The Progenitors of Type Ia Supernovae

August 4 – 9, 2019
Lijiang, China

Scientific Rationale:

The nature of the progenitors of Type Ia supernovae (SNe Ia) has remained unclear, even though SNe Ia play a vital role in many areas of modern astrophysics. Numerous progenitor models have been proposed in the past, including the single-degenerate (SD) model, the double-degenerate (DD) model, the sub-Chandrasekhar mass model, and quite a few variants of these. The progenitor debate has remained heated in recent years as new observations, new explosion simulations and new supernova models have provided a wealth of new, sometimes contradictory constraints; different population synthesis models also make different predictions, although - with standard assumptions - they generally do not produce the required rates in either the Chandrasekhar-mass SD or DD model. On the other hand, there has been controversy regarding whether sub-Chandrasekhar models can reproduce the observed properties of the majority of SN Ia explosions. Different observational constraints seem to favour different progenitor models. This conference will deepen our understanding of the progenitors of SNe Ia, elucidate the connection between the progenitors and the observed properties of SNe Ia and their remnants, and provide a roadmap of how to ultimately resolve the debate.

Topics:

- Observations of SNe Ia
- Supernova Remnants and Surviving Companions
- Signatures of the CS environment and Companion Constraints
- Progenitor models
- Explosion models
- Nucleosynthesis and Chemical Enrichment
- Binary Population Synthesis
- Progenitor Evolution and Supernova Cosmology

SOC:

Joe Anderson, Carles Badenes, Rosanne Di Stefano, Ryan J. Foley, Zhanwen Han (Chair), Chiaki Kobayashi, Kate Maguire, Paolo Mazzali, Philipp Podsiadlowski (Chair), Friedrich Roepke, Ken J. Shen, Mark Sullivan, Lifan Wang, Sung-Chul Yoon

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Conference Company:

Tengchi (Kunming) Convention and Exhibition Corporation
Xiaoqiong Huang (+8615912432453), Qing Wang (+8613888137379)

Website: http://sn.csp.escience.cn

Reception:
August 4, 5:30–8:00pm, Restaurant, the 2nd floor, Hexi Hotel (和玺酒店)

Banquet:
August 8, 6:30–9:30pm, Xiaonanguo Restaurant (小南国)

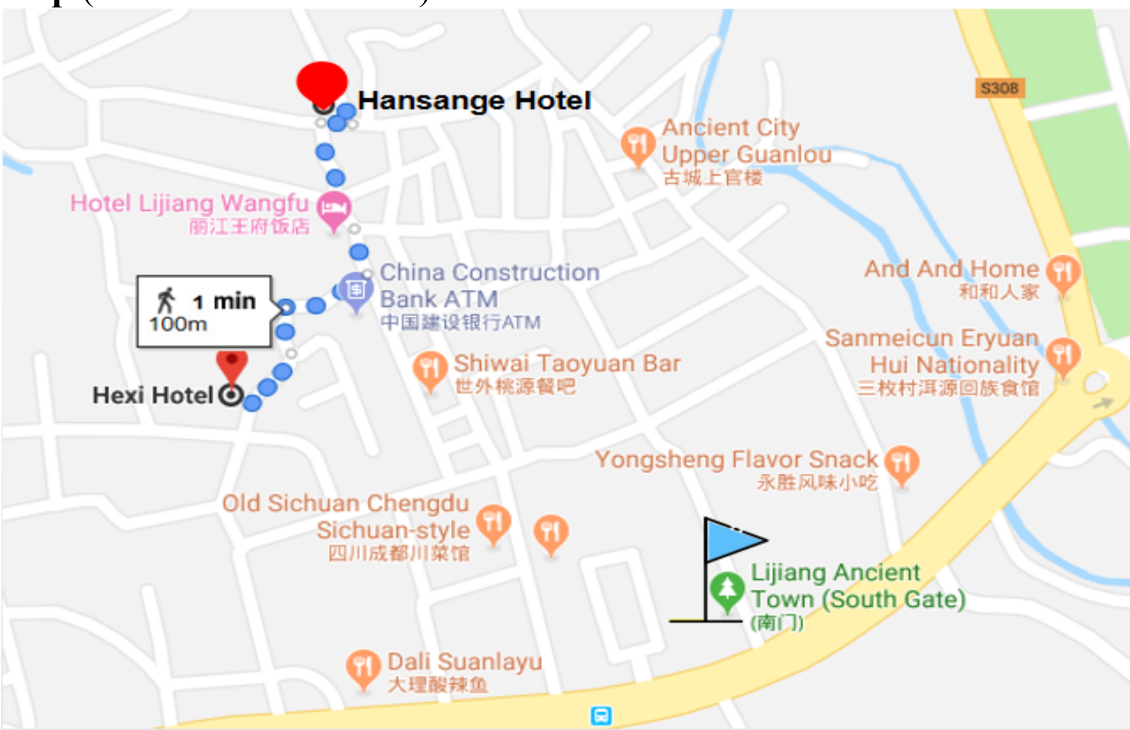
Breakfast (covered in the accommodation):
6:30–9:00am, Restaurant, the 2nd floor, Hexi Hotel (和玺酒店)

Lunch (covered):
August 5-9, 12:00–13:20, Restaurant, the 2nd floor, Hexi Hotel (和玺酒店)

Dinner (not covered), some recommended restaurants：
1.古城上官楼 Ancient City Upper Guanlou
2.三牧村洱源回族食馆 Sanmucun Eryuan Hui Nationality
3.永胜风味小吃 Yongsheng Fiavor Snack
4.世外桃源餐吧 Shiwai Taoyuan Bar
5.和和人家 And And Home
Note: There are some volunteers at the help desk in the Lobby of the Hexi Hotel who can help attendees to find restaurants for the dinner during the meeting. You can also contact Dongdong Liu for any help (liudongdong@ynao.ac.cn, +8618206840413).

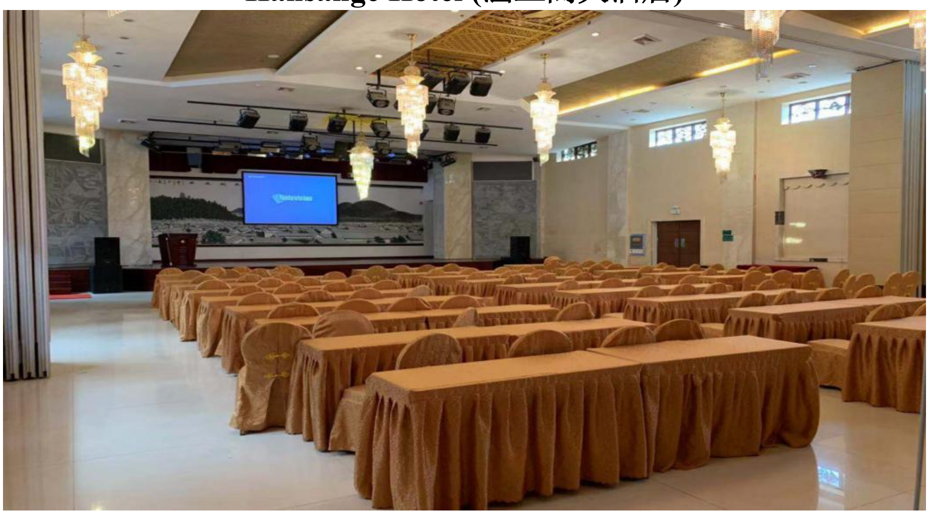
Conference Venue:
Conference Room: the 1st floor, Hansange Hotel (涵三阁大酒店，very close to the Hexi Hotel)

Map (around the Hexi hotel):



Hexi Hotel (和玺酒店)

Hansange Hotel (涵三阁大酒店)



Conference Room

Local Transportation

1、Lijiang Sanyi International Airport (LJG) → Hexi Hotel (和玺酒店)

The Hexi Hotel is about 26 km away from Lijiang Sanyi International Airport (LJG, 丽江三义国际机场). One should go to the South Gate of Lijiang Ancient Town (丽江古城南门) first, and then walk to the Hexi Hotel (和玺酒店, about 5mins).

By taxi: taking around 30 minutes, costing around 80 RMB Yuan;

Bus route 1: from Sanyi Airport, walking 900 meters to the Airport Intersection Bus Stop, taking the No. 27 bus through 28 stops to the Zhaoqing Market Bus Stop, walking 400 meters to the Hexi Hotel ;

Bus route 2: walking to the Sanyi Airport Bus Station (Domestic Arrivals Gate 3), taking an airport bus through 1 stop to the Civil Aviation Blue Sky Hotel Bus Station, then taking a taxi (4.5km, about 16 minutes, about 15 RMB Yuan) to the South Gate of the Lijiang Old Town scenic area.

2、Lijiang Railway Station → Hexi Hotel (和玺酒店) about 7 km

One should go to the South Gate of Lijiang Ancient Town (丽江古城南门) first, and then walk to the Hexi Hotel (和玺酒店, about 5mins).

By taxi: taking about 15 minutes, costing about 30 RMB Yuan;

Bus route: walking 130 meters from the Lijiang Railway Station to the Railway Bus Station, taking the No. 16 bus through 3 stops to the Zhongyi Market Bus Stop, walking 600 meters to the Hexi Hotel ;

Long-distance bus route: taking a minibus to the South Gate of the Lijiang Old Town scenic area from the parking lot of the railway station, 10 RMB Yuan per person. (Note: get on the bus and tell the driver you wish to disembark at the South Gate, which should sound like "wor yao dzai nan men shar tcher").

3、Lijiang Long-Distance Bus Station → Hexi Hotel (和玺酒店) about 2 km

One should go to the South Gate of Lijiang Ancient Town (丽江古城南门) first, and then walk to the Hexi Hotel (和玺酒店, about 5mins).

By taxi: taking around 7 minutes, costing about 10 RMB Yuan;

Bus route: walking 200 meters from the Lijiang Long-Distance Bus Station to the closest regular bus station, taking the No.12 bus through 3 stops to the Nanmen Street Bus Stop, walking 300 meters to the Hexi Hotel.

Note: if you need airport drop-off, please consult the conference company at the day of registration or during the meeting at the lobby of the Hexi hotel (there is a help desk).

Date: August 5-9, 2019
Venue: Hansange Hotel

Conference Programme

Day 1, Monday, August 5

9:00-9:15 Welcome Remarks

Session I

The Progenitors of SNe Ia: Setting the Scene

Chair: Philipp Podsiadlowski

09:15-09:45 **Ken'ichi Nomoto:** Progenitors of SNe Ia and nucleosynthesis constraints
09:45-10:15 **Peter Hoeflich:** Progenitors of SNe Ia

10:15-10:45 Morning tea/coffee break

10:45-11:15 **Rosanne Di Stefano:** New three-star Models for SNe Ia
11:15-11:45 **Paolo Mazzali:** Characterizing the nature of SNe Ia
11:45-12:15 **Lifan Wang:** SNe Ia: polarimetry and progenitors

12:15-13:30 Lunch break

Session II

Observations of SNe Ia

Chair: Xiaofeng Wang

13:30-13:55 **Mark Magee:** Modelling the early time behaviour of SNe Ia: effects of the 56Ni distribution
13:55-14:20 **Patrick Kelly:** A new route to estimating SN Ia luminosities and insights into progenitor populations
14:20-14:45 **Christopher Ashall:** Using near-infrared spectroscopy to determine the location of the outer 56Ni in SNe Ia
14:45-15:10 **Saurabh Jha:** Type Iax SNe
15:10-15:25 **Elena Pian:** THESEUS, a small ESA payload for multiwavelength transients
15:25-15:40 **Samuel Wyatt:** Strong, early near infrared carbon absorption in the transitional type Ia SN 2015bp/SNHunt281

15:40-16:10 Afternoon tea/coffee break

16:10-18:00 Chairs: Lifan Wang, Paolo Mazzali
Discussion Period #1:
What do observations tell us about SNe Ia? How do they constrain progenitor models?

Day 2, Tuesday, August 6

Session III

SN Remnants and Surviving Companions

Chair: Xiangdong Li

9:00-9:30 **Carles Badenes:** The SN remnant view of type Ia progenitors
9:30-9:55 **Gilles Ferrand:** From the thermonuclear SN to the SN remnant
9:55-10:20 **Hiroya Yamaguchi:** Tycho's SN remnant

10:20-10:30 Conference photo
10:30-11:00 Morning tea/coffee break

11:00-11:25 **Ivo Seitenzahl:** SN Ia remnant tomography
11:25-11:50 **Zhengwei Liu:** Imprints of a non-degenerate companion star in SNe Ia
11:50-12:15 **Satoru Katsuda:** Linking overluminous Ia and Ia-CSM from observations of SN remnants

12:15-13:30 Lunch break

Session III

SN Remnants and Surviving Companions

Chair: Keiichi Maeda

13:30-13:55 **Curtis McCully:** 10 years in the life of SN 2012Z
13:55-14:20 **Xiangcun Meng:** BLAPS: the possible surviving companions of SNe Ia
14:20-14:45 **Jozsef Vinko:** Constraints on the ejecta masses of SNe Ia from photometry
14:45-15:00 **Jose Prieto:** Contraining explosions and progenitors of SNe Ia from ~100 nebular-phase spectra
15:00 -15:10 **Wenxiong Li:** Observations of type Ia SN 2014J for nearly 900 days and constraints on Its progenitor system
15:10-15:20 **Callum McCutcheon:** The surviving companion of SNe Ia in the single-degenerate channel
15:20-15:30 **Yaotian Zeng:** 3D Hydrodynamical simulation of ejecta-companion interactions for type Iax SNe

15:30-16:00 Afternoon tea/coffee break

16:00-18:00 Chairs: Carles Badenes, Rosanne Di Stefano
Discussion Period #2
Confronting progenitor models with observations

Day 3, Wednesday, August 7

Session IV

Signatures of the CS environment and Companion Constraints

Chair: Saurabh Jha

8:30-9:00 **Xiaofeng Wang:** New constraints on progenitors of SNe Ia
9:00-9:25 **D. Andrew Howell:** Using Las Cumbres Observatory to reveal early bumps in the lightcurves of SNe Ia
9:25-9:50 **Yi Yang:** Spectropolarimetry of Infant SNe Ia

9:50-10:20 Morning tea/coffee break

10:20-10:50 **Keiichi Maeda:** Diversity of SNe Ia in the rising phase
10:50-11:15 **Mattia Bulla:** Where is the dust? Estimating the location of dust in [some] SNe Ia
11:15-11:40 **Ji-An Jiang:** Multiple origins of early-excess SNe Ia and associated subclasses
11:40-11:55 **Maokai Hu:** Dust scattering: effects on light curves and polarization evolution of SNe Ia with CSM

12:00-13:00 Lunch break

13:00-20:30 Social event (Half day tour of the Tiger-Leaping Gorge, after which we will have a dinner on the way to hotel at around 19:00)

Day 4, Thursday, August 8

Session V

Progenitor models and Binary Population Synthesis

Chair: Chiaki Kobayashi

9:00-9:25 **Doron Kushnir:** Simulating collisions of white dwarfs as a primary channel for SNe Ia
9:25-9:55 **Noam Soker:** SN Ia scenarios in 2019: a rising demand for clean and symmetrical explosions
9:55-10:10 **Chengyuan Wu:** Outcomes of double WD mergers

10:10-10:40 Morning tea/coffee break

10:40-11:05 **Bo Wang:** WD+He star binaries as the progenitors of SNe Ia
11:05-11:30 **Takashi Moriya:** Circumstellar properties of SNe Ia from the helium star donor channel
11:30-11:55 **Patrick Neunteufel:** The implications of magnetic torques for the single degenerate helium donor channel
11:55-12:10 **Dongdong Liu:** The formation of double massive WDs and SNe Ia

12:10-13:30 Lunch break

Session VI

Explosion models

Chair: Peter Hoeflich

13:30-14:00 **Friedrich K. Roepke:** Testing SN Ia progenitor channels in a consistent modeling pipeline
14:00-14:15 **Sabrina Gronow:** Double detonations of sub-Chandrasekhar mass white dwarfs
14:15-14:30 **Florian Lach:** Type Iax SNe from deflagrations of Chandrasekhar mass WDs
14:30-14:45 **Yossef Zenati:** Calcium-rich SNe from disruptions of CO WDs by hybrid He-CO WDs
14:45-15:00 **Ataru Tanikawa:** Three dimensional simulations of double-detonation explosions in double-degenerate systems for SNe Ia
15:00-15:10 **Rachael C. Amaro:** NIR and optical observations of ASASSN-14lp: new clues to its progenitor

15:10-15:40 Afternoon tea/coffee break

15:40-17:40 Chair**:** Zhanwen Han, Friedrich K. Roepke
Discussion Period #3
Progenitor models, binary population synthesis, and explosion modelling

18:30-21:30 Conference dinner

Day 5, Friday, August 9

Session VII

Progenitor Evolution, Chemical Enrichment and Supernova Cosmology

Chair: Noam Soker

9:00-9:30 **Chiaki Kobayashi:** Constraining SN Ia progenitors from galactic chemical evolution
9:30-9:55 **Christa Gall:** Lensed Ia SNe: single- vs. double-degenerate
9:55-10:20 **David Jones:** How much do cosmological constraints from SNe Ia depend on SN physics?

10:20-10:50 Morning tea/coffee break

10:50-11:15 **Yen-Chen Pan:** Probing the progenitor metallicity of SNe Ia with ultraviolet spectra
11:05-11:30 **Armin Rest:** High-cadence light curves of SNe Ia from the Kepler telescope
11:30-11:55 **Lluis Galbany:** A SN in the borough: integral field spectroscopy of SN Ia host galaxies

12:00-13:30 Lunch break

Session VII

Progenitor Evolution, Chemical Enrichment and Supernova Cosmology

Chair: Mark Magee

13:30-13:55 **Jeremy Mould:** The OzDES SN project
13:55-14:10 **Joris Vos:** The TESS view of the SN Ia progenitor HD 49798
14:10-14:25 **Jujia Zhang:** First 450 days observation of SN 2018zd: from type IIn to type IIP
14:25-14:40 **Matthew Siebert:** Investigating the diversity of SN Ia spectra with the open-source relational database Kaepora
14:40-14:50 **Lei Hu:** SN by feeding incompletely time sampled spectral data
14:50-15:00 **Wei-Min Liu:** Can the friction of the nova envelope account for the extra angular momentum loss in cataclysmic variables?
15:00-15:10 **Noriaki Arima:** SN survey with the wide-field CMOS camera Tomo-e Gozen
15:10-15:20 **Miho Kawabata:** Long-term optical/NIR observations of type Iax SN 2014dt
15:20-15:30 **Emmanouela Paraskeva:** Early high-cadence observations of supernovae: revealing features of variability and identifying their diversity

15:30-16:00 Afternoon tea/coffee break

16:00-18:00 Chair: Ken'ichi Nomoto, Philipp Podsiadlowski
Discussion Period #4
How to solve the progenitor conundrum: a roadmap for the future of SN Ia research

Abstract List

(Alphabetical order by last name)

NIR and Optical Observations of ASASSN-14lp: New Clues to its Progenitor

Rachael C. Amaro & David Sand

I will present the H-band wavelength region of thirty-seven post-maximum light SNe Ia near-infrared (NIR) spectra extending from +5 d to +20 d relative to the epoch of B-band maximum. I will introduce a new observable, the blue- edge velocity, vedge, of the prominent Fe/Co/Ni-peak H-band emission feature. vedge corresponds to the sharp transition between the complete and incomplete silicon burning regions in the ejecta. It measures the point in velocity space where the outer ^{56}Ni mass fraction, XNi, falls to the order of 0.03-0.10. Inspection of the +10±3 d spectra indicates that vedge is correlated with the color-stretch parameter, sBV. These results follow the previous findings that brighter SNe Ia tend to have ^{56}Ni located at higher velocities as compared to sub-luminous objects. As vedge is a model-independent parameter, I will demonstrate how it can be used in combination with traditional observational diagnostics to provide a new avenue to robustly distinguish between leading SNe Ia explosion models.

Supernova survey with the wide-field CMOS camera Tomo-e Gozen

Noriaki Arima, Tomoki Morokuma, Shigeyuki Sako, Mamoru Doi

Tomo-e Gozen is a wide-field, high-speed CMOS camera mounted on the 105-cm Schmidt telescope at the Kiso Observatory of the University of Tokyo. In April 2019, a total of 84 chips of CMOS sensors was mounted on the focal plane and the full Tomo-e Gozen was completed. It has a very wide field-of-view of 20 square degrees and can take consecutive images at 2 frames per second.

One of the main science programs with the Tomo-e Gozen is a high-cadence survey observation optimized for supernovae. It can survey 7000 square degrees every 2 hours and visit a field typically 3-5 times per night, reaching about 18 mag depth. The first supernova discovered with the Tomo-e Gozen is SN2019cxx on April 5 2019. This was spectroscopically observed with Gemini-N/GMOS and Seimei/KOOLS-IFU and identified as a type Ia supernova at z=0.025. In this poster, we will introduce the Tomo-e Gozen and report its status and recent results.

Using Near-Infrared Spectroscopy to determine the location of the outer 56Ni in Type Ia Supernovae

Christopher Ashall

I will present the H-band wavelength region of thirty-seven post-maximum light SNe Ia near-infrared (NIR) spectra extending from +5 d to +20 d relative to the epoch of B-band maximum. I will introduce a new observable, the blue- edge velocity, vedge, of the prominent Fe/Co/Ni-peak H-band emission feature. vedge corresponds to the sharp transition between the complete and incomplete silicon burning regions in the ejecta. It measures the point in velocity space where the outer ^{56}Ni mass fraction, XNi, falls to the order of 0.03-0.10. Inspection of the +10±3 d spectra indicates that vedge is correlated with the color-stretch parameter, sBV. These results follow the previous findings that brighter SNe Ia tend to have ^{56}Ni located at higher velocities as compared to sub-luminous objects. As vedge is a model-independent parameter, I will demonstrate how it can be used in combination with traditional observational diagnostics to provide a new avenue to robustly distinguish between leading SNe Ia explosion models.

The Supernova Remnant View of Type Ia Progenitors

Carles Badenes

The observational properties of young Supernova Remnants are very sensitive to the details of the SN explosion and the physical structure of the material surrounding the progenitor, up to radii of several pc. I will review a few selected results from SNRs that reveal key insights on SN Ia progenitors, including their pre-explosion mass-loss, the physical mechanism responsible for the explosion, and the mass of the exploding WD.

Where is the dust? Estimating the location of dust in [some] Type Ia supernovae
Mattia Bulla, Ariel Goobar, Suhail Dhawan

The use of Type Ia supernovae as distance indicators has led to the breakthrough discovery of the accelerated expansion of the Universe. Twenty years later, however, we are still left with the embarrassing question of what are the progenitor system(s) and explosion mechanism(s) of Type Ia supernovae. The circumstellar medium around the exploding system is a possible discriminant between different scenarios, with some models predicting large amounts of gas and dust while others a cleaner environment. In this talk, I will discuss a new technique to infer dust location towards some Type Ia supernovae and to help discriminate between a circumstellar and an interstellar origin for the observed extinction. In particular, I will show that the time-evolution of the colour excess E(B−V) places strong constraints on the distance between dust and the supernova. I will then present distance values estimated for a sample of 48 Type Ia supernovae, and show that the extinction observed in all of these events arises from dust located within interstellar clouds. The absence of dust at circumstellar scales suggests a relatively clean environment around the explosion site, providing strong arguments against some progenitor scenarios of Type Ia supernovae.

New Three-Star Models for Type Ia Supernovae
Rosanne Di Stefano

Many binaries with the potential to produce Type Ia supernovae begin their lives in hierarchical triples. During the past year we have extended the evolution of these triples to include the effects of mass transfer from the star in the outer orbit. The results are new evolutionary paths to Type Ia supernovae which are considered to be hybrids of double-degenerate and single-degenerate models. This new class of progenitor models has several detectable consequences. The challenge for the future is to determine the contributions of these triples in which mass is transferred from the third star, to the rates, delay times, and characteristics of Type Ia supernovae.

From the thermonuclear supernova to the supernova remnant
Gilles Ferrand

Recent progress in the simulation of supernovae (SNe) has shown the importance of turbulence and asymmetries in successful explosions, which prompts us to revisit the subsequent phase, the supernova remnant (SNR). Can we use the SNR morphology as a probe of the explosion mechanism? Recent work has shown the interest of this approach for a core-collapse SNR like Cas A. Here we argue for the case of a Type Ia SNR like Tycho. Our project is making the link between two communities, the one studying the explosion and the one studying the remnant. We have run 3D simulations of a SNR starting from the output of a 3D simulation of the thermonuclear explosion of a Chandrasekhar-mass white dwarf. By analyzing the wave fronts we have quantified the imprint of the explosion on the remnant over time. Assuming a uniform ambient medium, we find that the impact of the SN on the SNR may still be visible after hundreds of years. And interestingly, the newly simulated maps look more realistic than in previous works based on spherically symmetric ejecta profiles.

A supernova in the borough: Integral field spectroscopy of SN Ia host galaxies
Lluis Galbany

Integral Field Spectroscopy (IFS) applied to supernova (SN) environmental studies have shown the potential of this technique to directly characterize the galactic environmental parameters at SN Ia locations, compare them to those at different locations of the galaxy, and put constraints on progenitor stars for different SN types. Here, I will summarize past efforts of studying supernova environments with either global/local photometry/spectroscopy, and current efforts for improvement from the PISCO and AMUSING IFS surveys, that have put together more than 500 SN Ia hosts observed with IFS.

Lensed Ia supernovae: single-degenerate vs. double degenerate
Christa Gall

VLT/X-shooter observations of the quadruply imaged type Ia SN iPTF16geu reveals complex Na ID and Ca HK absorption systems at the redshift of the supernova. Accompanying He I absorption indicates the existence of circumstellar material (similar to that seen in iPTF11kx), suggesting a single degenerate progenitor system. I will address the prospects of constraining the delay time distribution (with contributions from both single and double degenerate progenitor channels) by observing highly magnified SNe Ia at high redshift (z~1) in wide-field transient surveys.

Double detonations of sub-Chandrasekhar mass white dwarfs
Sabrina Gronow & Friedrich K. Roepke

The progenitor system and the details of the explosion mechanism of Type Ia supernovae are unknown. Different scenarios are being investigated. In the double detonation scenario a helium shell was accreted onto a sub-Chandrasekhar mass carbon-oxygen white dwarf. Arising instabilities lead to a helium detonation at the base of the shell. This can trigger a second detonation in the carbon-oxygen core. Our simulations focus on studying the propagation of the helium shell detonation and the ignition of the core detonation of the explosion mechanism. For this, new numerical techniques are used. We find a detonation ignition mechanism which received little attention before and show that the success of this mechanism and the nucleosynthesis yields in the helium shell detonation ejecta depend on how the core-shell interface is modeled.

Progenitors of Type Ia Supernovae
Peter Hoeflich

Thermonuclear Supernovae, so called Type Ia SNe, are one of the building blocks of modern cosmology and laboratories for the explosion physics of White Dwarfs stars (WD) in close binary systems. The second star may be a WD, so called double degenerate systems, or a non-degenerated star, so called single degenerate system. Light curves and spectra of the explosion look similar because a 'stellar amnesia'. Basic nuclear physics determines the progenitor structure and the explosion physics, breaking the link between progenitor evolution, and the explosion. The results are three main classes of explosion scenarios with can be classified distinguished by their trigger mechanism: a) dynamical merging, b) surface helium detonation, and c) compressional heating in an accreting WD approaching the Chandrasekar mass. For distinguishing scenarios and progenitor systems, we identify the outer most layers, asymmetries, and the production of EC elements in the center high-density burning. We give an overview how recent advances in observational constrains and progenitor and explosion models show emerging links between the progenitor and their environment with light curves and spectral flux and polarization signatures, SN-remnants and Mid-IR. Finally, we discuss the future prospects with ground upcoming ground based, ELT, GMT and space based such as TESS, JWST, Euclide and WFIRST instruments.

Using Las Cumbres Observatory to reveal early bumps in the lightcurves of SNe Ia
D. Andrew Howell

Several SNe Ia have had blue bumps in their early light curves, predicted by Kasen (2010) to arise from the supernova ejecta interacting with a companion star. Las Cumbres Observatory has been instrumental in either putting limits on, or observing these bumps with its global network of telescopes making possible around the clock observations. I'll talk about our work in Bianco et al. (2011), Cao et al. (2015), Marion et al. (2016), Miller et al. (2018), Hosseinzadeh et al. (2018), Sand et al. (2018, 2019), Leloudas et al. (2019), and Li et al. (2019). I'll review the similarities and differences between the blue bumps as well as the interpretation that they arise from interactions with a progenitor. It remains a mystery why nebular Hydrogen-alpha is not seen in some cases. I'll review the simulation and radiative transfer theory in search of explanations. Finally, I'll mention the role the Global Supernova Project, in conjunction with TESS and Swift in such searches for blue bumps.

Supernova by feeding incompletely time sampled spectral data
Lei Hu

Upcoming large survey LSST will deliver the variability information from the southern transient universe to 24th-27th magnitude. The unprecedented number of new Type Ia supernovae are expected to be discovered by the precisely-calibrated LSST system, while it is not realistic nor cost effective to do well-sampled spectroscopic follow-up for each detection. To save the precious observation time, we proposed a generative AI model based on LSTM, which has been successfully applied in stock market prediction and text generation, to construct the whole spectral life of one supernova by feeding under sampling real spectrum data. The model also has potential to help build a priority hierarchy of spectroscopic follow-up.

Dust Scattering: Effects on Light Curves and Polarization Evolution of SNe Ia with CSM
Maokai Hu

I will introduce my recent work about the effects of dust scattering on the light curves and polarization evolution of SNe Ia with CSM. The radiative transfer problem is solved by Monte Carlo process based on Mie scattering. Our simulations exhibit the detailed properties of the LCs and polarization evolution relating to several different distributions of CSM, including the shell, blob, disk and asymmetric shell structures. Meanwhile, our dust scattering model can give fine fitting on the LCs of high-velocity SNe Ia and the polarization signals of SN 2014J. If possible, I also want to have a discussion about the influence of the CSM on the early LCs of SNe Ia.

Type Iax Supernovae
Saurabh Jha

In recent years we have learned that not all white dwarf supernovae are normal type Ia supernovae (SN Ia). I will discuss the largest class of "peculiar" white dwarf supernovae, type Iax supernovae (SN Iax). Surprisingly, we may have a better understanding of the progenitors and explosion mechanism for SN Iax than we do for SN Ia. I will review the evidence in favor of this claim.

Multiple Origins of Early-excess SNe Ia and Associated Subclasses
Ji-An Jiang

Type Ia supernovae that show peculiar early-phase light curves ("early-excess SNe Ia") have been proposed as powerful indicators of the single degenerate progenitor system. Although a dozen of early-excess SNe Ia have been discovered in recent years, all of them show discrepancies to the prediction of collisions between supernova ejecta and non-degenerate companion stars, indicating multiple origins of the early-excess features. In this talk, I am going to introduce our recent studies of early-excess SNe Ia and the implications on the explosion physics of SNe Ia in specific subclasses.

How Much Do Cosmological Constraints from SNe Ia Depend on Supernova Physics?
David Jones

Recent cosmological measurements rely minimally on theoretical insights into the nature of Type Ia supernova (SN Ia) physics and progenitor systems. Instead, given the wealth of existing data, fully empirical models for SNe Ia are used to provide distance measurements. I will discuss the ways in which empirical models for determining SN Ia distances are subject to uncertainties in the treatment of SN color, correlations of SN distance measurements with host galaxy properties, and the evolution of progenitor properties with redshift, and the best ways to control for these uncertainties in recent and forthcoming cosmological analyses.

Linking Overluminous Ia and Ia-CSM from Observations of Supernova Remnants

Satoru Katsuda, Koji Mori, Keiichi Maeda, Masaomi Tanaka, Katsuji Koyama,
Hiroshi Tsunemi, Hiroshi Nakajima, Yoshitomo Maeda, Masanobu Ozaki, Robert Petre

We show that X-ray line intensity ratios of iron-group elements (IGEs) to intermediate-mass elements (IMEs) for type-Ia supernova remnants (SNRs) can be a good measure to identify subclasses of their SNe. After calibrating this method for Tycho's SNR and SNR 0509-67.5, we argue that Kepler's SN produced a large amount of IGEs with a possible subclass of either overluminous Ia or Ia-CSM. On the other hand, we find N overabundance from Kepler's SNR, based on high-resolution X-ray spectroscopy with XMM-Newton's grating spectrometer. This is evidence for a circumstellar medium from a progenitor system. Given that the light curve of Kepler's SN (SN 1604) does not resemble those expected for Ia-CSM but rather looks like a normal or overluminous type Ia, Kepler's SN was likely to be an overluminous (91T-like) Ia event. We thus argue that Kepler's SN was an overluminous (91T-like) event that recently started to interact with the massive CSM, supporting the possible link between 91T-like SNe and Ia-CSM SNe (Leloudas et al. 2015).

Long-term Optical/NIR Observations of type Iax SN 2014dt

Miho Kawabata, Koji Kawabata, Keiichi Maeda, Masayuki Yamanaka,
Tatsuya Nakaoka, Katsutoshi Takaki, Katsura Matsumoto, Daiki Fukushim

Type Ia supernova (SNe Ia) have been used to measure cosmic-scale distances of galaxies, since there are well-established correlation between the peak luminosity and following decline rates. However, a part of SNe Ia show deviated properties; some of them show fainter peak magnitude (>~1mag), bluer continuum and slower expansion velocity. Recently, these outliers are called SN 2002cx-like SN or SNe Iax. SN 2014dt was discovered on 29 October 2014 at ~1 week after its maximum light, and then classified as SN Iax. SN 2014dt is the nearest SNe Iax that have ever discovered. We successfully monitored the tails of the light curves in detail, well beyond 410 days after the maximum light. The light curves of SN 2014dt show slow decline after 60 days through 410 days.

The light curve is overall explained by a combination of normally-declining component and much slowly-declining one. The former would be caused by the ejecta and the latter by inner dense core, possibly the bound remnant. It is consistent with the prediction of the weak deflagration model, leaving a bound white dwarf remnant after the explosion.

A New Route to Estimating Supernova Ia Luminosities and Insights into Progenitor Populations

Patrick Kelly

I will discuss a new approach to the calibration of Type Ia supernova (SN) luminosities that may yield significantly more precise distances, as well as information about the progenitor populations of SN Ia. Only a relatively small sample exists of supernovae (SNe) Ia with sufficiently early observations to determine their time of first light within less than a day. A new fitting technique, however, that uses photometric observations taken within eight days of peak appears to be able to estimate the time of first light with a precision of less than a day. The inferred rise times can be used in combination with photospheric velocity in a fireball model to construct physically motivated estimates for SN Ia luminosities. In our sample, the SNe Ia with high photospheric velocities exhibit systematically lower luminosities after correction using the fireball model. The 22 SNe that have comparatively low velocities exhibit an intrinsic scatter smaller than 0.07 mag with 68% confidence. I may also briefly discuss ongoing work on the relation of calibrated Type Ia luminosities to their host-galaxy environments.

Constraining SNIa progenitors from Galactic Chemical Evolution
Chiaki Kobayashi

In our quest to identify the progenitors of Type Ia supernovae (SNe Ia), we first update the nucleosynthesis yields both for Chandrasekhar (Ch) and sub-Ch mass white dwarfs (WDs), for a wide range of metallicity, with our two-dimensional hydrodynamical code and the latest nuclear reaction rates. We then include the yields in our galactic chemical evolution code to predict the evolution of elemental abundances in the solar neighborhood and dwarf spheroidal (dSph) galaxies. In the observations of the solar neighborhood stars, Mn shows an opposite trend to alpha elements, showing an increase toward higher metallicities, which is very well reproduced by deflagration-detonation transition of Ch-mass WDs, but never by double detonations of sub-Ch- mass WDs alone. The problem of Ch-mass SNe Ia was the Ni over-production at high metallicities. However, we found that Ni yields of Ch-mass SNe Ia are much lower with the solar-scaled initial composition than in previous works, which keeps the predicted Ni abundance within the observational scatter. From the evolutionary trends of elemental abundances in the solar neighborhood, we conclude that the contribution of sub-Ch-mass SNe Ia is up to 25%. In dSph galaxies, however, the contribution of sub-Ch-mass SNe Ia seems to be higher than in the solar neighborhood. In dSphs, sub-Ch-mass SNe Ia cause a decrease of [(alpha, Cr, Mn, Ni)/Fe], while so-called SNe Iax can increase Mn and Ni abundances if they are pure deflagrations. Future observations of dSph stars will provide more stringent constraints on the progenitor systems and explosion mechanism of SNe Ia.

Simulating collisions of white dwarfs as a primary channel for type Ia supernovae
Doron Kushnir

We have recently suggested that the majority of type Ia supernovae (SNe Ia) may result from direct collisions of white-dwarf (WD) stars. The collisions possibly occur at a sufficient rate due to the 3-body evolution of triple systems with two WDs and a third companion. The explosion is triggered by the shock waves that result from the collision, which occurs at velocities of thousands of kilometers per second. Using numerical hydrodynamic simulations and analytical work we resolved the process of ignition of a detonation, which turned out to be approximately planar and non-turbulent.

Accurate high-resolution three-dimensional (3D) calculations of a comprehensive set of collisions including various combinations of WD masses and the full range of impact parameters, which was never done before, is crucial for validating or ruling out collisions as the main channel for SNe Ia. The physics involved is well known and the successful explosion of the high-resolution subsample of zero-impact collisions using two-dimensional simulations and a set of low-resolution 3D simulations has been firmly established. These sets were shown to qualitatively reproduce main features of observed SNe Ia, including the observed range of 56Ni yields and a bimodal velocity distribution of 56Ni in the nebular phase observations, which is a possible smoking gun for collisions.

I will describe a novel numerical scheme that allows to perform high-resolution 3D simulations and quantitative statistical comparison with observations.

Type Iax Supernovae from Deflagrations of Chandrasekhar Mass White Dwarfs
Florian Lach

In addition to the bulk of normal Type Ia supernovae a variety of subclasses exist. The largest of these is the subclass of Type Iax supernovae. The corresponding events are fainter than normal Type Ia supernovae, they lack the characteristic second maximum in the near-infrared light curves and their ejecta structure is well mixed. Moreover, their spectra show only weak features of intermediate mass elements but signs of iron group elements at early times and lack a transition to the nebular phase at very late times.

It has been demonstrated that these features can largely be reproduced by deflagrations in Chandrasekhar-mass carbon-oxygen white dwarfs. These kinds of explosion predict the existence of a bound remnant. This hypothesis is also supported by observations. However, it has not been studied yet whether this scenario can cover the wide ranges of properties of Type Iax supernovae such as the large spread in peak luminosities and thus explain the entire subclass. We present the results of state-of-the-art full star simulations of deflagrations in carbon-oxygen white dwarfs exploring the parameter space of the progenitor, i.e.its metallicity, its central density and the number, size and location of theignition kernels. For this purpose, we employed the hydrodynamics code LEAFS to simulate the explosion phase as well as the nuclear network code YANN to evaluate detailed nucleosynthesis yields in a postprocessing step. Finally, radiative transfer calculations using the ARTIS code were used to assess whether the models match observed spectra and light curves of Type Iax supernovae.

Observations of SN 2014J for Nearly 900 Days and Constraints on Its Progenitor System

Wenxiong Li

We present extensive ground-based and Hubble Space Telescope (HST) photometry of the highly reddened, very nearby type Ia supernova (SN Ia) 2014J in M82, covering the phases from 9 days before to about 900 days after the B-band maximum. SN 2014J is similar to other normal SNe Ia near the maximum light, but it shows flux excess in the B band in the early nebular phase. This excess flux emission can be due to light scattering by some structures of circumstellar materials located at a few 10^17 cm,consistent with a single degenerate progenitor system or a double degenerate progenitor system with mass outflows in the final evolution or magnetically driven winds around the binary system. At t+300 to +500 days past the B-band maximum, the light curve of SN 2014J shows a faster decline relative to the 56Ni decay. Such a feature can be attributed to the significant weakening of the emission features around [Fe III] λ4700 and [Fe II] λ5200 rather than the positron escape as previously suggested. Analysis of the HST images taken at t>600 days confirms that the luminosity of SN 2014J maintains a flat evolution at the very late phase. Fitting the late-time pseudobolometric light curve with radioactive decay of 56Ni, 57Ni and 55Fe isotopes, we obtain the mass ratio 57Ni/56 Ni as 0.035 ± 0.011, which is consistent with the corresponding value predicted from the 2D and 3D delayed-detonation models. Combined with early-time analysis, we propose that delayed- detonation through single degenerate scenario is most likely favored for SN 2014J.

The formation of double massive WD and SNe Ia

Dongdong Liu

Type Ia supernovae (SNe Ia) have been successfully employed as standard cosmological distance indicators. It has been found that the Universe is expanding at an increasing rate via the observation of SNe Ia, which reveals the existence of dark energy. However, the progenitors of SNe Ia are still unclear, which may affect the accuracy of the measured distance. Recently, both observational and some theoretical studies slightly favor the double-degenerate model, in which the merging of double Carbon-Oxygen white dwarfs (CO WDs) would produce SNe Ia if their total mass is larger than the Chandrasekhar limit. In this report, I will introduce the proposed CO WD+He subgiant channel for producing double WDs and then form SNe Ia based on the double degenerate model. Previous studies on the double-degenerate model still have deficit with the observed SNe Ia with delay times shorter than 1Gyr and longer than 8 Gyr. After considering the WD+He subgiant channel, we found that the distributions of the predicted SN Ia ages are comparable with the observed results. I will also introduce our recent studies on the formation of SNe Ia from the violent mergers of double CO WD.

Can the Friction of the Nova Envelope Account for the Extra Angular Momentum Loss in Cataclysmic Variables?
Wei-Min Liu

It has been shown that the rate of angular momentum loss (AML) in cataclysmic variables (CVs) below the period gap is about 2.47 times that caused by gravitational radiation (GR), suggesting an extra AML mechanism aside from GR. Several potential mechanisms have been proposed but none of them has been verified. In this work, we examine whether AML caused by friction between the expanding nova envelope and the donor star can account for the required AML rate. By adopting various expanding velocities of the envelope, we have calculated the evolution of CVs with typical initial parameters. Our results show that this friction interaction unlikely solves the extra AML problem unless the expanding velocities are extremely low. Thus, there should be a more efficient AML mechanism that plays a role in CV evolution.

Imprints of a non-degenerate companion star in Type Ia supernovae
Zhengwei Liu

The identity of the progenitor systems of Type Ia supernovae (SNe Ia) is still uncertain, although various potential progenitor models have been proposed for SNe Ia. In this talk, I will mainly focus on the single-degenerate scenario. I will discuss imprints of a non-degenerate companion star in SNe Ia by summarizing the results of recent modelling of ejecta-companion interaction and long-term evolution of post-explosion companion stars. Theoretical predictions will be compared with current observations to place constraints on the single-degenerate scenario origin for SNe Ia.

Title: Diversity of SNe Ia in the Rising Phase
Keiichi Maeda

The modern transient surveys and follow-up programs now allow to provide intensive observational data of SNe Ia from the infant phase within the first few days since the explosion. There are an increasing number of SNe Ia that show early excess as compared to others; initially this signal was expected to be a smoking gun for a non-degenerate companion star, but it is now recognized that there are indeed several other physical processes (interaction with circumstellar material, mixing of 56Ni out to surface, ash of surface helium detonation) that could produce qualitatively similar signals. I will introduce these possibilities and discuss how they could be distinguished; the examples include a peculiar SN Ia MUSSES1604D discovered by the Subaru/HSC, and relations between the properties of the early flash and those in the main 56Ni peak.

Modelling the early time behaviour of type Ia supernovae: Effects of the 56Ni distribution
Mark Magee

Despite being generally regarded as a homogeneous group, it is becoming increasingly evident that normal SNe Ia can show significant diversity. Differences in the explosion mechanisms and conditions are imprinted on the light curve shapes and colours, allowing for the interrogation of the physical conditions within the supernova. In this talk, I will show how differences in the nucleosynthesis of the explosion impacts the light curves and discuss how key physical parameters (such as the density profile) have been neglected in previous studies. I will present models calculated with our radiative transfer code and show that these may be used to provide constraints on the explosion mechanism for individual objects and to determine the exact explosion date. I will also discuss what observations are necessary to constrain the properties of future objects. This will become increasingly important in future years, as upcoming surveys discover SNe at earlier times, and in greater numbers.

Characterizing the nature of Type Ia Supernovae
Paolo Mazzali

Type Ia SNe are thermonuclear explosions that destroy white dwarfs. They have been used to map the Universe and discover Dark Energy. Yet, the details of their origin are debated, with different progenitor channels and explosion mechanisms competing for the limelight.

In this talk, I will discuss some of the common properties of SNe Ia, and show how they can be used to infer the character of the bulk of the events. I will then focus on different types of outliers and discuss the evidence that they represent different channels, which also exist but do not constitute the bulk of the population.

10 years in the life of SN 2012Z
Curtis McCully

Type Iax supernovae (SNe) are one of the largest classes of "peculiar type Ia" SNe. SN 2012Z was one of the brightest, nearby type Iax SNe to date. In deep HST pre-explosion imaging, we discovered a source that was consistent with the position of the SN, We interpreted this as the progenitor system, likely a white dwarf accreting from a helium star companion. However, the alignment could be chance or more provacatively, the source could have been the star that exploded. If this was true, it would have had profound implications on the division between thermonuclear and core collapse SNe. To test this, we observed SN 2012Z nearly four years after explosion, when we expected the SN to be dimmer than the source in the pre-explosion images. Instead, the light curve of SN 2012Z leveled off approaching a constant brightness (unlike the normal Ia SN 2011fe which continued to decline). Surprisingly, SN 2012Z was more than a magnitude brighter than the source in the pre-explosion images. This could imply that we are seeing a bound remnant or that the companion star was shock heated, ideas that we will test with HST observations that are planned soon

The surviving companion of Type Ia Supernovae in the single-degenerate channel
Callum McCutcheon

Type Ia supernovae are important high-energy cosmological events for astronomers, enabling us to compute distances far beyond the reach of parallax methods, however their progenitor channels are a topic of great debate, owing to the events' short timescales and scarcity of recent data. We employ the FLASH grid-based hydrodynamics code to investigate the impact of the Type Ia supernova ejecta on its companion star in the single-degenerate scenario in 2D, with special interest in simulating the capture of heavy elements. This work hopes to explore the effect of different supernova explosion models on the composition and properties of the surviving companion star, with a view to further testing in 3D.

BLAPS: the Possible Surviving Companions of Type Ia Supernovae
Xiangcun Meng

The debate on the progenitor nature of type Ia supernovae (SNe Ia) is still endless, although they are so important in many astrophysical fields. The single degenerate (SD) model predicts that there are many surviving companions in the Galaxy if the SD model contributes to a part of SNe Ia. The discovery of such surviving companion would be evidence to support the SD model. Recently, a new kind of mysterious variables are discovered, i.e. blue large-amplitude pulsators (BLAPs). We found that all the properties of the BLAPs may be reasonably reproduced by the surviving companions of SNe Ia. On the contrary, no any other channel may simultaneously explain all the properties of the BLAPs. Therefore, we suggest that the BLAPs are the surviving companions of SNe Ia, and the discovery of the BLAPs supports the SD model.

Circumstellar properties of Type Ia supernovae from the helium star donor channel
Takashi Moriya

We investigate predicted circumstellar properties of Type Ia supernova progenitor systems with non-degenerate helium star donors. It has been suggested that systems consisting of a carbon+oxygen white dwarf and a helium star can lead to Type Ia supernova explosions. Binary evolution calculations for the helium star donor channel predict that such progenitor system is in either a stable helium-shell burning phase or a weak helium-shell flash phase at the time of the Type Ia supernova explosion. By taking the binary evolution models of Wang et al. (2009), we show that a large fraction of the progenitor systems with a helium star donor have low enough density to explain the current non-detection of radio emission from Type Ia supernovae. Most of the progenitor systems in the weak helium-shell flash phase at the time of the Type Ia supernova explosions, which may dominate the prompt (short delay time) Type Ia supernova population, have both low circumstellar density and a faint helium star donor to account for the non detection of radio emission and a pre-explosion companion star in SN 2011fe and SN 2014J. We suggest that both SN 2011fe and SN 2014J could be prompt Type Ia supernovae from the helium star donor model.

The OzDES supernova project
Jeremy Mould

The OzDES project targets the hosts of supernovae (SNe) found by the Dark Energy Survey to obtain redshifts and construct a Hubble diagram. We can also coadd these spectra to study SN host properties, such as age and metallicity. This, in turn, informs us about the progenitors. Here we focus on a carefully scrutinized SNIa sample. Across the redshift range (0,1) of OzDES, we see that SNIa hosts 5 Gyrs ago were on average more metal poor with a larger fraction of billion year old stars.

The implications of magnetic torques for the single degenerate helium donor channel
Patrick Neunteufel, S.-C. Yoon, N. Langer

Close binary stars consisting of one carbon oxygen white dwarf (CO WD) and one non-degenerate helium rich companion star (He star) has been considered a favoured channel for the production of thermonuclear supernovae, including Type Ia SNe, for a while. In this scenario, known, inter alia, as the single degenerate He donor channel, the WD accretes helium rich material from its companion, leading, in some cases, to a thermonuclear explosion while the WD is still appreciably below the Chandrasekhar-mass. The favoured mechanism to induce these thermonuclear detonations is known as the double detonation scenario, where the mass transfer rates are low enough to allow for the steady accumulation of helium on the WD.

However, the structural response of the WD to the accumulation of angular momentum is decisive in whether these systems can be considered viable progenitors of any thermonuclear supernovae. This talk will give a brief overview of angular momentum dissipation in accreting WDs, depending on input physics, then focus on the problem of magnetic torques. It will be demonstrated that the inclusion of magnetic torques leads to quasi solid-body rotation in the accretor and that the resulting change to the density profile of the WD requires significantly larger amounts of material to be accreted in order to reach helium ignition conditions.

This talk will further present the results of a detailed parameter study of fully resolved binary systems, discussing the parameters of close CO WD plus He star systems leading to a double detonation, as well as the characteristics of the plethora of associated outcomes, concluding that the single degenerate double detonation scenario is not a likely progenitor mechanism for Type Ia SNe, but should instead lead to either systems capable of producing SNe in a double degenerate setting or produce sub-luminous nova-like events.

Progenitors of Type Ia Supernovae and Nucleosynthesis Constraints
Ken'ichi Nomoto

For the SD scenario, I will present the evolution of rotating, mass-accreting white dwarfs (WDs). For the DD scenario, I will discuss how the final outcome depends on the binary parameters such as the mass ratio. I will also show nucleosynthesis constraints on the Chandra and sub-Chandra progenitors.

Probing the Progenitor Metallicity of SNe Ia with Ultraviolet Spectra
Yen-Chen Pan

Ultraviolet (UV) observations of Type Ia supernovae (SNe Ia) are useful tools for understanding progenitor systems and explosion physics. In particular, UV spectra of SNe Ia, which probe the outermost layers, are strongly affected by the progenitor metallicity. Theory suggests that SN Ia progenitor metallicity is correlated with its peak luminosity, but not its light-curve shape. This effect should lead to an increased Hubble scatter, reducing the precision with which we measure distances. If the mean progenitor metallicity changes with redshift, cosmological measurements could be biased. Models also indicate that changing progenitor metallicity will have little effect on the appearance of optical SN data, but significantly alter UV spectra. Here we use the largest UV spectroscopic sample of SNe Ia to date to study the metallicity effect. With this sample, we confirm theoretical predictions that SN Ia UV spectra are strong metallicity indicators. Our findings show that UV spectra are promising tools to further our understanding of SN Ia while directly improving the utility of SN Ia for cosmology.

Early high-cadence observations of supernovae: revealing features of variability and identifying their diversity
Emmanouela Paraskeva, Alceste Z. Bonanos

High-cadence photometry on the early evolutionary stage of supernova light curves has the potential to provide a better understanding of nearly every aspect of SNe, from their explosion physics to their progenitors and the circumstellar environment. Given the increasing rate of discovery of bright supernovae before their maximum brightness from modern time-domain optical surveys, we have the opportunity to capture their intraday behaviour near the time of their explosions. We present results of monitoring the optical light curves of ~9 bright SNe, primarily using the 2.3m Aristarchos telescope and 1.2m Kryoneri telescope. The supernovae were observed over several nights during the early and late evolution with a cadence of 30-120s and high precision differential aperture photometry was derived. Differential light curves with respect to all comparison stars available on each night, as well as reconstructed light curves after implementing the Trend Filtering Algorithm (TFA; Kovacs et al. 2005) are presented. We derive the decline slope of each supernova on each night and quantify the precision of our photometry and variability in the light curves, after accounting for sources of systematic error. We encourage further high-cadence photometric monitoring of bright SNe with the goal of identifying explosion mechanisms, binary-star interaction, progenitor channels, or properties of the explosion environment.

THESEUS, a small ESA payload for multiwavelength transients
Elena Pian, Lorenzo Amati

The Transient High Energy Sky and Early Universe Surveyor is a small ESA space mission (M5 tier) admitted to a Phase A feasibility study. It carries a large FOV gamma-ray camera, a smaller FOV X-ray instrument and a 70cm infrared telescope. While optimized for high-redshift GRBs, it will accomplish a large range of scientific tasks in time domain astrophysics. If finally approved, it will be launched in 2032.

100IAS: Contraining Explosions and Progenitors of SN Ia from ~100 Nebular-phase Spectra

Jose Prieto

I'll present some of the latest results from the 100IAS survey, a complete sample of ~100 nebular phase optical spectra of SN Ia at z<0.02 from 5-10m aperture telescopes. I'll highlight new constraints from 100IAS on the progenitors and explosion mechanism of SN Ia from the asymmetries in the broad forbidden emission lines and the detection of narrow H-alpha in emission in nebular phase spectra. In particular, I'll discuss the recent findings of two fast declining, low peak luminosity SN Ia that show narrow H-alpha in emission in their nebular phase spectra, one of them showing properties that are more broadly consistent with the predictions of stripped hydrogen from a non-degenerate companion in a single-degenerate system.

High-cadence Light Curves of SN Ia from the Kepler Telescope

Armin Rest, Giorgios Dimitriadis, Ashley Villar, Gautham Narayan, Ryan Ridden-Harper, Brad Tucker, Peter Garnavich, Ed Shaya, Dan Kasen, SteveMargheim, Ryan Foley

Despite the expanding set of SNe Ia discovered in recent surveys like PS1, ATLAS, PTF, and ASAS-SN, several fundamental questions remain of the nature of these explosions and their progenitor systems. The early light curves of SN Ia may contain signatures of the different progenitor systems, and clues about the explosion physics. However, it has been difficult to obtain early light curve data with sufficient cadence and accuracy from the ground. With Kepler, we have been able to obtain high-cadence early light curves with exquisite photometric accuracy for about a dozen SN Ia. I will discuss the constraints this sample gives us on the nature of SN Ia progenitors.

Testing Type Ia supernova progenitor channels in a consistent modeling pipeline

Friedrich K Roepke

Despite substantial progress in theoretical modeling and numerical simulations over the past years, our understanding of the physical mechanism of Type Ia supernovae remains incomplete. This has two main reasons. The progenitor systems from which these explosions arise have not been identified, and therefore the initial conditions for the explosion simulations are uncertain. Modeling the explosion stage itself is a severe multi-scale multi-physics challenge and relies on assumptions and approximations.

Some of these approximations could, however, be mitigated with multidimensional hydro dynamical simulations. They form a cornerstone of a consistent modeling pipeline that follows a progenitor model over explosion and nucleosynthesis to the formation of observables, thus allowing direct comparison of model predictions with astronomical data. For concluding back from this comparison on the validity of the assumed progenitor/explosion model, tunable parameters have to be avoided. I will discuss how such a modeling pipeline can be constructed and how it is used to test different progenitor channels and explosion models of Type Ia supernovae. From this approach, a comprehensive picture of models related to distinct sub-classes of Type Ia supernovae starts to emerge.

Type Ia supernova remnant tomography

Ivo Seitenzahl, Parviz Ghavamian, J. Martin Laming, Frédéric P. A. Vogt

We report the discovery of optical emission from the non-radiative shocked ejecta of three young Type Ia supernova remnants (SNRs): SNR 0519-69.0, SNR 0509-67.5, and N103B. Deep integral field spectroscopic observations reveal broad and spatially resolved [Fe XIV] 5303A emission. The width of the broad line reveals, for the first time, the reverse shock speeds. For two of the remnants we can constrain the underlying supernova explosions with evolutionary models. SNR 0519-69.0 is well explained by a standard near-Chandrasekhar mass explosion, whereas for SNR 0509-67.5 our analysis suggests an energetic sub-Chandrasekhar mass explosion. With [S XII], [Fe IX], and [Fe XV] also detected, we can uniquely visualize different layers of the explosion. We refer to this new analysis technique as "supernova remnant tomography".

Investigating the Diversity of SN Ia Spectra with the Open-Source Relational Database Kaepora
Matthew Siebert

Understanding the large diversity of optical properties of SNe Ia is essential for improving their cosmological utility. We present a public, open-source relational database (we name kaepora) containing a sample of 4975 spectra of 777 Type Ia supernovae (SNe Ia). Since we draw from many sources, we significantly improve the spectra by inspecting these data for quality, removing galactic emission lines and cosmic rays, generating variance spectra, and correcting for the reddening caused by both MW and host-galaxy dust. With our database, we organize this homogenized dataset by 56 unique categories of SN-specific and spectrum-specific meta data. With kaepora, we produce composite spectra of subpopulations of SNe Ia and examine how spectral features correlate with various SN properties. These composite spectra reproduce known correlations with phase, light-curve shape, and host-galaxy morphology. With our large data set, we are also able to generate fine-grained composite spectra simultaneously over both phase and light-curve shape. The color evolution of our composite spectra is consistent with other SN Ia template spectra, and the spectral properties of our composite spectra are in rough agreement with these template spectra with some subtle differences. We also investigate the spectral differences of SNe Ia that occur in galaxies with varying morphologies.

Supernovae Ia scenarios in 2019: a rising demand for clean and symmetrical explosions
Noam Soker

I argue that the morphologies of supernova remnants (SNRs) that some type Ia supernova (SNe Ia) scenarios predict are not compatible with observations that show SNRs Ia to be mainly spherical or axisymmetrical. I discuss binary scenarios where the exploding white dwarf (WD) gains mass by merging with another WD or with a core of a giant star, or by accreting mass from a companion that survives the explosion. I then show that a time delay from the merger/accretion episode that takes place in most SNe Ia, but not in all SNe Ia, might resolve the tension between some scenarios and the morphologies of SNRs. This merger/accretion to explosion delay (MED) time allows (but not in all cases) the circumstellar matter to be dispersed to prevent early emission excess. I discuss the MED time in relation to the delay time distribution (DTD) from star formation to explosion, as well as in relation to the common envelope to explosion delay (CEED) time. The CEED time distribution hints that the parameters that dictate a short CEED time (< million year) are somewhat different than those that dictate a delay of billions of years.

Three dimensional simulations of double-detonation explosions in DD systems for SNe Ia
Ataru Tanikawa, Ken'ichi Nomoto, Naohito Nakasato, Keiichi Maeda

We have studied double-detonation explosions in double-degenerate systems for type Ia supernovae (SNe Ia) by means of three dimensional simulations. We have found that only the primary white dwarfs (WDs) explode in some cases, while the explosions of the primary WDs induce the explosions of the companion WDs in the other cases. In the former case, the supernova ejecta contain materials stripped from the companion WDs. The stripped materials consist of carbon and oxygen (CO) when the companion WDs are CO WDs, and contribute to low-velocity ejecta components. These features could explain oxygen emissions in nebular phases in several sub-luminous SNe Ia (e.g. iPTF14atg), and low-velocity C seen in several SNe Ia. The latter case yields a large amount of Nickel-56. Thus, it could be counterparts of luminous SNe Ia, such as SN1991T and SN1999aa.

Constraints on the Ejecta Masses of Type Ia Supernovae from Photometry

Jozsef Vinko, Reka Konyves-Toth

One of the most important observational constraints for the progenitors of Type Ia supernovae is the total mass of the ejecta. It has been known for decades that one can get useful estimates on the ejecta mass from the timescales of the light curve. For example, in the radiation-diffusion model introduced by Arnett (1982), the rise time from first light to maximum is proportional to the ratio of the ejecta mass and the expansion velocity. Thus, in principle, having an observational constraint on the velocity, the ejecta mass can be estimated. The caveat of this approach is that the result also depends on the average optical opacity in the ejecta that is poorly constrained. A possibility for breaking the degeneracy is the usage of the late-time decline rate, influenced by the efficiency of the trapping of gamma-rays from radioactive decay, which is also proportional to the total mass of the ejecta. The gamma-ray leakage timescale also depends on the ratio of the mass and the velocity, but it is related to the gamma-ray opacity in the ejecta that is known much better than the electron scattering optical opacity. This approach was applied in several studies, recently by Scalzo et al. (2018), to estimate the ejecta masses of Type Ia SNe. The inferred ejecta masses range from ~1 to ~2 solar masses and positively correlate with the amount of 56Ni synthesized during explosion.

In this work we combine the constraints from the rise time and the decline rate to derive ejected masses for 17 recent SNe Ia. We get similar relations between the ejecta mass and other physical parameters as Scalzo et al., even though our sample does not contain super-Chandrasekhar (M > 1.5 M_solar) events. More recently Khatami & Kasen (2018) introduced a new semi-analytical formula for relating the rise time to the diffusion timescale that takes into account the effect of different Ni-mixing within the ejecta. Using this prescription we also show that the inferred rise times for our sample are consistent with the models having centrally-condensed Ni-distribution, confirming the validity of the Arnett model that is commonly used for estimating ejecta masses.

The TESS view of the SN Ia progenitor HD 49798

Joris Vos, Ingrid Pelisoli, Veronika Schaffenroth, Nicole Reindl, Stephan Geier

HD 49798 is a hot subdwarf binary that has been the topic of many studies since its discovery in 1963. While the primary is undoubtedly a heavy sdO star, there is no consensus yet on its companion, which can be a white dwarf (WD) or a neutron star (NS). The masses of both stars are estimated at 1.50 +- 0.05 Msol and 1.28 +- 0.05 Msol for the sdO and companion respectively.

Based on the newly obtained TESS light curve, and archival spectra obtained with HARPS we present a new view on HD 49798. The light curve can only be explained by a reflection effect of the companion onto the sdO star, indicating that the effective temperature of the companion is significantly higher than that of the sdO star. The obtained temperature matches well with cooling tracks of massive WDs. Furthermore, MESA models accreting mass lost from the sdO in a wind onto a cool WD can not reproduce the effective temperature necessary to fit the reflection effect. The reflection effect in the light curve can not be modeled with a NS star companion.

These new results point to the companion in HD 49798 being a young very hot WD star. This makes HD 49798 a prime candidate for a SN Ia progenitor system.

WD+He star binaries as the progenitors of SNe Ia
Bo Wang

The WD+He star systems have been proposed to explain the formation of young type Ia supernovae (SNe Ia). In this talk, I will present our latest progress on the WD+He star systems as the progenitors of SNe Ia. We found two possible outcomes for models in which the WD steadily grows in mass towards the Chandrasekhar limit. For relatively low He accretion rates carbon ignition occurs in the center, leading to an SN Ia explosion, whereas for relatively high accretion rates carbon is ignited off-center, probably leading to collapse. Thus the parameter space producing SNe Ia is reduced compared to what was assumed in earlier papers, in which the possibility of off-center ignition was ignored. We then applied these results in binary population synthesis modelling, finding a modest reduction in the expected birthrate of SNe Ia resulting from the WD+He star channel.

New Constraints on Progenitors of Type Ia Supernovae
Xiaofeng Wang

Type Ia supernovae play key roles in revealing the accelerating expansion of the universe, but our knowledge about their progenitors is still very limited. Here we report the discovery of a rigid dichotomy in circumstellar (CS) environments around two subclasses of type Ia supernovae (SNe Ia) as defined by their distinct photospheric velocities. For the SNe Ia with high photospheric velocities (HV), we found a significant excess flux in blue light during 60-100 days past maximum, while this phenomenon is absent for SNe with normal photospheric velocity (Normal). This blue excess can be attributed to light echoes by circumstellar dust located at a distance of about 1-3x10^{17}cm from the HV subclass. Moreover, we also found that the HV SNe Ia show systematically evolving Na~ I absorption line by performing a systematic search of variable interstellar Na~ I absorption lines in spectra of all SNe Ia, whereas this evolution is rarely seen in Normal ones. The evolving Na~I absorption can be modeled in terms of photoionization model, with the location of the gas clouds at a distance of about 2x10^{17} cm, in striking agreement with the location of CS dust inferred from B-band light curve excess. These observations show clearly the HV subclass of SNe Ia are likely from single degenerate progenitor channel (i.e., symbiotic system), while the NV subclass may arise from double degenerate progenitor systems.

Outcomes of double white dwarf mergers
Chengyuan Wu, Bo Wang, Dongdong Liu

The double-degenerate model, involving the merger of double carbon–oxygen white dwarfs, is one of the two classic models for the progenitors of Type Ia supernovae. Previous studies suggested that off-centre carbon burning would occur if the mass accretion rate is relatively high during the merging process, leading to the formation of oxygen–neon cores that may collapse into neutron stars. However, the off-centre carbon burning is still incompletely understood, especially when the inwardly propagating burning wave reaches the centre. Here, we report the propagating characteristics of burning wave sand the subsequently evolutionary outcomes of these CO cores. We found that the final outcomes of CO WDs strongly depend on mass accretion rates based on the thick-disc assumption, which can be divided into four situations: (1) explosive carbon ignition in the centre, then SNe Ia; (2) OSi cores, then neutron stars;(3) ONe cores, then e-capture SNe; (4) off-centre oxygen and neon ignition, then off-centre explosion or Si–Fe cores. Our results indicate that the final fates of double CO WD mergers are strongly dependent on the merging processes.

Strong, Early Near Infrared Carbon Absorption in the Transitional Type Ia SN 2015bp/SNHunt281

Samuel Wyatt, David Sand, Eric Hsiao, Chris Burns, Stefano Valenti, Azalee Bostroem

We present results of the transitional type Ia supernova SN 2015bp which shows strong early optical carbon coinciding with equally strong near infrared (NIR) carbon. Throughout the analysis, we make comparisons to a very similar transitional type Ia SN, iPTF13ebh, which showed very strong NIR carbon absorption with weak/no optical carbon absorption. Photometric and spectroscopic measurements are presented, and are compared to other notable SNe Ia. Both visibly detected optical C II and NIR C I at concurrent epochs confirm the presence of the unburned material. We also analyze other transitional type Ia SNe, and find that the optical C II absorption feature is almost always observed at early epochs.

Tycho's Supernova Remnant

Hiroya Yamaguchi

Tycho's Supernova (SN 1572) is known to be a 'typical' Type Ia supernova with a normal brightness that synthesized ~0.7 Msun of 56Ni. The remnant of this supernova, Tycho's SNR, is now bright in X-ray, particularly suitable for studying progenitor's nature in detail. In this talk, I will review recent observational results on this supernova remnant. The remnant exhibits relatively symmetric morphology and structured chemical composition, but does show some small- scale non-uniform ejecta distribution, possibly due to the asymmetric supernova explosion. We have recently discovered significant deceleration of the blast wave velocity in the western rim, suggesting the presence of a dense cavity wall originating from pre-explosion stellar wind activities.

Title: Spectropolarimetry of Infant Type Ia Supernovae

Yi Yang

The explosion process of supernova is so dominant that the ejecta wipe out almost all traces of the pre-explosion configuration within a few days. Conventional photometry or spectroscopy provide limited information on the structures of the circumstellar medium as well as the SN ejecta themselves, projected and smeared into the single dimension of radial velocity. Critical information about the interaction of the ejecta with a companion and any circumstellar matter is encoded in the geometry of the explosion, which cannot be spatially resolved, can only be probed with polarimetry. I will present our recent VLT spectropolarimetry observations of young Type Ia supernovae and how it constrains the explosion mechanisms.

Calcium-rich supernovae from disruptions of CO white-dwarfs by hybrid He-CO white-dwarfs

Yossef Zenati, Hagai Perets, Silvia Toonen

Abstract Calcium-rich (SN 2005E-like) explosions are ultra faint (typical {\rm M_{B}\sim-15}), Helium and Calcium-rich supernovae (SNe), mostly observed in old stellar environments. Several models for such SNe had been explored and debated, but non were able to consistently reproduce the observed proper- ties of Ca-rich SNe, nor their rates and host-galaxy distributions. Here we show that the disruptions of Carbon-Oxygen (CO) white dwarfs (WDs) by hybrid Helium-CO (HeCO) WDs during their merger could explain the origin and properties of Ca-rich SNe. We make use of detailed multi-dimensional hydro-dynamical-thermonuclear (FLASH) simulations models of HeCO-CO WD-WD mergers to characterize such explosions. We find that the accretion of CO material onto a HeCO-WD heat its He-shell and eventually leads to its detonation and ejection and the production of a sub-energetic (\sim10^{49}erg) He-rich SN, while leaving the CO core of the HeCO-WD intact. We model the detailed light-curve and spectra of such explosions to find an excellent agreement with observations. Using population synthesis studies we also predict the rate of such SNe to be 10-30\% of the type Ia SN rate, and find that a large fraction of such HeCO-CO WD-mergers should occur in old stellar environments. We thereby provide a viable, consistent model for the origins of Ca-rich SNe, their properties and demographics. These findings can shed new light on the role of Ca-rich SNe in the chemical evolution of galaxies and the intra-cluster medium, and their contribution to the observed 511 kev signal in the Galaxy. Finally, the origins of such SNe points to the key-role of HeCO WDs as SN progenitors, and their potential role as progenitors of other thermonuclear SNe including normal type Ia SNe.

3D Hydrodynamical Simulation of Ejecta-Companion Interactions for Type Iax Supernovae

Yaotian Zeng

Type Ia supernovae play a crucial role in astrophysics. Unfortunately, the nature of their progenitor systems and explosion mechanisms are still unclear. It has been suggested that an important sub-luminous class named type Iax supernovae (SNe Iax) may be produced from a failed deflagration explosion of a WD in a binary system with a He companion star. No He line has yet been detected in late-time spectra of SNe Iax, which indicates the mass of stripped He- rich material is less than 0.01 solar masses. We study the interaction between explosion ejecta and its He companion star by performing three-dimensional simulations with the smoothed particle hydrodynamics method. We find about 0.005 solar masses of He material can be stripped from the companion star by the SN explosion, which is lower than the upper limit given by observation. Our results can naturally explain non-detection He line in late-time spectra of SNe Iax.

First 450 days observation of supernova SN 2018zd: from type IIn to type IIP

Jujia Zhang

This talk will introduce the observation and on-going study of a peculiar core-collapse supernova SN 2018zd. Strong interaction was found in the early spectra of this SN and disappeared a few days later. We monitored it densely at the Lijiang 2.4m telescope based on the LiONS (Lijiang One hour per Night Supernova) project, covering from +2 days to +457 days after the explosion. Some other telescopes were also involved in the observation campaign. We are studying the properties of this explosion with the data, e.g., the mass loss history of the progenitor and the contribution from the interaction.

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