# Astrophysical Big Bang Laboratory

**PI:** Shigehiro Nagataki (Ph.D of Science), Associate Chief Scientist

1. **Abstract**

Our laboratory, Astrophysical Big Bang Laboratory (ABBL), was established on 1st Apr. 2013. Our group focuses on unveiling lots of mysteries surrounding astrophysical explosive phenomena such as supernovae (SNe) and gamma-ray bursts (GRBs). SNe and GRBs are the most powerful explosions in the universe, and yet very little are known about their explosion mechanisms. These astrophysical big bangs continue to fascinate us with their unknown physics and puzzling astronomical phenomena such as gravitational waves, r-process nucleosynthesis, particle acceleration, high-energy gamma-rays/neutrinos, ultra-high energy cosmic rays. Through our theoretical and computational approaches, we strive to reveal the complete pictures of these violent explosions and provide the state-of-the-art physical interpretations for current, cutting-edge observations as well as useful predictions for future observations by the next-generation astronomical observatories. We are more than passionate to co-operate with researchers in RIKEN as well as all other interested groups in Japan and the world, and together we would like to establish a Utopia in RIKEN for scientists.

Deep understanding on mathematical and computational physics is very important to solve fundamental, unsolved problems in astrophysics. Our group has joined one of the Pioneering Projects, “Interdisciplinary Theoretical Science Research Group (iTHES)” (Group Director is Dr. Tetsuo Hatsuda) from FY2014, to solve such problems by enhancing communications with researchers of nuclear physics, condensed matter, chemistry, and biology in RIKEN. These activities should be also helpful to increase our group’s activities in astrophysics. Shigehiro Nagataki, the PI of ABBL, has been a team leader of Interdisciplinary Mathematical and Computational Collaboration Team of iTHES. Due to the great success of iTHES, a new program, “Interdisciplinary Theoretical and Mathematical Science Program (iTHEMS)” has been approved by MEXT in FY2016 (Program Director is Tetsuo Hatsuda). iTHEMS has a same concept with iTHES, but iTHEMS includes Mathematics. Shigehiro Nagataki has been a Deputy Program Director of iTHEMS. We will achieve our scientific goal through good communications & collaborations among ABBL, iTHES, and iTHEMS members.
To enhance activities in nuclear-astrophysics in RIKEN, which is one of our dreams, further communications & collaborations with Nishina Center are crucial. The state-of-the-art equation of state for dense matter and nuclear reaction data for various channels can be provided by Nishina Center groups, which are essential to unveil the phenomena of SNe and GRBs. Our group had joint meetings with Dr. Nakatsukasa’s group continuously since FY2013. Even after Dr. Nakatsukasa’s moving to Tsukuba University, we have been organizing the joint meetings occasionally by inviting nuclear physicists as speakers. Our group has joined one of the Pioneering Projects, “Extreme precisions to explore fundamental physics with exotic particles (Triple-E)” (Group Director: Dr. Yasunori Yamazaki). This project definitely helps our group to enhance communications and collaborations with Nishina Center, especially Dr. Uesaka’s group. We also believe that our group can contribute especially to new science of RIBF through this project.

Super-computing is indispensable for unveiling the explosion mechanisms of SNe and GRBs. Full-understanding of them is still not achieved even by using K-computer. We would like to achieve the complete understanding of the explosion mechanisms using super-computers in RIKEN, National Astronomical Observatory of Japan (NAOJ), Yukawa Institute for Theoretical Physics (YITP), and Max Planck Institute for Astrophysics (MPA). Dr. Tomoya Takiwaki, who did numerical simulations of SNe by K-computer supported by HPCI Strategic Program Field 5 “The origin of matter and the universe” joined our group from 1st Aug. 2014, obtained lots of fruitful results on SNe and GRBs in our group, and got a permanent position of Assistant Professor at NAOJ successfully in 2016 (he is also keeping affiliation of ABBL as a visiting researcher). We will continue to encourage excellent researchers of this field to join our group from all over the world, so that our group in RIKEN keeps leading the world in this field.

As mentioned above, our group has already decided to lead the world in the field of astrophysical big bangs. For the purpose, we are seeking for top-ranked researchers in the world, encouraging them to join our group, and doing the-state-of-the-art researches in this field. We are succeeding to have an international laboratory composed of 8 Japanese including PI and 9 non-Japanese (2 from Russia & China, and 1 from Italy, Hong-Kong, Thailand, USA, France), including Alumni who succeeded to get their next positions, such as a faculty position (full professor, tenured) at Yunnan Observatory in China, a lecturer position at Kyoto University (tenured), a lecturer position at National Institute of Technology Asahikawa College (tenured), an assistant professor position at NAOJ (tenured), an assistant professor position at Jagellonian University (tenure-track), Kavli IPMU at the
University of Tokyo, Purdue University, and assistant professor position at Tohoku University (for outreach). Among the 8 alumni, 5 got tenure or tenure-track positions successfully. Among the total 17 members, 3 joined ABBL from Stanford Univ., 3 from Max Planck Institute, and 1 from UCLA. We are sure that we can establish a top-ranked lab. in the world and achieve our goals & dreams in the near future leading the world.

2. Key Words

3. Members

**Principal Investigator**
Shigehiro Nagataki
Associate Chief Scientist

Haoning He
Postdoctoral Researcher

**Core Members**
Hirotaka Ito
Research Scientist

Masaomi Ono
Research Scientist

Jin Matsumoto
Special Postdoctoral Researcher

Annop Wongwathanarat
Foreign Postdoctoral Researcher

Past Core Members
Donald Warren
Foreign Postdoctoral Researcher

Jirong Mao
Faculty at Yunnan Observatory

Susumu Inoue
Research Scientist

Shiu-Hang Lee
Lecturer at Kyoto University

Gilles Ferrand
Research Scientist

Maria Giovanna Dainotti
Assistant professor at Jagellonian U.
Marie Curie Fellow at Stanford Univ.

Yuto Teraki
Postdoc at YITP at Kyoto U.

Tomoya Takiwaki
Assistant Professor at NAOJ
Visiting Scientist of RIKEN

Tomohide Wada
Assistant Professor at Tohoku U.
(Outreach)

Maxim Barkov
Postdoc at Purdue University
Visiting Scientist of RIKEN

Assistant
Tamaki Shibasaki

Long Term Visitors
Zhaoming Gan (Shanghai Astronomical Observatory : 2016/9/1 – 2016/10/31)

Short Term Visitors
Norita Kawanaka (U. Tokyo)
Kyohei Kawaguchi (Kyoto U.)
Eiji Kido (U. Tokyo)
Paz Beniamini (Hebrew U.)
Katsuaki Asano (U. Tokyo)
Yoshiyuki Inoue (JAXA)
Koh Takahashi (U. Tokyo)
Yutaka Ohira (Aoyama Gakuin U.)
Ko Nakamura (Waseda U.)
Yosuke Matsumoto (Chiba U.)
Oliver Just (MPA)

Yutaka Fujita (Osaka U.)
Kimitake Hayasaki (Chungbuk National U.)
Ken Ohsuga (NAOJ)
Satoru Katsuda (Chuou U.)
Shota Shibagaki (U.Tokyo/NAOJ)
Ke Fang (U. Maryland)
Amir Levinson (Tel Aviv U.)
Kumiko Kotera (IAP)
Philipp Edelmann (Heidelberg Institute for Theoretical Studies)
Michael Gabler (MPA)
Gavin Lamb (Liverpool John Moores U)
Denis Allard (APC)
Kotaro Kyutoku (KEK)
Xiaping Tang (MPA)
Kenichi Nishikawa (U. Alabama)
Alexander Kusenko (UCLA)

4. Achievements
(1) Press Release etc.


(2) Lectures
Susumu Inoue, Part-time Lecturer on


(3) Papers in Journals (Refereed)
R. U. Abbasi et al. “The energy spectrum of cosmic rays above $10^{17.2}$ eV measured by the fluorescence detectors of the Telescope Array experiment in seven years” Astroparticle Physics, Volume 80, p. 131-140, July 2016.


(4) Oral Presentations at International Meetings (Invited Talks)
Susumu Inoue “AGN Winds and NGC 1068” MAGIC Collaboration Meeting, Zürich, Switzerland, 2016/06/15.

Susumu Inoue “Fast Radio Bursts and VHE Prospects” MAGIC Collaboration Meeting, Zürich, Switzerland, 2016/06/15.

Shigehiro Nagataki “Theoretical Studies on Supernovae and Gamma-Ray Bursts” Frontiers of Nonlinear Physics, Nizhny Novgorod-St. Petersburg, Russia, 2016/7/20.


(5) Oral Presentations at International Meetings (Contributed Talks):
Warren III Donald Cameron, Ellison, D.C., Barkov, M.V., Nagataki, S. “GRB Afterglows produced by nonlinear diffusive shock acceleration” CTA Consortium Meeting Kashiwa, Japan, 2016/05/16.

Susumu Inoue “Gamma Ray Emission from AGN winds” CTA Consortium Meeting Kashiwa, Japan, 2016/05/16.

Wongwathanarat Annop, “3D Long-time Core-collapse Supernova Simulations” SNR2016: an odyssey in space after stellar death, Chania, Greece, 8 June 2016.

Wongwathanarat Annop, “Neutron star kicks by gravitational tug-boat mechanism” 10th BONN one day workshop on neutron stars, Bonn, Germany, 20 June 2016.


Warren III Donald Cameron, Ellison, D.C., Barkov, M.V., Nagataki, S. “Shock acceleration of cosmic rays in GRB afterglows, or: Low energy, high impact” Huntsville GRB symposium, Huntsville, USA, 2016/10/26.


Susumu Inoue “Status of the FRB Program” MAGIC Collaboration Meeting,
Dortmund, Germany, 2016/11/23.


(6) Oral Presentations at Domestic Meetings (Invited/Keynote Talks)


Jin Matsumoto “Condition for the growth of the Rayleigh-Taylor instability at the relativistic jet interface” RIKEN-RESCEU meeting, Tokyo, Japan, 2016/07/26.

Warren III Donald Cameron, Ellison, D.C., Barkov, M.V., Nagataki, S. “Nonlinear cosmic ray acceleration in GRB afterglows” RIKEN-RESCEU meeting, Tokyo, Japan, 2016/07/27.

Jin Matsumoto “宇宙ジェット研究におけるデータ同化の展望” 理研データ同化ワークショップ, Kobe, Japan, 2016/10/14.

Susumu Inoue “Transient Science with CTA” 高エネルギーガンマ線でみる極限宇宙 2016, Kashiwa, Japan, 2016/12/16.

(7) Oral Presentations at Domestic Meetings (Contributed Talks)


Hirotaka Ito, Amir Levinson, Boris Stern, Shigehiro Nagataki “相対論的放射媒体衝撃波の物理”, 高エネルギー宇宙物理学研究会, Sagamihara, Japan, 2016/12/2.


Shigehiro Nagataki “ABBL の宇宙とiTHEMS の宇宙” iTHES 神戸研究会, Kobe, Japan, 2016/12/26.

Shigehiro Nagataki “Introduction of Interdisciplinary Theoretical & Mathematical Sciences” 特異点と時空、および関連する物理, Tokyo, Japan, 2016/12/27.

Susumu Inoue “電波分散および 21cm 吸収線系を用いた観測的宇宙論” 銀河進化と遠方宇宙 (IV), Kumamoto, Japan, 2017/1/8.


(8) Outreach

Shigehiro Nagataki “「重力波」ってなんだったの？ 理化学研究所・長瀧先生に聞
いてみた” ネタリか, 2016/6/5.
http://netallica.yahoo.co.jp/news/20160605-60039541-netallicaq


Shigehiro Nagataki “宇宙の誕生・現在・未来：人類は宇宙をどこまで理解したか” 平成28年度和光市民大学, Wako, Japan, 2016/12/15.


(9) Seminar Talks (International) Hirotaka Ito, Shigehiro Nagataki, Jin Matsumoto, Don Warren, Shiu-Hang Lee, Alexey Tolstov, Maxim Barkov, Akira Mizuta, Shoichi Yamada, Asaf Pe'er, Masaomi Ono, Maria Dainotti, Seiji Harikae “Photospheric Emission from Structured Jet” The University of Texas at Austin, USA, 2016/10/31.

Wongwathanarat Annop “Connecting core-collapse supernova simulations with observations” Mahidol University, Bangkok, Thailand, 28 Feb 2017.


Masaomi Ono, “Three dimensional numerical modeling of the evolution from supernovae to their supernova remnants” 早稲田大学理論宇宙物理学研究室セミナー, Waseda U., Tokyo, Japan, 2017/1/20.

(11) Poster Presentations at International Meetings


Warren III Donald Cameron, Ellison, D.C., Barkov, M.V., Nagataki, S. “Nonlinear cosmic ray acceleration during gamma-ray burst afterglows”
Particle Astrophysics and Cosmology Including Fundamental Interactions (PACIFIC) Moorea, French Polynesia 10-17 September 2016.


(12) Poster Presentations at Domestic Meetings

(13) Meetings organized or co-organized by our group

Nuclei in the Cosmos School, 13-17 June 2016, Niigata U., Niigata, Japan.
