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The Death of Massive Stars: Supernovae and Gamma-Ray Bursts

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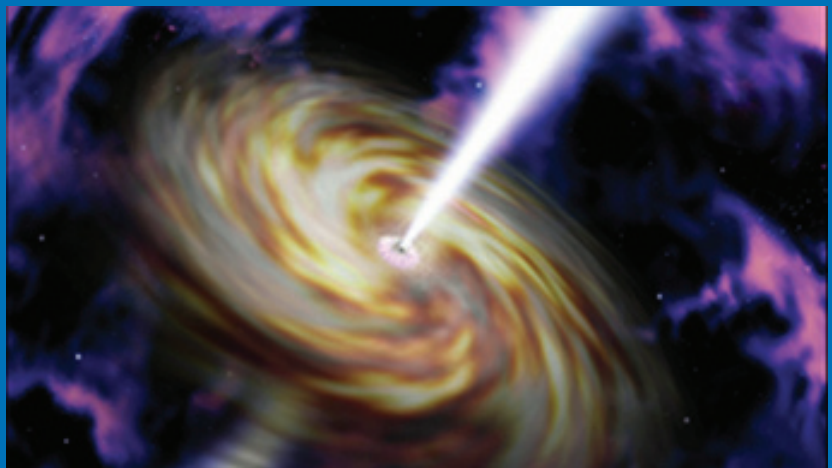
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THE DEATH OF MASSIVE STARS:
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COVER ILLUSTRATION: DEATH OF A MASSIVE STAR

An illustration of the death of a rapidly rotating massive star shortly after its core collapse. A highly relativistic jet is launched along the rotation axis.

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Preface

IAU Symposium 279 took place in Nikko, in the Tochigi Prefecture of Japan. Its science motivation centers around the death of stars that are larger than eight solar masses. These massive stars end their lives in a fiery explosion and are manifest as core-collapse supernovae or gamma-ray bursts. In rare cases, a highly stripped massive star explodes and exhibits properties of both core-collapse supernovae and gamma-ray bursts: the prototype of this class is the nearby (35 Mpc) core-collapse explosion of supernova SN 1998bw, accompanied by the gamma-ray burst of 25 April 1998, in the direction of the Telescopium constellation. In contrast, there are clear cases in which no bright supernova is found to be associated with a gamma-ray burst, and vice versa. The quest in understanding supernovae and gamma-ray bursts, and the connection between them, has raised many questions. Since the elements synthesized in the explosion of massive stars are the building blocks for much of the visible Universe, it is important to understand the life cycle of these massive stars.

This symposium brought together international leaders, in both theory and observation, who study core-collapse supernovae and gamma-ray bursts, to discuss the range of activities in the field. These include: stellar evolution and explosion; progenitors, environments and host galaxies; astroparticle physics; as well as multi-wavelength observations of these objects and their use as cosmological probes, particularly in the very early Universe. The symposium, opened by the welcoming address of Nobu Kawai, was divided into eight sessions, 62 talks, and 82 posters. The 158 participants came from 25 countries with 28 invited and 34 contributed speakers, of which five and six were women, respectively. A very large fraction of participants were younger scientists. We had the honor and privilege of having with us for the whole meeting Thierry Montmerle, Assistant General Secretary of the IAU Executive Committee, who also delivered a talk on the future organization of the IAU.

Our understanding of the lives and death of stars with masses greater than eight solar masses are beginning to expand thanks to increasingly powerful diagnostic tools, models, and numerical simulations that have become available. These resources are helping identify the evolutionary channels and eventual fates of massive stars, as well as investigating how a fraction of them are able to produce high-energy emission and jets, and possibly accelerate cosmic rays. The talks during the meeting focused on twelve primary themes:

- What are the differing models relating to the death of massive stars telling us;
- X-ray and optical properties of all classes of supernovae including the superluminous supernovae (sometimes referred to as “Quimbies,” derived from the last name of Robert Quimby, a Symposium participant who has critically contributed to the discovery and investigation of these sources);
 - What we are learning from multi-wavelength observations of the prompt and afterglow phases of gamma-ray bursts;
 - What we are learning from X-ray to radio observations of core-collapse supernovae and their remnants, including the nearest and by far best studied SN 1987A in the Large Magellanic Cloud, that had just celebrated its Silver Jubilee at the time of the Symposium;
 - The challenges associated with observing and constraining the progenitors of gamma-ray bursts and supernovae;

- Current thoughts and scenarios on supernova theory and the role of asymmetry in the explosion;
- Gravitational waves and gamma-ray bursts;
- Host galaxies and the local environments, particularly the metallicities, of gamma-ray bursts and core-collapse supernovae;
- Current theories in early Universe star formation including Population III stars;
- Using gamma-ray bursts as probes of the early Universe and looking into correlations that may turn them into standard candles;
- Understanding the shock break out of supernovae, i.e. the blast driven by the re-bouncing of the collapse stall, that produces a bright multi-wavelength early outburst;
- The possible connection between short gamma-ray bursts and magnetars, highly magnetized and rapidly spinning neutron stars.

Some speakers tackled the above fundamental issues by focussing on one particular source of specific relevance, a sub-set, or an entire class. Every one did an excellent job in underlining the merits of any particular observing campaign or technique, or of dedicated models and/or simulations. The picture that emerged is that much more data are necessary to develop reliable interpretative paradigms. Thanks to the systematic, sensitive, wide-field optical and radio surveys that are already taking place or are soon to be on line, the near-term future looks promising with regards to data accumulation. It is also highly desirable that space-based assets keep pace by ensuring continuity in the X- and gamma-ray regime in the follow-up and monitoring of supernovae and gamma-ray bursts.

All talks generated lively debates that often continued during the coffee break sessions or were resumed during lunches and dinners. The symposium was concluded by Shri Kulkarni, who summarized the content of the meeting as well as included some of his own thoughts about our current understanding in the field. One invited talk was not given: Chris Fryer had a last minute emergency that prevented him from giving his talk on Stellar Collapse and Gamma-Ray Burst Explosion Mechanisms.

No more appropriate setting could be chosen for the Symposium than the little and lovely city of Nikko. Its magic atmosphere fascinated the participants, who cherished the opportunity of discovering this Japanese hidden gemstone, and to discuss science in this pure, quiet and inspiring mountain environment.

We would like to thank all the people, entities and authorities who helped this event happen. We are grateful to the participants, speakers, session chairpersons, and Science Organizing Committee who ensured a high scientific standard and lively forum for the exchange of new ideas and concepts. We are also grateful to the secretaries, assistants, and Local Organizing Committee whose active support made possible the realization of the numerous details always associated with such a symposium. A special thanks goes to Takeo Minezaki, whose help as an assistant editor was invaluable, and to Tanja Karthaus (IAC) and Sarah Tayler (SRON) for their careful transcription of the discussion sheets.

*Elena Pian, Nobu Kawai, and Pete Roming, co-chairs SOC,
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June 6, 2012*

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Post Symposium Address by the Local Organizing Committee

Dear colleagues,

It is a great pleasure to observe that the IAU symposium 279 has been a great success. As mentioned by Prof. Kawai at the opening address, we suffered from the huge earthquake which hit the northern part of Japan on March 11, 2011, that created many tragic stories. While the Kanto-area including Nikko and Tokyo was not seriously damaged, many side effects have been unavoidably there. Because of this, the symposium organizing efforts suffered from various uncertainties, including the postponement from the original schedule (April, 2011) to March, 2012. The difficulties have been overcome by the help and devotion of many people involved in the organization, and I want to take this opportunity to thank all them on behalf of the Local Organizing Committee.

We have very efficient, self-sacrificing people in the LOC: Katsuaki Asano, Yoichi Yatsu, Takuya Ohkawa from Tokyo Tech.; Masaomi Tanaka and Kei Kotake from NAOJ; Aya Bamba from Aoyama Univ.; Takeo Minezaki from U. Tokyo; and Toru Tamagawa from RIKEN. They all actively worked on the LOC, and without their great efforts the symposium would never have taken place. Pete Roming, Elena Pian, and Nobu Kawai, as SOC chairs, have provided great supervision of the LOC efforts.

There are many people who are not listed in the organizing committee despite their great contributions to the symposium. You saw many students (from Tokyo Tech. and IPMU) assisting during the symposium sessions and coffee breaks. I'd like to thank the secretaries from these institutes and the company Quality Management – especially Yasuko Konagai, Rie Ujita, Yasuhiro Kato, and Noriko Kagaya who provided the critical help necessary for the symposium. I also want to express my gratitude to the IAU secretaries for their continuous help, especially on how to proceed with the symposium organization after the earthquake on March, 2011. I am happy to see that Thierry Montmerle from the IAU, whose advice was most critical for the reorganization, made it to the symposium. There are many institutions who supported the symposium, as you can see in the preface and the opening address of this proceedings edition.

I also want to emphasize that the people in Nikko area were very helpful during the symposium organization. The hotel Nikko Senhime Monogatari provided the beautiful venue, and the staff was very flexible and helpful in providing the warm and stimulating atmosphere. As you might have noticed, everywhere you went people in the Nikko area were all friendly and always willing to provide help - beautiful landscapes and people. I am sure that with all that Nikko has to offer, that shortly the city will fully recover from the economic damage they suffered as a place of tourism after the earthquake - I hope that the symposium had a good effect on this respect as well.

Last but not least, I want to remark that the symposium was successful thanks to the excellent talks and active discussions from all the participants. I hope that every participant feels the same way as I do and that they enjoyed the symposium very much - thanks very much to all of you, and I look forward to seeing you again.

Keiichi Maeda, LOC chair
20 June 2012

Welcome Address

I would like to welcome all of you to IAU Symposium 279 titled “Death of Massive Stars.” The idea of having a symposium in Japan that deals with supernovae and gamma-ray bursts together was originally suggested by Pete Roming, who is here to chair the session today. I enthusiastically agreed with his idea, and suggested to have it here in Nikko. This is actually my home town; I spent my childhood here. Some of my old friends still live here, and the owner of this hotel is actually my classmate from the primary school. I am really happy to see the impressive program in this symposium thanks to the SOC. In particular Elena Pian did a superb job in assembling the ideas. I hope you enjoy the discussions here, and gain some new research ideas during this meeting.

As all of you are aware, this symposium was originally scheduled in April of last year, but was postponed due to the huge earthquake that hit northern Japan exactly one year ago yesterday. Because of the earthquake, and the subsequent Tsunami, which is the largest in Japanese history, lives of 20,000 people were lost. Here, I would like to propose a moment of silence for them with our eyes closed.

Thank you.

Immediately after the earthquake, eastern Japan, including Tokyo and Nikko was in severe confusion. In two weeks or so, the situation in Tokyo and Nikko was more or less back to normal, except for some inconvenience to save electric power. However, we realized that the accident at the Fukushima Nuclear power plant was a very strong concern in and outside Japan, and we ourselves did not know how it was going to be settled. After discussion with the IAU, we decided to postpone the symposium to now. This is rather unusual, because IAU symposia are selected on a yearly basis, and this symposium had been selected for 2011. IAU allocates some yearly budgets for symposia and moving a symposium to the next year causes non-trivial arrangements at IAU. I would like to thank the IAU for supporting this symposium, and also all the efforts they made to make it happen despite all of the trouble.

Here in Japan, we also obtained funding for supporting this symposium, and it also was approved for the fiscal year 2011, which ends this month. That is why we set the new date in March. The weather in March in Nikko is not so nice as in April, as you may have already noticed. Furthermore, we have some snow today. It is actually, uncommon even here in Nikko in March. However, I hope that the shrines here, that are selected as UNESCO’s World Cultural Heritage, look more beautiful with snow, and I hope you have time to see them during this week. Wednesday afternoon is allocated to relax and see this beautiful and interesting area.

Lastly, I thank the support from the IAU; the Ministry of Education, Culture, Sport, Science and Technology of Japan; Japan Society for Promotion of Science; Institute for Physics and Mathematics of the Universe of the University of Tokyo; Global COE Program “Quantum Physics and Nanoscience,” Tokyo Institute of Technology; and Southwest Research Institute. It is also supported by the Astronomical Society of Japan.

Please enjoy the meeting.

*Nobuyuki Kawai, co-chair SOC
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