29.

[67] Ohtani, Y., Suzuki, A., Shigeyama, T., et al. 2018, Astrophys. J. , 853, 52.

[68] Tsujimoto, T., Matsuno, T., Aoki, W., et al. 2017, Astrophys. J. , 850, L12.

[69] Jiang, J.-A., Doi, M., Maeda, K., Shigeyama, T., et al. 2017, Nature, 550, 80.

[70] Komiya, Y. & Shigeyama, T. 2017, Astrophys. J. , 846, 143.

[71] Nakano, T., Murakami, H., Furuta, Y., et al. 2017, Publications of the Astronomical Society of Japan, 69, 40.

[72] Kikuta, S., Imanishi, M., Matsuoka, Y., Matsuda, Y., Shimasaku, K., Nakata, F.: "Active Galactic Nucleus Environments and Feedback to Neighboring Galaxies at $z \sim 5$ Probed by Lyα Emitters", The Astrophysical Journal, **841** (2017) 128

[73] Malkan, M. A. et al. (including Shimasaku, K.): "Lyman-break Galaxies at $z \sim 3$ in the Subaru Deep Field: Luminosity Function, Clustering, and [O III] Emission", The Astrophysical Journal, **850** (2017) 5

[74] Kusakabe, H., Shimasaku, K., Ouchi, M., Nakajima, K., Goto, R., Hashimoto, T., Konno, A., Harikane, Y., Silverman, J. D., & Capak, P. L.: "The stellar mass, star formation rate and dark matter halo properties of LAEs at $z \sim 2$," Publications of the Astronomical Society of Japan, **70** (2018) 4

[75] Aihara, H. et al. (including Shimasaku, K.): "The Hyper Suprime-Cam SSP Survey: Overview and survey design", Publications of the Astronomical Society of Japan, **70** (2018) S4

[76] Aihara, H. et al. (including Shimasaku, K.): "First data release of the Hyper Suprime-Cam Subaru Strategic Program", Publications of the Astronomical Society of Japan, **70** (2018) S8

[77] Ono, Y. et al. (including Shimasaku, K): "Great Optically Luminous Dropout Research Using Subaru HSC (GOLDRUSH). I. UV luminosity functions at $z \sim 4 - 7$ derived with the half-million dropouts on the 100 deg2 sky", Publications of the Astronomical Society of Japan, **70** (2018) S10

[78] Harikane, Y. et al. (including Shimasaku, K.): "GOLDRUSH. II. Clustering of galaxies at $z \sim 4 - 6$ revealed with the half-million dropouts over the 100 deg^2 area corresponding to 1 Gpc^3", Publications of the Astronomical Society of Japan, **70** (2018) S11

[79] Ouchi, M. et al. (including Shimasaku, K): "Systematic Identification of LAEs for Visible Exploration and Reionization Research Using Subaru HSC (SILVERRUSH). I. Program strategy and clustering properties of ~ 2000 Lyα emitters at $z = 6 - -7$ over the $0.3 - -0.5$ Gpc^2 survey area", Publications of the Astronomical Society of Japan, **70** (2018) S13

[80] Shibuya, T., Ouchi, M., Konno, A., Higuchi, R., Harikane, Y., Ono, Y., Shimasaku, K., Taniguchi, Y., Kobayashi, M. A. R., Kajisawa, M., Nagao, T., Furusawa, H., Goto, T., Kashikawa, N., Komiyama, Y., Kusakabe, H., Lee, C. -H., Momose, R., Nakajima, K., Tanaka, M., Wang, S. -Y., & Yuma, S.: "SILVERRUSH. II. First Catalogs and Properties of ∼2,000 Lyα Emitters and Blobs at $z \sim 6$–7 Identified over the 14−−21 deg^2 Sky,", Publications of the Astronomical Society of Japan, **70** (2018) S14

[81] Shibuya, T., Ouchi, M., Harikane, Y., Rauch, M., Ono, Y., Mukae, S., Higuchi, R., Kojima, T., Yuma, S., Lee, C. -H., Furusawa, H., Konno, A., Martin, C. L., Shimasaku, K., Taniguchi, Y., Kobayashi, M. A. R., Kajisawa, M., Nagao, T., Goto, T., Kashikawa, N., Komiyama, Y., Kusakabe, H., Momose, R., Nakajima, K., Tanaka, M., & Wang, S. -Y.: "SILVERRUSH. III. Deep Optical and Near-Infrared Spectroscopy for Lyα and UV-Nebular Lines of Bright Lyα Emitters at $z = 6$–7,", Publications of the Astronomical Society of Japan, **70** (2018) S15

[82] Konno, A., Ouchi, M., Shibuya, T., Ono, Y., Shimasaku, K., Taniguchi, Y., Nagao, T., Kobayashi, M. A. R., Kajisawa, M., Kashikawa, N., Inoue, A. K., Oguri, M., Furusawa, H., Goto, T., Harikane, Y., Higuchi, R., Komiyama, Y., Kusakabe, H., Miyazaki, S., Nakajima, K., & Wang, S. -Y.: "SILVERRUSH. IV. Lyα Luminosity Functions at $z = 5.7$ and 6.6 Studied with $\sim 1,300$ LAEs on the 14–21 deg^2 Sky,", Publications of the Astronomical Society of Japan, **70** (2018) S16

[83] Okamura, T., Shimasaku, K., Kawamata, R.: "Angular Momentum Evolution of Stellar Disks at High Redshifts", The Astrophysical Journal, **854** (2018) 22

[84] Ishigaki, M., Kawamata, R., Ouchi, M., Oguri, M., Shimasaku, K., Ono, Y.: "Full-data Results of Hubble Frontier Fields: UV Luminosity Functions at $z \sim 6 - -10$ and a Consistent Picture of Cosmic Reionization", The Astrophysical Journal, **854** (2018) 73

[85] Kawamata, R., Ishigaki, M., Shimasaku, K., Oguri, M., Ouchi, M., Tanigawa, S.: "Size–Luminosity Relations and UV Luminosity Functions at $z = 6 - -9$ Simultaneously Derived from the Complete Hubble Frontier Fields Data", The Astrophysical Journal, **855** (2018) 4

[86] Ota Kazuaki, Iye Masanori, Kashikawa Nobunari, Konno Akira, Nakata Fumiaki, Totani Tomonori, Kobayashi Masakazu A. R., Fudamoto Yoshinobu, Seko Akifumi, Toshikawa Jun, Ichikawa Akie, Shibuya Takatoshi, Onoue Masafusa "A New Constraint on Reionization from the Evolution of the Ly α Luminosity Function at z ? 6-7 Probed by a Deep Census of z = 7.0 Ly α Emitter Candidates to 0.3L", The Astrophysical Journal, Volume 844, Issue 1, article id. 85, 37 pp. (2017)

[87] Tomonori Totani, "Gravity with free initial conditions: A solution to the cosmological constant problem testable by CMB B -mode polarization", Physical Review D, Volume 96, Issue 8, id.084062 (2017)

[88] Kataoka Jun, Sofue Yoshiaki, Inoue Yoshiyuki, Akita Masahiro, Nakashima Shinya, Totani Tomonori "X-Ray and Gamma-Ray Observations of the Fermi Bubbles and NPS/Loop I Structures", Galaxies, vol. 6, issue 1, p. 27 (2018)

[89] Bhandari, S. et al. (Totani, T. 45th among 175 authors), "The SUrvey for Pulsars and Extragalactic Radio Bursts - II. New FRB discoveries and their follow-up", Monthly Notices of the Royal Astronomical Society, Volume 475, Issue 2, p.1427-1446 (2018)

[90] Tsuna Daichi, Kawanaka Norita, Totani Tomonori "X-ray detectability of accreting isolated black holes in our Galaxy", Monthly Notices of the Royal Astronomical Society, Volume 477, Issue 1, p.791-801 (2018)

[91] Yamasaki Shotaro, Totani Tomonori, Kiuchi Kenta "Repeating and non-repeating fast radio bursts from binary neutron star mergers", PASJ, 70, 39 (2018)

[92] Tonegawa Motonari, Okumura Teppei, Totani Tomonori, Dalton Gavin, Glazebrook Karl, Yabe Kiyoto "The Subaru FMOS galaxy redshift survey (FastSound). V. Intrinsic alignments of emission-line galaxies at z ? 1.4", PASJ 70, 41 (2018)

[93] Sudoh Takahiro, Totani Tomonori, Kawanaka Norita "High-energy gamma-ray and neutrino production in star-forming galaxies across cosmic time: Difficulties in explaining the IceCube data", PASJ 70, 49 (2018)

[94] K. Horiguchi, K. Ichiki and J. Yokoyama, "Revisiting the oscillations in the cosmic microwave background angular power spectra at $\ell \sim 120$ in the Planck 2015 data," PTEP **2017** (2017) no.9, 093E01

[95] N. Oshita, "The generalized second law of thermodynamics and cosmological decoherence" Physical Review D **97**, 023510 (2018)

[96] T. Hayashinaka and S. Xue, "Physical renormalization condition for de Sitter QED, " Physical Review D in press.

[97] A. Kamada, H. J. Kim, H. Kim and T. Sekiguchi, "Self-heating dark matter via the semi-annihilation," Review Letters in press.

[98] T. Nakama, T. Suyama, K. Kohri, N. Hiroshima, “Constraints on small-scale primordial power by annihilation signals from extragalactic dark matter minihalos,” Phys. Rev. D **97** (2018) no.2, 023539

[99] H. W. H. Tahara and J. Yokoyama, “CMB B-mode auto-bispectrum produced by primordial gravitational waves,” PTEP **2018** (2018) no.1, 013E03

[100] T. Sekiguchi, T. Takahashi, H. Tashiro and S. Yokoyama, “21 cm Angular Power Spectrum from Minihalos as a Probe of Primordial Spectral Runnings,” JCAP **1802**, no. 02, 053 (2018)

[101] S. Morisaki, T. Suyama, “Spontaneous scalarization with an extremely massive field and heavy neutron stars,” Phys. Rev. D **96** (2017) no.8, 084026

[102] K. Takahashi, H. Motohashi, T. Suyama, and T. Kobayashi, “General invertible transformation and physical degrees of freedom,” Phys. Rev. D **95**, 084053 (2017) [arXiv:1702.01849 [gr-qc]].

[103] D. A. Tretyakova and K. Takahashi, “Stable black holes in shift-symmetric Horndeski theories,” Class. Quant. Grav. **34**, 175007 (2017) [arXiv:1702.03502 [gr-qc]].

[104] K. Takahashi and T. Kobayashi, “Extended mimetic gravity: Hamiltonian analysis and gradient instabilities,” JCAP **1711**, 038 (2017) [arXiv:1708.02951 [gr-qc]].

[105] N. Oshita and Y. Wu, “ Role of spacetime bounda

[106] Shingo Hirano, Takashi Hosokawa, Naoki Yoshida, Rolf Kuiper: “Supersonic Gas Streams Enhance the Formation of Massive Blackholes in the Early Universe”, Science, **68** (2017) 104

[107] Satoshi Tanaka, Kohji Yoshikawa, Takashi Minoshima, Naoki Yoshida: “Multi-Dimensional Vlasov-Poisson Simulations with High-Order Monotonicity and Positivity Preserving Schemes”, The Astrophysical Journal, **849** (2017) 76

[108] Masato Shirasaki, Naoki Yoshida, “Probing the Shape and Internal Structure of Dark Matter Halos with the Halo-Shear-Shear Three-Point Correlation”, MNRAS, 475 (2018) 1665

[109] Akisato Kimura, et al. (including Naoki Yoshida): “Single-epoch supernova classification with deep convolutional neural network”, The 37th IEEE International Conference on Distributed Computing, (2017) 47

[110] Shigeki Inoue, Naoki Yoshida: “Spiral Arm Instability: Giant Clump Formation via Fragmentation of a Galactic Spiral Arm”, MNRAS **474** (2017) 3466

[111] Ayuki Kamada, Tomo Takahashi, Kazunori Kohri, Naoki Yoshida: “Effects of electrically charged dark matter on cosmic microwave background anisotropies”
Physical Review D **95** (2017) 023502

5.3 International Conference Talks

5.3.1 Contributed talks

[112] K. Miyake, H. Noda, S. Yamada, M. Seino, K. Nakazawa, K. Makishima, “ The two primary X-ray continua and their variability in SWIFT J2127.4+5654”, “ European Week of Astronomy and Space Science “ , 26–30 June 2017, Prague, Czech Republic

[113] K. Ono, S. Sakurai, Z. Zhang, K. Nakazawa, K.Yamaoka, K. Makishima, “Resolving a Hard-to-Soft State Transition of Aquila X-1”, “Europian Week of Astronmy and Space Science”, 26–30 June 2017, Prague, Czech Republic

[114] K. Ono, K. Makishima, Z. Zhang, K. Yamaoka, K. Nakazawa, “The Unified understanding of the Aquila X-1 hard-to-soft state transition and its implication for the cosmic battery effect” “Asia-Pacific Regional IAU Meeting”, 3–7 July 2017, Taipei, Taiwan

[115] Y. Wada, T. Enoto, Y. Furuta, K. Nakazawa, T. Yuasa, K. Okuda, K. Makishima, M. Sato, Y. Sato, T. Nakano, D. Umemoto, H. Tsuchiya, ”Initial results from a multi-point mapping observation of thundercloud high-energy radiation in coastal area of Japan sea ” , “ American Geophysical Union Fall Meeting 2017 “ , 11 - 15 December 2017, New Orleans, USA

[116] Suzuki H., Bamba A., Nakazawa K., Yamazaki R., “ Thermal X-ray Studies on Escaping of Accelerated Protons and Shock-Cloud Interaction “ , “ SNR workshop 2017 ” , 28-29 September 2017, Nagoya, Japan

[117] Suzuki H., Bamba A., Nakazawa K., Yamazaki R., “Thermal X-ray studies on escaping of accelerated protons from SNR shocks “ , “ 7th International Fermi Symposium ” , 15-20 October 2017, Garmisch-Partenkirchen, Germany

[118] T. Kasuga, " Study of Ejecta Expansion in Kepler ' s SNR with Suzaku " , " SNR workshop 2017 " , 28–29 September 2017, Nagoya, Japan

[119] Kazumi Kashiyama: "An FRB in a bottle? : a multi-wavelength approach"; TeVPA2017 (Colombus, OH, USA, 8/7, 2017)

[120] Kazumi Kashiyama: "An FRB in a bottle?"; KIAA-WAP II (Beijing, China, 8/17, 2017)

[121] Masamune Oguri: "Clusters of galaxies in Subaru Hyper Suprime-Cam survey"; Galaxy Evolution Across Time (ENS, Paris, France, June 2017)

[122] Masamune Oguri: "Ultra high magnification microlensing"; PACIFIC 2018 symposium (Kiroro, Hokkaido, February 2018)

[123] Ayako Ishii, Toshikazu Shigeyama, & Masaomi Tanaka "Free neutron ejection from shock breakout in binary neutron star merger", 2017, INT-JINA Symposium: First multi-messenger observations of a neutron star merger and its implications for nuclear physics, 2018/03/14 at University of Washington

[124] T. Suda, T. R. Saitoh, Y. Moritani, T. Shigeyama, " Search for long period binaries using coronagraphic instruments " , CHARIS International Workshop (National Astronomical Observatory of Japan, Tokyo, Japan, Dec. 15-17, 2017)

[125] Shimasaku, K.: "High-z WG", Hyper Suprime-Cam Collaboration Meeting (Sendai, Japan, May 15-17, 2017)

[126] Kawamata, R. et al. (including Shimasaku, K.): "Size–luminosity relations and UV luminosity functions at $z = 6$–9 simultaneously derived from the complete Hubble Frontier Fields data", East Asian Young Astronomers Meeting 2017 (Ishigaki, Okinawa, Japan, Nov 13-17, 2017)

[127] Kusakabe, H. et al. (including Shimasaku, K.): "Star Formation Activity of Lyα emitters at $z \sim 2$", East Asian Young Astronomers Meeting 2017 (Ishigaki, Okinawa, Japan, Nov 13-17, 2017)

[128] Kusakabe, H. et al. (including Shimasaku, K.): "The origin of diffuse Lyα halos around LAEs", Sakura CLAW (Tokyo, Japan, Mar 26-30, 2018)

[129] Totani, T. "Difficulties for Star-Forming Galaxies as the Sources of the IceCube Neutrinos", 29th International Texas Symposium on Relativistic Astrophysics, Cape Town, South Africa, 2017/12/3–8

[130] Totani, T. "Repeating and Non-Repeating Fast Radio Bursts from Binary Neutron Star Mergers", 29th International Texas Symposium on Relativistic Astrophysics, Cape Town, South Africa, 2017/12/3–8

[131] Sudoh, T., Totani, T., Makiya, R., Nagashima, M. "Testing anthropic reasoning for this cosmological constant with a realistic galaxy formation model", International Conference on the physics of Fine-Tuning, Crete, Greece, 2017/06/19–22

[132] Sudoh, T., Totani, T., Kawanaka, N., "Difficulties of Star-forming Galaxies as the Source of IceCube Neutrinos " , TeVPA2017, Ohio, USA, 2017/08/06–11

[133] J. Yokoyama, "Creation of an inflationary universe in the final stage of black hole evaporation," PACIFIC2018, Kiroro, Hokkaido, 2018/2/14

[134] J. Yokoyama, "Inflationary universe from a black hole," Conference on particles and cosmology, Nanyang Technological University, Singapore, 2018/3/5

[135] N. Oshita, " Stochastic inflation and the second law of thermodynamics " , RESCEU Summer School 2017, Yamaguchi, Japan, 2017/7/30

[136] T. Hayashinaka, "A non-perturbative approach to de Sitter QED," RESCEU Summer School 2017, Yamaguchi, Japan, 2017/7/30

[137] K. Takahashi, "Relation between field transformations and physical DOFs in scalar-tensor theories," RESCEU Summer School 2017, Yamaguchi, Japan, 2017/8/1

[138] N. Oshita and J. Yokoyama, " The birth of an inflationary universe in the ultimate fate of an evaporating black hole " , COSMO-17, the University Paris, France, 2017/8/28

[139] T. Hayashinaka, " A non-perturbative approach to de Sitter QED, " COSMO-17, Paris, 2017/8/28-2017/9/1

[140] K. Takahashi, "Relation between field transformations and physical degrees of freedom in scalar-tensor theories," COSMO-17, Paris, 2017/8/30

[141] Y.-P. Wu, "Inflationary phase transitions in the primordial fluctuations," 2017 NCTS Workshop on Dark Matter, Particles and Cosmos, Donghua University, Taiwan, 2017/10/14

[142] K. Takahashi, "Extended mimetic gravity: Hamiltonian analysis and gradient instabilities," JGRG27, Hiroshima, 2017/11/28

[143] M. He, “Higgs-R^2 Inflation”, The 27th Workshop on General Relativity and Gravitation in Japan- JGRG27, Saijo, Higashi-hiroshima, Japan, 2017/11/30

[144] Y.-P. Wu, ”Inflationary fluctuations with phase transitions,” 27th Workshop on General Relativity and Gravitation in Japan (JGRG27), Hiroshima, 2017/11/30

[145] N. Oshita, “ Probing atoms of spacetime with ringdown gravitational waves from a perturbed black hole ” , JGRG27, Higashi-Hiroshima, Japan, 2017/11/30

[146] T. Suyama, “Primordial black holes in the era of gravitational wave astronomy”, Area workshop of “Gravitational Wave Physics and Astronomy: Genesis” Tohoku University, Sendai, 2017/12/7

[147] M. He, “Higgs-R^2 Inflation”, CosPA 2017, niversity, Kyoto, 2017/12/12

[148] Y.-P. Wu, ”Inflationary fluctuations with phase transitions,” CosPA2017, Kyoto University, Kyoto, 2017/12/12

[149] T. Sekiguchi, ”Late-time magnetogenesis with dark photon,” CosPA2017, Kyoto University, Kyoto, 2017/12/12

[150] H. Tahara, “Anisotropic inflation without a vector field” CosPA2017, Kyoto University, Kyoto, 2017/12/13

[151] N. Oshita, “Spontaneous creation of an inflationary universe out of a black hole,” CosPA2017, Kyoto University, Kyoto, 2017/12/13

[152] N. Oshita, “ Probing microscopic structure of spacetime with ringdown gravitational waves ” , YKIS2018a Symposium General Relativity -The Next Generation-, Kyoto University, Japan, 2018/2/19-23

[153] K. Takahashi, “Extended mimetic gravity: Hamiltonian analysis and gradient instabilities,” YKIS2018a Symposium, Kyoto, 2018/2/21-22

[154] Naoki Yoshida: “ Statistical Computational Cosmology ” , JST/NSF Joint Symposium on Big Data (Tokyo, December 15, 2017)

[155] Naoki Yoshida: “ Big Data Cosmology with Subaru HSC ” , 3rd CREST International Symposium on Big Data Application (Tokyo, January 17, 2018)

5.3.2 Invited talks

[156] A. Bamba, “ Recent Progress on Supernova Remnants - Progenitors, Evolution, Cosmic-ray Acceleration ” , “ X-ray Universe 2017 ” . Roma, Italy, 2017, Jun.

[157] A. Bamba, “ X-ray Observations of Supernova Remnants ” , “ Asia-Pacific Regional IAU Meeting ” , Taipei, Taiwan, 2017, Jul.

[158] A. Bamba, “Recent Progress on Supernova Remnants - Present achievements and Future -“ , “SNR workshop 2017 ” , Nagoya University, Japan, 2017, Sep.28-29

[159] Shigeyama, T. ”Origin of r-process elements in dwarf spheroidal galaxies”, 2017,Workshop ”Theories of Astrophysical Big Bangs”, 2017/11/10 at RIKEN

[160] T. Suyama, “LIGO and Primordial Black Holes”, Conference on Particle Physics, HongKong University of Science and Technology, HongKong, 2017/6/25-30

[161] J. Yokoyama, “Creation of the inflationary universe out of a black hole,” International Conference on Gravitation and Cosmology, Ehwa women’s university, Seoul, Korea, 2017/7/5

[162] J. Yokoyama, “The Universe after G-inflation,” Dark Side of the Universe, IBS CTPU, Daejeong, Korea, 2017/7/13

[163] J. Yokoyama, “Inflation (and dark energy): Large or Small?” 4th Korea-Japan joint workshop on Dark Energy at KMI, Nagoya University, Nagoya, 2017/8/28

[164] N. Oshita, “Creation of an inflationary universe out of an evaporating black hole,”NCTS Workshop on Dark Matter, Particles and Cosmos, National Dong Hwa University, Taiwan, 2017/10/16

[165] J. Yokoyama, “Creation of the inflationary universe out of a black hole,” The First Symposium of the BRICS Association on Gravity, Astrophysics and Cosmology, Yangzhou University, Yangzhou, China, 2017/10/19

[166] T. Sekiguchi, ”Cosmological implications of axion like particle coupled to hidden photon,” Workshop on Beyond Standard Model and the Early Universe, Tohoku University, 2017/10/26

[167] J. Yokoyama, "Spontaneous genesis after G inflation" 3rd LeCosPA symposium "Cosmic Prospects", LeCosPA, National Taiwan University, Taipei, Taiwan, 2017/11/28

[168] T. Sekiguchi, "cosmological abundance of axions coupled to hidden photons,"New perspective of light particles, IBS-CTPU, 2017/11/28

[169] J. Yokoyama, "Approaches to inflationary cosmology," 5th international meeting on frontiers of physics, Kuara Lumpur, 2017/12/8

[170] Naoki Yoshida: " Fragmentation of disks and filaments in the early universe ", Disk Instability across Cosmic Scales, (Sesto, Italy, July 19, 2017)

[171] Naoki Yoshida: " Formation of primordial stars and blackholes ", Star Formation in Different Environment (Quy Nhon, Vietnam, August 10, 2017)

[172] Naoki Yoshida: " Cosmology and fundamental physics with big astronomical data ", 2017 IEEE International workshop on machine learning and signal processing (Tokyo, September 28, 2017)

[173] Naoki Yoshida: " Formation of primordial stars and blackholes ", IAU333 Peering towards Cosmic Dawn (Dubrovnik, Croatia, October 3, 2017)

[174] Naoki Yoshida: " Multi label classification of supernovae detected with Subaru HSC ", 3rd International Symposium on Big-data Analytics in Science and Engineering (Aizu, November 28, 2017)

[175] Naoki Yoshida: "Formation of Astrophysical Blackholes", NCTS Annual Thoery Meeting (Taiwan, December 7, 2017)

[176] Naoki Yoshida: " Simulating Cosmic Structure Formation ", SIAM Conference on Parallel Processing for Scientific Computing (PP18) (Tokyo, March 7, 2018)

6 Project 2. Gravitational-wave astrophysics and experimental gravity

6.1 Activity Report

Our research group studies black holes, exotic compact objects, and the Universe using gravitational waves. Gravitational waves are waves of spacetime curvature generated by the movement of mass and momentum. There are many reasons why gravitational waves are an interesting way to explore the sky. Because gravitational waves are generated by physical processes different from those that produce light or radio waves (which are generated by the movement of electric charges and currents), gravitational waves carry fundamentally different information about their sources than is carried by electromagnetic waves. Gravitational waves interact weakly with matter allowing them to propagate through material that would be opaque to electromagnetic energy. For example we believe gravitational waves can escape the dense deep cores of supernovæ, and show us the earliest moments of the Big Bang. The Earth, too, is transparent to gravitational waves, so gravitational-wave telescopes can look straight down through the Earth as easily as they look up, allowing gravitational-wave telescopes to monitor the whole sky continuously, day and night. Gravitational waves are the only significant form of energy expected to be radiated by some of the most exotic events in the universe like the collisions of black holes.

Our research group's members are members of the LIGO Scientific Collaboration (LSC) and KAGRA Collaboration, and we analyze data collected by the two LIGO gravitational-wave antennas in the United States, the Virgo antenna in Italy, the GEO600 antenna in Germany, and (in the future) the KAGRA antenna being built in Japan. During this past academic year the Advanced LIGO antennas completed their second observing, "O2". In the final months of O2, LIGO was joined by the Advanced Virgo detector, which became operational for the first time. In the coming years we hope to see KAGRA join the international network of gravitational-wave telescopes. Members of our group are active in all aspects of observational gravitational-wave astronomy, the following are some highlights from FY2017.

6.1.1 Compact Objects

When heavy stars exhaust their fuel supply they undergo gravitational collapse. The end state of this process can be a neutron star or a black hole. There are many of these in the Universe, and occasionally they collide with one another. These collisions are very powerful sources of gravitational radiation. Since the first detection of gravitational waves from the collision of a pair of black holes in September, 2015, we have been able to study the behaviour of strongly curve spacetime.

This past academic year, our group made significant contributions to several major discoveries of the LIGO Scientific Collaboration and Virgo Collaboration. Our signal detection system discovered the black hole collision GW170814 using the Advanced Virgo detector, the first gravitational-wave signal observed by the new detector. Shortly after the same system discovered GW170817, the gravitational waves from what is believed to have been a pair of neutron stars. Unlike black holes, neutron stars are composed of matter, and so their collisions were expected to be significant sources of electromagnetic radiation because material is available to generate it. Indeed, the gravitational waves from GW170817 were followed less than 2 seconds later by gamma rays, and as the Earth rotate and night fell over South America, the Swope telescope of the Las Campanas Observatory in Chile discovered light coming from the location of the explosion. The arrival of the gamma rays nearly simultaneously with the gravitational waves shows that gravity travels at the speed of light to very high precision, and this has been a major step forward in our understanding of the nature of spacetime.

Following these detections, our group contributed to the interpretation of the signals, performing the "parameter estimation" for GW170814, GW170817 and other significant discoveries in O2.

Since the end of the O2 observing run, we have been preparing the detection system for the comping O3 observing run, and look forward to making more exciting discoveries.

6.1.2 Other Exotica

Cosmic strings are theoretical topological defect structures left over from the cooling process of the early Universe. Although none have ever been discovered, a broad spectrum of theories of fundamental physics predict their existence. Although they might exist, they might also be so rare that none are present in the part of the Universe visible to us. Either way, searching for them and either confirming their existence or putting limits on their number will teach us a great deal about fundamental physics. Members of our group led the development of the LSC and Virgo Collaboration's cosmic string detection pipeline and we recently completed the search for gravitational-wave bursts from cosmic strings in the O2 data, and will be publishing the results shortly.

6.1.3 Stochastic Gravitational-wave Background

While some gravitational wave sources like GW170817 are close, loud, and infrequent, we also anticipate classes of gravitational wave sources that are distant, quiet, and numerous. Rather than distinct, impulsive, signals being detected from such sources we expect to observe them collectively as a diffuse "glow" of random gravitational radiation coming from all directions on the sky — a stochastic gravitational-wave background. While spacetime fluctuations in the very early Universe are expected to contribute to a cosmological gravitational-wave background, that is expected to be very weak and undetectable with modern equipment. A detectable astrophysical stochastic background of gravitational radiation could come from more recent processes, for example black hole collisions in the early Universe, a population of cosmic strings, and so on. Many of the possible sources of a stochastic gravitational wave background are conjectural; their discovery would be a tremendous breakthrough. This past year our group has begun contributing to the effort to find such gravitational waves, specifically with a search for gravitational waves generated by clouds of bosonic particles condensed around spinning black holes, extracting rotational energy from the hole via the superradiant instability. This work is on-going and is expected to lead to a published result in the coming academic year.

6.1.4 Infrastructure for Future Observations

As gravitational wave detectors are becoming more sensitive, the rate of detections is increasing, and we are quickly reaching the point at which it is no longer possible for people to manually study gravitational-wave candidates one at a time. It is critical to the progress of the field to automate the statistical analysis of signals to understand their properties, and our group is working to ensure we are ready for the "O3" and future observing runs of the Advanced LIGO, Advanced Virgo, and KAGRA detectors.

6.1.5 The Tomo-e Gozen Camera

We are developing an optical wide-field camera, called the Tomo-e Gozen (Tomo-e) on the 1.05-m Kiso Schmidt telescope. Tomo-e will use 84 CMOS sensors within the focal plane of 9 degree in diameter, and will cover 20 square degrees with decent spatial sampling on the sky (1.27 arcsec/pixel). Newly developed CMOS sensors by CANON are used which have a large pixel size, very low dark current and low readout noise. Compared with wide-field CCD cameras, Tomo-e can take images much faster (2 frames per second), which enables very wide and fast transient searches (fastest among all astronomy telescopes over the world at V 17 − 19 magnitude). The major funding source is a grant-in-aid for scientific research S titled " Study of binary neutron star merger by high cadence optical observations " (PI Toshikazu Shigeyama). In February 2018, Tomo-e Q1 (21 sensors) was installed on the prime focus of the Kiso Schmidt telescope, and was commissioned successfully. The first light of full Tomo-e (84 sensors) is scheduled in December 2018.

6.1.6 People and Things

The 2017 through 2018 academic year saw our group's membership change significantly. We have been joined by 1 new master's student and 1 new postdoctoral fellow, and our assistant professor was promoted to an associate professor position at Osaka City University. Our current members are Dr. Kipp Cannon, Mr. Soichiro Morisaki, Mr. Hiroaki Ohta, Mr. Leo Tsukada, Mr. Daichi Tsuna, Mr. Takuya Tsutsui, and Dr. Koh Ueno.

Our group enjoyed substantial international conference participation in the 2017–2018 academic year. Group members gave talks in Korea, the United States, Canada, and of course many meetings around Japan. Thanks to succesfully obtaining external funding, Mr. Leo Tsukada spent several months visiting Dr. Vuk Mandic's research group at the University of Minnesota-Twin Cities, where he developed the techniques for searching for stochastic gravitational-wave signals described above. All members of the group travelled to Pennsylvania State University to visit the research group of Dr. Chad Hanna. The discovery of the neutron star collision GW170817 generated significant interest from the mass media, and members of our group were invited to write columns for magazines and participate in television documentaries about the discovery.

6.2 Publication List

[1] T. Akutsu, M. Ando, S. Araki, et al. (KAGRA Collaboration), Construction of KAGRA: an underground gravitational-wave observatory, Progress of Theoretical and Experimental Physics 2018, 013F01 (2018).

[2] Yuta Michimura, Tomofumi Shimoda, Takahiro Miyamoto, et al., Mirror actuation design for the interferometer control of the KAGRA gravitational wave telescope, Classical and Quantum Gravity 34, 225001 (2017).

[3] Yuta Michimura, Yuya Kuwahara, Takafumi Ushiba, Nobuyuki Matsumoto, Masaki Ando, Optical levitation of a mirror for reaching the standard quantum limit, Optics Express 25, 13799 (2017).

[4] Ayaka Shoda, Yuya Kuwahara, Masaki Ando, et al., Ground-based low-frequency gravitational-wave detector with multiple outputs Physical Review D95, 082004 (2017).

[5] Masaomi Tanaka et al. (including Mamoru Doi): " Kilonova from post-merger ejecta as an optical and near-Infrared counterpart of GW170817", Publications of the Astronomical Society of Japan, **69** (2017) 102

[6] Yosuke Utsumi et al. (including Mamoru Doi): " J-GEM observations of an electromagnetic counterpart to the neutron star merger GW170817 ", Publications of the Astronomical Society of Japan, **69** (2017) 101

[7] Tomoki Morokuma et al. (including Mamoru Doi): " OISTER optical and near-infrared monitoring observations of peculiar radio-loud active galactic nucleus SDSS J110006.07+442144.3 ", Publications of the Astronomical Society of Japan, **69** (2017) 82

[8] Ji-an Jiang, Mamoru Doi, Keiichi Maeda, Toshikazu Shigeyama et al.: " A hybrid type Ia supernova with an early flash triggered by helium-shell detonation ", Mature, **550** (2017) 80-83

[9] B. P. Abbott et al. (including Mamoru Doi): " Multi-messenger Observations of a Binary Neutron Star Merger ", The Astrophysical Journal Letters, **848** (2017) L12

[10] Mitsuru Kokubo et al. (including Mamoru Doi): " H α Intensity Map of the Repeating Fast Radio Burst FRB 121102 Host Galaxy from Subaru/Kyoto 3DII AO-assisted Optical Integral-field Spectroscopy ", The Astrophysical Journal, **844** (2017) 95

[11] Abbott, B. P. *et al.* (LIGO Scientific Collaboration). Calibration of the Advanced LIGO detectors for the discovery of the binary black-hole merger GW150914. *Phys. Rev.*, D95(6):062003, March 2017. doi:10.1103/PhysRevD.95.062003. .

[12] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Directional limits on persistent gravitational waves from Advanced LIGO ' s first observing run. *Phys. Rev. Lett.*, 118(12):121102, March 2017. doi:10.1103/PhysRevLett.118.121102. .

[13] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Upper limits on the stochastic gravitational-wave background from Advanced LIGO ' s first observing run. *Phys. Rev. Lett.*, 118(12):121101, March 2017. doi:10.1103/PhysRevLett.118.121101. erratum [21], .

[14] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Effects of waveform model systematics on the interpretation of GW150914. *Class. Quant. Grav.*, 34(10):104002, April 2017. doi:10.1088/1361-6382/aa6854. .

[15] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). First search for gravitational waves from known pulsars with Advanced LIGO. *Astrophys. J.*, 839(1):12, April 2017. doi:10.3847/1538-4357/aa677f. .

[16] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Search for continuous gravitational waves from neutron stars in globular cluster NGC 6544. *Phys. Rev.*, D95(8):082005, April 2017. doi:10.1103/PhysRevD.95.082005. .

[17] Abbott, B. P. *et al.* (LIGO Scientific Collaboration, Virgo Collaboration, IPN Collaboration). Search for gravitational waves associated with gamma-ray bursts during the first Advanced LIGO observing run and implications for the origin of GRB 150906B. *Astrophys. J.*, 841(2):89, May 2017. doi:10.3847/1538-4357/aa6c47. .

[18] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). GW170104: Observation of a 50-solar-mass binary black hole coalescence at redshift 0.2. *Phys. Rev. Lett.*, 118(22):221101, June 2017. doi:10.1103/PhysRevLett.118.221101. .

[19] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Search for gravitational waves from Scorpius X-1 in the first Advanced LIGO observing run with a hidden Markov model. *Phys. Rev.*, D95(12):122003, June 2017. doi:10.1103/PhysRevD.95.122003. .

[20] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Search for intermediate mass black hole binaries in the first observing run of Advanced LIGO. *Phys. Rev.*, D96(2):022001, July 2017. doi:10.1103/PhysRevD.96.022001. .

[21] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Erratum: Upper limits on the stochastic gravitational-wave background from Advanced LIGO ' s first observing run [Phys. Rev. Lett. 118, 121101 (2017)]. *Phys. Rev. Lett.*, 119(12):029901, July 2017. doi:10.1103/PhysRevLett.119.029901. (141st author of 995).

[22] Albert, A. *et al.* (ANTARES Collaboration, IceCube Collaboration, LIGO Scientific Collaboration and Virgo Collaboration). Search for high-energy neutrinos from gravitational wave event GW151226 and candidate LVT151012 with ANTARES and IceCube. *Phys. Rev.*, D96(2):022005, July 2017. doi:10.1103/PhysRevD.96.022005. .

[23] Abbot, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). All-sky search for periodic gravitational waves in the O1 LIGO data. *Phys. Rev.*, D96(6):062002, September 2017. doi:10.1103/PhysRevD.96.062002. .

[24] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Upper limits on gravitational waves from Scorpius X-1 from a model-based cross-correlation search in Advanced LIGO data. *Astrophys. J.*, 847(1):47, September 2017. doi:10.3847/1538-4357/aa86f0. .

[25] Abbott, B. P. *et al.* (LIGO Scientific Collaboration, Virgo Collaboration, Fermi Gammay-Ray Burst Monitor, and INTEGRAL). Gravitational waves and gamma-rays from a binary neutron star merger: GW170817 and GRB 170817A. *Astrophys. J.*, 848(2):L13, October 2017. doi:10.3847/2041-8213/aa920c. .

[26] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). GW170814: A three-detector observation of gravitational waves from a binary black hole coalescence. *Phys. Rev. Lett.*, 119(14):141101, October 2017. doi:10.1103/PhysRevLett.119.141101. .

[27] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). GW170817: Observation of gravitational waves from a binary neutron star inspiral. *Phys. Rev. Lett.*, 119(16):161101, October 2017. doi:10.1103/PhysRevLett.119.161101. .

[28] Abbott, B. P. *et al.* (LIGO Scientific Collaboration, Virgo Collaboration, Fermi GBM, INTEGRAL, IceCube Collaboration, AstroSat Cadmium Zinc Telluride Imager Team, IPN Collaboration, The Insight-Hxmt Collaboration, ANTARES Collaboration, The Swift Collaboration, AGILE Team, The 1M2H Team, The Dark Energy Camera GW-EM Collaboration, the DES Collaboration, The DLT40 Collaboration, GRAWITA: GRAvitational Wave Inaf TeAm, The Fermi Large Area Telescope Collaboration, ATCA: Australia Telescope Compact Array, ASKAP: Australian SKA Pathfinder, Las Cumbres Observatory Group, OzGrav, DWF (Deeper, Wider, Faster Program), AST3, CAASTRO Collaborations, The VINROUGE Collaboration, MASTER Collaboration, J-GEM, GROWTH, JAGWAR, Caltech- NRAO, TTU-NRAO, NuSTAR Collaborations, Pan-STARRS, The MAXI Team, TZAC Consortium, KU Collaboration, Nordic Optical Telescope, ePESSTO, GROND, Texas Tech University, SALT Group, TOROS: Transient Robotic Observatory of the South Collaboration, The BOOTES Collaboration, MWA: Murchison Widefield Array, The CALET Collaboration, IKI-GW Follow-up Collaboration, H.E.S.S. Collaboration, LOFAR Collaboration, LWA: Long Wavelength Array, HAWC Collaboration, The Pierre Auger Collaboration, ALMA Collaboration, Euro VLBI Team, Pi of the Sky

Collaboration, The Chandra Team at McGill University, DFN: Desert Fireball Network, ATLAS, High Time Resolution Universe Survey, RIMAS, RATIR, SKA South Africa/MeerKAT). Multi-messenger observations of a binary neutron star merger. *Astrophys. J.*, 848(2):L12, October 2017. doi:10.3847/2041-8213/aa91c9. .

[29] Abbot, B. P. *et al.* (LIGO Scientific Collaboration, Virgo Collaboration, 1M2H Collaboration, Dark Energy Camera GW-EM Collaboration and the DES Collaboration, DLT40 Collaboration, Las Cumbres Observatory Collaboration, VINROUGE Collaboration, MASTER Collaboration). A gravitational-wave standard siren measurement of the Hubble constant. *Nature*, 551:85–88, November 2017. doi:10.1038/nature24471. .

[30] Albert, A. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Search for high-energy neutrinos from binary neutron star merger GW170817 with ANTARES, IceCube, and the Pierre Auger observatory. *Astrophys. J.*, 850(2):L35, November 2017. doi:10.3847/2041-8213/aa9aed. .

[31] Abbot, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). First low-frequency Einstein@Home all-sky search for continuous gravitational waves in Advanced LIGO data. *Phys. Rev.*, D96(12):122004, December 2017. doi:10.1103/PhysRevD.96.122004. .

[32] Abbot, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). First narrow-band search for continuous gravitational waves from known pulsars in advanced detector data. *Phys. Rev.*, D96(12):122006, December 2017. doi:10.1103/PhysRevD.96.122006. .

[33] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Estimating the contribution of dynamical ejecta in the kilonova associated with GW170817. *Astrophys. J.*, 850(2):L39, December 2017. doi:10.3847/2041-8213/aa9478. .

[34] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). GW170608: Observation of a 19 solar-mass binary black hole coalescence. *Astrophys. J.*, 851(2):L35, December 2017. doi:10.3847/2041-8213/aa9f0c. .

[35] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). On the progenitor of binary neutron star merger GW170817. *Astrophys. J.*, 850(2):L40, December 2017. doi:10.3847/2041-8213/aa93fc. .

[36] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). Search for post-merger gravitational waves from the remnant of the binary neutron star merger GW170817. *Astrophys. J.*, 851(1):L16, December 2017. doi:10.3847/2041-8213/aa9a35. .

[37] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). First search for nontensorial gravitational waves from known pulsars. *Phys. Rev. Lett.*, 120(3):031104, January 2018. doi:10.1103/PhysRevLett.120.031104. .

[38] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). All-sky search for long-duration gravitational wave transients in the first Advanced LIGO observing run. *Class. Quant. Grav.*, 35(6):065009, February 2018. doi:10.1088/1361-6382/aaab76. .

[39] Abbott, B. P. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). GW170817: Implications for the stochastic gravitational-wave background from compact binary coalescences. *Phys. Rev. Lett.*, 120(9):091101, February 2018. doi:10.1103/PhysRevLett.120.091101. .

[40] Tsuna, D., Kawanaka, N., Totani, T. X-ray Detectability of Accreting Isolated Black Holes in our Galaxy *Mon. Notices Royal Astron. Soc.*, 477(1):791, June 2018. doi:10.1093/mnras/sty699. .

[41] Tomoka Tosaki, Kotaro Kohno, et al.: "A statistical study of giant molecular clouds traced by ^{13}CO, C^{18}O, CS, and CH_3OH in the disk of NGC 1068 based on ALMA observations", Publications of the Astronomical Society of Japan, **69** (2017) 18

[42] Hayashi Masao, Tadayuki Kodama, Kotaro Kohno, et al.: "Evolutionary Phases of Gas-rich Galaxies in a Galaxy Cluster at $z = 1.46$", The Astrophysical Journal, **841** (2017) L21

[43] Ken-ichi Tadaki, et al. (including Kotaro Kohno): "Rotating Starburst Cores in Massive Galaxies at $z = 2.5$", The Astrophysical Journal, **841** (2017) L25

[44] Minju M. Lee, et al. (including Kotaro Kohno): "A Radio-to-mm Census of Star-forming Galaxies in Protocluster 4C23.56 at Z = 2.5: Gas Mass and Its Fraction Revealed with ALMA", The Astrophysical Journal, **842** (2017) 55

[45] Natsuki H. Hayatsu et al. (including Kotaro Kohno): "ALMA deep field in SSA22: Blindly detected CO emitters and [C II] emitter candidates", Publications of the Astronomical Society of Japan, **69** (2017) 45

[46] Daniel Espada et al. (including Kotaro Kohno): "Disentangling the Circumnuclear Environs of Centaurus A. III. An Inner Molecular Ring, Nuclear Shocks, and the CO to Warm H_2 Interface", The Astrophysical Journal, **843** (2017) 136

[47] Takuji Yamashita et al. (including Kotaro Kohno): "Cold Molecular Gas Along the Merger Sequence in Local Luminous Infrared Galaxies", The Astrophysical Journal, **844** (2017) 96

[48] Yuki Yamaguchi, Kotaro Kohno et al.: "Blind Millimeter Line Emitter Search using ALMA Data Toward Gravitational Lensing Clusters", The Astrophysical Journal, **845** (2017) 108

[49] Takuma Izumi, Kotaro Kohno et al.: "On the Disappearance of a Cold Molecular Torus around the Low-luminosity Active Galactic Nucleus of NGC 1097", The Astrophysical Journal, **845** (2017) L5

[50] Ryo Ando, Koichiro Nakanishi, Kotaro Kohno et al.: "Diverse Nuclear Star-forming Activities in the Heart of NGC 253 Resolved with 10-pc-scale ALMA Images", The Astrophysical Journal, **849** (2017) 81

[51] Soh Ikarashi et al. (including Kotaro Kohno): "Very Compact Millimeter Sizes for Composite Star-forming/AGN Submillimeter Galaxies", The Astrophysical Journal, **849** (2017) 36

[52] Wei-Hao Wang et al. (including Kotaro Kohno): "SCUBA-2 Ultra Deep Imaging EAO Survey (STUDIES): Faint-end Counts at 450 μm", The Astrophysical Journal, **850** (2017) 37

[53] Luigi Spinoglio et al. (including Kotaro Kohno): "Galaxy Evolution Studies with the SPace IR Telescope for Cosmology and Astrophysics (SPICA): The Power of IR Spectroscopy", Publications of the Astronomical Society of Australia, **34** (2017) e057

[54] Hidehiro Kaneda et al. (including Kotaro Kohno): "Unbiased Large Spectroscopic Surveys of Galaxies Selected by SPICA Using Dust Bands", Publications of the Astronomical Society of Australia, **34** (2017) e059

[55] Yiping Ao et al. (including Kotaro Kohno): "Deep Submillimeter and Radio Observations in the SSA22 Field. I. Powering Sources and the Lyα Escape Fraction of Lyα Blobs", The Astrophysical Journal, **850** (2017) 178

[56] Yoshihiro Ueda, Bunyo Hatsukade, Kotaro Kohno et al.: "ALMA 26 arcmin^2 Survey of GOODS-S at One-millimeter (ASAGAO): X-Ray AGN Properties of Millimeter-selected Galaxies", The Astrophysical Journal, **853** (2018) 24

[57] Taku Nakajima, Shuro Takano, Kotaro Kohno et al.: "A molecular line survey toward the nearby galaxies NGC 1068, NGC 253, and IC 342 at 3 mm with the Nobeyama 45 m radio telescope: Impact of an AGN on 1 kpc scale molecular abundances", Publications of the Astronomical Society of Japan, **70** (2018) 7

[58] Yoshiki Matsuoka et al. (including Kotaro Kohno): "Subaru High-z Exploration of Low-Luminosity Quasars (SHELLQs). II. Discovery of 32 quasars and luminous galaxies at $5.7 < z < 6.8$", Publications of the Astronomical Society of Japan, **70** (2018) 35

[59] S. Morisaki, T. Suyama, "Spontaneous scalarization with an extremely massive field and heavy neutron stars," Phys. Rev. D **96** (2017) no.8, 084026

[60] C. Ringeval, T. Suyama, "Stochastic gravitational waves from cosmic string loops in scaling," JCAP **1712** (2017) no.12, 027

[61] B. Kocsis, T. Suyama, T. Tanaka, S. Yokoyama, "Hidden universality in the merger rate distribution in the primordial black hole scenario," Astrophys.J. **854** (2018) no.1, 41

[62] T. Nakama, T. Suyama, K. Kohri, N. Hiroshima, "Constraints on small-scale primordial power by annihilation signals from extragalactic dark matter minihalos," Phys. Rev. D **97** (2018) no.2, 023539

[63] M. Sasaki, T. Suyama, T. Tanaka, S. Yokoyama, "Primordial black holes -perspectives in gravitational wave astronomy-," Class. Quant. Grav. **35** (2018) no.6, 063001

6.3 International Conference Talks

6.3.1 Contributed talks

[64] Masaki Ando: Status of TOBA torsion bar experiment, Workshop on Future Instruments for Gravity-based Earthquake (Jan 10th, 2018, France).

[65] Y. Enomoto, et al.: Signal Recycling Mirror Reflectivity, 18th KAGRA face-to-face meeting (Dec. 2017, Tokyo Institute of Technology).

[66] K. Komori, et al.: Towards observation of quantum radiation pressure fluctuation acting on a torsion pendulum, 18th KAGRA face-to-face meeting (Dec. 2017, Tokyo Institute of Technology).

[67] Satoru Takano, et al.: The current status of TOrsion Bar Antenna (TOBA), 18th KAGRA Face to Face Meeting (Dec 2017, Tokyo Institute of Technology).

[68] Ching Pin Ooi, et al.: Investigation of mechanical loss in torsion pendulums, 18th KAGRA Face to Face Meeting (Dec 2017, Tokyo Institute of Technology).

[69] Y. Enomoto, et al.: Expected Sensitivity Growth and Signal Recycling, 17th KAGRA face-to-face meeting (Aug. 2017, University of Toyama).

[70] K. Komori, et al.: Suspension thermal noise calculations for KAGRA, 17th KAGRA face-to-face meeting (Aug. 2017, University of Toyama).

[71] K. Komori, et al.: Proposal to update the latest estimated sensitivity of KAGRA, 17th KAGRA face-to-face meeting (Aug. 2017, University of Toyama).

[72] K. Komori, et al.: Scientific targets of future KAGRA, 17th KAGRA face-to-face meeting (Aug. 2017, University of Toyama).

[73] Yuta Michimura: Summary of KSC Session, 17th KAGRA Face to Face Meeting (Aug. 2017, University of Toyama).

[74] Yuta Michimura for the KAGRA Collaboration: The status of KAGRA underground cryogenic gravitational wave telescope, XV International Conference on Topics in Astroparticle and Underground Physics, (Jul 2017, Sudbury).

[75] Yuta Michimura, et al.: Possibility of Upgrading KAGRA, 3rd KAGRA International Workshop (May 2017, Taipei).

[76] Masaki Ando: Observation Scenario Paper and Roadmap, 3rd KAGRA International Workshop (May 2017, Taipei).

[77] Tomofumi Shimoda, et al.: Seismic Cross-Coupling Noise in TOrsion-Bar Antenna, GWADW2017 (May 9th, 2017, Australia).

[78] N. Aritomi, et al.: Monolithic Power Recycling Michelson Interferometer for TOBA, GWADW2017 (May 9th, 2017, Australia).

[79] Yuta Michimura: Optical Cavity Tests of Lorentz Invariance, Light driven Nuclear-Particle physics and Cosmology 2017 (Apr 2017, Yokohama).

[80] Mitsuda, K., Doi, M., Morokuma, T., Suzuki, N., Yasuda, N., Perlmutter, S., Aldering, G., Meyers, J.: "Isophote Shapes Of Early-Type Galaxies In Massive Clusters at z ?1 and 0", Galaxy evolution across cosmic time (Paris, France, June 12-16, 2017)

[81] Ryou Ohsawa, Shigeyuki Sako, Toshikazu Shigeyama, Mamoru Doi, Kentaro Motohara, Tomoki Morokuma, Naoto Kobayashi, Nozomu Tominaga, Masaomi Tanaka, and Tomo-e Gozen Project Team, "Development of a Wide-Field CMOS Camera: Tomo-e Gozen and Contributions to EM Follow-up Observations of Gravitational Wave Events", Gravitational Wave Physics and Astronomy Workshop 2017 (Annecy, France, May 30 - June 2, 2017)

[82] Mamoru Doi, on behalf of TAO project: "The University of Tokyo Atacama Observatory (TAO) project", Chajnantor Working Group 2017 (OSF-ALMA, Chile, May 21-22, 2017)

[83] Ryou Ohsawa, Shigeyuki Sako, Mamoru Doi, Naoto Kobayashi, Fumihiko Usui, Jun-ichi Watanabe, Ko Arimatsu, Seitaro Urakawa, Shin-ichiro Okumura, Maokoto Yoshikawa, and Tomo-e Gozen Development Team, "Contributions to Observations of Near-Earth Objects by a Wide-Field CMOS Camera Tomo-e", International Academy of Astronautics Planetary Defense Conference 2017, (Tokyo, Japan, May 15-19, 2017)

[84] Kotaro Kohno: "Quest for dusty high-z star-forming galaxies based on unbiased ALMA deep surveys", Distant Galaxies from the Far South (Bariloche, Argentina, December 11-15, 2017)

[85] Kotaro Kohno: "Blind spectroscopic galaxy surveys using an ultra-wide-band imaging spectrograph on AtLAST and LST (and LMT)", AtLAST workshop (ESO, Garching, Germany, January 17-19, 2018)

[86] T. Suyama, "PBH binary formation in radiation dominated era", Focus week on primordial black holes, Kavli IPMU, Kashiwa, 2017/11/13-17

[87] T. Suyama, "Primordial black holes in the era of gravitational wave astronomy", Area workshop of "Gravitational Wave Physics and Astronomy: Genesis" Tohoku University, Sendai, 2017/12/7

[88] T. Suyama, "Spontaneous scalarization with an extremely massive field and heavy neutron stars", Gravity@Malta 2018, University of Malta, Malta, 2018/1/22-25

[89] T. Suyama, "Hidden universality in the merger rate of the primordial black hole binaries", Third symposium on "Why does the Universe Accelerate?", Tohoku University, Sendai, 2018/2/10-12

[90] T. Suyama, "LIGO and Primordial Black Holes", Conference on Particle Physics, HongKong University of Science and Technology, HongKong, 2017/6/25-30

[91] T. Suyama, "Primordial black holes in the era of gravitational wave astronomy", Third LeCosPA symposium, National Taiwan University, Taipei, 2017/11/27-29

[92] T. Suyama, "Primordial black holes and gravitational waves", CosPA2017, Kyoto University, Kyoto, 2017/12/11-15

[93] T. Suyama, "Spontaneous scalarization and heavy neutron stars", YKIS2018a Symposium "General Relativity - The Next Generation-", Kyoto University, Kyoto, 2018/2/19-23

6.3.2 Invited talks

[94] Masaki Ando: KAGRA and B-DECIGO, YKIS2018a Symposium (Feb. 19th, 2018, Kyoto University).

[95] Masaki Ando: Observation of Gravitational Waves, Japan-France Workshop " Neutron Star Mergers and Galactic Chemical Evolution " (Oct. 20th, 2017, NAOJ).

[96] Yuta Michimura: Laser Interferometry for Gravitational Wave Astronomy, International OSA Network of Students 2017 (Oct 2017, Okinawa).

[97] Masaki Ando: Science and Design of DECIGO and B-DECIGO, ISGW2017: International Symposium on Gravitational Waves (May 26th, 2017, Beijing, China).

[98] Masaki Ando: Science and Design of DECIGO and B-DECIGO, The 2nd ASTROD International Workshop (May 22nd, 2017, National Tsing Hua Univ., Taiwan).

[99] Masaki Ando: Science and Design of DECIGO and B-DECIGO, The 3rd KAGRA International Workshop (May 21st, 2017, Academia Sinica, Taiwan).

[100] Yuta Michimura, et al.: Possible KAGRA Upgrades, Gravitational Wave Advanced Detector Workshop 2017 (May 2017, Australia).

[101] Masaki Ando, et al.: Status of TOBA for Low-frequency GW Observations, Gravitational Wave Advanced Detector Workshop 2017 (May 2017, Australia).

[102] Kotaro Kohno: "Molecular gas properties of the heavily obscured active nucleus in NGC 7172 selected by Swift/BAT all sky survey", Behind the Curtain of Dust II (BCD2017) - The Molecular and Multi-Wavelength View of Activity in (U)LIRGs (Haus Sexten, Sesto, Italy, June 3-7, 2017)

[103] Kotaro Kohno: "Multi-wavelength surveys of dusty star-forming galaxies using AzTEC, SCUBA2, Subaru and ALMA", SMG20 - Twenty years of Submillimetre Galaxies: star-forming galaxies at high redshifts (Durham, UK, July 31-August 2, 2017)

[104] Kotaro Kohno: "Dusty star-forming galaxies explored with ALMA", Star Formation in Different Environments 2017 (SFDE2017): From local clouds to distant galaxies (ICISE, Quy Nhon, VietNam, August 6-12, 2017)

[105] Kotaro Kohno: "Unveiling dust-enshrouded activities in high-redshift galaxies using ALMA and infrared space telescopes", The Cosmic Wheel and the Legacy of the AKARI archive: from galaxies and stars to planets and life (Ito Hall, The University of Tokyo, Hongo, Japan, October 17-20, 2017)

[106] Kotaro Kohno: "Galactic nuclei and feedback processes", The origin of galaxies, stars, and planets in the era of ALMA (Pasadena, CA, USA, November 29-December 1, 2017)

7 Project 3. Formation and characterization of planetary systems

7.1 Activity Report

Project 3 "Formation and characterization of planetary systems" approaches the problem both theoretically and observationally through the collaboration with members in Departments of Physics, Astronomy, and Earth and Planetary Sciences. We show several highlights of our research this year.

7.1.1 Systematic Search for Rings around *Kepler* Planets

We perform a systematic search for rings around 168 *Kepler* planets with sufficient signal-to-noise ratios that are selected from all the archived data of the short-cadence. We fit ringed and ringless models to their lightcurves, and compare the fitting results to search for the signatures of planetary rings. First, we identify 29 tentative systems, for which the ringed models exhibit statistically improvement over the ringless models. The lightcurves of those systems are individually examined, but we are not able to identify any candidate that indicates evidence for rings. In turn, we find out several mechanisms of false-positives that would reproduce ring-like signals, and the null detection enables us to place upper limits on the size of rings. Furthermore, assuming the tidal alignment between axes of the planetary rings and orbits, we conclude that the probability of planets with an outer ring twice larger than the planetary radius is less than 15 percent. Even though the majority of our targets are short-period planets, our null detection provides statistical and quantitative constraints on largely uncertain theoretical models of origin, formation, and evolution of planetary rings.

7.1.2 Application of asteroseismology to spin-orbit angle distribution of transiting exoplanetary systems

Advances in asteroseismology of solar-like stars, now provide a unique method to estimate the stellar inclination. This enables to evaluate the spin-orbit angle of transiting planetary systems, in a complementary fashion to the Rossiter-McLaughlin effect, a well-established method to estimate the *projected* spin-orbit angle λ. Although the asteroseismic method has been broadly applied to the *Kepler* data, its reliability has yet to be assessed intensively. We evaluate the accuracy of i_* from asteroseismology of solar-like stars using 3000 simulated power spectra. We derive analytical criteria for the reliable asteroseismic estimate, which indicates that reliable measurements are possible in the range of $20^\circ \lesssim i_* \lesssim 80^\circ$ only for stars with high signal-to-noise ratio. We also analyse and measure the stellar inclination of 94 *Kepler* main-sequence solar-like stars, among which 33 are planetary hosts.

7.1.3 Exoplanet Observations and Instrumentations

Direct imaging of exoplanets and their forming regions such as circumstellar disks is technically challenging but an important step from detection to characterization of exoplanets and disks. The SEEDS project using the HiCIAO camera on the 8.2m Subaru telescope has been successful to study young stars in very high-contrast since 2009. After its main survey phase, we are engaged in extending this study using new direct imaging instruments, SCExAO and CHARIS. The former is an extreme adaptive optics system and the latter is a near-infrared integral field unit (IFU) spectrometer dedicated for high contrast imaging and

spectroscopy. In this year, we have published several SCExAO science papers, SEEDS papers using the main survey data and their follow-up data, and the instrument papers. Notable are the CHARIS reduction pipeline paper (Brandt et al. 2017), and the vector vortex coronagraph paper (Kuhn et al. 2018).
In order to explore the small planets such as exo-Earths, we are also developing several other instruments for exoplanet observations: (a) an Earth-like planet hunting radial velocity instrument working at near-infrared and combined with a laser-frequency comb (IRD) for the Subaru telescope, which will be very powerful to detect habitable planets around nearby M stars, (b) a TESS-follow-up optical transit camera, MuSCAT2 for the TCS 1.52m telescope at Teide Observatory in the Canary Islands, Spain, (c) a coronagraph for earth-like planet imaging on the 30m telescope TMT, SEIT, and (d) a coronagraph for NASA WFIRST 2.4m space telescope mission. Both IRD and MuSCAT2 have successfully completed in FY2017. We also jointly operate the 1.4m IRSF telescope, the SIRIUS camera, and its polarimeter SIRPOL in South Africa with the Nagoya and other universities, and conducting a near-infrared polarization survey of various targets. This is the most extensive near-infrared polarization study ever made and providing useful astronomical data for astrobiology such as life homochirarity.

7.1.4 Solar System Explorations

We are engaged in missions for both small and large bodies in the solar system. In FY2017, however, we were very much focused on small-body mission activities because the arrival of Hayabuas2 to target asteroid Ryugu in the beginning of FY2018 and its main mission phase would continue throughout the rest of the year.

We conducted a series of calibration observations/analyses for multi-band camera on Hayabusa2 in 2017, using Jupiter, Saturn, and stars throughout the calendar year of 2017 as a part of pre-arrival preparation. These observation results indicate that the camera system on Hayabusa2 is in a good condition without any noticeable damage or major deterioration since the pre-flight calibrations. We also conducted the first observation of Ryugu with our camera at distance about 10^6 km in Feb. 2018. Although the signal-to-noise ratio of the obtained data of Ryugu in this "first light" observation was not very high, they were good enough to validate our light flux estimates and overall spectral shape of Ryugu.

We also conducted a couple of series of studies based on asteroid Itokawa data. One was on principal-component analysis of its surface multi-band visible spectra. The results indicate that compositionally very homogeneous Itokawa surface exhibits wide range of space weathering and that its spectral trend due to space weathering can account for the difference between Q-type asteroids and S-type asteroids. Such direct connection between these two types of asteroids has not been demonstrated with actual asteroid spectra. Such demonstration strongly suggests that this method is also useful for Hayabusa2 data analysis of C-type asteroid. The other is on impact experiments in the laboratory, investigating cratering efficiency on granular targets, whose constituent grains are comparable to that of projectiles. Such geometric cofiguration has not been studies before because it would not occur on large planetary bodies. However, this is a universal problem on small bodies. In particular, asteroid mission data from Hayabusa, Hayabusa2, NASA's OSIRIS-REx and DART, will have this problem. Our result show that crater size scaling on granular target is greatly modified from the classic gravity scaling law when the projectile/targe grain size ratio is close to unity or smaller. However, the ratio is more than three, the resulting scaling law is not very different from gravity scaling law. This is very different from our conventional wisdom that crater size under such condition should be ruled by a strength-scaling law. This result will have major implications for crater chronology on small bodies.

7.1.5 Theoretical prediction for transmission spectra of hydrogen-rich atmospheres of transiting exoplanets

The space telescope *Kepler* discovered a great number of super-Earth-sized exoplanets with short orbital periods. Those planets must have formed afar and migrated to their present location. Their bulk and atmospheric compositions provide a clue to planet formation. Follow-up observations have determined the masses of some of the *Kepler* planets. Their mass-vs-radius relationships indicate that close-in super-Earths have diverse atmospheres. Recently, properties of exoplanet atmospheres have been constrained via multi-wavelength transit observation, which measures an apparent decrease in stellar brightness during planetary transit. Sets of transit depths so far measured at different wavelengths (called transmission spectra) are somewhat diverse: some show distinct molecular-absorption features, some show Rayleigh slope features in the visible, some contain featureless spectra in the near-infrared [3]. Those facts imply the existence of photochemically-produced haze in the atmospheres, especially of warm super-Earths. We have developed a new computation code for modeling the atmospheric chemistry, deriving the spatial and size distributions of haze particles via direct simulation of the creation, growth, and settling of hydrocarbon haze particles, and then generating transmission spectra of UV-irradiated, solar-abundance atmospheres of close-in warm ($\sim$ 500K) exoplanets. We have found that the haze is distributed in the atmosphere much more broadly than previously assumed, and consists of particles of various sizes. We have also demonstrated that the observed diversity of transmission spectra can be explained by the difference in the production rate of haze monomers, which is related to the UV irradiation intensity from host stars.

7.1.6 Direct Detection of Titanium Oxide in an ultra hot Jupiter

We detected Titanium Oxide (TiO) in an ultra hot Jupiter, WASP-33b, using a high-dispersion spectrograph (HDS) on Subaru telescope [4]. TiO is one of the essential molecules which determines the thermal structure of the planetary atmosphere. TiO works as a stellar light absorber in the high-altitude atmosphere and potentially induces the temperature inversion layer, like Ozone in our Earth. Our detection opens a new aspect of the atmospheric chemistry in ultra hot Jupiters.

7.1.7 Discovery of self-lensing binaries

We discovered four new self-lensing binaries in the Kepler dataset [5]. We confirmed those binaries by radial velocity follow-up observations, which revealed that those systems are a white dwarf (WD)-star binary with a long period orbit (a yr scale). Three of those are on the theoretical period-WD mass plane of the stable mass transfer by Rappaport, suggesting that those systems are a field blue straggler. The rest is a mysterious extremely low mass WD. This success proved that the method that found those systems work well and can be applied to a near-future survey of long-period transiting planets in the TESS era.

7.2 Publication List

[1] Genda, H., Iizuka, T., Sasaki, T., Ueno, Y., & Ikoma, M.: "Ejection of iron-bearing giant-impact fragments and the dynamical and geochemical influence of the fragment re-accretion." E&PSL 470 (2017)

[2] Kurosaki, K. & Ikoma, M.: "Acceleration of cooling of ice giants by condensation in early atmospheres." Astron. J. 153 (2017)

[3] Kawashima, Y. & Ikoma, M. :"Theoretical transmission spectra of exoplanet atmospheres with hydrocarbon haze: Effect of creation, growth, and settling of haze particles. I. Model description and first results." Astrophys. J. 853 (2018)

[4] Stevanus K. Nugroho, Hajime Kawahara, Kento Masuda, Teruyuki Hirano, Takayuki Kotani, Akito Tajitsu: "High-Resolution Spectroscopic Detection of TiO and Stratosphere in the Day-side of WASP-33b", The Astronomical Journal, **154** (2017) 221

[5] Hajime Kawahara, Kento Masuda, Morgan MacLeod, David W. Latham, Allyson Bieryla, Othman Benomar: "Discovery of Three Self-lensing Binaries from Kepler", The Astronomical Journal, **155** (2018) 144

[6] Cho, Y., M. Horiuchi, K. Shibasaki, S. Kameda and S. Sugita: "Quantitative Potassium Measurements with Laser-Induced Breakdown Spectroscopy Using Low-Energy Lasers: Application to In Situ K-Ar Geochronology for Planetary Exploration", Appl. Spectroscopy 71 (2017)

[7] Cho, Y., S. Kameda, M. Okuno, M. Horiuchi, K. Shibasaki, R. Wagatsuma, Y. Aida, Y. N. Miura, K. Yoshioka, R. Okazaki, S. and Sugita: "Experimental characterization of elastomeric O-rings as reusable seals for mass spectrometric measurements: application to in situ K-Ar dating on Mars.", Adv. Sp. Res., 60 (2017)

[8] Kameda, S, S. Ikezawa, M. Sato, M. Kuwabara, N. Osada, G. Murakami, K. Yoshioka, I. Yoshikawa, M. Taguchi, R. Funase, S. Sugita, Y. Miyoshi, M. Fujimoto: "Ecliptic north-south symmetry of hydrogen geocorona: hydrogen geocorona.", Geophys. Res. Lett. 44 (2017).

[9] Koga, S. C., S. Sugita, S. Kamata, M. Ishiguro, T. Hiroi, E. Tatsumi, S. Sasaki:"Spectral decomposition of asteroid Itokawa based on principal component analysis", Icarus, 299 (2018)

[10] Suzuki, H., M. Yamada, K. Kameda, T. Kouyama, E. Tatsumi, R. Honda, H. Sawada, N. Ogawa, T. Morota, C. Honda, N. Sakatani, M. Hayakawa, Y. Yokota, Y. Yukio, and S. Sugita: "Initial inflight calibration for Hayabusa2 optical navigation camera (ONC) for science observations of asteroid Ryugu", Icarus, 300 (2018)

[11] Tatsumi, E. and S. Sugita:"Cratering efficiency on coarse-grain targets: implications for the dynamical evolution of asteroid 25143 Itokawa", Icarus, 300 (2018)

[12] Kuwahara, H., H. Gotou, T. Shinmei, N. Ogawa, A. Yamaguchi, N. Takahata, Y. Sano, T. Yagi, S. Sugita:"High pressure experiments on metal-silicate partitioning of chlorine in a magma ocean: Implications for terrestrial chlorine depletion", Geochim. Gchiphys. Geosys., 8, 1-7, (2018)

[13] Le Corre, L., V. Reddy, J. A. Sanchez, D. Takir, E. Cloutis, A. Thirouin, K. Becker, J.Y. Li1, S. Sugita, E. Tatsumi:"Ground-based Characterization of Hayabusa2 Mission Target Asteroid 162173 Ryugu: Constraining Mineralogical Composition in Preparation for S/C Operations", MNRAS, 475 (2018)

[14] Hong, P., Y. Sekine,T. Sasamori,S. Sugita: "Experimental study of heterogeneous organic chemistry induced by far ultraviolet light: Implications for growth of organic aerosols by CH3 addition in the atmospheres of Titan and early Earth", Icarus, Volume 307 (2018)

[15] Tatsumi, E., D. Domingue, N. Hirata, K. Kitazato, F. Vilas, S. Lederer, P. R. Weissmann, S. C. Lowry, and S. Sugita: "Vis-NIR Disk-integrated Photometry of Asteroid 25143 Itokawa Around Opposition by AMICA/Hayabusa", Icarus, in press.

[16] Thuillet, F., P. Michel, C. Maurel, R.-L. Ballouz, Y. Zhang, D. C. Richardson, and J. Biele, E. Tatsumi, and S. Sugita,:"Numerical modeling of lander interaction with a low-gravity asteroid regolith surface Application to MASCOT onboard Hayabusa2", Astron. Astrophys., in press.

[17] Soma, T., Sakai, N., Watanabe, Y., & Yamamoto, S., "Complex Organic Molecules in Taurus Molecular Cloud-1", ApJ, 854, 116 (11pp) (2018).

[18] Oya Y., Moriwaki, K., Onishi, S., Sakai, N., López-Sepulcre, A., Favre, C., Watanabe, Y., Ceccarelli, C., Lefloch, B., & Yamamoto, S., "Chemical and Physical Picture of IRAS 16293−2422 Source B at a Subarcsecond Scale Studied with ALMA", ApJ, 854, 96 (19pp) (2018).

[19] Nishimura, Y., Watanabe, Y., Harada, N., Sakai, N., Shimonishi, T., Aikawa, Y., Kawamura, A., & Yamamoto, S., "Molecular-cloud-scale Chemical Composition II. A Mapping Spectral Line Survey toward W3(OH) in the 3 mm Band", ApJ, 848, 17 (18pp) (2017).

[20] Watanabe, Y., Sakai, N., Lopez-Sepulcre, A., Sakai, T., Hirota, T., Liu, S.-Y., Su, Y.-N., & Yamamoto, S., "Discovery of Striking Difference of Molecular-emission-line Richness in the Potential Proto-binary System NGC 2264 CMM3", ApJ, 847, 108 (8pp) (2017).

[21] Watanabe, Y., Nishimura, Y., Harada, N., Sakai, N., Shimonishi, T., Aikawa, Y., Kawamura, A., & Yamamoto, S., "Molecular-cloud-scale Chemical Composition I. A Mapping Spectral Line Survey toward W51 in the 3 mm Band", ApJ, 845, 116 (30pp) (2017).

[22] Zhiwei Chen, Zhibo Jiang, Motohide Tamura, Jungmi Kwon, A. Roman-Lopes: " A Curved Magnetic Field in the Ring-like Shell of Bubble N4 ", The Astrophysical Journal, **838**, article id. 80, 5 pp. (2017)

[23] Norio Narita, Teruyuki Hirano, Akihiko Fukui, Yasunori Hori, Fei Dai, Liang Yu, John Livingston, Tsuguru Ryu, Grzegorz Nowak, Masayuki Kuzuhara, Bun'ei Sato, Yoichi Takeda, Simon Albrecht, Tomoyuki Kudo, Nobuhiko Kusakabe, Enric Palle, Ignasi Ribas, Motohide Tamura, Vincent Van Eylen, Joshua N. Winn: " The K2-ESPRINT project. VI. K2-105 b, a hot Neptune around a metal-rich G-dwarf ", Publications of the Astronomical Society of Japan, **69**, id.29 (2017)

[24] Masahiro Onitsuka, Akihiko Fukui, Norio Narita, Teruyuki Hirano, Nobuhiko Kusakabe, Tsuguru Ryu, Motohide Tamura: " Multi-color simultaneous photometry of the T-Tauri star with planetary candidate, CVSO 30T ", Publications of the Astronomical Society of Japan, **69** id.L2 (2017)

[25] Hauyu Baobab Liu, Eduard I. Vorobyov, Ruobing Dong, Michael M. Dunham, Michihiro Takami, Roberto Galvan-Madrid, Jun Hashimoto, Agnes Kospal, Thomas Henning, Motohide Tamura, Luis F. Rodriguez, Naomi Hirano, Yasuhiro Hasegawa, Misato Fukagawa, Carlos Carrasco-Gonzalez, Marco Tazzari: " A concordant scenario to explain FU Orionis from deep centimeter and millimeter interferometric observations ", Astronomy & Astrophysics, **602**, id.A19, 10 pp. (2017)

[26] Derek Ward-Thompson, Kate Pattle, Pierre Bastien, Ray S. Furuya, Woojin Kwon, Shih-Ping Lai, Keping Qiu, David Berry, Minho Choi, Simon Coude James Di Francesco, Thiem Hoang, Erica Franzmann, Per Friberg, Sarah F. Graves, Jane S. Greaves, Martin Houde, Doug Johnstone, Jason M. Kirk, Patrick M. Koch,

Jungmi Kwon, Chang Won Lee, Di Li, Brenda C. Matthews, Joseph C. Mottram, Harriet Parsons, Andy Pon, Ramprasad Rao, Mark Rawlings, Hiroko Shinnaga, Sarah Sadavoy, Sven van Loo, Yusuke Aso, Do-Young Byun, Chakali Eswaraiah, Huei-Ru Chen, Mike C.-Y. Chen, Wen Ping Chen, Tao-Chung Ching, Jungyeon Cho, Antonio Chrysostomou, Eun Jung Chung, Yasuo Doi, Emily Drabek-Maunder, Stewart P. S. Eyres, Jason Fiege, Rachel K. Friesen, Gary Fuller, Tim Gledhill, Matt J. Griffin, Qilao Gu, Tetsuo Hasegawa, Jennifer Hatchell, Saeko S. Hayashi, Wayne Holland, Tsuyoshi Inoue, Shu-ichiro Inutsuka, Kazunari Iwasaki, Il-Gyo Jeong, Ji-hyun Kang, Miju Kang, Sung-ju Kang, Koji S. Kawabata, Francisca Kemper, Gwanjeong Kim, Jongsoo Kim, Kee-Tae Kim, Kyoung Hee Kim, Mi-Ryang Kim, Shinyoung Kim, Kevin M. Lacaille, Jeong-Eun Lee, Sang-Sung Lee, Dalei Li, Hua-bai Li, Hong-Li Liu, Junhao Liu, Sheng-Yuan Liu Tie Liu, A-Ran Lyo, Steve Mairs, Masafumi Matsumura, Gerald H. Moriarty-Schieven, Fumitaka Nakamura, Hiroyuki Nakanishi, Nagayoshi Ohashi, Takashi Onaka, Nicolas Peretto, Tae-Soo Pyo, Lei Qian, Brendan Retter, John Richer, Andrew Rigby, Jean-Francois Robitaille, Giorgio Savini, Anna M. M. Scaife, Archana Soam, Motohide Tamura, Ya-Wen Tang, Kohji Tomisaka, Hongchi Wang, Jia-Wei Wang, Anthony P. Whitworth, Hsi-Wei Yen, Hyunju Yoo, Jinghua Yuan, Chuan-Peng Zhang, Guoyin Zhang, Jianjun Zhou, Lei Zhu, Philippe Andre, C. Darren Dowell, Sam Falle, Yusuke Tsukamoto: " First Results from BISTRO: A SCUBA-2 Polarimeter Survey of the Gould Belt ", The Astrophysical Journal, **842**, article id. 66, 10 pp. (2017)

[27] Ryo Kandori, Motohide Tamura, Nobuhiko Kusakabe, Yasushi Nakajima, Jungmi Kwon, Takahiro Nagayama, Tetsuya Nagata, Kohji Tomisaka, Kenichi Tatematsu: " Distortion of Magnetic Fields in a Starless Core: Near-infrared Polarimetry of FeSt 1-457 ", The Astrophysical Journal, **845**, article id. 32, 10 pp. (2017)

[28] Kenji Takizawa, Jun Minagawa, Motohide Tamura, Nobuhiko Kusakabe, Norio Narita: " Red-edge position of habitable exoplanets around M-dwarfs ", Scientific Reports, **7**, id. 7561 (2017)

[29] Taichi Uyama, Takayuki Tanigawa, Jun Hashimoto, Motohide Tamura, Yuhiko Aoyama, Timothy D. Brandt, Masato Ishizuka: " Constraining Accretion Signatures of Exoplanets in the TW Hya Transitional Disk ", The Astronomical Journal, **154**, article id. 90, 6 pp. (2017)

[30] Ryo Kandori, Motohide Tamura, Kohji Tomisaka, Yasushi Nakajima, Nobuhiko Kusakabe, Jungmi Kwon, Takahiro Nagayama, Tetsuya Nagata, Kenichi Tatematsu: " Distortion of Magnetic Fields in a Starless Core II: 3D Magnetic Field Structure of FeSt 1-457 ", The Astrophysical Journal, **848**, article id. 110, 7 pp. (2017)

[31] Timothy D. Brandt, Maxime Rizzo, Tyler Groff, Jeffrey Chilcote, Johnny P. Greco, N. Jeremy Kasdin, Mary Anne Limbach, Michael Galvin, Craig Loomis, Gillian Knapp, Michael W. McElwain, Nemanja Jovanovic, Thayne Currie, Kyle Mede, Motohide Tamura, Naruhisa Takato, Masahiko Hayashi: " Data reduction pipeline for the CHARIS integral-field spectrograph I: detector readout calibration and data cube extraction ", Journal of Astronomical Telescopes, Instruments, and Systems, **3**, id. 048002 (2017)

[32] Chakali Eswaraiah, Shih-Ping Lai, Wen-Ping Chen, A. K. Pandey, M. Tamura, G. Maheswar, S. Sharma, Jia-Wei Wang, S. Nishiyama, Y. Nakajima, Jungmi Kwon, R. Purcell, A. M. Magalhaes: " Understanding the Links among the Magnetic Fields, Filament, Bipolar Bubble, and Star Formation in RCW 57A Using NIR Polarimetry ", The Astrophysical Journal, **850**, article id. 195, 22 pp. (2017)

[33] Evan A. Rich, John P. Wisniewski, Michael W. McElwain, Jun Hashimoto, Tomoyuki Kudo, Nobuhiko Kusakabe, Yoshiko K. Okamoto, Lyu Abe, Eiji Akiyama, Wolfgang Brandner, Timothy D. Brandt, Phillip Cargile, Joseph C. Carson, Thayne M. Currie, Sebastian Egner, Markus Feldt, Misato Fukagawa, Miwa Goto, Carol A. Grady, Olivier Guyon, Yutaka Hayano, Masahiko Hayashi, Saeko S. Hayashi, Leslie Hebb, Krzysztof G. He?miniak, Thomas Henning, Klaus W. Hodapp, Miki Ishii, Masanori Iye, Markus Janson, Ryo Kandori, Gillian R. Knapp, Masayuki Kuzuhara, Jungmi Kwon, Taro Matsuo, Satoshi Mayama, Shoken Miyama, Munetake Momose, Jun-Ichi Morino, Amaya Moro-Martin, Takao Nakagawa, Tetsuo Nishimura, Daehyeon Oh, Tae-Soo Pyo, Joshua Schlieder, Eugene Serabyn, Michael L. Sitko, Takuya Suenaga, Hiroshi Suto, Ryuji Suzuki, Yasuhiro H. Takahashi, Michihiro Takami, Naruhisa Takato, Hiroshi Terada, Christian Thalmann, Daigo Tomono, Edwin L. Turner, Makoto Watanabe, Toru Yamada, Hideki Takami, Tomonori Usuda, Motohide Tamura: " The fundamental stellar parameters of FGK stars in the SEEDS survey ", Monthly Notices of the Royal Astronomical Society, **472**, p.1736-1752 (2017)

[34] T. Baug, L. K. Dewangan, D. K. Ojha, Kengo Tachihara, A. K. Pandey, Saurabh Sharma, M. Tamura, J. P. Ninan, S. K. Ghosh: " Star Formation in the Sh 2-53 Region Influenced by Accreting Molecular Filaments ", The Astrophysical Journal, **852**, article id. 119, 12 pp. (2018)

[35] Jungmi Kwon, Takao Nakagawa, Motohide Tamura, James H. Hough, Minho Choi, Ryo Kandori, Tetsuya Nagata, Miju Kang: " First Near-infrared Imaging Polarimetry of Young Stellar Objects in the Circinus Molecular Cloud ", The Astrophysical Journal Supplement Series, **234**, article id. 42, 18 pp. (2018)

[36] John H. Livingston, Fei Dai, Teruyuki Hirano, Davide Gandolfi, Grzegorz Nowak, Michael Endl, Sergio Velasco, Akihiko Fukui, Norio Narita, Jorge Prieto-Arranz, Oscar Barragan, Felice Cusano, Simon Albrecht,

Juan Cabrera , William D. Cochran, Szilard Csizmadia, Hans J. Deeg, Philipp Eigmuller, Anders Erikson, Malcolm Fridlund1, Sascha Grziwa, Eike W. Guenther, Artie P. Hatzes, Kiyoe Kawauchi, Judith Korth, David Nespral, Enric Palle, Martin Patzold, Carina M. Persson, Heike Rauer, Alexis M. S. Smith, Motohide Tamura, Yusuke Tanaka, Vincent Van Eylen, Noriharu Watanabe, Joshua N. Winn: " Three Small Planets Transiting a Hyades Star ", The Astronomical Journal, **155**, article id. 115, 11 pp. (2018)

[37] Teruyuki Hirano, Fei Dai, Davide Gandolfi, Akihiko Fukui, John H. Livingston, Kohei Miyakawa, Michael Endl, William D. Cochran, Francisco J. Alonso-Floriano, Masayuki Kuzuhara, David Montes, Tsuguru Ryu, Simon Albrecht, Oscar Barragan, Juan Cabrera, Szilard Csizmadia, Hans Deeg, Philipp Eigmuller , Anders Erikson, Malcolm Fridlund, Sascha Grziwa, Eike W. Guenther, Artie P. Hatzes, Judith Korth, Tomoyuki Kudo, Nobuhiko Kusakabe, Norio Narita, David Nespral, Grzegorz Nowak, Martin Patzold, Enric Palle, Carina M. Persson, Jorge Prieto-Arranz, Heike Rauer, Ignasi Ribas, Bunei Sato, Alexis M. S. Smith, Motohide Tamura, Yusuke Tanaka, Vincent Van Eylen, Joshua N. Winn: " Exoplanets around Low-mass Stars Unveiled by K2 ", The Astronomical Journal, **155** article id. 127, 23 pp. (2018)

[38] J. Kuhn, E. Serabyn, J. Lozi, N. Jovanovic, T. Currie, O. Guyon, T. Kudo, F. Martinache, K. Liewer, G. Singh, M. Tamura, D. Mawet, J. Hagelberg, D. Defrere: " An H-band Vector Vortex Coronagraph for the Subaru Coronagraphic Extreme-adaptive Optics System ", Publications of the Astronomical Society of the Pacific, **130**, pp. 035001 (2018)

7.3 International Conference Talks

7.3.1 Contributed talks

[39] Schmitz, N., Jaumann, R., Koncz, A., Schroeder, S., Trauthan, F., Mottola, S. Hoffmann, H. Michaelis, H.; Otto, K., Sugita, S. and Perez-Prieto (2018), L., The Camera of the MASCOT Asteroid Lander on Board Hayabusa 2 ? Science Objectives, Imaging Sequences, and Instrument Design, XXXXIX, Houston, TX, USA, March 20-24, #2818, pp.1-2.

[40] Ehlmann, B. L., A. Klesh, T. Alsedairy, R. Dekany, J. Dickson, C. Edwards, F. Forget, A. Fraeman, D. McCleese, S. Murchie, T. Usui, S. Sugita, K. Yoshioka, J. Baker (2018), Mars Nano Orbiter: A Cubesat for Mars System Science, XXXXIX, Houston, TX, USA, March 20-24, #2818, pp.1-2.

[41] Sugita, S., E. Tatsumi, T. Kouyama, S. Kameda, Y. Yokota, S. Sakatani, H. Suzuki, M. Yamada, H. Sawada, R. Honda, C. Honda, T. Morota, K. Ogawa, M. Hayakawa, K. Yoshioka, N. Ogawa, N., Tanabe, H. Kamiyoshihara, Y. Iijima, ONC Team (2018), Pre-Arrival Scientific Calibration of the Hayabusa2 Multi-Band Visible Camera, XXXXIX, Houston, TX, USA, March 20-24, #2818, pp.1-2.

[42] Tatsumi, E., S. Sugita (2018), Itokawa's Orbital Transition from Main Belt to Near-Earth Orbit as Derived from Spectral Ages of Quasi-Circular Depressions on Itokawa, XXXXIX, Houston, TX, USA, March 20-24, #1945, pp.1-2.

[43] Tatsumi, E., D. Domingue, N. Hirata, K. Kitazato, F. Vilas, S. M. Lederer, P. R. Weissman, S. C. Lowrys, S. Sugita (2018), Regolith Properties on the S-Type Asteroid Itokawa Estimated from Photometrical Measurements, XXXXIX, Houston, TX, USA, March 20-24, #1921, pp.1-2.

[44] Yabuta, H. ,N. Hirata, R. Honda, Y. Ishihara, K. Kitazato, M. Komatsu, A. Miura, K. Matsumoto, T. Morota, T. Nakamura, A. Nakato, T. Noguchi, T. Okada, N. Sakatani, S. Sugita, S. Tachibana, S. Tanaka, E. Tatsumi, S. Watanabe, T. Yamaguchi, Y. Yamamoto, Hayabusa2 Lssaa Team (2018), Hayabusa2 Landing Site Selection (LSS) Training: Summary Report of Scientific Evaluation, XXXXIX, Houston, TX, USA, March 20-24, #1921, pp.1-2.

[45] Horiuchi, M., M. Hosokawa, A. Kawashima, M. Uno, Y. Cho, S. Kameda, Y. N. Miura, S. Kasahara, S. Sugita (2017), K-Ar Dating System for Mars Lander Missions, AOGS Mtg., PS05-13-A014.

[46] Yasushi Suto: "Non-sphericity of collisionless gravitating systems in the universe"; invited talk at an international conference "Collisionless Boltzmann (Vlasov)Equaton and Modeling of Self-Gravitating Systems and Plasmas", October 30-November 3, 2017, Centre International de Rencontres Mathematiques, Marseille, France.

[47] Yasushi Suto: "Reliability of the asteroseismic measurement of the stellar obliquity"; invited talk at NAOJ workshop "Asteroseismology and its impact on other branches of astronomy", March 19-20, 2018, University of Tokyo

[48] Chiba, Y., Sakai, N., Ebisawa, Y., Yoshida, K., Sakai, T., Watanabe, Y & Yamamoto, S., "A New Terahertz Emission Spectrometer at RIKEN", 34th International Symposium on Free Radicals, Hayama, Japan, 27th Aug. - 1st Sep., 2017

[49] Chiba, Y., Sakai, N., Ebisawa, Y., Yoshida, K., Sakai, T., Watanabe, Y & Yamamoto, S., "A New Emission Spectrometer at RIKEN", Laboratory Astrophysics Workshop 2017, Bonn, Germany, 29th Nov. - 1st Dec, 2017

7.3.2 Invited talks

[50] Ikoma, M., Sato, B., Sekii, T., Hanayama, H., Ida, S. + JOVIAL team. Probing the interior of Jupiter toward unveiling its formation: A new attempt with Jovian seismology. IAG-IASPEI, Kobe International Conf. Center, Kobe, Japan. July 30 - August 4, 2017 (31 July, 2017)

[51] Ikoma. M. Accretion Limit of Snowy Protoplanetary Envelope. 10th RESCEU - 2nd Planet2 Symposium on Planet Formation around Snow Line, Univ. Tokyo, Tokyo, Japan. Nov. 28-30, 2017 (29 Nov., 2017)

[52] Ikoma, M. Late-stage Accretion and Subsequent Evolution of Giant Planets. CHARIS International Workshop, NAOJ, Tokyo, Japan. Dec. 15-17, 2017 (15 Dec. 2017).

[53] Ikoma, M. Late-stage Capture of Solids by Proto-gas Giants. Workshop on Giant Planet Formation, Evolution and Interior, University of Zurich, Zurich, Switzerland. March 9-10, 2018 (10 March 2018).

[54] Oya, Y., "L483: Warm carbon-chain chemistry source harboring Hot Corino activity", Symposium "Evolution of Molecules in Space", 27th - 29th June, 2017, Hokkaido University