

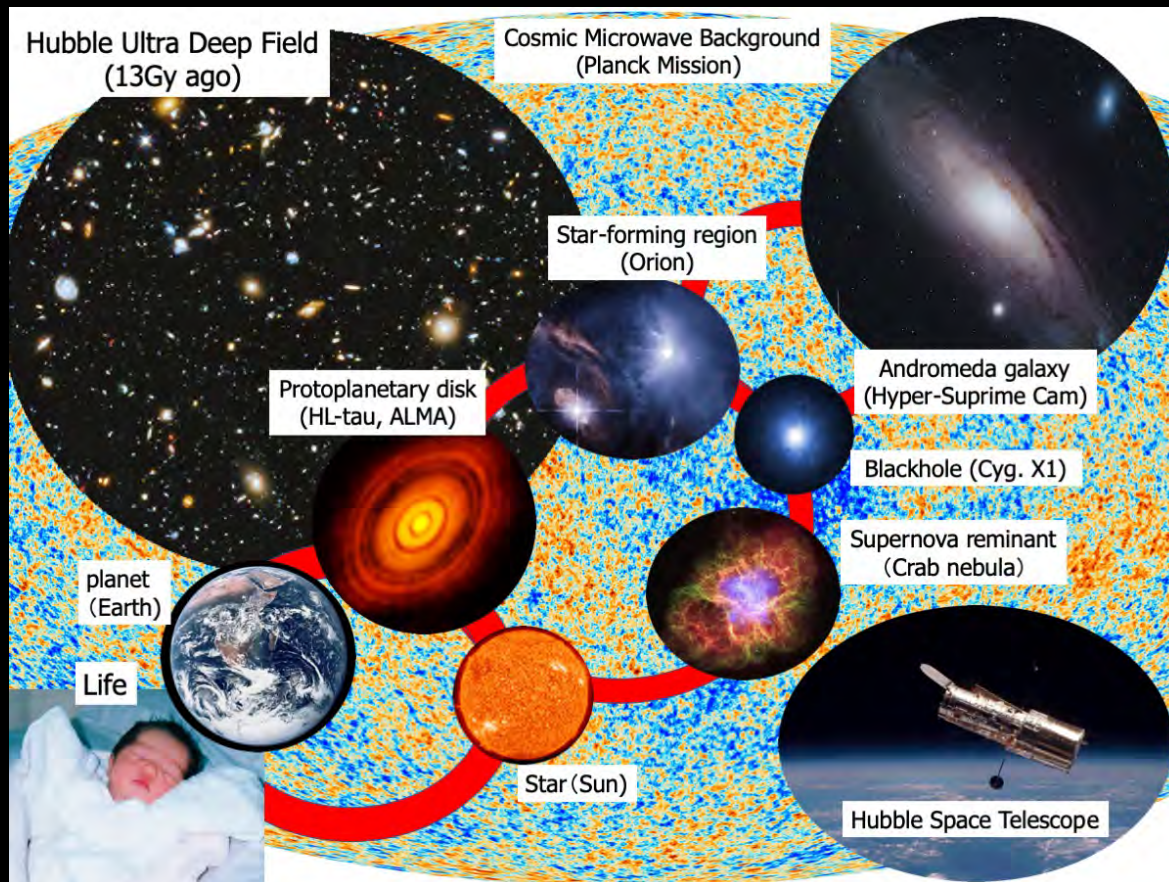
Report from RESCEU: 2012-2019

For the external visiting committee review

9:15-9:45 February 14, 2020

http://www-utap.phys.s.u-tokyo.ac.jp/~suto/mypresentation_2020e.html

Yasushi Suto (Director of RESCEU, The University of Tokyo)



Plan

- Overview of RESCEU (10min)
 - Director (Yasushi Suto)
- Individual presentations (5min each)
 - 1. Jun'ichi Yokoyama
 - 2. Kipp Cannon
 - 3. Toshikazu Shigeyama
- Questions and discussion (5min)

Overview of RESCEU

Yasushi Suto

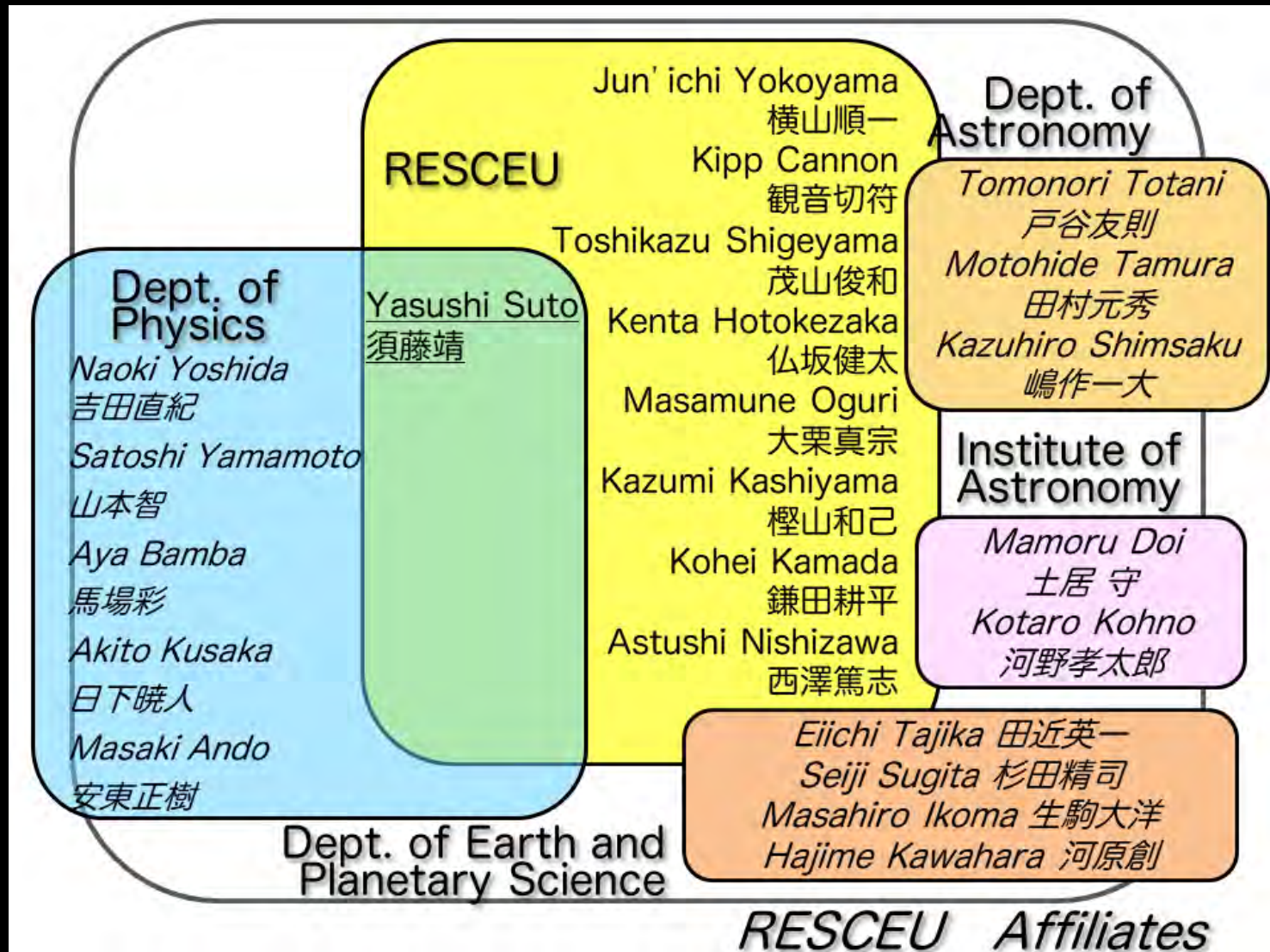


Brief history of RESCEU



- **RE**Search **C**enter for the **E**arly **U**niverse
 - *Not RESCUE*
- **1995**: selected as one of the first Center-Of-Excellence programs initiated by Japanese Ministry of Education (PI: Katsuhiko Sato)
- **1999**: officially approved as a research center in the University of Tokyo
 - 1 full prof., 1 associate prof., 2 assistant profs.
- **2019**: expanded significantly
 - 2 full profs., 2 associate profs., 4 assistant profs. (tenure)
 - 15 affiliate members from Depts. of Astronomy, Physics and Earth/Planetary Science, the Univ. of Tokyo

RESCEU members and affiliates



RESCEU: research projects

	2012	2013	2014	2015		2016	2017	2018	2019
Proj. 1	Very Early Universe and Large-scale Structure				Proj. 1	1: Evolution of the Universe and Cosmic Structures			
Proj. 2	Theory of Galaxy Evolution								
Proj. 3	Formation and Evolution of Galaxies and Clusters of Galaxies								
Proj. 4	Chemical Evolution from Protostellar Cores to Protoplanetary Disks				Proj. 2	2: Gravitational-wave Astrophysics and Experimental Gravity			
	Formation and Evolution of Massive Galaxies and Super Massive Blackholes								
Proj. 5	Search for Gravitational Waves								
Proj. 6	Direct Search for Dark Matter and Solar Axion				Proj. 3	3: Formation and Characterization of Planetary Systems			
Proj. 7	Cosmic X-ray and Gamma-ray Studies with Scientific Satellites								
	Balloon observations of cosmic anti-protons*								
Proj. 8		Study of Extra-Solar Planets							

RESCEU international symposia

- Nov. 2012: (8th@Tokyo) General Relativity and Gravitation
- Dec. 2016: (9th@Tokyo) Gravitational-Wave Astrophysics in the High Event Rate Regime
- Nov. 2017: (10th@Tokyo) Planet Formation around Snowline
- Oct. 2019: (11th@Tokyo) Gravitational-Wave Physics and Astronomy Workshop: GWPAW 2019
- Oct. 2019: (12th@Okinawa) From Protoplanetary Disks through Planetary System Architecture to Planetary Atmospheres and Habitability



RESCEU summer schools



- 2012: Urabandai
- 2013: Zao
- 2014: Asama
- 2015: Nikko
- 2016: Hida
- 2017: Yamaguchi
- 2018: Hakodate
- 2019: Kakunodate





Project I Evolution of the Universe and Cosmic Structures

Jun'ichi Yokoyama	RESCEU	Early Universe, Seed Fluctuations
Toshikazu Shigeyama	RESCEU	Supernovae, Chemical Evolution of Galaxies
Naoki Yoshida	Physics	First Star to Galaxy Formation Simulations
Tomonori Totani	Astronomy	High Energy Astrophysics
Aya Bamba	Physics	X and Gamma ray Astrophysics
Kazuhiro Shimasaku	Astronomy	Observational Cosmology
Akito Kusaka	Physics	B-mode Polarization of CMB
Masamune Oguri	RESCEU	Gravitational Lensing
Kohei Kamada	RESCEU	Particle Cosmology

To clarify the entire evolution history of the Universe from its quantum creation to the present state full of hierarchical structures in close connection with various observations as shown in the figure.

Space GW detector



CMB polarization



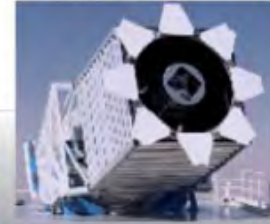
Laser interferometer



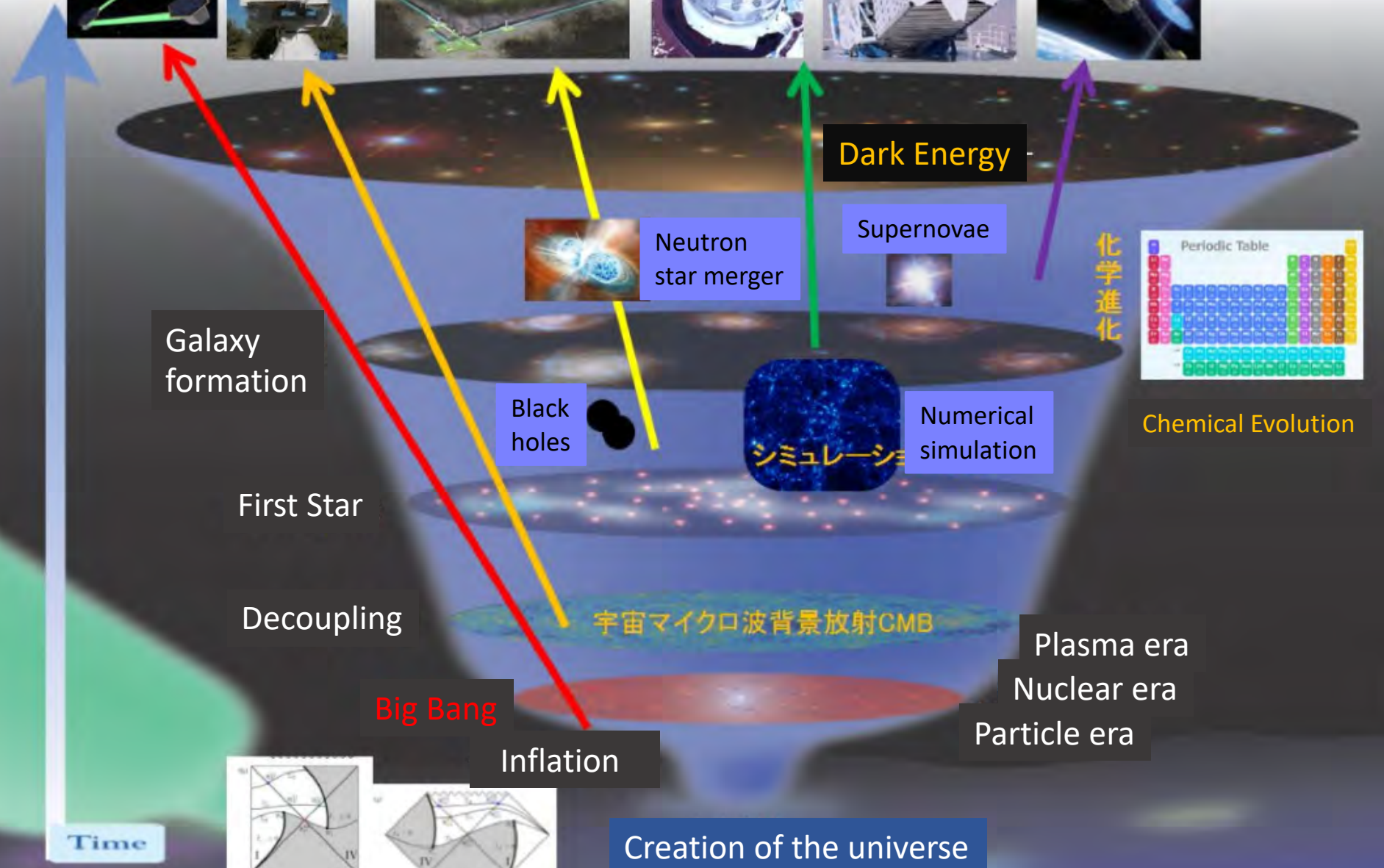
SUBARU



SDSS



X-ray satellite



Dark Energy

Supernovae

Neutron star merger



Galaxy formation

Black holes



Numerical simulation

化学進化



Chemical Evolution

First Star

Decoupling

宇宙マイクロ波背景放射CMB

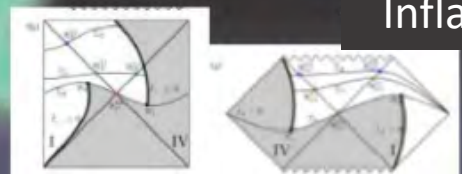
Big Bang

Inflation

Plasma era
Nuclear era
Particle era

Creation of the universe

Time



Project 3: Formation and characterization of planetary systems

Member	Affiliation	Research title
Yasushi Suto (PI)	Physics	Dynamics and architecture of exoplanetary systems
Motohide Tamura	Astronomy	Exoplanet observations and instrumentations
Seiji Sugita	Earth and Planetary Sciences	An asteroid sample-return mission and feasibility study for an exoplanet observation satellite
Satoshi Yamamoto	Physics	Physics and chemistry of protoplanetary disk formation
Eiichi Tajika	Earth and Planetary Sciences	Diversity and evolution of habitable planets
Masahiro Ikoma	Earth and Planetary Sciences	Diversity and origins of exoplanetary atmospheres
Hajime Kawahara	Earth and Planetary Sciences	Exploring instrumentation and methods for characterizing exoplanets

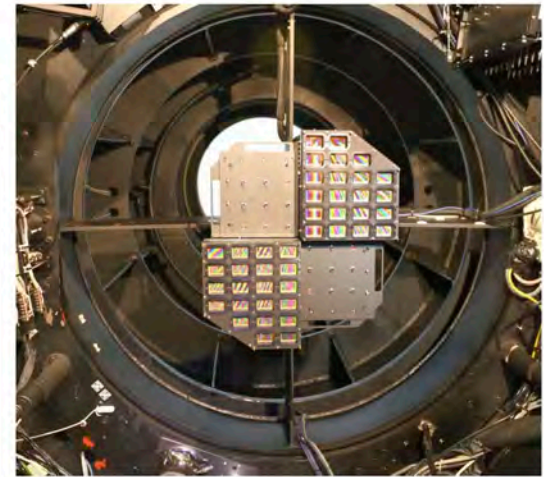
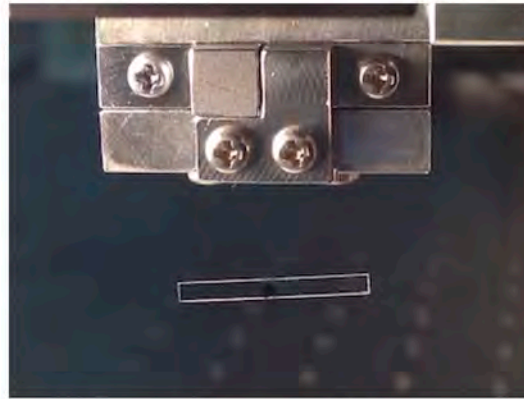
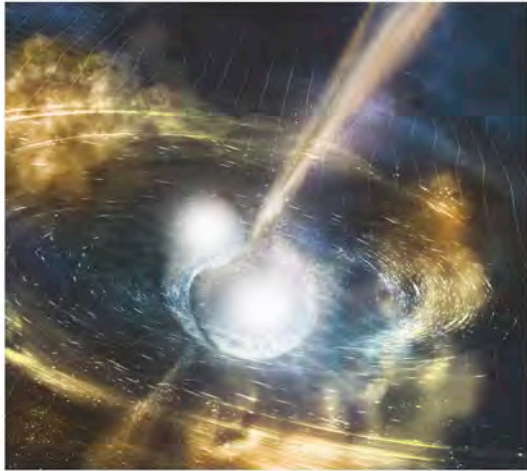


Project 2: Gravitational-wave Astrophysics and Experimental Gravity

A nexus for diverse experimental and theoretical research programs ranging from numerical relativity and modified gravity theory to optical and radio astrophysical transient searches to GW observations and novel GW detector design. We share the common theme of being linked by multi-messenger astronomy.

Member	Affiliation	Research Title
Masaki Ando	Physics	GW Experiment and Astrophysics.
Kipp Cannon	RESCEU	Detection and interpretation of GWs emitted by the collisions of compact objects.
Mamoru Doi	Astronomy	Identifications of GW sources by wide-field and multi-color optical observations.
Kotaro Kohno	Astronomy	Radio/submm follow up of candidate sources of GWs.

Project 2: Gravitational-wave Astrophysics and Experimental Gravity



Artist's impression of Optical torsion bar neutron star collision.

Subarus' Suprime-Cam

JSPS core-to-core program PLANET² (2016-2021)

From planet formation and evolution
to origin of water and life in the Solar system

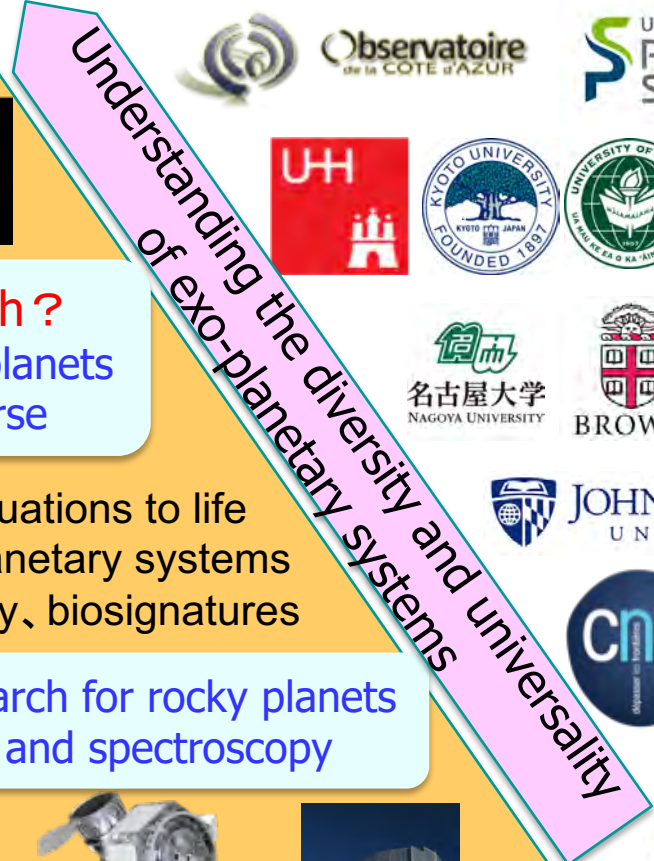


Second earth ?
Life harboring planets
in the universe

from cosmological fluctuations to life
origin and evolution of planetary systems
origin of water and delivery, biosignatures

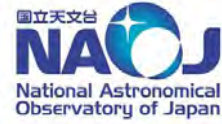
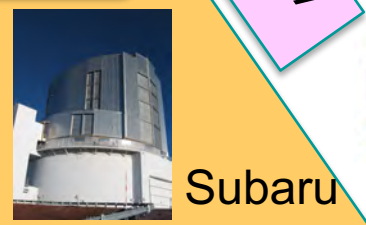
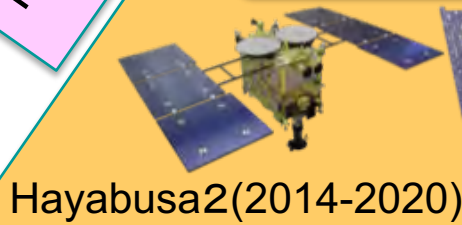
Primordial material in
the Solar small-bodies

Search for rocky planets
and spectroscopy



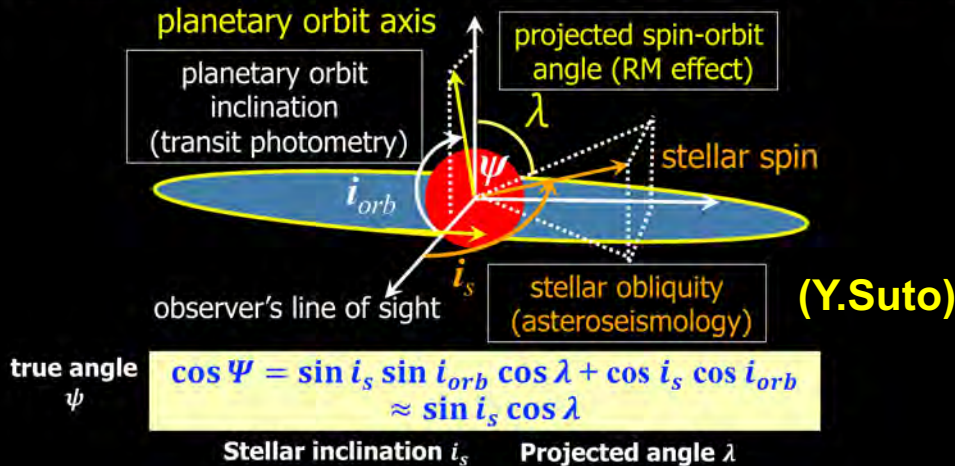
Primordial material in the Solar system from
sample return

Understanding the diversity and universality
of exo-planetary systems

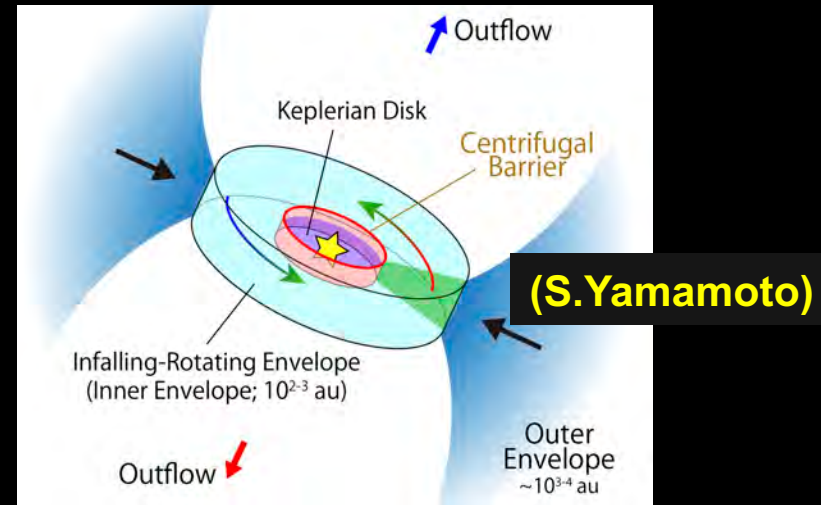


Project 3: research highlights

Spin-orbit architecture of a planetary system



Protoplanetary disk structure from ALMA



Asteroid Ryugu (Hayabusa2 mission)

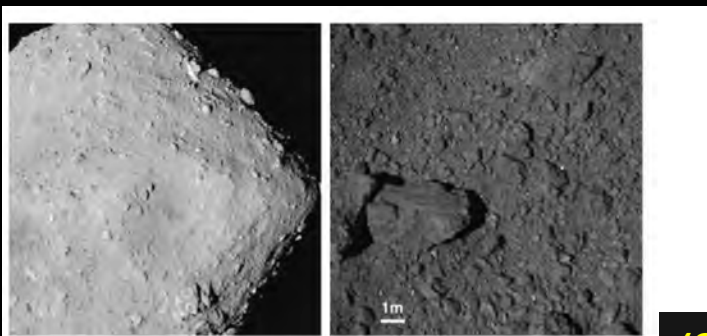
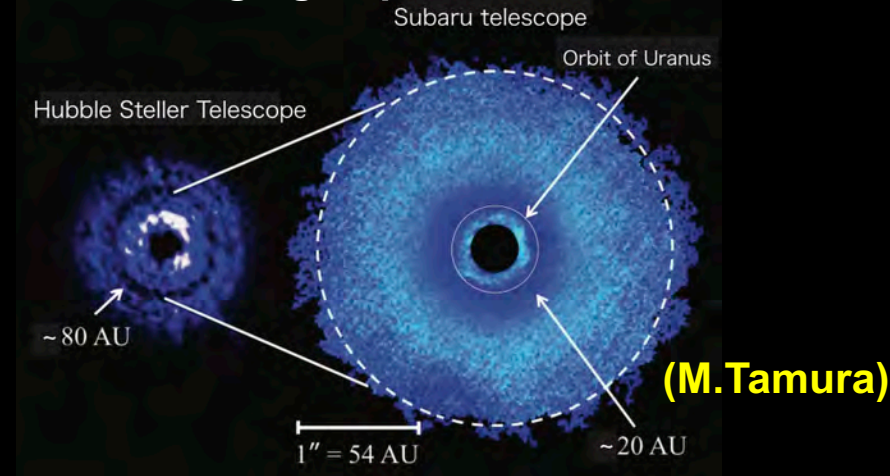


Image of the asteroid Ryugu taken by Hayabusa 2
(Image from JAXA, U Tokyo, Kochi U, Rikkyo U, Nagoya U
Chiba Institute of Technology, Meiji U, Aizu U, AIST)

(S.Sugita)

Direct imaging of planets with Subaru



Future direction

- Continue to play a role of research hub for astrophysicists among different departments in the University of Tokyo
- Near-future focus
 - Big data from cosmological and time-domain surveys (Subaru, LightBird, LSST, WFIRST)
 - Gravitational-wave astrophysics (LIGO/VIRGO, KAGRA, Tomo-e gozen)
 - Solar and exoplanetary sciences (Subaru, Hayabusa2, CHEOPS, PLATO)
- Reorganize major projects flexibly according to (unpredictable but definitely emerging) future surprises



Individual presentation

1. Jun'ichi Yokoyama

Jun'ichi Yokoyama 横山順一 2012-2020 Cosmology & Gravitational Waves

Research & Education

2012 (1 PhD, 2 MS) 8 papers
"Generalized Higgs Inflation"
Most general model of Higgs inflation

2013 (0 PhD, 1 MS) 6
"Cosmology based on $f(R)$ gravity
admits 1eV sterile neutrinos"
PRL editor's choice

2014 (1 PhD, 2 MS) 7
"Toward the detection of gravitational
waves under non-Gaussian noises I"
Proc Japan Academy, Invited Paper

RESCEU Activities

2011/11/16 Attended the naming
ceremony of KAGRA and decided to
create a data analysis team here.

2012/7 Hired Yosuke Itoh from LIGO,
and organized the first KAGRA data
analysis school.

2012/11 Organized RESCEU Symposium
on Gravitation, inviting top leaders of
LIGO & Virgo to ask for support letters.

2013/7 Established "Gravitational Wave
Physics Research Consortium" w/YITP

2013/11 Applied for a new position
to the University headquarter

2014/6 Application approved and
RESCEU obtained one professor position.

Community Service
mainly through



2011-2013
Editor of AAPPS
Bulletin from JPS

2013
Asia Pacific Physics
Conference in
Japan

2014-16
Deputy Editor-in-
Chief of AAPPS
Bulletin

Jun'ichi Yokoyama 横山順一 2012-2020 Cosmology & Gravitational Waves

Research & Education

2015 (2 PhD, 1 MS) 9 papers
"Inflation with a constant rate of roll"
96 citations

2016 (1 PhD, 2 MS) 9
"Entropic interpretation of the
Hawking-Moss bounce "

2017 (2 PhD, 1 MS) 2
"Note on Reheating in G-inflation"
Collaboration with Canada (JSPS)

2018 (1 PhD, 1 MS) 9
"Creation of an inflationary universe
out of a black hole"

2019 (1 PhD, 2 MS) 9
"Application of the independent
component analysis to iKAGRA data"
First paper using KAGRA data
(full author paper)

RESCEU Activities

2016/2/1 Kipp Cannon joined RESCEU
2016/2/11 Detection of gravitational
waves announced!

Primordial BHs, about which I
worked out ~20yrs ago,
became very popular.

2017 Binary Neutron Star Coalescence
GW170817 discovered by Kipp

4 papers were published in PRL
to constrain modified gravity
using our formula derived in 2011.

2018 Requested another position for
GW astrophysics (led by Director Suto)
2019/9 Kenta Hotokezaka joined.

2019/3 Organized a workshop on
Space-based GW detection

Community Service mainly through



2015
Division of Astrophysics
& Grav.
Secretary general

2017-19
Council member
& Secretary

2018
Attended EPS
executive meeting
2019
Organized APPC14

2020-
President of AAPPS

Future Plan

1 Contribute to the first detection of GW by KAGRA, applying the independent component analysis to remove noises effectively.

2 Falsify (or confirm?) PBH Hypothesis of “LIGO BHs” using pulsar timing data, as formation of PBHs are associated with creation of large tensor perturbation on light year scale. (Saito & JY 2009).

Multiwavelength
Gravitational Wave
Astrophysics

Social Activities:

To make AAPPS survive and thrive, pursue division formation of condensed matter physics and then particle physics



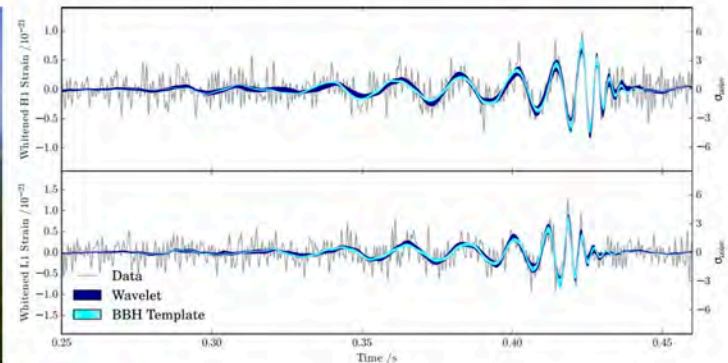
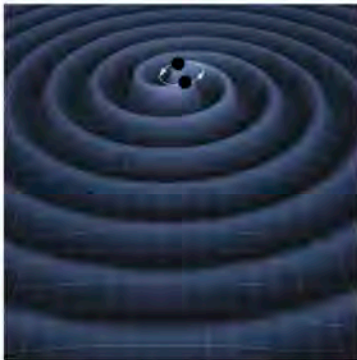


Individual presentation

2. Kipp Cannon

Introduction

- ▶ This group's topic is gravitational-wave astrophysics: studying the universe and the things that fill it by observing spacetime curvature perturbations created by the movement of masses and momenta.
- ▶ All group members are members of one of or both of the LIGO Scientific Collaboration and the KAGRA Collaboration.



Introduction

- ▶ Majority of the group's activities focused on detection and interpretation of gravitational-wave signals.



Group Members and Research Topics

- ▶ M students:
 - ▶ **Chiwai Chan**: noise model for significance assessment constructed from gravitational-wave detector data contaminated with signals.
 - ▶ **Minori Shikauchi**: detecting long duration ratio transients from compact object mergers.
 - ▶ **Takuya Tsutsui**: ultra-fast source localization for compact object collisions (successfully defended).
- ▶ D students:
 - ▶ **Soichiro Morisaki**: fast intrinsic source parameter estimation for compact object collisions (successfully defended).
 - ▶ **Hiroaki Ohta**: modelling detection sensitivity in gravitational-wave searches for compact object collisions.
 - ▶ **Leo Tsukada**: searches for astrophysical stochastic gravitational-wave backgrounds.
 - ▶ **Daichi Tsuna**: searching for gravitational-waves from cosmic strings.

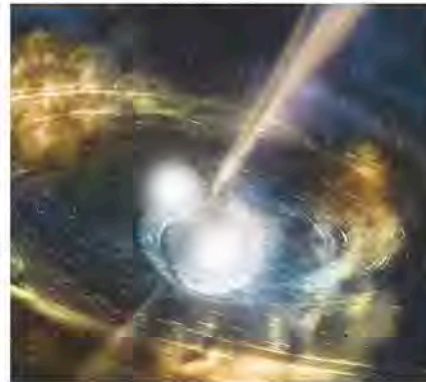


Group Members and Research Topics

- ▶ Postdoctoral researchers:
 - ▶ **Heather Fong**: modelling and inferring properties of ensembles of compact object collisions.
 - ▶ **Koh Ueno**: targetted searches for exotic compact objects, compact object searches in a four-detector network with KAGRA.
- ▶ Faculty:
 - ▶ **Kipp Cannon**: a little bit of each of the above.
 - ▶ **Atsushi Nishizawa**: observational constraints on cosmological models.

Activities

- ▶ Some notable results:
 - ▶ Group members played a major role in the discovery of GW170817, the first observation of a neutron star collision, and Science Magazine's 2017 breakthrough of the year.



- ▶ Group members have contributed significantly to developing the infrastructure required to incorporate Japan's KAGRA detector into the international detector network.



Individual presentation

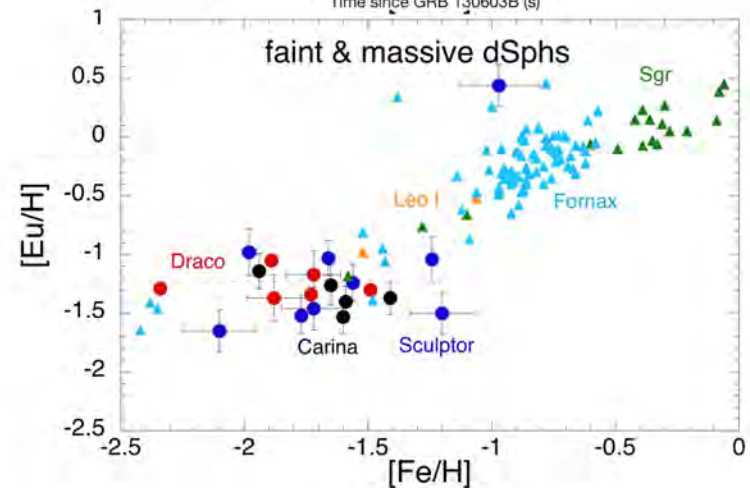
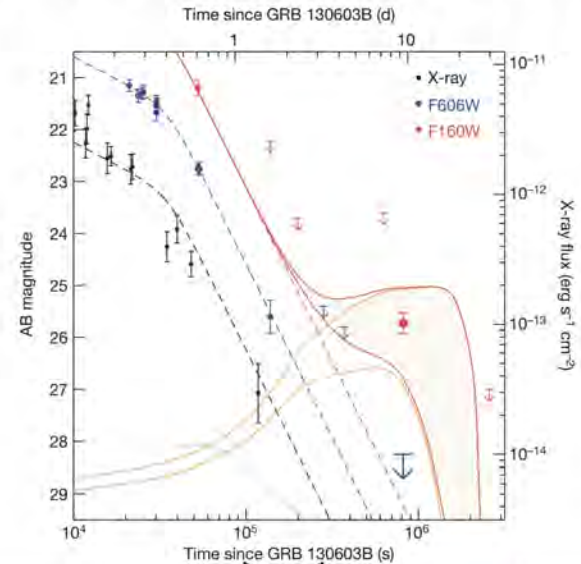
3. Toshikazu Shigeyama

Contents

- Origin of r-process elements
 - Event rate of neutron star mergers (NSMs)
 - Tsujimoto, Shigeyama 2014
 - Optical follow up observations of gravitational wave events from NSMs using the Tomo-e camera
- Which white dwarf ends up with a supernova Ia?
 - Early observations of supernovae Ia
 - Kutsuna, Shigeyama 2015, Jiang, Doi, Maeda, Shigeyama+ 2017
 - Fate of merging white dwarfs=> rapidly rotating massive white dwarf?
 - Kashiyama, Fujisawa, Shigeyama 2019

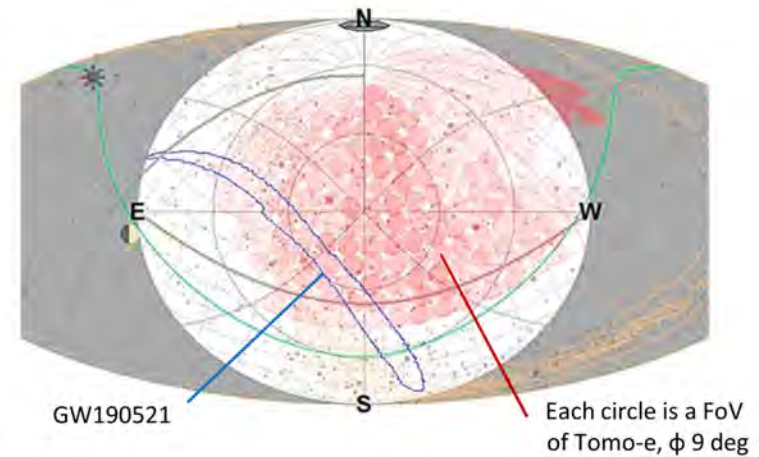
Origin of r-process elements

- Short duration GRB 130603B=Binary neutron star merger (NSM)
 - Detection of a kilonova (Tanvir+ 2013)=> ejection of r-process elements (mass~0.01 Msun)
- Abundance analyses of an r-process element Eu for stars in dSph galaxies
 - One NSM per 1,000-2,000 CCSNe =720-1,400 Gpc⁻³yr⁻¹ (Tsujiimoto & TS 2014)
 - NSMs detected by GW=> 250-2,810 Gpc⁻³yr⁻¹ (Abbott+ 2020)



Tomo-e project

- To further explore features of kilonovae
 - Quick optical follow up observations of GW detections from NSM
- Tomo-e camera (84 big CMOS chips) mounted on the Kiso Schmidt telescope (1.05 m)
 - FOV=20 deg²
- Theoretical predictions on the early phase
 - emission from free neutron layer



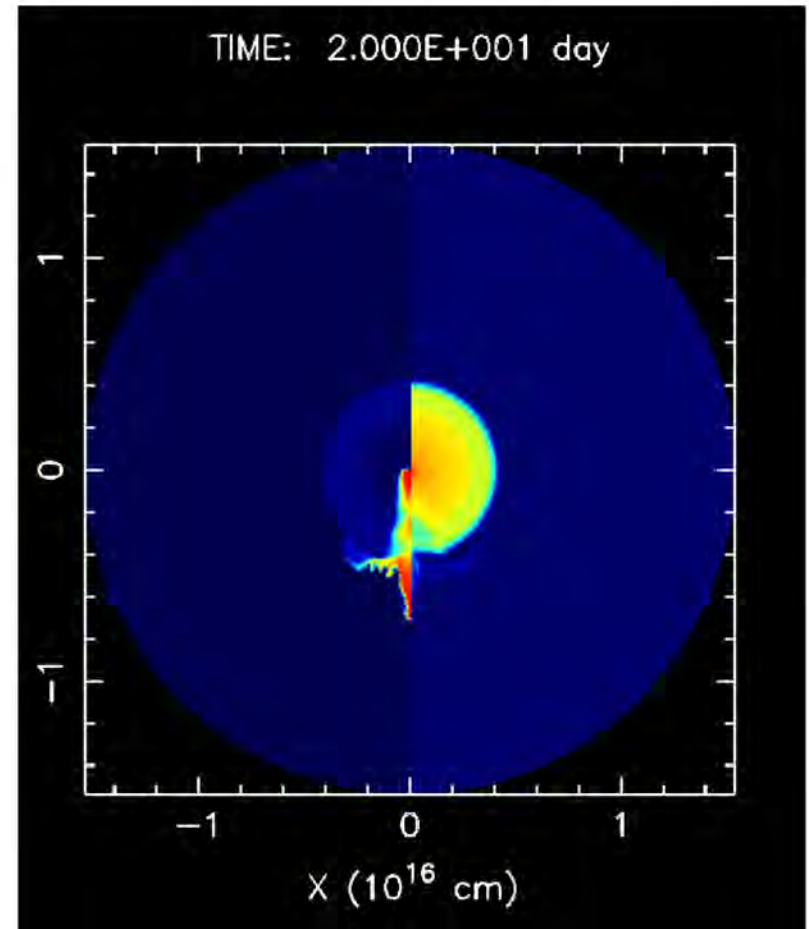
All sky survey with 2 hour cadence

Progenitor system of type Ia supernovae

- Double degenerate (DD) scenario and/or Single degenerate (SD) scenario
- Investigate light curves in the early phases (To test SD scenario)
 - Search for signatures of companion stars
- Construct a model of merging products of two white dwarfs (To test DD scenario)
 - Fast rotating massive white dwarf with intense wind

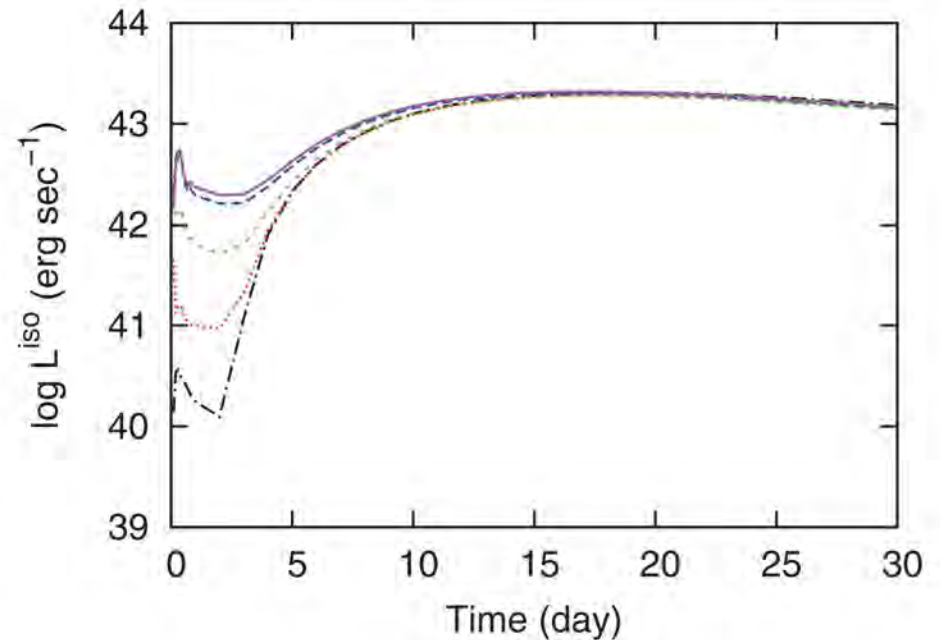
Test of SD scenario

- 2D radiation hydrodynamics
 - Kutsuna, Shigeyama 2015
- ejecta affected by the collision with the companion
- Light curves depending on the viewing angle



2D radiation hydrodynamics

- 2D radiation hydrodynamics
 - Kutsuna, Shigeyama 2015
 - ejecta affected by the collision with the companion
 - Light curves depending on the viewing angle



Early phase of SN Ia

- SN 2016jhr
 - Jiang, Doi, Maeda, Shigeyama, et al. 2017
- First few observations captured signatures of a trigger of the explosion
 - He detonation on the surface of the white dwarf
- Importance of high cadence observations

