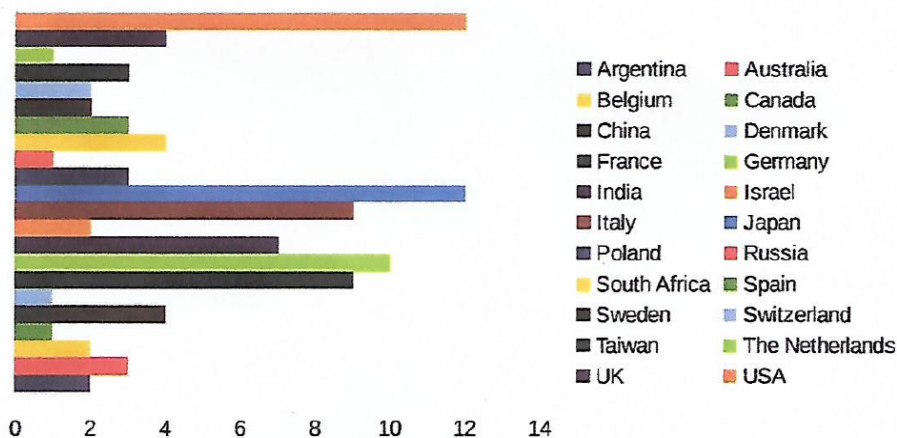


**Post-Meeting Report of the IAUS 331 : « SN 1987A, 30 years later »**

1. Meeting number: Symposium 331
2. Meeting title: SN 1987A, 30 years later (Cosmic Rays and Nuclei from Supernovae and their aftermaths)
3. Coordinating division: Division G (Stars and Stellar Physics)
4. Dedication of meeting (if any): celebration of the 30th anniversary of SN 1987A in the Large Magellanic Cloud
5. Location (city, country): Le Village de Corail, Saint-Gilles Les Bains, La Réunion Island, France
6. Dates of meeting: from 20th February to 24th February 2017
7. Number of participants and represented countries: 89 [+ 8 accompanying persons]
8. List of represented countries: 22



9. Report submitted by: **Dr M. Renaud & Dr A. Marcowith, on behalf of the IAUS 331 SOC/LOC**

10. Date and place: *28.03.2017, Montpellier*

11. Signature of SOC Chairperson:

## **Final Scientific Program**

(Contributed : « Academic » : black, IAU grantee : red, Invited : green )

### **List of invited review speakers (in green in the following program):**

Poonam Chandra (*NCRA-TIFR, India*), You-Hua Chu (*ASIAA, Taiwan*), Anne Decourchelle (*CEA/SaP, France*), Fiorenza Donato (*Univ. Torino, Italy*), Claes Fransson (*OKC, Sweden*), Christopher L. Fryer (*LANL, USA*), Brian Grefenstette (*SRL, Caltech, USA*), Alexander Heger (*MoCA, Monash Univ., Australia*), Raphaël Hirschi (*Keele Univ., UK*), Robert P. Kirshner (*CfA Harvard, USA*), Kei Kotake (*Fukuoka Univ., Japan*), Shiu-Hang Lee (*ISAS/JAXA, Japan*), Julie McEnery (*NASA/GSFC, USA*), Giovanni Morlino (*INFN/Gran Sasso Science Institute, Italy*), Salvatore Orlando (*INAF/OAPa, Italy*), Georg Raffelt (*MPP, Germany*), Irene Tamborra (*NBIA, Denmark*), Stefano Valenti (*UC Davis, USA*), Giovanna Zandarò (*ICRAR, Australia*)

### **1) Massive Stars as SN progenitors: Observations of RSGs/BSGs/WRs and their surroundings – Stellar Evolution (mass loss, rotation, binarity, magnetic field, instabilities) [chair: R. Diehl]**

**Monday, 09:00 – 10:30 : 3×C, 1×I**

**Monday, 11:00 – 12:30 : 3×C, 1×I**

- 1- The Progenitors of Core-Collapse Supernovae, **R. Hirschi**
- 2- Single versus binary star progenitors of Type IIb supernovae, **N. Sravan**
- 3- Evolution and explosions of stars leading to type IIP or IIb supernovae through MESA and SNEC, **S. Das & A. Ray**
- 4- The Type IIb Supernova 2016gkg and Its Remarkable Blue Progenitor **C. Kilpatrick**
- 5- CSI in Supernova Remnants, **Y.-H. Chu**
- 6- Unveiling the structure of the progenitors of type II-P Supernovae through multiwaveband observations, **F. Sutaria**
- 7- Outbursts of evolved massive stars: SN 2015bh and its relatives, **C. Thöne**
- 8- Fermi acceleration under control: eta Carinae, **R. Walter**

### **2) SN explosion mechanisms: theory and multi-dimensional simulations of neutrino-/non-neutrino-driven mechanisms [chair: T. Janka]**

**Monday, 14:00 – 15:30 : 3×C, 1×I**

**Monday, 16:00 – 17:50 : 4×C, 1×I**

- 1- Observational Constraints on the Supernova Engine, **C. Fryer**
- 2- Hydrodynamic Simulations of Axisymmetric Supernovae Explosion, **N. Afsariardchi**
- 3- Linking 3D CCSN simulations with observations, **A. Wongwathanarat**
- 4- Three Dimensional Simulations of Core-Collapse Supernovae in FLASH, **E. O'Connor**
- 5- Explosion and Nucleosynthesis of Massive and Very Massive Stars, **A. Heger**
- 6- Jets in supernovae and SNRs, **N. Soker**
- 7- Magnetically assisted explosions of weakly magnetized stars, **H. Sawai**
- 8- Incidence of stellar rotation on the explosion mechanism of massive stars, **R. Kazeroni**
- 9- How to form a millisecond magnetar ? Magnetic field amplification in protoneutron stars, **J. Guilet**

**3) SNe as stellar explosive outcomes: SN properties - SN-GRB connection [chair: A. Ray]**

Tuesday, 09:00 – 10:30 : 3×C, 1×I

Tuesday, 11:00 – 12:30 : 3×C, 1×I

- 1- Constraints on the progenitors from radio and X-ray observations of core collapse supernovae, **P. Chandra**
- 2- Constraining magnetic field amplification in SN shocks using radio observations of SNe 2011fe and 2014J, **E. Kundu**
- 3- Supernova 1986J: a Neutron Star or Black Hole in the Center?, **M. Bietenholz**
- 4- Spatial distribution of different subtypes of Core-Collapse and Thermonuclear Supernovae in the galaxies, **D. Tsvetkov**
- 5- Massive Stars explosions, **S. Valenti**
- 6- Properties of X-ray emission of an aspherical shock breakout, **Y. Ohtani**
- 7- The diversity of GRBs and their supernovae: GRB-SN, kilonovae and SN-less GRBs, **A. de Ugarte Postigo**
- 8- Radioactive decay of GRB-SNe at late-times, **K. Misra**

**4) SN outcomes and impacts: SNRs : dynamics, ejecta, dust – Nucleosynthesis – Feedback on ISM [chair: M. Renaud]**

Tuesday, 14:00 – 15:30 : 3×C, 1×I

Tuesday, 16:00 – 17:30 : 3×C, 1×I

Wednesday, 14:00 – 15:30 : 3×C, 1×I

Wednesday, 16:00 – 17:00 : 3×C

- 9- Constraining pulsar birth properties with supernova X-ray observations, **Y. Gallant**
- 10- The impact of reverberation on pulsars of low spin-down power: A rotationally-powered magnetar nebula around Swift 1834.9-0846, **D. F. Torres**
- 1- Supernova remnants dynamics, **A. Decourchelle**
- 2- The infancy of supernova remnants: evolving a supernova into its remnant in 3D, **M. Gabler**
- 3- Bridging the gap between SNe and their remnants through multi-dimensional hydrodynamic modeling, **S. Orlando**
- 4- MUSE Integral Field Observation of the Oxygen-rich SNR 1E0102, **I. Seitenzahl**
- 5- Ultraviolet Extinction of a Few Supernova Remnants, **M. Sun**
- 6- Detections of Thermal X-Ray Emission and Proper Motions in RX J1713.7-3946, **S. Katsuda**
- (end of the day)*-----
- 7- High-resolution imaging of SNR IC443 and W44 with the Sardinia Radio Telescope at 7 GHz, **E. Egron**
- 8- Evidence for a wide electron spectra scatter among different SNR regions from high radio-frequencies observations, **A. Pellizzoni**
- 9- 325 MHz and 610 MHz Radio Counterparts of SNR G353.6-0.7 a.k.a. HESS J1731-347, **Nayana, A.J.**
- 10- Bringing the High Energy Sky into Focus: NuSTAR's View of Supernova Remnants, **B. Grefenstette**
- 11- Gamma ray line measurements from supernova explosions, **R. Diehl**
- 12- 3D Supernova Explosion Models for the Production and Distribution of  $^{44}\text{Ti}$  and  $^{56}\text{Ni}$  in Cassiopeia A, **H.-T. Janka**
- 13- Discovery of Titanium-K Lines in the Northeastern Jet of Cas A, **T. Ikeda**

**5) Poster session: [chair: M. Renaud]**

**Wednesday, 17:30 – 18:30 (11 3+2min talks)**

- 1- Characterization of Supernova Remnants in M83, **C.-J. Li**
- 2- Multi-wavelength Characterization of Type Ia Supernova Remnants, **P.-S. Ou**
- 3- High-resolution spectral imaging of Supernova Remnants IC443 and W44 at 22 GHz with the Sardinia Radio Telescope, **S. Loru**
- 4- Investigating the region of 3C397 in High Energy Gamma-rays, **P. Bhattacharjee**
- 5- Disentangling the hadronic from the leptonic emission in the composite SNR G326.3-1.8, **J. Devin**
- 6- Upper limits on gamma-ray emission from SNe serendipitously observed with H.E.S.S., **R. Simoni**
- 7- 3D dust radiative transfer simulations of SN1987A, **M. Baes**
- 8- Cosmic-Ray Lithium Production in the Nova Ejecta, **N. Kawanaka**
- 9- Measuring Distances to the Galactic Supernova Remnants Using Red Clump Stars, **S. Shan**
- 10- MHD Simulation of Supernova Remnants, **M. Zhang**
- 11- Supernova Remnants with Astrosat, **F. Sutaria**

**6) Particle acceleration and Origin of Cosmic Rays: Diffusive Shock Acceleration Theory and 3D simulations — Magnetic field constraints — Review on CR measurements [chair: Y. Gallant]**

**Thursday, 09:00 – 10:40 : 2×C, 2×I**

**Thursday, 11:10 – 12:30 : 4×C**

- 1- Cosmic ray astroparticle physics: current status and future perspectives, **F. Donato**
- 2- The SNR-CR connection: a modern prospective, **G. Morlino**
- 3- X-ray Synchrotron Polarization from Turbulent Plasmas in Supernova Remnants, **M. G. Baring**
- 4- Balmer-dominated shocks in Tycho's SNR: omnipresence of CRs, **S. Knezevic**
- 5- Spatio-temporal evolution of the nonresonant Bell's instability in the precursors of young supernova remnant shocks, **O. Kobzar**
- 6- Nonrelativistic perpendicular shocks modeling young supernova remnants through kinetic simulations, **J. Niemiec**
- 7- Turbulent magnetic reconnection and particle acceleration at nonrelativistic shocks of young supernova remnants, **A. Bohdan**
- 8- Linking SNe and SNRs. Time-dependent injection in SN 1987A and gamma-ray emission of IC 443, **O. Petruk**

**7) SN 1987A, 30 years later: Historical review – Multi-wavelength properties of the remnant in connection with the above-listed sessions [chair: T. Janka]**

Thursday, 14:00 – 15:30 : 3×C, 1×I

Thursday, 16:00 – 17:30 : 3×C, 1×I

Thursday, evening “Celebrating the SN 1987A 30th anniversary” : 2×I

- 1- SN 1987A at 30 years, **C. Fransson**
- 2- X-raying the evolution of SN 1987A, **V. Kashyap**
- 3- Investigating the origin of the X-ray emission from SN 1987A, **S. Orlando (for M. Miceli)**
- 4- ALMA observations of Molecules in Supernova 1987A, **M. Matsuura**
- 5- Particle accelerators in the Large Magellanic Cloud, **P. Martin**
- 6- H.E.S.S. Observations of the Large Magellanic Cloud, **N. Komin**
- 7- The Radio Remnant of Supernova 1987A - A Broader View, **G. Zanardo**
- 8- High-resolution observations of dust in SN1987A, **P. Cigan**
- 9- Supernova 1987A and the Birth of Neutrino Astronomy, **G. Raffelt**
- 10- SN 1987A: The Supernova of a Lifetime, **R. Kirshner**

**8) Non-thermal multi-wavelength/multi-messenger data on SNe/SNRs: Radio/X-ray/GeV/TeV observations and broadband modeling — New windows : Gravitational Waves, Neutrinos — Future facilities & perspectives (Advanced LIGO/Virgo, KM3NeT, IceCube-Gen2, SKA, LSST, Athena, MeV, CTA) [chairs: R. Diehl & G. Raffelt]**

Friday, 09:00 – 10:30 : 3×C, 1×I

Friday, 11:00 – 12:30 : 3×C, 1×I

Friday, 14:00 – 15:40 : 2×C, 2×I

Friday, 16:10 – 17:30 : 4×C

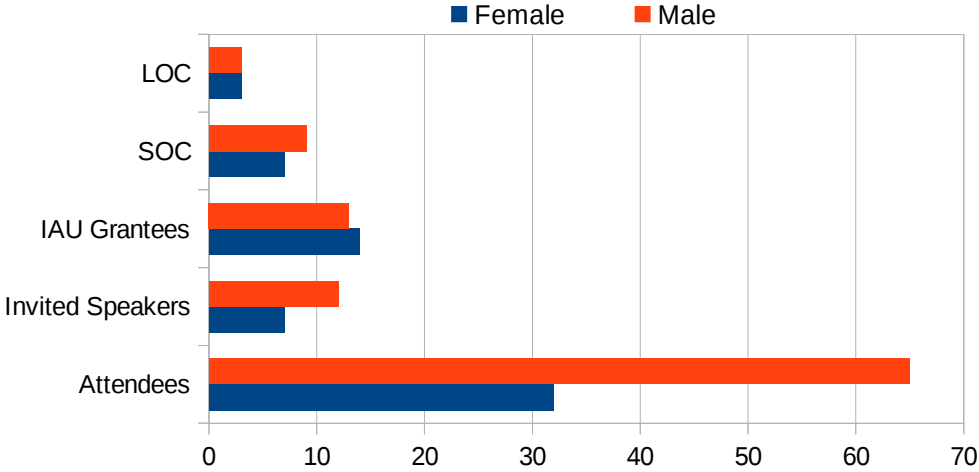
- 1- Supernova Remnants and high and very high energy gamma-ray observations, **J. McEnery**
- 2- Understanding X-ray and gamma-ray emission of RX J1713.7-3946, **J. Ballet**
- 3- The role of the diffusive protons in the gamma-ray emission of SNR RX J1713.7-3946, **X. Zhang**
- 4- The origin of gamma rays in RX J1713.7-3946 and the other shell-like SNRs; evidence for the dominant contribution of the hadronic gamma-rays, **Y. Fukui**
- 5- Now and the Future of Broadband SNR Models, **H. Lee**
- 6- Fermi LAT observations of Supernova Remnants, **F. de Palma**
- 7- The GeV Gamma-Ray Emission Detected by Fermi-LAT Adjacent to SNR Kesteven 41, **B. Liu**
- 8- Overview of VHE gamma-ray emission from the SNRs detected by MAGIC, **S. Masuda**
- 9- VHE gamma-rays from the remnants of Galactic core-collapse supernovae, **R. Chaves**
- 10- Morphology studies and resolved spectroscopy of the Vela Jr. Supernova remnant with H.E.S.S., **I. Sushch**
- 11- Multimessenger predictions from 3D Core-Collapse Supernova Models, **K. Kotake**
- 12- Supernova lessons from low- and high-energy neutrinos, **I. Tamborra**
- 13- Are supernova remnants in the Galaxy and star-forming regions sources of high-energy neutrinos?, **S. Razzaque**
- 14- ANTARES and KM3NeT programs for the supernova neutrino detection, **V. Kulikovskiy**
- 15- Synergy SKA-CTA: supernova remnants as cosmic accelerators, **A. Ingallinera**
- 16- e-ASTROGAM : towards a new space mission for gamma-ray astronomy, **R. Diehl (for V. Tatischeff)**

## List of participants

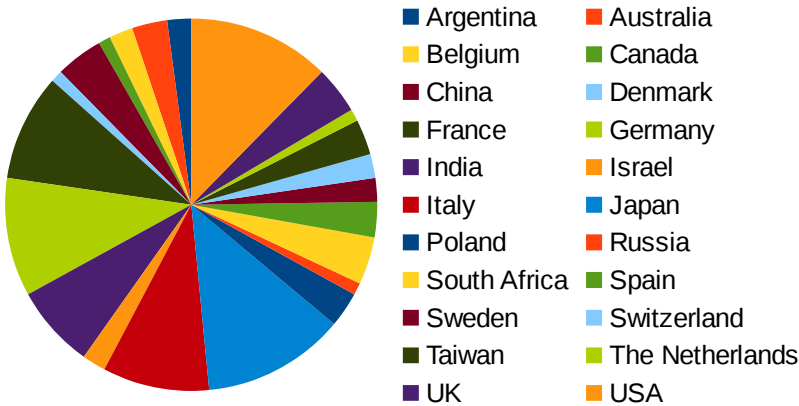
<b>Last Name</b>	<b>First Name</b>	<b>Gender</b>	<b>Affiliation</b>
A.J	Nayana	Female	NCRA-TIFR, Pune, India
Afsariardchi	Niloufar	Female	University of Toronto, Canada
Baes	Maarten	Male	Universiteit Gent, Belgium
Ballet	Jean	Male	CEA/Sap, Saclay, France
Baring	Matthew	Male	Rice University, Houston, USA
Bhattacharjee	Pooja	Female	Bose Institute, Kolkata, India
Bietenholz	Michael	Male	HartRAO, Krugersdorp, South Africa
Bohdan	Artem	Male	IFJ-PAN, Krakow, Poland
Castelletti	Gabriela	Female	IAFE, Buenos Aires, Argentina
Chandra	Poonam	Female	NCRA-TIFR, Pune, India
Chaves	Ryan	Male	LUPM, Montpellier, France
Chu	You-Hua	Female	ASIAA, Taipei, Taiwan
Cigan	Phillip	Male	School of Physics and Astronomy, Cardiff, UK
de Palma	Francesco	Male	INFN Bari, Italy
de Ugarte Postigo	Antonio	Male	IAA-CSIC, Granada, Spain
Decourchelle	Anne	Female	CEA/Sap, Saclay, France
Devin	Justine	Female	LUPM, Montpellier, France
Diehl	Roland	Male	MPE, Garching, Germany
Donato	Fiorenza	Female	Torino University, Italy
Egron	Elise	Female	INAF – Cagliari Observatory, Italy
Fransson	Claes	Male	Stockholm University, Sweden
Fryer	Chris	Male	LANL, Los Alamos, USA
Fukui	Yasuo	Male	Nagoya University, Japan
Gabler	Michael	Male	MPA, Garching, Germany
Gallant	Yves	Male	LUPM, Montpellier, France
Glas	Robert	Male	MPA, Garching, Germany
Grefenstette	Brian	Male	Caltech, Pasadena, USA
Guilet	Jerome	Male	MPA, Garching, Germany
Heger	Alexander	Male	MoCA, Clayton, Australia
Hirschi	Raphael	Male	Keele University, UK
Ikeda	Takuma	Male	Rikkyo University, Tokyo, Japan
Ingallinera	Adriano	Male	INAF – OACT, Catania, Italy
Janka	Hans-Thomas	Male	MPA, Garching, Germany
Kashyap	Vinay	Male	Dept of Astronomy, Harvard University, USA
Katsuda	Satoru	Male	Chuo University, Tokyo, Japan
Kawanaka	Norita	Male	Kyoto University, Japan
Kazeroni	Remi	Male	MPA, Garching, Germany
Kilpatrick	Charles	Male	Univ. of California, Santa Cruz, USA
Kirshner	Robert	Male	Gordon and Betty Moore Foundation, USA
Knezevic	Sladjana	Female	Weizmann Institute of Science, Rehovot, Israel
Kobzar	Oleh	Male	IFJ-PAN, Krakow, Poland
Komin	Nukri	Male	Wits University, Johannesburg, South Africa
Kotake	Kei	Male	Fukuoka University, Japan
Kulikovskiy	Vladimir	Male	CPPM, Marseille, France
Kundu	Esha	Female	Stockholm University, Sweden
Lebre	Agnes	Female	LUPM, Montpellier, France

Lee	Herman (Shiu-Hang)	Male	Kyoto University, Japan
Li	Chuan-Jui	Male	ASIAA, Taipei, Taiwan
Liu	Bing	Female	Nanjing University, China
Loru	Sara	Female	INAF – Cagliari Observatory, Italy
Martin	Pierrick	Male	IRAP, Toulouse, France
Masuda	Shu	Male	Dept of Physics, Kyoto University, Japan
Matsuura	Mikako	Female	School of Physics and Astronomy, Cardiff, UK
McEnergy	Julie	Female	NASA/GSFC, Greenbelt, USA
Misra	Kuntal	Female	ARIES, Nainital, India
Morlino	Giovanni	Male	GSSI, L'Aquila, Italy
Niemiec	Jacek	Male	IFJ-PAN, Krakow, Poland
O'Connor	Evan	Male	North Carolina State Univ., Raleigh, USA
Ohtani	Yukari	Female	NAOJ, Tokyo, Japan
Orlando	Salvatore	Male	INAF – Palermo Observatory, Italy
Ou	Po-Sheng	Male	ASIAA, Taipei, Taiwan
Pellizzoni	Alberto	Male	INAF – Cagliari Observatory, Italy
Petruk	Oleh	Male	INAF – Palermo Observatory, Italy
Raffelt	Georg	Male	MPP, Munich, Germany
Rahman	Ninoy	Male	MPA, Garching, Germany
Ray	Alak	Male	TIFR, Mumbai, India
Razzaque	Soebur	Male	University of Johannesburg, South Africa
Renaud	Matthieu	Male	LUPM, Montpellier, France
Sawai	Hidetomo	Male	RIST, Kobe, Japan
Seitenzahl	Ivo	Male	Australian National University, Australia
Shan	Susu	Female	NAO-CAS, Beijing, China
Simoni	Rachel	Female	API, Amsterdam, The Netherlands
Soker	Noam	Male	Technion
Pravan	Niharika	Female	Northwestern University, Evanston, USA
Stockinger	Georg	Male	MPA, Garching, Germany
Sun	Mingxu	Male	Beijing Normal University, China
Supan	Jorge Leonardo	Male	IAFE, Buenos Aires, Argentina
Sushch	Iurii	Male	DESY, Zeuthen, Germany
Sutaria	Firoza	Female	IIA, Bangalore, India
Tamborra	Irene	Female	NBI, Copenhagen, Denmark
Thone	Christina	Female	IAA-CSIC, Granada, Spain
Torres	Diego F.	Male	ICREA & IEEC-CSIC, Barcelona, Spain
Totani	Tomonori	Male	The University of Tokyo, Japan
Tsvetkov	Dmitry	Male	SAI, Moscow, Russia
Valenti	Stefano	Male	UC Davis, USA
Walter	Roland	Male	ISDC, University of Geneva, Switzerland
Wongwathanarat	Annop	Male	RIKEN, Wako, Japan
Zanardo	Giovanna	Female	ICRAR, West Perth, Australia
Zhang	Xiao	Male	Nanjing University, China

Among the 89 participants, there have been 26 [29.2%] women and 63 [70.8%] men. Among the 97 attendees (i.e. including accompanying persons), the gender distribution was: F: 32 [33%], M: 65 [67%]. Among the 19 invited speakers, the gender breakdown was as follows: 7 [36.9%] women and 12 [63.1%] men. The gender balance among the LOC, SOC and IAU grantees (see also below) is clearly seen in the following double bar chart:



The geographical distribution of these 97 attendees (coming from 22 countries worldwide) is illustrated in the following diagram and world map:





### List of IAU Grant Recipients

Family Name	First Name	Gender	Affiliation	Nationality	amount received (€)
A.J	Nayana	Female	NCRA-TIFR, Pune, India	Indian	750
BHATTACHARJEE	Pooja	Female	Bose Institute, Kolkata, India	Indian	1100
BOHDAN	Artem	Male	IFJ-PAN, Krakow, Poland	Ukrainian	500
CASTELLETTI	Gabriela	Female	IAFE, Buenos Aires, Argentina	Argentinian	1100 → 670
CIGAN	Phillip	Male	School of Physics and Astronomy, Cardiff, UK	USA	750
DE UGARTE POSTIGO	Antonio	Male	IAA-CSIC, Granada, Spain	Spanish	750
DEVIN	Justine	Female	LUPM, Montpellier, France	French	750
GABLER	Michael	Male	MPA, Garching, Germany	German	250
GUILLET	Jerome	Male	MPA, Garching, Germany	French	250
INGALLINERA	Adriano	Male	INAF - OACT, Catania, Italy	Italian	750
KILPATRICK	Charles	Male	Univ. of California, Santa Cruz, USA	USA	750
KNEZEVIC	Sladjana	Female	Weizmann Institute of Science, Rehovot, Israel	Serbian	500
KOBZAR	Oleh	Male	IFJ-PAN, Krakow, Poland	Ukrainian	500
LIU	Bing	Female	Nanjing University, China	Chinese	750
LORU	Sara	Female	INAF - Cagliari Observatory, Italy	Italian	750
MICELI	Marco	Male	Universita di Palermo, Italy	Italian	500 → 0
MISRA	Kuntal	Female	ARIES, Nainital, India	Indian	750
OHTANI	Yukari	Female	NAOJ, Tokyo, Japan	Japanese	750
PETRUK	Oleh	Male	IAPMM, Lviv, Ukraine	Ukrainian	1100
SHAN	Susu	Female	NAO-CAS, Beijing, China	Chinese	750
SIMONI	Rachel	Female	API, Amsterdam, The Netherlands	French	750
SRAVAN	Niharika	Female	Northwestern University, Evanston, USA	Indian	750
SUPAN	Jorge	Male	IAFE, Buenos Aires, Argentina	Argentinian	1100 → 670
SUTARIA	Firoza	Female	IIA, Bangalore, India	Indian	750
THÖNE	Christina	Female	IAA-CSIC, Granada, Spain	German	750
WONGWATHANARAT	Annop	Male	RIKEN, Wako, Japan	Thai	1100
ZHANG	Xiao	Male	Nanjing University, China	Chinese	750

As seen from the above table, the gender distribution of the IAU grantees is well balanced, with 14 [51.9%] women and 13 [48.1%] men, coming from 12 different countries worldwide. The three names shaded in grey correspond to grantees who couldn't finally come to the meeting. Among them, two researchers from Argentina had already received part of their allocated grant in the form of plane tickets covering part of their flight itinerary (for an amount of 670 EUR each). Unfortunately, they couldn't take their flights at the Buenos Aires airport because of expired certificates of vaccination against yellow fever according to the new national regulations. Thus, these tickets couldn't be refunded on such a short notice.

## **Executive Summary of the Meeting**

The Symposium IAUS 331 was held on 20-24 February 2017 at Le Village de Corail (Saint-Gilles Les Bains) in La Réunion Island, a french overseas department in the Indian Ocean, at the occasion of the 30<sup>th</sup> anniversary of SN 1987A. The main goal of the meeting was to bring together the SN and SNR communities, theorists, observers and instrumentalists from diverse geographical regions and fields of expertise, in order to make the link between the stellar progenitors and the multi-wavelength/-messenger manifestation of their aftermaths in terms of extreme sources of high-energy particles and nuclei. Taking place in a large conference room within the holiday village, in an inclusive environment, free of harassment, the meeting was thus divided into seven, interconnected, sessions:

- (1) Massive stars as SN progenitors
- (2) SN explosion mechanisms
- (3) SN properties and SN-GRB connection
- (4) SN outcomes and impacts
- (5) Particle acceleration and origin of Cosmic Rays
- (6) SN 1987A, 30 years later
- (7) Multi-wavelength/messenger data on SNe and SNRs

with a total of 74 talks (55, 15+5 min long, contributed and 19, 25+5 min long, invited) and 11 posters which have been presented during a 1-hour poster session. All the slides are freely available at: <https://iaus331.lupm.in2p3.fr/programme/scientific-programme/>. There was a great diversity in the topics addressed during the meeting, and its interdisciplinary approach has been well received by the participants, as shown by the lively questions during the sessions and the numerous informal discussions at coffee/lunch breaks. We have noted that only three oral presentations haven't triggered any discussion, while most of the talks have resulted in at least three questions.

The meeting location in La Réunion Island has allowed a greater participation by scientists from Asia in particular (India, China, Japan, Taiwan), but also from South Africa and Australia. We have paid special attention to guarantee gender, geographical and generational balance among the invited speakers and the IAU grant recipients (F: 7+14, M: 12+13, coming from 17 countries worldwide), echoing that found in the SOC and LOC members (F: 7+3, M: 9+3 from 12 countries). Giving the opportunity to young researchers to present their work has been made possible thanks to the support from 14 institutions at the international (through the IAU sponsorship for travel grants), national (CNRS, Univ. Montpellier, LUPM, 4 National Programs, 2 French Societies, The OSU/OREME Observatory, The OCEVU Laboratory of Excellence) and local (Les Makes Observatory, The administrative Region Réunion) scales.

Besides the scientific program whose highlights are detailed in the next section, there were several social events. A conference has been given by Lola Massé, the scientific officer of The National Marine Reserve of Reunion, presenting the marine environment of the island and emphasizing the need to preserve it for a sustainable use. Two excursions were organized, one to the so-called « Maïdo » and the other to the active volcano « Le Piton de la Fournaise » (on Saturday the 25<sup>th</sup>, after the meeting). The first excursion was the opportunity to visit one of the most spectacular viewpoints, at 2100 m asl, on the (most remote, yet inhabited) cirque of Mafate, in the heart of the National Park, known to be the historical site of « maroon » slaves back in the early 19th century. This was accompanied by a free walking tour in a nearby forest of endemic species of Great Tamarinds. The second excursion consisted in a

guided tour to the Volcano itself and the related places of interest, with a visit of the Museum « La Cité du Volcan » accompanied by two professional agents. Also, a conference dinner took place at Le Village de Corail with a local (« maloya ») music band. We received very positive feedback regarding the organization and location of the meeting, its scientific content, as well as all these social events.

Within the framework of this Symposium, we also set up an outreach program comprising:

– three public lectures, relayed by local media (newspapers and radio) through a press conference on Monday the 20<sup>th</sup>, on these « celestial explosions and their remnants » (focusing on the historical Galactic SNRs but also including SN 1987A) at Le Village de Corail (on Friday the 24<sup>th</sup>) and on the two campuses of the University of La Réunion in Saint-Denis (March the 7<sup>th</sup>) and Le Tampon (March the 9<sup>th</sup>). About 200 people in total, from different horizons (members of local astronomical associations, scholars, general amateurs), have attended these conferences.

– 15 meetings between astronomers/astrophysicists and students in high schools and colleges of the island, spread over three weeks (during and after the Symposium). Nearly a thousand of students have benefited from these interventions which have given the opportunity to promote astronomy by discussing the different career paths and the profession, and presenting different fields of research ranging from stars, (exo)planets to Supernovae and their remnants. Such an initiative has been received very positively by the students and teachers. We note that several of them had carried out an educational project with their students in connection with the annular solar eclipse of 2016 September 1<sup>st</sup> seen from La Réunion and which had triggered a great public interest thanks to the efforts from the people at Les Makes Observatory.

Finally, one of the SOC co-chairs (A. Ray) has been invited to write a News & Views item in the recently launched *Nature Astronomy* Journal to recount the Symposium IAUS 331 celebrating the 30th anniversary of the so-called « *Supernova of a lifetime* », SN 1987A.

#### **Scientific Organizing Committee:**

**Co-Chairs:** A. Bykov (*IOFFE, St-Petersburg, Russia*), G. Dubner (*IAFE, Buenos Aires, Argentina*), A. Marcowith (*LUPM, Montpellier, France*), A. Ray (*TIFR, Mumbai, India*), M. Renaud (*LUPM, Montpellier, France*)

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## **Summary of the Scientific Highlights of the Meeting**

Seven interconnected sessions made up the scientific program of the Symposium IAUS 331: « SN 1987A, 30 years later » (20-24 February 2017, La Réunion Island) and we summarize below the main topics addressed, and the open issues discussed, at the meeting.

### **Massive stars as SN progenitors – SN properties and SN-GRB connection**

To make the link between the stellar progenitors with the core-collapse (cc-)SN types, several key ingredients need to be thoroughly investigated, such as convection, rotation, magnetic fields, mass loss (through eruptive/episodic phases and stellar winds) and CSM interaction, and binarity. The latter two parameters have been discussed in the cases of type IIP-IIL-IIc and I Ib SNe, respectively. Important insights can be gained through multi-wavelength observations of the circumstellar environment around massive stars and SNe/SNRs and through direct VLBI imaging of nearby, radio-bright SNe. Also, numerical models of stellar evolution can now be confronted to radio, UV-Optical-(Near)Infrared, and X-ray observations with dense temporal coverage from the early to the late SN phases in order to constrain the properties of cc-SN progenitors. Nevertheless, the great diversity of super-luminous SNe, new (fast evolving SN) transients and GRB-SNe makes it difficult to pinpoint their origins.

### **SN explosion mechanisms**

Observational constraints and theoretical aspects on the SN engine (birth conditions and properties of compact remnants, explosion energies and asymmetries, nucleosynthesis yields, gravitational wave and neutrino signals) have been presented. State-of-the-art multidimensional simulations of cc-SNe based on the neutrino-driven mechanism can lead to successful explosions although the most important physics and the main source(s) of instabilities are still being investigated, such as the progenitor models, the neutrino interaction rates, and the stellar magnetic field and rotation. Nevertheless, neutrino-driven explosion models in 3D begin to make predictions that can be tested by observations, e.g. of young SNRs. Alternative scenarios, including collapsars, magnetar-powered explosions, and jet-feedback mechanism have also been discussed.

### **SN outcomes and impacts – Particle acceleration and the origin of Cosmic Rays (CRs)**

Hydrodynamics and spectro-morphological properties of young SNRs have been reviewed. The link between the SN progenitors and their remnants has been extensively discussed through detailed multidimensional simulations, from the onset of the explosion to the first stages of the SNR evolution. Several talks have presented new multi-wavelength observations of SNRs, in particular X-ray and gamma-ray spatially- and spectrally-resolved measurements of nuclei in young SNRs (Cas A and SN 1987A, see also below). It was extensively discussed how such crucial constraints on the explosion asymmetries and hence on the SN engine can be best used to validate and improve the physics ingredients in simulations. The current measurements of the composition and spectrum of Galactic CRs and the modern aspects of the non-linear diffusive shock acceleration in SNRs have been reviewed. Detailed kinetic simulations of the spatio-temporal evolution of instabilities and turbulent magnetic reconnection at SNR shocks have been complemented by talks on the X-ray polarimetry as a key diagnostic of CR-generated turbulence and radio and Balmer line observations of SNRs.

### **SN 1987A, 30 years later**

Bringing together all the above-mentioned topics, this session focused on the wealth of multi-wavelength, spatially-resolved information on SN 1987A for nearly thirty years. Thus, there were talks on the progenitor properties and environment, the shock physics in such a complex morphology (3-D hydrodynamical models and particle acceleration probed by radio and gamma-ray observations), the nucleosynthesis products, and the high-resolution observations of the distribution of molecules and ring/ejecta dust. Two « historical » talks by Georg Raffelt

(detection of neutrinos and prospects) and Robert Kirshner (early multi- $\lambda$  observations and new constraints on the central point source emission) have completed this session in order to celebrate the 30<sup>th</sup> anniversary of this unique event.

**Multi-wavelength/messenger data on SNe and SNRs**

Observational constraints with current ground-based and space telescopes and instruments, prospects with upcoming facilities (SKA, JWST, Astrosat, Athena, e-ASTROGAM, CTA, KM3NeT, IceCube-Gen2, Super-Kamiokande, KAGRA) and theoretical aspects on the multi-wavelength and multi-messenger (gravitational waves and low/high-energy neutrinos) signatures of SNe and their remnants (e.g. broadband emission from radio to VHE gamma-rays) have been presented during the last session in order to emphasize the importance to tackle the above-mentioned topics (explosion mechanism, nucleosynthesis and particle acceleration) from all these different means.