SUPERNOVAE
THROUGH THE AGES
UNDERSTANDING THE PAST TO PREPARE FOR THE FUTURE

EASTER ISLAND 8–13 AUGUST 2016

MILLENNIUM INSTITUTE OF ASTROPHYSICS

ABSTRACTS BOOKLET

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TALKS

1.-
SESSION: Cultural
NAME: Cristian Moreno Pakarati
AFFILIATION: Ahirenga Research
TITTLE: A new proposal for a division of Easter Island's history
ABSTRACT:
This paper presents an original interpretation of the long-term history of the island, dividing it in three main periods. By this, it pretends to contribute a new vision on a topic long abandoned by the growingly specialized archaeology that focuses more and more on the smallest of details. The scheme is as follows: a first period, as an era of open ocean navigation and relatively frequent contact with other Polynesian people; a second period, as an era of extreme isolation where the Rapanui culture developed many of its unique traits within the Polynesian and World context; and a third period, of contacts with "the West", starting in 1722 with the Dutch expedition of Roggeveen. By this, it pretends to simplify the timeline of events on the island and contextualize better the statue-carving era and the Bird-cult of Easter Island.

2.-
SESSION: 01
NAME: Edmundo Edwards
AFFILIATION: Pacific Islands Research Institute
TITTLE: Archeoastronomy of Eastern Polynesia and Easter Island
ABSTRACT:
Some 3,500 years ago in a span of about 500 years, the Lapita, the ancestors of the Polynesians, used their knowledge of the stars to settle an area 4,300 km wide in what is considered one of the speediest human expansions of the pre-historic world. Their descendants, the Polynesians, eventually settled hundreds of islands crossing millions of square kilometres of water without navigational instruments, guided by nothing more than complex astronomical observations and an understanding of natural signs. These navigators, or wayfinders, as they are known today, were undeniably skilled specialists who passed astronomical information from one generation to the next for over three thousands years. However, the observation of astronomical phenomena was not limited to navigation and served a far more important function carried out by powerful astronomer priests: to establish a cycle of yearly activities, where the cosmic rising and setting of specific stars and asterisms determined when certain events took place. Depending on the timing of astronomical events, skywatchers announced when festivities, ceremonies, prohibitions, and the seasons started and ended. Astronomer priests studied the Sun, Moon, stars, and planets from special structures built in places with the best vantage point for each astronomic event, and ceremonial constructions were often aligned to astronomic phenomena. In this lecture we will learn about the studies in archeoastronomy carried out by E. Edwards and his team for several decades in Eastern Polynesia and Easter Island and the role of astronomical phenomena in Polynesian cosmogony, mythology, and religion, as well as itspractical application in everyday life, particularly in navigation, time reckoning, and in the regulation of farming and fishing activities.

3.-
SESSION: 01
NAME: Mario Hamuy
AFFILIATION: Universidad de Chile -- Millennium Institute of Astrophysics
TITTLE: Conference Introduction
ABSTRACT: –

4.-
SESSION: 01
NAME: Mark Phillips
AFFILIATION: Las Campanas Observatories, Carnegie Institution for Science
TITTLE: Ruminations on a Life in Chile or: How I Learned to Stop Worrying and Love Exploding Stars
ABSTRACT: –

5.-
SESSION: 01
NAME: Nicholas Suntzeff
AFFILIATION: Texas A&M University
TITTLE: Anyone Can Do Photometry If It Is Clear
ABSTRACT: –

6.-
SESSION: 02
NAME: Chris Curtin
AFFILIATION: Swinburne University
TITTLE: Detections of Superluminous Supernovae at z ~ 2-5 from SUDSS and u-SUDSS
ABSTRACT:
The Survey Using DECam for Superluminous Supernovea (SUDSS) is completing its third year and is slated to produce the first bulk sample of superluminous supernovae (SLSNe) at z>1. SLSNe have widespread applications but, because of their rarity, few have been studied. The SUDSS sample will represent a major step forward in SLSN research as large volumes and high numbers of events are detectable at high redshift. As part of the SUDSS team, we employ a Lyman break galaxy selection and monitoring technique that pushes the redshift limits of SUDSS beyond what is possible with difference imaging techniques alone, to redshifts of z ~ 4-5. In addition, we initiated a program, u-SUDSS, that provides deep u-band imaging to enable a large number of supernova detections at z ~ 2-3. Our galaxy selection and monitoring technique accurately searches for events in specific redshift ranges, greatly increasing the efficiency of detections by filtering out low redshift transients. The known redshift range of events also allows for a good estimation of time dilation, enabling the strategic stacking of epochs to adjust the survey cadence and increase depth. With these enhancements we aim to double the number of SUDSS supernovae detected per field covered, with all detections above z~1.7. I will discuss our technique, our harvest of SLSNe candidates from the first 3 seasons of data, and our prospects for future detections and spectroscopic follow-up.

7.-
SESSION: 02
NAME: Ariel Goobar
AFFILIATION: Stockholm University
TITTLE: SNe Ia in the PTF and ZTF eras: lessons and prospects
ABSTRACT:
Since its start in 2009, the single band survey at the Palomar Transient Factory has discovered ~2700 SNe, including over 1800 spectroscopically identified SNe Ia in the low-z universe, many of these with exceptionally good coverage in time and multi-wavelength follow-up. These measurements provide an important testbed for the studies of the potential astrophysical uncertainties limiting the accuracy of SNe Ia in cosmology. ZTF, to see first light in early 2017, will increase the survey speed by about and order of magnitude and could provide the key low redshift anchoring sample for precision cosmology to complement the higher redshift SNIa samples from LSST and WFIRST.

8.-
SESSION: 02
NAME: Andy Howell
AFFILIATION: LCOGT/UCSB
TITTLE: Core collapse supernovae: from the normal to the extreme
ABSTRACT:
The LCOGT Supernova Key Project is a 3 year program to obtain lightcurves and spectra of approximately 500 SNe. With the 11 one and two meter telescopes of LCOGT, placed around the globe, we can build large samples of supernovae with unprecedented cadence control. I will talk about our first large sample of SNe IIL and SNe IIP, and whether they are distinct categories or blend together. I'll also explore correlations between lightcurve plateau length, rise time, and other properties of the SNe. Finally, I'll talk about unusual superluminous SNe, and the newfound class of fast-rising intermediate-luminosity events.

9.-
SESSION: 02
NAME: Erik Kool
AFFILIATION: Macquarie University / AAO
TITTLE: The SUNBIRD project: Uncovering supernovae in luminous infrared galaxies
ABSTRACT:
A substantial number of core-collapse supernovae (CCSNe) are expected to be hosted by luminous infrared galaxies (LIRGs), due to the intense star formation rate (SFR) of these galaxies, but very few have been found. This makes these very dusty LIRGs prominent hunting grounds to resolve the so called “Supernova Rate problem”, where up to half of the CCSNe expected from the measured cosmic SFR are not observed. In the SUNBIRD (Supernovae UNmasked By InfraRed Detection) project we aim to uncover dust-obscured supernovae by monitoring over 25 LIRGs, using near-infrared Laser Guide Star Adaptive Optics imaging on the Gemini South and Keck telescopes. Such discoveries are vital for determining the fraction of all supernovae which will be missed as a result of dust obscuration by current and future optical surveys. I present the first results of SUNBIRD, which includes both supernova detections very close to galactic nuclei as well as in surprisingly isolated regions of these LIRGs.

10.-
SESSION: 02
NAME: Armin Rest
AFFILIATION: STScI
TITTLE: An Astronomical Time Machine: Light Echoes from Historic Supernovae and Eruptions
ABSTRACT:
Tycho Brahe's observations of a supernova (SN) in 1572 challenged the teachings of Aristotle that the celestial realm was unchanging. We have discovered a way to see the same light that Tycho saw 440 years ago by observing SN light that only now reaches Earth after bouncing off dust filaments. These light echoes (LEs) give us a unique opportunity in astronomy: direct observation of the cause (the explosion) as well as the effect (the expanded remnant) of the same astronomical event. Furthermore, multiple LEs allow us to see the same explosion from different directions, providing the only way to directly map asymmetry. I will discuss how the unprecedented three-dimensional view of these historic events allows us to make connections between the underlying physics and observed cosmic explosions.

11..-
SESSION: 02
NAME: Benjamin Shappee
AFFILIATION: Carnegie Observatories
TITTLE: The All-Sky Automated Survey for Supernovae (ASAS-SN)
ABSTRACT:
For the first time, the entire visible sky is being surveyed for the violent, variable, and transient events that shape our universe. To accomplish this, my collaborators and I built the All-Sky Automated Survey for Supernovae (ASAS-SN), which is a long-term project to monitor the whole sky, at high cadence, using a global network of robotic telescopes. The primary goal of ASAS-SN is to find the closest and brightest supernovae (SNe) with an unbiased search: ASAS-SN now discovers about two-thirds of all bright (V<17 mag) supernovae. However, this systematic all-sky technique also allows ASAS-SN to discover many other interesting galactic and extragalactic transients. During this talk, I will give a quick overview of the ASAS-SN survey and highlight some of our more interesting discoveries including ASASSN-15lh, the most luminous supernovae ever discovered, and ASASSN-14lp, one of the earliest observed Type Ia supernovae.

12.-
SESSION: 02
NAME: Maximilian Stritzinger
AFFILIATION: Aarhus University
TITTLE: Carnegie Supernova Project observations of stripped-envelope core-collapse supernovae
ABSTRACT:
The Carnegie Supernova Project (CSP) was a dedicated supernova follow-up program based at the Las Campanas Observatory that collected science data of young, low-redshift supernova between 2004 and 2009. I will present the CSP photometric data release of 34 stripped-envelope core-collapse supernovae, of which 24 have at least some near-infrared photometry. The definitive optical and near-IR photometry of this sample is used to devise robust methods to estimate the host-galaxy reddening. Armed with accurate estimates of host reddening the broad-band photometry of each supernova is used to construct full UVOIR bolometric light curves, which are fit with a grid of hydro-dynamical explosion models based on hydrogen deficient He-core stars. In addition, visual-wavelength spectroscopy is used to search for correlations between various spectral and light curve properties as well as to produce mean template spectra of the different sub-classes of stripped-envelope core-collapse supernovae.

13.-
SESSION: 02
NAME: Schuyler Van Dyk
AFFILIATION: IPAC/Caltech
TITTLE: Supernova Science with a WFIRST Nearby Galaxy GO Program
ABSTRACT:
A Wide-Field Infrared Survey Telescope (WFIRST) Guest Observer (GO) program to image galaxies in the Local Volume should enable time domain science. Supernovae, supernova impostors, and intermediate luminosity optical transients (ILOTs) can be detected and monitored. For nearby SNe the near-infrared is an important window, particularly SNe Ia, to examine their behavior as “standardizable candles,” and to reveal preexisting or forming dust generally. WFIRST will also provide an excellent platform for testing the hypothesis of “failed SNe.” The full mosaics will also provide an incredible archival database for future SN and transient object precursor identification and characterization; this is especially crucial for characterizing SN Ia progenitor systems, as well as ILOT precursors, which may be intrinsically dust-obscured.

14.-
SESSION: 03
NAME: Federica Bianco
AFFILIATION: NYU
TITTLE: A Roadmap to the LSST transient sky
ABSTRACT:
The night sky came alive in the past decade as never before, with synoptic surveys monitoring astronomical changes on time scales of fractions of seconds to years. The era of time domain astronomy will culminate with the Large Synoptic Survey Telescope (LSST, 2020), but what are the real prospects and the problems SN science will encounter in the LSST era? The LSST Transients and Variable Stars (TVS) Collaboration which I chair along with Ashish Mahabal and I chair is generating a roadmap to prepare the community for the study of the transient sky in the LSST age, including the challenges presented by petabyte scale data and the discovery of thousands of transients per minute. LSST cadence choices critically affect our ability to classify and respond to SN-like transients, and our ability to deepen our understanding of SN throughout the 10 years of the LSST survey. As a representative of the TVS collaboration I will described the challenges and the required work, theoretical and observational, that we are identifying as key to enable the success of the LSST transient survey and of LSST as a SN survey in particular.

15.-
SESSION: 03
NAME: Santiago González-Gaitán
AFFILIATION: Universidad de Chile
TITTLE: SN II spectral template and variability
ABSTRACT:
We present the Expectation Maximization Principal Component (EMPCA) analysis of a large sample of type II supernova spectra. EMPCA provides a way to find the parameters that account for the maximum variation of spectral features with the possibility to include errors and missing data. By using more than 1300 spectra of 160 SNe II at different epochs, we are able to compare these principal components with traditional spectroscopic and photometric observables such as Halpha absorption, plateau length and slope, and give a new insight into the physics of such explosions. Furthermore, we construct an up-to-date spectrophotometric template of SNe II that is useful for many astrophysical contexts as well as for S- and K-corrections for SN II cosmology.

16.-
SESSION: 03
NAME: James Guillochon
AFFILIATION: Harvard
TITTLE: An Open Catalog for Supernova Data
ABSTRACT:
The Open Supernova Catalog is a new webpage with a collection of published observations and metadata for presently 18,000+ supernovae (SNe) and SNe candidates. The catalog is freely available on the web (http://sne.space), with its main interface having been designed to be a user-friendly, rapidly-searchable table accessible on desktop and mobile devices. In addition to the primary table which contains SNe metadata, an individual page is generated for each SN which displays its metadata, light curves, and spectra. The data presented in the catalog is automatically rebuilt on a daily basis and is constructed by parsing several dozen sources, including the data presented in the supernova literature, i.e. “primary” sources, and from “secondary” sources such as other web-based catalogs. Individual SN data is stored in the hierarchical, human- and machine-readable JSON format, with the entirety of each SN’s data being contained within a single JSON file bearing its name. The setup I’ll present, which is based upon open source software maintained via git repositories hosted on GitHub, enables anyone to download the

entirety of the supernova dataset to their home computer in minutes, and to easily make contributions of their own data back to the catalog. As the SN dataset continues to grow, we hope that the catalog we have designed will be a valuable tool for the community to analyze both historical and contemporary supernovae.

17.-
SESSION: 03
NAME: Wolfgang Kerzendorf
AFFILIATION: European Southern Observatory
TITTLE: Dalek - Automatic supernova spectral fitting within a Bayesian framework
ABSTRACT:
Comparing physical models with observations is one of the main challenges in supernova research. One particularly complex task is the analysis of the evolving spectral sequences. These complex sequences also contain a wealth of information about the object and are thus invaluable to the understanding of these objects. With the profusion of data in the “big data” era, it is essential to have tools that allow automated extraction of physical quantities from the abundance of spectra. We have created a code (TARDIS - Kerzendorf & Sim 2014) that can quickly synthesize supernova spectra with some physical accuracy (using well tested methods). The code is designed to accommodate new physics in a modular form that will allow us to test the systematic uncertainty of several approximations. In addition to the spectral synthesis code we have created a framework (nicknamed Dalek) that uses sophisticated algorithms to find the maximum likelihood of parameters for a given observed spectrum as well as exploring the uncertainties. In this talk, I will introduce the code, then will give an overview of some of the preliminary results and will close with an overview of our future research.

18.-
SESSION: 03
NAME: Adam Miller
AFFILIATION: JPL/Caltech
TITTLE: Enhanced Transient Discovery via Machine Learning: Insight from the Palomar Transient Factory
ABSTRACT:
In this talk, I will describe several machine-learning backed systems employed by the Palomar Transient Factory (PTF). These systems have been designed and optimized to facilitate the rapid identification of new transients in PTF observations. First, I will detail several generations of software that segregate bona fide astrophysical transients from subtraction artefacts in image differencing products, known as RealBogus. The PTF subtraction pipeline produces ~10^6 transient candidates per night; RealBogus filters these to the ~200 most-likely-real candidates. Thus, RealBogus reduces the problem to one that is tractable for human scanning, while only rejecting ~5% of the real transients. Second, I will summarize the deployment of a new PTF star-galaxy separation model, which is used to remove stars from the PTF transient-candidate stream. The new model, which reduces the number of galaxies removed from the stream by a factor of ~15, provides a critical improvement in the era of searching for the rarest of needles in the haystack: electromagnetic counterparts to LIGO gravitational-wave events. In conclusion, I will discuss advantages and disadvantages of machine-learning models and provide my opinion on whether or not they are appropriate for next generation surveys such as LSST.

19.-
SESSION: 03
NAME: Anais Möller
AFFILIATION: Australian National University - CAASTRO
TITTLE: Supernova photometric classification in SNLS with machine learning
ABSTRACT:

In the era of large surveys, photometric classification of supernovae (SNe) has become an important research field due to limited spectroscopic resources for candidate follow-up and classification. Machine learning algorithms are appropriate for automated photometric classification of large SN datasets in current and future surveys such as SNLS, DES and LSST. In this work, we present a new photometric classification of type Ia supernovae using redshifts obtained directly from SN light-curves and machine learning techniques. Our method is applied to data from the SNLS deferred pipeline, a purely photometric pipeline that contains SNe Ia at high-redshifts (0.2<z<1.1). We study different algorithms such as Random Forest and Boosted Decision Trees. Their performance is evaluated using both synthetic SNe and data from SNLS 3-year processing which contains both large spectroscopically and photometrically selected type Ia samples. We find that it is possible to obtain a large type Ia SN sample with an estimated contamination of less than 5%. We investigate the differences between classifying a controlled, simulated, sample and real SN survey data. In particular, we find that applying a thorough set of pre-selection cuts to the SN sample is essential for good classification. This work demonstrates for the first time the feasibility of machine learning classification in a high-z SN survey with application to real SN data.

20.-
SESSION: 03
NAME: Gautham Narayan
AFFILIATION: NOAO/University of Arizona
TITTLE: Finding Interesting Supernovae or "How to Swim in the Big Data Flood"
ABSTRACT:
LSST will provide us with petabytes of images, and an unparalleled window into the time-domain. The CfA/JHU transient science client operated on Pan-STARRS 1 (PS1) Medium Deep Survey (MDS) images from 2010-4, and discovered over 5000 supernovae in 800+ TB of images. LSST will achieve similar numbers within months. Within this alert flood, we must identify, characterize, filter, and prioritize the most interesting transients for rapid follow-up. With LSST, "interesting" will include not only extreme and peculiar events, and low-redshift events discovered very early that can be studied in detail, but also members of classes that have never been seen before. I'll discuss our work on the Arizona-NOAO Temporal Analysis and Response to Events System (ANTARES); a joint project of the U.S. National Optical Astronomy Observatory and the Department of Computer Science at the University of Arizona. We are using our experience with the previous generation of supernova surveys and big data to tackle the general problem of characterizing the entire transient and variable sky and understanding different populations. Our prototype is focused on identifying the "rarest of the rare" events in real-time, from "multi-messenger" data streams, to coordinate detailed follow-up studies spanning the entire electromagnetic spectrum. I'll describe the algorithms and architecture being developed to accomplish this ambitious goal, and present some of our preliminary results using existing data sets.

21.-
SESSION: 04
NAME: Francisco Förster
AFFILIATION: CMM/MAS
TITTLE: HiTS: The High cadence Transient Survey
ABSTRACT:
The High cadence Transient Survey (HiTS) is a survey which aims to discover and characterize young supernova (SN) explosions and other optical transients in real-time using the Dark Energy Camera (DECam) with a cadence of 1.6/2 hrs. I will first discuss the survey challenges, which include finding an optimal observational strategy, handling and storing a large stream of data and data products, implementing a custom made image processing pipeline to run in a distributed fashion, detecting and filtering candidates using machine learning, implementing efficient visualization tools and triggering follow up observations with other telescopes. In three observational campaigns (2013, 2014 and 2015) we have processed more than 1 Tpix in a typical stream of 40 Mbps, which after processing resulted in about 3 new candidates per minute, 5 to 6 minutes after every exposure. As a result, more than 120 SN candidates were detected in real–time, some of then younger than one day from shock

emergence. I will discuss our latest constraints on the presence of red supergiant shock breakouts and shock hit companion stars, as well as new evidence for high density circumstellar material around SN II progenitors. This work is the product of interdisciplinary collaborations which are likely to become the norm with the next generation of large survey telescopes such as LSST.

22.-
SESSION: 04
NAME: Emily Petroff
AFFILIATION: ASTRON
TITTLE: Extreme radio transients: fast radio bursts and beyond
ABSTRACT:
Fast radio bursts - millisecond-duration radio transients of possibly extragalactic origin - are quickly becoming a subject of intense interest in time-domain astronomy. FRBs have the exciting potential to be used as cosmological probes of both matter and fundamental parameters, but such studies require large populations. The progenitors of these bursts remain unknown although some theories predict association with optical transients or supernova-like events. Obtaining optical data for FRB events requires real-time identification in radio observations and triggering of external telescopes. I will discuss the status of real-time FRB detections, including the 5 FRBs that have been found in real-time as well as efforts underway at telescopes around the world to find more. Particularly, I will focus on the science extracted from 3 real-time events detected with the Parkes radio telescope within the last few years and results of the multi-wavelength follow-up from these bursts.

23.-
SESSION: 04
NAME: Anthony Piro
AFFILIATION: Carnegie Observatories
TITTLE: Learning About the Progenitors of Supernovae Using Their Early Light Curves
ABSTRACT:
One of the exciting developments in recent years is the growth of transient surveys that are able to find supernovae in the days after the explosion first takes place. This provides us with unique information that may help us finally unravel the details about their progenitors, many of which remain elusive. I will summarize efforts to combine observations with theoretical modeling to use early light curves in this way, from constraining the radius and environment around the exploding star to even looking for a stellar companion.

24.-
SESSION: 04
NAME: Leo Singer
AFFILIATION: NASA/GSFC
TITTLE: The detection of gravitational waves
ABSTRACT: –

25.-
SESSION: 04
NAME: Masaomi Tanaka
AFFILIATION: National Astronomical Observatory of Japan
TITTLE: Kilonova Emission from Compact Binary Mergers

ABSTRACT:
Mergers of compact stars, i.e., neutron star (NS) and black hole (BH), are promising candidates for direct detection of gravitational waves (GWs). Detection of electromagnetic (EM) counterparts is essentially important to understand the nature of GW sources. "Kilonova" is optical and near infrared emission from compact binary mergers, powered by radioactive decays of r-process nuclei. The emission mechanism is similar to that of Type Ia/Ibc supernovae, but the binary merger ejecta has a much smaller mass (~0.01 Msun) with a faster velocity (~0.1c), and is dominated by r-process elements. We have performed multi-dimensional radiative transfer simulations for the kilonova emission (Tanaka & Hotokezaka 2013, ApJ, 775, 113; Tanaka et al. 2014, ApJ, 780, 31). We find that the expected EM luminosity is about 10^40-10^41 erg/s with a timescale of about 10 days, and that the spectral peak is located at the red edge of the optical or near-infrared wavelengths. Based on these results, we discuss strategies of the transient surveys to detect the EM counterpart of the GW sources.

26.-
SESSION: 04
NAME: Nozomu Tominaga
AFFILIATION: Konan University
TITTLE: Transient surveys with Subaru/Hyper Suprime-Cam
ABSTRACT:
Hyper Suprime-Cam (HSC) is the new instrument on the Subaru telescope with wide field-of-view (1.77deg2) and has been commissioned from Feb 2014. The HSC has the most efficient wide-field deep imaging capability per unit time and thus the most powerful instrument to detect transients. In order to maximize scientific outcomes from HSC, we developed a quick image subtraction system to realize prompt detection of transients. The system had been primarily applied to a high-cadence survey of supernova shock breakouts. This provided a list of transients about 30 minutes after each exposure and enabled us to make public some of supernova candidates immediately after the observing runs. The system also realizes realtime optical transient finding in target of opportunity observations following up transients found by other facilities, e.g., a fast radio burst and an optical counterpart of gravitational waves. In this presentation, I summarize results of transient surveys with Subaru/Hyper Suprime-Cam.

27.-
SESSION: 04
NAME: Brad Tucker
AFFILIATION: Mt. Stromlo Observatory, the Australian National University
TITTLE: KEGS - The Kepler Extra-Galactic Survey
ABSTRACT:
I will give an overview of the Kepler Extra-Galactic survey - a program using Kepler to search for supernovae, active galactic nuclei, and other transients in galaxies. To date we have found 17 supernova, and with 3 more years (through 2018) planned, including the forward-facing C17, we hope to discover 20 - 30 more SN. The 30-minute cadence of Kepler has revealed subtle features in the light-curves of these supernova not detectable with any other survey, including, shock break-out in a large number of SN, improving our understanding of supernova progenitors. We can also search in nearby galaxies for very fast and faint transients, filling in a previously unaccessible parameter space. Lastly, the precision data of any discovered type Ia supernova combined with ground based data can dramatically improve our use of type Ia for determining distances and measuring the properties of dark energy.

28.-
SESSION: 05
NAME: Melina Bersten

AFFILIATION: IALP-FCAGLP
TITTLE: Study of Core-Collape SN Progenitors from Light-Curves and Stellar-Evolution Models
ABSTRACT:
A very active area of research in the field of core-collapse supernovae (SNe) is the study of their progenitors and the links with different subtypes. Direct identification using pre- and post-SN images is a powerful method but it can only be applied to the most nearby events. An alternative method is the hydrodynamical modeling of SN light curves and expansion velocities, which can serve to characterize the progenitor (e.g. mass and radius) and the explosion itself (e.g. explosion energy and radioactive yields). This latter methodology is particularly powerful when combined with stellar evolution calculations. We will review some interesting examples where both methods were applied. We will also present the results of modeling a large set of observations.

29.-
SESSION: 05
NAME: Gaston Folatelli
AFFILIATION: IALP-CONICET
TITTLE: Identifying Progenitors of Stripped-Envelope Supernovae
ABSTRACT:
There are several pending questions about how massive stars produce the different types of supernovae (SNe) that we observe. Hydrogen-poor (aka stripped-envelope) SNe may provide important clues about the evolutionary paths of their progenitors. In particular, they may help disentangle the mass-loss processes at play, whether dominated by stellar winds or by binary interaction. We will discuss the identification of progenitors for a few Type IIb SNe (e.g., SN 2011dh, SN 2008ax). And we will present what could be the first confirmed progenitor detection of a Type Ib SN (iPTF13bvn). We will stress the role of binarity in shaping the properties of the SN and its surrounding medium.

30.-
SESSION: 05
NAME: Morgan Fraser
AFFILIATION: Institute of Astronomy, University of Cambridge
TITTLE: SN progenitors and links to stellar evolution models
ABSTRACT:
Nearby core-collapse supernovae provide a unique opportunity to test the connection between the final stages of massive stellar evolution and the characteristics of the subsequent explosion. Surveys using archival imaging of nearby galaxies have shown that most H-rich supernovae arise from relatively low mass red supergiants, while the progenitors of H-poor supernovae remain largely elusive. I will review the results of the ongoing observational effort to map out the fate of massive stars as a function of progenitor mass. I will highlight some of the complementary pieces of evidence from spectroscopic modelling, and place these in the context of our understanding of stellar evolution. Finally, I will discuss some of the most exciting results on optically-dark failed supernovae, and on pre-SN outbursts in massive stars.

31.-
SESSION: 05
NAME: Claudia Gutiérrez
AFFILIATION: Universidad de Chile - MAS - ESO
TITTLE: Spectral diversity of type II supernovae: characterization and correlations
ABSTRACT:
We present a spectroscopic and photometric analysis of type II Supernovae (SNe) obtained by the Carnegie Supernova Project (CSP) plus previous campaigns between 1986 and 2009. A total of 124 SNe with ~900 spectra were analyzed. The expansion

velocity of the ejecta in the photospheric phase, the pseudo-equivalent width of 11 features, the ratio of absorption to emission of Halpha and the velocity decline rate of Hbeta were analysed and correlated with photometric parameters. We find that SNe with higher velocities are brighter, have smaller pseudo-equivalent widths, faster declining light curves, shorter optically thick duration phases and plateau durations, and lower Ni mass. Discussion is presented on the physical meaning of all of our defined observational spectral and photometric parameters. A statistical processing reveals a continuum in spectral and photometric parameters. We speculate that this suggests a continuum in the underlying progenitor population.
We also study the nature of the extra absorption component on the blue side of Halpha P-Cygni profile. We concluded that this component in early spectra (before 35 days) is associated with Si II 6355, while in the plateau phase is related with high velocity features (HVFs) of hydrogen lines. The latter can be used to constrain the nature of the circumstellar environment of SNe II, and their progenitor stellar winds.

32.-
SESSION: 05
NAME: Brian Morsony
AFFILIATION: University of Maryland
TITTLE: Jet-powered Supernovae
ABSTRACT:
Supernovae are associated with a wide range of GRB-like events, indicating that jets are a relatively common feature of stellar explosions. Using hydrodynamic simulations, we find that by varying a single jet parameter (e.g. jet duration, total energy, or luminosity), we are able to create a range of events, from classical GRBs to low-E GRBs/relativistic supernovae to "normal" supernovae. The ability of a jet-driven explosion to leave no obvious signature of the jet indicates that jets may be ubiquitous in type Ib/c supernovae. We will present models of the observational properties of our simulated explosions, and discuss implications for current and upcoming optical and radio surveys.

33.-
SESSION: 05
NAME: Ondrej Pejcha
AFFILIATION: Princeton University
TITTLE: Observational Signatures of the Rugged Landscape of the Core-Collapse Supernova Explosions
ABSTRACT:
We show that the core-collapse supernova explosion mechanism together with the progenitor structure implies that successful explosions are intertwined with failures in a complex but well-defined pattern that is not well described by the progenitor initial mass. Other observables such as explosion energies, nickel yields, and remnant masses follow this trend. We present a new method to extract the supernova parameters from light curves and expansion velocities while taking into account all uncertainties and covariances of the model, and illustrate how can these observables constrain the explosion mechanism.

34.-
SESSION: 05
NAME: Jeffrey Silverman
AFFILIATION: University of Texas at Austin
TITTLE: Late-Time Spectral Observations of Type IIP Supernovae
ABSTRACT:
Type II-Plateau supernovae (SNe IIP) are H-rich explosions that come from red supergiant (RSG) progenitors. Despite the fact that they are the most common subtype of SN, little work has been done on late-time observations of SNe IIP owing to their relative faintness at these epochs. We analyze 91 late-time (older than about 100 days past explosion) optical spectra of 38 SNe

IIP, making this the largest sample of SN IIP nebular spectra ever studied. Quantitative criteria from the spectra themselves are employed to determine if an observation is truly nebular, and thus should be included in the study. We measure the fluxes, shapes, and velocities of various emission lines and investigate their temporal evolution. These values are also compared to photometric data in order to search for correlations that may allow us to gain insight into the RSG progenitors of SNe IIP and learn more about the details of the explosion itself.

35.-
SESSION: 05
NAME: Niharika Sravan
AFFILIATION: Northwestern University/CIERA
TITTLE: Single versus binary star progenitors of Type IIb supernovae
ABSTRACT:
Stripped-envelope supernovae (SNe) represent a challenge to our understanding of massive star evolution. Wind mass loss and binary interactions are the leading candidates to explain observations. The latter has gained support in the recent years with growing evidence that mass-loss rates due to line-driven winds are, in reality, 2 - 3 times lower. In this talk I will focus on a class of SNe known as Type IIb SNe. These initially exhibit strong Hydrogen spectral lines but they weaken and disappear over time and are thought to arise from progenitors that have retained a small amount of their Hydrogen envelope. They are also the only class of stripped-envelope SNe with identified progenitors. Thus they are powerful tools for testing our understanding of massive stellar evolution. To identify possible evolutionary pathways to Type IIb SNe, we use Modules for Experiments in Stellar Astrophysics (MESA) to model a large population of single and binary star sequences covering a broad parameter space with a wide range of component masses and initial orbital periods and identify those that undergo core-collapse with 0.01 to 0.5 solar masses of residual Hydrogen envelope. We find no single star Type IIb progenitors in the parameter space covered. We find a few binary Type IIb progenitors. These sequences have initial mass ratios greater than 0.6, wide orbital periods and undergo non-conservative mass transfer.

36.-
SESSION: 05
NAME: Tomoya Takiwaki
AFFILIATION: National Astronomincal Observatory of Japan
TITTLE: Toward multi-messenger observation of core-collapse supernovae from simulations of the central engine
ABSTRACT:
Several self-consistent simulations of core-collapse supernovae shows successful neutrino-driven explosions although there is room for sophistication. Utilizing such explosion models, we discuss the emission of neutrino, photons and gravitational wave and possible observational impact on that.

37.-
SESSION: 05
NAME: Sung-Chul Yoon
AFFILIATION: Seoul National University
TITTLE: The nature of Type IIb supernova progenitors
ABSTRACT:
It is believed that most of Type IIb supernovae originate from hydrogen deficient massive stars in binary systems. Some of their progenitors have been identified as a supergiant (e.g., SN 2011dh), while there also exists observational evidence that some SN IIb progenitors are fairly compact (e.g., SN 2013cu). In this talk, I will present new evolutionary models of massive binary stars and discuss how the nature of SN IIb progenitors at the pre-supernova stage would systematically depend on the initial binary

parameters. Specifically, we will show that the radius and surface temperature of a SN IIb progenitor is a sensitive function of the total mass of hydrogen left in the envelope for a given final mass, and that the solution of yellow supergiants is relatively difficult to obtain at solar metallicity. The dichotomy of the SN IIb progenitor size is clearly predicted by our models. Compact progenitors would be more common at lower metallicity and supergiant progenitors would have systematically more hydrogen than compact ones at all metallicities. We conclude the talk with a brief discussion on future observational tests of our model predictions.

38.-
SESSION: 05
NAME: Patrick Young
AFFILIATION: Arizona State University
TITTLE: Supernova Structure and Nucleosynthesis from Collapse to Remnant
ABSTRACT:
We present 3D simulations of the evolution of supernova structures from their inception in the stellar core through the development of a supernova remnant into the Sedov phase. Our simulations use multiple progenitors and structures of the circumstellar environment. These calculations demonstrate the role that supernova instabilities (the instabilities that develop as the shock drive through the star) play in defining the structure and long-term development of instabilities in supernova remnants even out to late times. We also present detailed nucleosynthetic maps for these simulated remnants.

39.-
SESSION: 06
NAME: Alexander Heger
AFFILIATION: Monash University
TITTLE: The First Supernovae
ABSTRACT:
The first stars mark the transition from the cosmic dark ages to the modern universe we know today, filled with stars, galaxies, and heavy elements essential to life. They are very unique because of the their pristine primordial initial composition and their pre-galactic formation. Their unique composition can dramatically alter their evolution, their structure, the way they die as supernovae, and their resulting nucleosynthesis. The very special environment and time in the evolution of the universe where they were borne, out of the dark matter halos preceding the first galaxies, along with their pristine composition, implies that they their initial mass function may have been quite different from that of all the later generations. Some speculations exist that even supermassive primordial stars may have formed that laid the basis for supermassive black holes in the centers of early galaxies, but generally it is assumed that these stars on average were significantly more massive than present-day stars. In this talk we will give an overview of the evolution and death of these first stars, with special focus on their supernova. We will also discuss nucleosynthesis signatures as possible diagnostics that have survived to the present day.

40.-
SESSION: 06
NAME: Daniel Whalen
AFFILIATION: Institute of Cosmology and Gravitation, University of Portsmouth
TITTLE: Finding the First Cosmic Explosions
ABSTRACT:
Primordial stars formed about 200 Myr after the big bang, ending the cosmic dark ages. They were the first great nucleosynthetic engines of the universe and may be the origins of the supermassive black holes found in most massive galaxies today. In spite of their importance to the evolution of the early universe not much is known for certain about the properties of Pop III stars. But with

the advent of JWST, WFIRST and the 30 m telescopes it may soon be possible to directly observe their supernovae in the NIR and thus unambiguously constrain the properties of the first stars. I will present radiation hydrodynamical calculations of the light curves of the first SNe in the universe and discuss strategies for their detection. I will also describe how some may already have been captured in surveys of galaxy cluster lenses such as CLASH, Frontier Fields and GLASS.

41.-
SESSION: 06
NAME: Takashi Yoshida
AFFILIATION: University of Tokyo
TITTLE: Luminous transients by mass ejection from very massive stars through pulsational pair-instability
ABSTRACT:
Evolved very massive stars with a CO core of 40-60 Msun pulsate by pulsational-pair instability (PPI) after the carbon burning. They eject several solar mass materials at most by the eruptive mass loss in each pulsation. The PPI ejecta collide with the circum-stellar medium (CSM) formed by previous ejection and would make luminous transients. We investigate the evolution and the mass ejection of very massive stars during the PPI stage. We calculate the evolution of 140, 200, and 250 Msun stars with Z=0.004. These stars evolve to CO stars with the mass of 55, 59, and 61 Msun after the carbon burning. They experience six, four, three pulsations during the PPI stage and the outer regions of four, five, and eight solar mass are ejected. The larger CO star has longer PPI period and ejects larger amount of mass. We also calculate the supernova (SN) explosions of these stars assuming the explosion energy of 1e51 and 1e52 erg. Then, we investigate light curves during the PPI stage and the SN explosions. The collisions of the PPI ejecta and the CSM make optically luminous transients with the bolometric magnitude (Mbol) of -16 to -20 depending on the mass ejection. The collision of the SN ejecta and the CSM can be luminous with Mbol of -21 - -22. These collision events could be observed as optically luminous transients such as type I superluminous SNe and SNe with precursor.

42.-
SESSION: 07
NAME: Eddie Baron
AFFILIATION: University of Oklahoma
TITTLE: Detailed Modeling of Early and Late Spectra of SN 2011fe and SN 2014J
ABSTRACT:
We discuss our results from early and late time modeling of the nearby supernovae SN 2011fe and 2014J. The day +100 spectrum can be well fit with models which neglect collisional and radiative data for forbidden lines. Curiously, including this data and recomputing the fit yields a quite similar spectrum, but with different combinations of lines forming some of the stronger features. At day +205 and later epochs, forbidden lines dominate much of the optical spectrum formation; however, our results indicate that recombination, not collisional excitation, is the most influential physical process driving spectrum formation at these late times. Consequently, our synthetic optical and UV spectra at all epochs presented here are formed almost exclusively through recombination-driven fluorescence. Furthermore, our models suggest that the ultraviolet spectrum even as late as day +360 is optically thick and consists of permitted lines from several iron-peak species. These results indicate that the transition to the ``nebular'' phase in type~Ia supernovae is complex and highly wavelength-dependent.

43.-
SESSION: 07
NAME: StéphaneBlondin
AFFILIATION: Laboratoire d'Astrophysique de Marseille
TITTLE: The case for multiple progenitor channels for Type Ia supernovae from radiative-transfer simulations
ABSTRACT:

I will present recent results of 1D non-LTE time-dependent radiative transfer simulations of Type Ia supernovae (SN Ia) light curves and spectra, based on 1D hydrodynamical models of the explosion. These include standard Chandrasekhar-mass delayed-detonation models as well as pure detonations of sub-Chandrasekhar-mass C+O White Dwarf progenitors. I will show that a low ejecta mass is essential in reproducing the rapidly-declining light curves characteristic of SN Ia at the faint end of the width-luminosity relation, but that sub-Chandrasekhar-mass models present fundamental difficulties with reproducing the post-maximum evolution of brighter events. These results imply that one needs both Chandrasekhar-mass and sub-Chandrasekhar-mass models to reproduce the full range of observed SN Ia properties, and hence makes a strong case for the existence of multiple progenitor channels for these events.

44.-
SESSION: 07
NAME: Xuefei Chen
AFFILIATION: Yunnan Observatories
TITTLE: Symbiotic stars and Type Ia supernovae
ABSTRACT:
Symbiotic stars (WD+RG) are likely progenitors of SNe Ia with long time delays. However, the birthrate from this channel would be insignificant were it not for some mechanism to enhance the rate of accretion on to the white dwarf, since mass transfer (Roche lobe overflow) from the giant to the WD is generally believed to be dynamically unstable. On the other hand, binary population synthesis cannot reproduce the orbital period distribution of symbiotic stars, and this is deemed to be a major challenge to binary evolution. Here we will show some results from our recent studies on binary evolution, which gave more relaxed conditions for dynamically stable mass transfer from giants to WDs than previously believed, and we can reproduce the period distribution of symbiotic stars and can therefore increase the birthrate of SNe Ia from the symbiotic channel naturally.

45.-
SESSION: 07
NAME: Suhail Dhawan
AFFILIATION: European Southern Observatory, Garching
TITTLE: A reddening-free method to estimate the 56Ni mass of Type Ia supernovae
ABSTRACT:
The increase in the number of Type Ia supernovae (SNe Ia) has demonstrated that the population shows larger diversity than has been assumed in the past. The reasons (e.g. parent population, explosion mechanism) for this diversity remain largely unknown. We have investigated a sample of SNe Ia near-infrared light curves and have correlated the phase of the second maximum with the bolometric peak luminosity. The peak bolometric luminosity is related to the time of the second maximum (relative to the B light curve maximum) as follows : Lmax(1043ergs−1) = (0.039 ± 0.004) × t2(J)(days) + (0.013 ± 0.106). 56Ni masses can be derived from the peak luminosity based on Arnett's rule, which states that the luminosity at maximum is equal to instantaneous energy generated by the nickel decay. We check this assumption against recent radiative-transfer calculations of Chandrasekhar-mass delayed detonation models and find this assumption is valid to within 10% in recent radiative-transfer calculations of Chandrasekhar-mass delayed detonation models. The Lmax vs. t2 relation is applied to a sample of 40 additional SNe Ia with significant reddening (E(B − V) > 0.1 mag) and a reddening-free bolometric luminosity function of SNe Ia is established. The method is tested with the 56Ni mass measurement from the direct observation of gamma−rays in the heavily absorbed SN 2014J and found to be fully consistent. Super-Chandrasekhar-mass explosions, in particular SN 2007if, do not follow the relations.

46.-
SESSION: 07
NAME: Subo Dong

AFFILIATION: Kavli Institute, Peking University
TITTLE: Testing SNe Ia Explosion Models with a Complete ASAS-SN Sample
ABSTRACT:
From archival data, we discover clear doubly peaked Co/Fe line profiles in 3 out of 20 SNe Ia with high-quality nebular-phase spectra. The doubly peaked profiles directly reflect a bimodal velocity distribution of the radioactive Ni56. Due to viewing angle effects, SNe Ia with intrinsic bimodality are likely common. Such bimodality is naturally expected from direct collisions of white dwarfs (WDs) due to the detonation of both WDs. Any major explosion model for SNe Ia should produce such bi-modality. We are conducting a long-term project to systematically collect nebular-phase spectra of a volume-limited complete SNe Ia sample enabled by the All Sky Automatic Survey for SuperNovae (ASAS-SN). Combined with multi-band light curves, this expected sample of ~100 SNe Ia will potentially be a gold standard for testing explosion models. The collision model can be unambiguously tested as the primary channel for SNe Ia from this complete sample, and the distribution of nebular line profiles will either be a smoking gun or rule it out.

47.-
SESSION: 07
NAME: Zhanwen Han
AFFILIATION: Yunnan Observatories of the Chinese Academy of Sciences
TITTLE: WD accretion and SNe Ia
ABSTRACT:
It is believed that SNe Ia are from thermonuclear explosion of carbon-oxygen white dwarfs (CO WDs) close to the Chandrasekhar mass limit. However, stellar evolution theory shows that the mass of CO WDs is less than 1.1Msun at their formation. In this talk, we will show how a WD accretes matter, burns hydrogen and helium at its surface, grows in mass till centre or off-centre carbon ignition when the WD explodes. We carried out a binary population synthsis study on the production of SNe Ia from various scenarios, including single degenerate scenario and violent merger scenario. We then compared the results of our model with that of observations and discuss its implications.

48.-
SESSION: 07
NAME: Peter Hoeflich
AFFILIATION: Florida State University
TITTLE: Type Ia Supernovae in a New Light: Probing the Signatures of the Progenitors and Progenitor Systems
ABSTRACT:
Thermonuclear supernovae, SNe Ia, are an essential tool for cosmology and are a key part of understanding the origin of elements. Although a two-parameter color/decline-rate correction allows their cosmological use with the present numbers of supernovae, precision observations show much more diversity as spectral variation and as secondary light-curve parameters. SNe Ia are thermonuclear explosions of white dwarfs (WD), either by accreting to the Chandrasekhar mass (M(Ch)) or by the dynamical merging of two WDs. Many channels may contribute to the population. The diversity in observations and theory demands a better understanding of the wide range of physics which, in addition to the progenitor system, includes nuclear burning, hydrodynamics and, possibly, magnetic fields. Advances in observations in the optical, near- and mid-IR opens new windows to the explosion physics, the initial condition and the imprint of the progenitor systems. We may already see tell-tails for most of the affects. Based on detailed explosion and radiation-hydrodynamical models, we will discuss the possible spectral and light curve signatures, required accuracies in observations, and benchmark them, among others, against SN2014J.

49.-
SESSION: 07
NAME: Boaz Katz
AFFILIATION: Weizmann Institute of Science
TITTLE: The (time weighted) integrated luminosity provides strong constraints on type Ia, II, Ibc and super-luminous supernova models
ABSTRACT:
Using robust energy conservation arguments, the value of the (time weighted) integrated bolometric luminosity is shown to provide strong constraints on the explosion models and power sources of various types of supernovae. For 56Ni powered supernovae (Ia, Ibc), it can be used to accurately measure the average column density of the ejecta. For type II, it provides a robust constraint on the explosion energy, progenitor radius and envelope mass. For supernovae where the power source of the emitted light is uncertain such as super-luminous supernovae, it provides an accurate test for 56Ni or other concrete sources.

50.-
SESSION: 07
NAME: Keiichi Maeda
AFFILIATION: Kyoto University
TITTLE: Type Ia Supernovae: Progenitor Scenarios and Observational Constraints
ABSTRACT:
Despite ongoing intensive studies, the progenitor systems of Type Ia Supernovae (SNe) is still obscured. In this talk, I will first summarize possible progenitor scenarios and their links to expected natures of the resulting explosion and their environment. Given the accumulating evidences of the diversities in observational properties of SNe Ia, it is possible that SNe Ia including outliers may represent different progenitor paths. I aim to provide a map (though tentative and biased) for the relation between the natures of SNe Ia and possible progenitor models, based on observational constraints on modes of explosions, circumstellar environment, and on a companion star. Depending on the length of the talk, I will especially focus on the probable progenitor paths to outliers (SNe Iax, super-luminous, and interacting SNe Ia) and their links to normal SNe Ia.

51.-
SESSION: 07
NAME: Ken Shen
AFFILIATION: UC Berkeley
TITTLE: Double detonation Type Ia supernovae in double white dwarf binaries
ABSTRACT:
Despite decades of concerted effort, the progenitors of Type Ia supernovae (SNe Ia) remain shrouded in mystery. In recent years, several lines of evidence have suggested that the previously favored scenario cannot be responsible for typical SNe Ia, at best accounting for peculiar SN Ia sub-classes. In this talk, I will describe our recent efforts towards establishing a less studied but extremely promising progenitor scenario as the main channel for producing SNe Ia. In this "double white dwarf double detonation" scenario, two white dwarfs (WDs) begin to merge due to the emission of gravitational waves, leading to violent helium-rich mass transfer onto the surface of the more massive WD. I will describe how the inclusion of often-neglected nuclear reactions is critical for the formation of a helium-burning detonation and demonstrate the convergence of the shock waves that lead to the carbon-burning detonation. Depending on how much mass is transferred prior to the SN Ia, the donor WD may survive the explosion. I will close by describing our new predictions for the observability of such a surviving companion in Galactic supernova remnants.

52.-
SESSION: 08
NAME: Lair Arcavi
AFFILIATION: LCOGT / UCSB
TITTLE: The Impossible Supernova
ABSTRACT:
Type IIP supernovae (SNe) are identified by a plateau in their light curve that lasts approximately 100 days, after which the spectra become nebular and the luminosity drops; thereafter following the Cobalt decay tail. I will present a SN which displays textbook IIP spectra, but otherwise has very peculiar properties. Its light curve remained luminous for over 500 days with at least 5 distinct peaks, yet no obvious signs of CSM interaction were detected. Its spectra were photospheric for this entire time, with very slowly declining velocities, implying very large photospheric radii at late times - in stark contradiction to the radii inferred from blackbody fits. This extraordinary SN, unlike any seen before, is likely powered by a central engine from an extremely rare H-rich progenitor system. Yet, accounting for the observed velocity, luminosity and blackbody radius evolution in a consistent manner remains a challenge to existing SN models.

53.-
SESSION: 08
NAME: Antonio de Ugarte Postigo
AFFILIATION: Instituto de Astrofísica de Andalucía (IAA-CSIC)
TITTLE: SN 2015bh in NGC2770: Defining a new class of stellar explosion
ABSTRACT:
Massive stars at the end of their lives are unstable and frequently expel large amounts of material. Some of these eruptions can be almost as bright as a core-collapse SN interacting with the previously ejected gas and resemble Type IIn SNe. Nowadays, for many IIn SNe their terminal nature is still disputed. An interesting example was SN 2009ip that showed variations in brightness years before its possible core-collapse. Here we present SN 2015bh in NGC 2770 (the host of 3 other Type Ib SNe) that shows striking similarities to SN 2009ip. It experienced short-term variability for at least 21 years before it brightened to a "precursor" in Feb-May 2015 and the "main event" or possible final explosion in May 2015, where it reached an absolute magnitude of -17.5. Its spectra are consistent with an LBV in outburst before May 2015 and a 1998S-type IIn during the main event, showing double P-Cygni line profiles, reminiscent of those exhibited by SN 2009ip. Whether SN 2009ip or SN 2015bh did survive the "main event" can still not be securely answered. The two events might be a rare new class of event showing Eta-Car type eruptions for many years before a hyper-eruption of a final core-collapse. Alternative explanations such as binary interaction are also possible. Future large-scale high-cadence surveys will detect more of these curious events which will help us to understand their nature.

54.-
SESSION: 08
NAME: Maria Drout
AFFILIATION: Carnegie Observatories
TITTLE: Probing the Extremes of Pre-SN Mass-Loss with the PS1-MDS
ABSTRACT:
A non-negligible fraction of massive stars undergo enhanced (possibly violent/eruptive) mass-loss in the final decades before core collapse. Theoretical models of such mass-loss are challenging and observational probes are necessary to help constrain the full diversity of pre-SN mass-loss (e.g. density profile, physical extent), the mechanism by which this mass is ejected, and the progenitors of various sub-classes of events. In this talk I will present new results from PS1 observations of super-luminous Type IIn SN (SLSN-II). In particular, I will highlight new constraints on the progenitors of SLSN-II based on a joint analysis of their explosion/CSM properties and host galaxy environments.

55.-
SESSION: 08
NAME: Saurabh Jha
AFFILIATION: Rutgers University
TITTLE: Type Iax Supernovae
ABSTRACT:
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), with prototypes like SN 2002cx and SN 2005hk. I will describe recent new Hubble Space Telescope observations of the SN Iax 2012Z, the only white dwarf supernova with a pre-explosion detection of a progenitor system. I will argue that, surprisingly, our understanding of the progenitors and explosions of SN Iax may actually be more certain than our understanding for normal SN Ia, and I will explore the implications of SN Iax for models of normal SN Ia.

56.-
SESSION: 08
NAME: Raffaella Margutti
AFFILIATION: NYU
TITTLE: Peculiar, Odd, and often a bit Extreme Stellar Explosions
ABSTRACT:
Recent observations across the electromagnetic spectrum unveiled our partial understanding of the physics that regulates stellar explosions, while exposing our ignorance of the last stages of evolution of massive stellar progenitors. In this talk I will present observations of a few among the most dramatic stellar explosions discovered in the past few years, including Relativistic SNe, Super-Luminous SNe and the SN chameleon 2014C. SN2014C underwent a complete metamorphosis, evolving from a normal H-stripped SN of type Ib into a strongly interacting SN of type IIn, thus violating the Type I vs. Type II SN classification that has existed for decades.

57.-
SESSION: 08
NAME: Takashi Moriya
AFFILIATION: National Astronomical Observatory of Japan
TITTLE: Light-curve and spectral properties of ultra-stripped core-collapse supernovae
ABSTRACT:
We discuss light-curve and spectral properties of ultra-stripped core-collapse supernovae. Ultra-stripped supernovae are supernovae with ejecta masses of only ~ 0.1 Msun whose progenitors lose their envelopes due to binary interactions with their compact companion stars. We follow the evolution of an ultra-stripped supernova progenitor until core collapse and perform explosive nucleosynthesis calculations. We then synthesize light curves and spectra of ultra-stripped supernovae based on the nucleosynthesis results. We show that ultra-stripped supernovae synthesize ~ 0.01 Msun of the radioactive 56Ni, and their typical peak luminosity is around 1e42 erg/s or -16 mag. Their typical rise time is 5-10 days. By comparing synthesized and observed spectra, we find that SN 2005ek, some of so-called calcium-rich gap transients like PTF10iuv, and some other transients may be related to ultra-stripped supernovae.

58.-
SESSION: 08
NAME: Matt Nicholl
AFFILIATION: Harvard CfA

TITTLE: SN 2015bn: a new benchmark dataset for understanding superluminous supernovae
ABSTRACT:
SN 2015bn was a Type I superluminous supernova (SLSN) at redshift z = 0.1136. As well as being one of the closest SLSNe I yet discovered, it is intrinsically brighter (MU ≈ −23.1) and in a fainter host galaxy (MB ≈ −16.0) than the other SLSNe at z = 0.1. We used this opportunity to collect the most extensive dataset for any SLSN I to date, including deep and densely-sampled spectroscopy and photometry, from the UV to the NIR, spanning a year in the SN rest-frame. SN 2015bn shows a very broad light curve with surprising undulations on a timescale of 30-50 days. The spectrum reveals extraordinarily slow evolution except for a rapid transformation between +7 and +20-30 days. Weak features may be tentatively linked to hydrogen and helium. With this benchmark dataset, we derive physical properties including the bolometric luminosity, and find slow velocity evolution and non-monotonic temperature and radial evolution. We interpret these observations in the context of competing models for the luminosity: magnetar, CSM interaction or 56Ni. Late-time radio observations are used to search for an off-axis GRB counterpart, and to place constraints on the density of the circumstellar environment.

59.-
SESSION: 08
NAME: Jose Prieto
AFFILIATION: Universidad Diego Portales/MAS
TITTLE: Interacting supernovae in ASAS-SN
ABSTRACT:
ASAS-SN is finding >50% of the bright (V < 17 mag) supernovae explosions all-sky, building a complete sample of nearby explosions that is ideal for detailed studies and rates estimates of different supernova types and sub-types. In this talk, I will present explosion and progenitor constraints derived from detailed follow-up observations of a sample of supernovae in ASAS-SN that show strong signs of interaction between the supernova shock and a dense circumstellar medium around the progenitor star, formed typically through multiple mass-loss episodes. Although rare, these objects are very important for understanding the latest stages of stellar evolution and mass-loss. The sample that I will present includes well-studied Type II, IIn, Ibn, and Ia-CSM supernovae. I will also discuss preliminary rates estimates for these explosions extracted from the first 2-3 years of ASAS-SN data and the implications for different progenitor scenarios.

60.-
SESSION: 08
NAME: Nathan Smith
AFFILIATION: University of Arizona
TITTLE: CSM Interaction in supernovae, pre-supernovae, and non-supernovae
ABSTRACT:
I'll talk about SN 2009ip and its kin, but also UGC 2773-OT and the light echoes of Eta Car.

61.-
SESSION: 08
NAME: Tamas Szalai
AFFILIATION: University of Szeged
TITTLE: The complex spectra of Type Iax SNe: spectral modelling and velocity measurements
ABSTRACT:
As we have shown in the case of SN 2011ay (Szalai et al. 2015), strong blending with metal features (those of Fe II, Ti II, Co II) could make the direct analysis of the broad spectral features of SNe Iax very difficult, even during the early phases. The effect of strong blending also makes the 'quick-look' velocity estimates uncertain; for example, measuring the absorption minimum of the

~λ6200 feature and assuming that it is due to purely Si II λ6355 might underestimate the photospheric velocity, because of the effect of blending with Fe II and Co II. This does not question the fact that SNe Iax generally have lower expansion velocities than SNe Ia, but the non-uniqueness of the spectrum modelling fits that will be presented in this talk makes the velocities of such events rather ill-constrained.

62.-
SESSION: 09
NAME: Chris Burns
AFFILIATION: Carnegie Observatories
TITTLE: A 20 Year Stretch of 15 Days, Is it Time for a Δ Change?
ABSTRACT:
The key success to supernova cosmology was the discovery that intrinsic luminosity and color of type Ia supernovae are highly correlated with the time scale over which the objects evolve (the luminosity-width relation). The first parameter used to characterize the width of the light-curves was developed by Mark Phillips and, thanks to ease with which it can be measured, is still the most used: delta_m15. But it has its limitations, particularly at both extremes of the luminosity-width relation, where dm15 fails to measure the actual rate of time evolution of the supernova and seems to be a poor predictor of its near infra-red properties. I will show how this break-down has perhaps led us to discount the use of certain sub-classes (the fast-decliners) as standard candles and that a simple change of parameter may fix the problem.

63.-
SESSION: 09
NAME: Tamara Davis
AFFILIATION: University of Queensland
TITTLE: Supernova Cosmology: Prospects and Pitfalls
ABSTRACT:
Existing supernova surveys are now compiling samples of thousands of type Ia supernovae, far exceeding to the dozens that were used by the original two teams to discover the acceleration of the expansion of the universe. As well as tracing the expansion history with beautiful precision and testing for time-varying dark energy, these samples will allow supernova cosmology to start answering new types of questions. For example, some of the scatter about the Hubble diagram is induced by lensing and peculiar velocities, which give insight into large scale structure, strength of clustering, and the behaviour of gravity on a range of scales. To realise this potential, however, we have to have exquisite control over systematics, and raise our statistical techniques to new levels to accommodate non-Gaussian uncertainties and potentially contaminated samples. I'll review these efforts with some specific insights from working with the Dark Energy Survey.

64.-
SESSION: 09
NAME: Mario Hamuy
AFFILIATION: Universidad de Chile -- Millennium Institute of Astrophysics
TITTLE: Cosmology from Type II Supernovae
ABSTRACT:
Understanding the nature of dark energy arguably constitutes one of the most important current scientific questions and entails a formidable theoretical, observational, and statistical challenge. The answer to this question will require a coordinated effort involving different techniques, each one with its own merits and systematics. Thus, it will be important to identify as many independent observational methods. Here I present novel methods to measure luminosity distances based on Type II SN, particularly those involving solely photometric information, as will be the case of future massive wide field surveys.

65.-
SESSION: 09
NAME: Patrick Kelly
AFFILIATION: University of California Berkeley
TITTLE: The Multiply Imaged Strongly Lensed Supernova Refsdal
ABSTRACT:
In 1964, Sjur Refsdal hypothesized that a supernova (SN) whose light takes multiple paths to reach us around a strong gravitational lens could be used as a highly powerful probe. For such a strongly lensed explosion, the time delays between the images of the SN should depend sensitively on the cosmic expansion rate and the distribution of matter within the lens. I will discuss the first strongly lensed SN resolved into multiple images, which appeared in near-infrared images taken in early November 2014 with the Hubble Space Telescope (HST). Four images of SN `Refsdal' were arranged in an Einstein cross configuration around an early-type galaxy in the MACS J1149.6+2223 cluster (z=0.54), and a year of observations show that it is broadly similar to the extremely well studied SN 1987A. Models of the cluster potential predicted that the SN should reappear within two years in a different image of its spiral host galaxy (z=1.49) closer to the cluster's center. In early December 2015, we detected the new image of the SN with HST, and anticipate a 1-2% measurement of its relative time delay, providing a rare test of blind model predictions.

66.-
SESSION: 09
NAME: Kevin Krisciunas
AFFILIATION: Texas A&M University
TITTLE: To What Extent Are Type Ia Supernovae Standard Candles in the Near-Infrared?
ABSTRACT:
The slope of the decline rate relation for Type Ia supernovae gets shallower as we proceed from the blue to the near-IR. Setting aside the fast declining Type Ia's that peak after the time of B-band maximum (which are sub-luminous in all bands), the evidence is that the early-peaking fast decliners have almost the same near-IR absolute magnitudes as the normal decliners and slowly declining objects. Almost but not quite. With the inclusion of light curves from the Carnegie Supernova Project and a simple Monte Carlo simulation based on the maximum magnitudes, decline rates, and their uncertainties, we can say that there is a non-zero slope (at one sigma significance) for the rest-frame J- and K-bands. In the H-band, however, the decline rate slope is essentially zero. Even though high redshift surveys have revealed very few fast decliners, with the increasing scope of present and future surveys, we need to take this into account.

67.-
SESSION: 09
NAME: Bruno Leibundgut
AFFILIATION: ESO
TITTLE: History of Supernovae as Distance Indicators
ABSTRACT:
Supernovae have always been used to measure cosmological distances. The large luminosity and a relatively uniform appearance have made them primary distance indicators and placed them in a leading role in cosmology. They have contributed to three revolutions in cosmic world views. The historical supernovae were recognised as coming from the beyond the planetary spheres, the projected overdensity of (super-)novae on nebulae hinted at the extragalactic nature of galaxies and the mapping of the cosmic expansion rate through supernovae led to the discovery of the accelerated expansion and dark energy. Several

different distance methods have been developed and refined for the various supernova types. Today supernovae provide individual extragalactic distances with an accuracy unmatched by any other method.

68.-
SESSION: 09
NAME: Eric Linder
AFFILIATION: LBL/KASI
TITTLE: What Will We Do With All The Supernovae? (Mark and Nick @ 75)
ABSTRACT:
At Mark and Nick's 75th, we will have an abundance of supernovae from next generation observations. I discuss how to use them for cosmology, the SN+BAO Hubble diagram, tests of isotropy, how to optimize follow up spectroscopy, and maybe even using exoplanet instrumentation to test progenitors.

69.-
SESSION: 10
NAME: Rahman Amanullah
AFFILIATION: Oskar Klein Centre, Stockholm University
TITTLE: Diversity and peculiarity of SN Ia reddening laws
ABSTRACT:
Precision measurements of the expansion history of the Universe based on SNe Ia are highly sensitive to empirical corrections for lightcurve shape and colors. For the latter, most cosmological studies derive reddening relations at odds with the common wisdom on dimming by dust in the interstellar medium of the host galaxy. In this talk I will present measurements of the reddening law of individual reddened SNe Ia based on ultraviolot to near-IR data. We find that the individual reddening laws, when characterized by the total-to-selective extinction Rv, can range between Rv=1.4(0.1) to Rv=2.8(0.1) when highly reddened objects E(B-V)>1 mag are considered. Adding UV photometry reduces the uncertainty of fitted Rv by 50% allowing us to also measure Rv of individual low-extinction objects which point to a similar diversity, currently not accounted for in the analyses when SNe Ia are used for studying the expansion history of the Universe. Possible explanations for low Rv will also be discussed.

70.-
SESSION: 10
NAME: Joseph Anderson
AFFILIATION: ESO Chile
TITTLE: Type II supernovae as environment metallicity indicators
ABSTRACT:
Understanding of the chemical enrichment of galaxies is of fundamental importance for our complete understanding of the Universe. However, extragalactic measurements of metallicity are almost exclusively achieved through emission line diagnostics which are plagued with systematics. In this contribution we present both models and observations which show that SNeII can be used as complementary metallicity indicators.
Spectral models present increasing metal-line strengths with increasing progenitor metallicity. We confirm this trend observationally by showing that the equivalent width of Fe 5018A measured in SNII spectra at 50 days post explosion has a statistically significant correlation with SN host HII region oxygen abundance. The implications of this trend are explored, together with an outlook to future uses of SNeII in this context. We also discuss the influence (or lack thereof) of progenitor metallicity on the observed diversity of SNII light-curves and spectra.

71.-
SESSION: 10
NAME: Alejandro Clocchiatti
AFFILIATION: Pontificia Universidad Catolica de Chile
TITTLE: Continuum Foreground Polarization and Absorption of Na I in Type Ia Supernovae
ABSTRACT:
We present a study of the continuum polarization over the 400-600nm wavelength range of 19 Type Ia SNe obtained with FORS at the VLT Telescope of the Paranal Observatory. Twelve SNe show narrow lines of Na I D at the velocity of their hosts (the sodium sample) and seven do not (the non--sodium sample). The continuum polarization of the sodium sample near maximum light displays a large range of values, from tenths of a percent up to ~8%. The non--sodium sample shows lower values. The continuum polarization of the sodium sample follows an approximately linear trend with wavelength. The values of mean polarization show a linear correlation with the color, color excess, and extinction in the visual band. There are correlations as well with the equivalent width of the Na I D and Ca II H & K lines, but with larger dispersion, and a noisy relation between the mean polarization the ratio of total to selective extinction (R_V). Stronger continuum polarization is observed in SNe with redder colors, larger color excesses, and extinctions. Higher polarization is associated with small values of R_V. Our results suggest that the dominant fraction of dust polarization originates in the host galaxies, but the polarizing dust cannot be too close to the SNe, at distances that we would associate with circumstellar regions. Also that Na I D lines from foreground matter in the SN host are usually associated with an ISM different from the Galactic one.

72.-
SESSION: 10
NAME: Christopher Frohmaier
AFFILIATION: University of Southampton
TITTLE: The rate of Type Ia supernovae in the local universe from the Palomar Transient Factory
ABSTRACT:
We present new results on the volumetric rate of type Ia supernovae (SNe Ia) in the local universe measured using the Palomar Transient Factory (PTF). PTF was an automated optical sky survey designed for transient discovery that spectroscopically confirmed 1800 supernovae over 2009-2012. With a 3-5 day observing cadence providing untargeted scans of the night sky, the PTF dataset is the perfect playground for a supernova rate calculation. We use three years of PTF data to construct a representative simulation of the survey in which we place Monte Carlo-ed explosions onto an artificial night sky. We re-run the survey to observe this sky, and compare the simulation results to the actual performance of PTF to weight the real supernovae, accounting for incompleteness in determining population numbers. We use this technique to calculate the most precise volumetric SN Ia rate to date, and show that it is about 30% lower than previous estimates.

73.-
SESSION: 10
NAME: Lluís Galbany
AFFILIATION: Universidad de Chile
TITTLE: Supernova environmental studies through Integral Field Spectroscopy
ABSTRACT:
The advent of Integral Field Spectroscopy (IFS) applied to supernova (SN) environmental studies have shown the potential of this technique to characterize the local environment, measure directly the galactic environmental parameters at SN locations, and compare them to those at different locations of the galaxy. I will present the first statistical study using IFS of nearby SN host galaxies provided by the CALIFA survey, which consists of 132 SN of all types in 115 galaxies. We recovered the sequence in association of different SN types to the star--forming (SF) regions by using several indicators of the ongoing and recent SF related to both the ionized gas and the stellar populations. While the total ongoing SF is on average the same for the three SN

types, SN Ibc/IIb tend to occur closer to SF regions and in higher SF density locations than SN II and SN Ia; the latter shows the weakest correlation. Core collapse SN (CCSN) also tend to explode at positions with younger stellar populations than the galaxy average, but the galaxy properties at SNIa locations are one average the same as the global galaxy properties. We found a sequence from higher to lower metallicity, form SN Ia to SN Ic-BL, and significant increasing ratio of SNIc at higher metallicities compared to other CCSN types. Our results support that none of the two proposed SN Ibc progenitors scenarios can be excluded, and the most probable situation is a combination of both.

74.-
SESSION: 10
NAME: Or Graur
AFFILIATION: New York University
TITTLE: Unraveling correlations between supernova rates and host-galaxy properties
ABSTRACT:
We still do not know what types of stellar systems end up exploding as most types of supernovae (SNe). Correlations between supernova rates and host-galaxy properties can be used to constrain progenitor models of different SN types, but some care is required. I will present several correlations between SN rates and various galaxy properties, measured with SN Ia, Ib/c, and II samples from the Sloan Digital Sky Survey and the Lick Observatory Supernova Search. These correlations are interrelated by galaxy scaling relations, so that it is not clear which galaxy property (or combination of properties) drives the correlations. Instead of relying on the the existence of these correlations, I will argue that a better tool to constrain SN progenitor models is the emergent structures seen in these rate correlations, and show how this applies to the progenitors of SNe Ia and SNe Ib/c.

75.-
SESSION: 10
NAME: Kara Ponder
AFFILIATION: University of Pittsburgh
TITTLE: SweetSpot: A Near Infrared Survey of Type Ia Supernovae in the Nearby Hubble Flow
ABSTRACT:
SweetSpot is an NOAO survey program on the WIYN 3.5-m telescope at Kitt Peak. It operated from 2012B-2015A and gathered ~114 near infrared (NIR) lightcurves located in the nearby Hubble flow 0.02<z<0.09. The aims of this survey are to test the standard nature of SNeIa in the NIR, explore their color evolution, study the dust of host galaxies, and provide an anchor for upcoming high redshift NIR surveys. Another primary goal of this survey is to investigate relationships between SNeIa observed in the NIR with their host galaxy properties previously done with optical lightcurves. In order to provide supplementary information about host galaxy properties, SweetSpot was awarded 4 extra nights with the WIYN 3.5-m Bench Spectrograph Integral Field Unit (IFU) HexPak. We obtained spatially resolved spectra for 32 host galaxies in the optical wavelength range 4600 - 7300 Angstroms. Here we will present results from the first data release containing ~70 SNeIa and preliminary results of host galaxy correlations with NIR lightcurves.

76.-
SESSION: 10
NAME: Steve Schulze
AFFILIATION: Pontificia Universidad Católica de Chile
TITTLE: The evolution of superluminous supernova host galaxies out to z ~ 4
ABSTRACT:
Superluminous supernovae (SLSNe) were only discovered recently, owing to their preference for occurring in faint dwarf galaxies. Understanding why stellar evolution yields different types of stellar explosions in these environments is fundamental to both

uncover the elusive progenitors of SLSNe and to study star formation in dwarf galaxies. In this talk, I will present our latest findings from the ongoing SUperluminous Supernova Host galaxIES (SUSHIES) survey. Our sample comprises of 60 H-rich and H-poor SLSNe out to z~4, i.e. almost every SLSN publicly announced before the end of 2014. Each host was part of a deep imaging campaign that probes the rest-frame UV to NIR. The size and the probed redshift interval of our sample allows constraining the redshift evolution of these peculiar galaxies for the first time. We find that SLSNe explode in metal-poor dwarf galaxies. One of our key result is that H-rich and H-poor SLSNe are predominantly found in galaxies with masses <10e9 solar masses in contrast to GRBs, which are also found in more massive galaxies. Moreover, the mass function of H-poor SLSN host galaxies shows no evolution up to z=1 and only a gradual increase at higher redshifts. Furthermore, I will give an outlook on our ongoing IFU campaign that aims to study the galaxy environment of SLSN host galaxies and in addition allows us to zoom in onto selected hosts.

77.-
SESSION: 10
NAME: Christina Thöne
AFFILIATION: IAA-CSIC
TITTLE: The hosts and galactic environments of CC SNe
ABSTRACT:
The environments and hosts of SNe can give us some additional information on the properties of the exploding star and its progenitor. The big question still remains whether we can distinguish the SN progenitors by their hosts and environments. While this seems to be true for extreme SNe like SLSNe primarily found in metal-poor dwarf galaxies, other types are less conclusive. In this talk I will review what we know about the hosts and environments of different SN types at varying spatial resolution, the conclusions we can (and cannot) derive and what ongoing and future observations might contribute to answer these questions.

POSTERS

1.-
SESSION: 02
NAME: Sang Chul Kim
AFFILIATION: Korea Astronomy and Space Science Institute
TITTLE: Introduction of Korea Microlensing Telescope Network Supernova Program
ABSTRACT:
The Korea Microlensing Telescope Network (KMTNet) is a network of three identical 1.6 m optical telescopes with wide field-of-view (2 deg X 2 deg; 0.4 arcsec/pixel) recently built in CTIO, SAAO, and SSO, which ensures 24-hour continuous sky coverage in the southern hemisphere. From October 2015 we have carried out the KMTNet Supernova Program (KSP) optimized for discovering and monitoring early and/or peculiar supernovae, optical transients, and related objects for five year period. We will show the system characteristics of the KMTNet and KSP, together with the status and early results of the KSP.

2.-
SESSION: 02
NAME: Jae-Joon Lee
AFFILIATION: Korea Astronomy & Space science Institute
TITTLE: KMTNet Supernova Project: Pipeline and Alerting System Development
ABSTRACT:
The KMTNet Supernovae Project utilizes the large 2 deg x 2 deg field of view of the three KMTNet telescopes to search and monitor supernovae, especially early ones, and other optical transients. A key component of the project is to build a data pipeline with a descent latency and an early alerting system that can handle the large volume of the data in an efficient and a prompt way, while minimizing false alarms, which casts a significant challenge to the software development. Here we present the current status of their development. The pipeline utilizes a difference image analysis technique to discover candidate transient sources after making correction of image distortion. In the early phase of the program, final selection of transient sources from candidates will mainly rely on multi-filter, multi-epoch and multi-site screening as well as human inspection, and an interactive web-based system is being developed for this purpose. We will also discuss the application of machine learning algorithms to select true transient sources from candidates, based on the training set collected in the early phase.

3.-
SESSION: 02
NAME: Brad Tucker
AFFILIATION: Mt. Stromlo Observatory - the Australian National University
TITTLE: GLUV - A UV Balloon-borne Survey
ABSTRACT:
We are currently starting to build a network of ultra-violet telescopes to survey both the dynamic and dark Universe. The telescopes will be flown on long-duration, high-altitude balloons. Providing access to high cadence near-UV photometry. We are looking at a balloon platform with a launch in 2018, and increase balloon flights overtime, with the aim to fly 30 - 50 at once. We will retrofit our balloons with small (20 - 30cm) telescopes operating in the near-UV (250 - 300nm). We will use the balloons to perform a wide-field, high-cadence UV survey.

4.-
SESSION: 02
NAME: Brad Tucker
AFFILIATION: Mt. Stromlo Observatory - the Australian National University
TITTLE: The SkyMapper Supernova Search
ABSTRACT:
The SkyMapper Transient (SMT) search is a rolling search of the southern and equatorial sky utilizing the SkyMapper Telescope at Siding Spring Observatory, covering approximately 1000 sq.deg per full night with a cadence of 3-4 nights. SkyMapper aims to have 150, well calibrated (~1%) low redshift (z<0.1) type Ia supernova. In addition, the SkyMapper Transient search is aiming to discover interesting transients and counterparts for gravitational waves and fast radio burst events. We will provide an update on the search.

5.-
SESSION: 03
NAME: Pablo Estévez
AFFILIATION: Dept Electrical Engineering, University of Chile and Millennium Institute of Astrophysics
TITTLE: Detecting Supernovae by Using Deep Learning
ABSTRACT:
Astronomy is facing a paradigm change due to the requirement of automatic data processing for the current and future massive surveys. The pipeline of the High Cadence Transient Survey (HiTS) searches for SNe in almost real-time. It takes the data stream of the Dark Energy Camera to output SNe candidates. In this work we apply Deep Learning (DL) to classify ~0.7 million transient sources found in the HiTS 2013 campaign through image differencing, plus ~0.7 million simulated SNe. The DL classifier is a convolutional neural network able to extract image features automatically. The performance of the DL classifier is compared to a Random Forest classifier with features designed manually through feature engineering. The DL classifier outperformed the RF classifier obtaining a significantly lower area-under-the-curve of the detection curve: false negative rate (FNR) vs. false positive rate (FPR). For example, setting FPR to 0.001, the DL achieved a FNR of 0.08 versus 0.15 for the random forest classifier.

6.-
SESSION: 03
NAME: Pablo Huijse
AFFILIATION: Millennium Institute of Astrophysics and University of Chile
TITTLE: Machine Learning Classification of multiband Supernovae Light Curves
ABSTRACT:
The Large Synoptic Survey Telescope (LSST) will generate 50 PB of light curve catalogs. The LSST and other near-future large optical surveys will greatly increase the current number of supernovae (SNe) light curves. Spectroscopic measurements provide very reliable information to perform SNe classification. But only a small percentage of the observed SNe can be spectroscopically confirmed. Exploiting the vast available photometric data is key to improve the current cosmological models. In this work we propose an automatic semi-supervised machine learning approach for SNe classification. Light curves are compared using correntropy, a generalized correlation function. The main challenges are the class imbalance, the difference in sample size, the uneven sampling and the noise in the light curves. We test our methods using the corrected Supernovae Photometric Classification Challenge (SSPhotCC) database and compare to current approaches.

7.-
SESSION: 03
NAME: Makoto Uemura
AFFILIATION: Hiroshima University
TITTLE: High-dimensional data-driven approach to type Ia supernovae:Variable selection for the peak luminosity and classification
ABSTRACT:
We introduce our two recent works on type Ia supernovae (SNe Ia) based on high-dimensional data-driven techniques. The diversity in their peak luminosity can be reduced by corrections in several variables. The color and decay rate have been used as the explanatory variables of the peak luminosity in past studies. However, it has been proposed that their spectral data could give a better model of it. In our approach, we use cross-validation in order to control the generalization error and a LASSO-type estimator in order to choose the set of variables. Using spectral data taken from the UC Berkeley supernova database, our analysis confirmed that the peak luminosity depends on the color and decay rate, and does not support adding any other variables in order to have a better generalization error. On the other hand, this analysis is based on the assumption that all SNIa originate in a single population, while it is not trivial. We used a visual analytics tool for the asymmetric biclustering method to find both a good set of variables and samples at the same time. We found that SNe Ia can be divided into two categories by the expansion velocity of ejecta. In addition, the two sub-groups can be characterized by the strength of silicon lines. Those examples demonstrate that the high-dimensional data-driven approach is useful for the big-data era of supernovae.

8.-
SESSION: 04
NAME: Ji-an Jiang
AFFILIATION: University of Tokyo
TITTLE: Deep Multi--Band Early-Phase Type Ia Supernova Survey with Subaru/Hyper Suprime-Cam
ABSTRACT:
Although Type Ia supernovae (SNe Ia) serve as a powerful cosmological distance indicator, their origins remain unknown. Observations of SNe Ia obtained within a few days of the explosion can provide new and robust constraints on their progenitors. Systematic studies of early-phase SNe Ia are now possible with the most powerful optical imaging survey instrument in the world — the Subaru Hyper Suprime-Cam (HSC). The Multi-band Survey with the Subaru telescope for Early-phase SNe Ia (MUSSES) is a new project that aims to comprehensively investigate the early-phase photometric and spectroscopic behavior of SNe Ia using Subaru and other 2-10 m class telescopes. Results from the first MUSSES observing run in April 2016 identified total 9 early-phase SN candidates with 4 of them being spectroscopically confirmed as SNe Ia. The peculiar early-phase light curve of one MUSSES SN Ia, discovered within ~1 day of its explosion, exhibits the signature of the “companion-induced shock emission”.

9.-
SESSION: 04
NAME: Yukari Ohtani
AFFILIATION: National Astronomical Observatory of Japan
TITTLE: Influence of shock asymmetry on spectrum and light curve of shock breakout in a circumstellar medium
ABSTRACT:
Shock breakout is the earliest appearance of a shock passing through the outer layer of a massive star, and the emission properties include precious information on the nature of stellar explosion. XRO 080109/SN 2008D is an example, of which duration is 400 sec and spectrum has a power-law distribution. Since the duration corresponds to the light crossing time of the emission region, the outburst has been believed as shock breakout in a dense circumstellar medium. To explain the power-law spectrum, Suzuki and Shigeyama (2010) indicated how bulk-Comptonization influences on thermal emission. In the same year, they suggested that the shape of the observed light curve (rapid 100 sec rise and slower decay) may be interpreted as a sign of

the shock asymmetry. However, the former studies (e.g., Svirski and Nakar 2014, Couch et al. 2011, Suzuki and Shigeyama 2010) do not explain both the observed light curve and spectrum by using a hydrodynamical model. In this study, we try to explain the emission properties using a Monte-Carlo method and an axisymmetric shock model. We assume that the shape of the shock front is like an ellipsoid of revolution. The result shows that it might be possible to reproduce both the observed light curve and spectrum, if the oblateness of the shock front is 0.3, the viewing angle is at least 30 degree off the axis of symmetry, and the radial velocity of the shock is higher than 0.5 c.

10.-
SESSION: 04
NAME: Alessandro Razza
AFFILIATION: Universidad de Chile/Millennium Institute of Astrophysics
TITTLE: HiTS light curve characterization from image subtraction between DECam and SOI/DuPont
ABSTRACT:
To date, numerous telescopes and computing facilities are playing a key role in time domain astronomy, surveying the sky continuously in search of supernova (SN) transients. The High cadence Transient Survey (HiTS) makes use of a novel pipeline to perform real-time image subtraction and detection of SN candidates, with high cadence. Discoveries are performed with Dark Energy Camera (DECam) mounted on the 4-m Blanco Telescope at Cerro Tololo, although the full characterization of SN light curves requires a follow-up activity eventually provided by a combination of telescopes. Hence, a more complete picture of the observed diversity of SN light curves is obtained including both the early rise (provided by DECam) and the later time evolution (e.g. provided by SOAR or DuPont) for these SNe. By implementing a modified pipeline, we perform image subtractions between DECam and SOI or Du Pont data in order to extract clean light curves from the HiTS dataset. HiTS is making a transition from being a monochromatic survey, looking for shock breakouts, to a multiband experiment looking for very young SN rising light curves, which makes this work more relevant for building the light curves to probe different aspects about the progenitors of these cosmic explosions.

11.-
SESSION: 05
NAME: Claudia Agliozzo
AFFILIATION: Universidad Andres Bello
TITTLE: The mass-loss before the end: two luminous blue variables with a collimated stellar wind
ABSTRACT:
Recently, the classical view of luminous blue variables (LBVs) as a phase of post-main sequence evolution of a single massive star has been challenged by Smith & Tombleson (2015, MNRAS, 447,598S), that proposed that LBVs are mass-gainers in binary systems with Wolf Rayet (WR) stars (or Type Ibc Supernovae), which are the mass-donor. Humphreys et al. 2016 (arXiv160301278H) defended the accepted description of LBVs as evolved massive stars that have to lose quickly their H envelope through severe mass-loss, before to evolve as WRs. There is a growing evidence that H-poor Core Collapse-SNe progenitors consist of both binary and single stars. The mechanism that induces some LBVs to explode as Type IIn SNe is not know. The debate is very active and the mass-loss suffered by LBVs is still poorly understood. We gathered a multiwavelength dataset consisting of high-spectral resolution optical data and centimeter and sub-millimeter images, of two well-studied Magellanic LBVs. We found a complex mass-loss, with signatures of variability, such as have been seen previously (e.g. Stahl et al. 1983,A&A,127,49S). Our data reveal signatures of collimated stellar winds. Moreover, the outer nebulae are not equatorial disks as previously thought but instead they are a conical helix. We propose a new scenario for these stars where the mass-loss geometry is influenced by an external factor rather than intrinsic asymmetries of the mass-loss. I will discuss the simplest and most convincing scenario.

12.-
SESSION: 05
NAME: Joseph Anderson
AFFILIATION: ESO Chile
TITTLE: CSP14acu: the lowest metallicity type II supernova, from the highest mass progenitor
ABSTRACT:
To-date, there is a distinct lack of observational evidence for type II supernovae (SNe II) with progenitor masses higher than ~18 msun. There is also a lack of SNe II that have been discovered within low-luminosity host galaxies. In this contribution I present photospheric and nebular phase observations of the SN II; CSP14acu. This SN exploded in an extreme low-luminosity host (dimmer than ~-13 Mb), and displayed photospheric-phase spectra consistent with the explosion of a <0.1 zsun progenitor. While the photospheric-phase observations were otherwise relatively normal, the nebular spectrum is (to our knowledge) unique for SNe II. Both the width of the emission lines, together with the relative strength of [O I] and [Ca I] in relation to H-alpha, are best explained by a progenitor mass higher than any previous SN II.

13.-
SESSION: 05
NAME: Gennady Bisnovatyi-Kogan
AFFILIATION: Space Research Institute Rus. Acad. Sci., Moscow
TITTLE: Magnetorotational mechanism of a core-collapse supernova explosion
ABSTRACT:
Magnetorotational mechanism of explosion is working in core-collapse supernova. The main energy source is a rotational energy of the new born neutron star, and magnetic field induces a transformation of this energy into the energy of the expanding shock wave. The energy release is enough for explanation of observations. The time of such transformation depends weakly on the initial magnetic field strength, because of development of the magnetorotational instability, connected with a growth of the toroidal component of a magnetic field due to differential rotation (MRDI). Topology of the explosion depends on the form of the magnetic field. Jet is formed at a dipole-like magnetic field configuration. Recent results of 2-D calculations are presented, based on the advanced equation of state of a hot superdense matter, and improved neutrino transfer.

14.-
SESSION: 05
NAME: Gantcho Gantchev
AFFILIATION: Department of Astronomy, Physics Faculty, Sofia
TITTLE: Structure Functions of Luminous Blue Variables in M33 and M31
ABSTRACT:
We calculated the structure functions in order to characterize the variability of ~30 known or suspected LBVs in the M33 (Massey et al. 2007) and 4 famous LBVs in the M31 (Hubble & Sandage 1953, Rosino & Bianchini 1973 and Sharov 1990) galaxies on different time scales. The data reduction of ~500 000 stellar-like objects in the M33 galaxy was performed by the CASU (Cambridge Astronomy Survey Unit) Astronomical Data Centre in the Institute of Astronomy, University of Cambridge. The observations were carried out with the 2.6m VISTA telescope at the Cerro Paranal, Chile. More than 500 images in that passband were obtained with the OmegaCAM, a large format (16k x16k pixels) CCD camera, and each of them covers a field of view of 1°x1°. The current time span of the data is 2.1 yrs until the end of 2014. The r-band aperture photometry was externally calibrated by cross identification of ~52000 stars from SDSS. Magnitude zero points were derived as the mean of the median values in >20 bins (5mag difference) of the OmegaCam instrumental magnitudes. Recent studies (Groh et al. 2013) show that before going supernova, models of rotating stars of 20 or more solar masses can also undergo the LBV phase right after the Red supergiant (RSG) one. In this research on well known and candidate LBV stars, we present the light curves of the studied variables, their structure functions and the derived slopes and characteristic time scale for each variable.

15.-
SESSION: 05
NAME: Hyun-Jeong Kim
AFFILIATION: Seoul National University
TITTLE: The qWR Star HD45166 as a Type Ib Supernova Progenitor
ABSTRACT:
Recent observations indicate that Type Ib/c supernovae (SNe Ib/c) have an ejecta mass of about 2.0 - 4.0 Msun, on average. This implies that most of Type Ib SNe originate from hydrogen-deficient stars that are produced via mass transfer in binary systems with a relatively low-mass of M = ~ 3.0 - 6.0 Msun, rather than massive Wolf-Rayet stars with M > 10 Msun. In this regard, the quasi-Wolf-Rayet (qWR) star in the binary system HD45166 is particularly important for constraining the pre-SN evolution of SNe Ib/c progenitors. HD45166 is a binary system consisting of a qWR star and a main sequence star with a spectral type of B7V, in a 1.596 day orbit. This qWR star is hydrogen-deficient, having a surface hydrogen mass fraction of ~0.33, and believed to be on the helium main-sequence. Its inferred mass is 4.2 Msun, which matches very well with the expected masses of SN Ib/c progenitors in binary systems. Using both stellar evolution and non-LTE stellar atmospheric models, we investigated the possible evolutionary paths of massive binary systems that can lead to formation of HD45166. We find that HD45166 can be produced via common envelope ejection from a binary system with initial masses of 15 Msun and 4.8 Msun for primary and secondary stars, respectively, if the Scwartzschild criterion for convection is adopted. The qWR star in HD45166 is expected to undergo Case BB mass transfer during the post He burning phase, and to explode as a Type Ib SN in about 1.0 Myr.

16.-
SESSION: 05
NAME: Hideaki Matsumura
AFFILIATION: Kyoto University
TITTLE: Suzaku Observation of G166.0+4.3: A Core-Collapse Supernova Remnant with an Unusual Morphology
ABSTRACT:
"G166.1+4.3 is a Galactic supernova remnant (SNR) whose synchrotron radio emission is extremely asymmetric: A large bipolar structure in southwest (Wing region) with a smaller semicircle shell in northeast (Shell region). As G166.1+4.3 has centrally-filled X-ray emission, it is classified as a mixed-morphology SNR. The origin of the unusual structure is still unclear. A recent Fermi observation discovered a GeV gamma-ray emission from the northeast part of this remnant (Miguel 2013), suggesting an association with nearby molecular clouds.
We have performed a long-time (totally 230 ks) observation of G166.1+4.3 with the Suzaku X-ray satellite in 2014. From the spectral analysis of G166.1+4.3, the total ejecta mass is estimated to be larger than 8 solar masses. While no candidate for progenitor has been detected around this remnant, a core-collapse SN is preferable as its origin. We also found that the Fe-rich ejecta asymmetrically spread over the Wing region. A spatially-resolved spectral analysis shows that the plasma parameters significantly differ between Wing and Shell. The Wing region represents a normal ionization-dominant spectrum; the Shell spectrum suggests a recombination dominant plasma. Although such “recombining plasmas” have been found from several other mixed-morphology SNRs (e.g., W49B: Ozawa et al. 2009; IC 443: Yamaguchi et al. 2009), its origin remains an open question. These results suggest an inhomogeneous ambient medium in the vicinity of G166.1+4.3."

17.-
SESSION: 05
NAME: Nicolas Meza Retamal
AFFILIATION: PUC/MAS
TITTLE: A sub-solar metallicity type II-P Supernova at ESO 467-G051: ASASSN-14jb
ABSTRACT:

We present optical photometry and spectroscopy of the Type II-P supernova ASASSN-14jb, as well as VLT MUSE IFU observations (from the AMUSING project) of its host galaxy and a nebular-phase spectrum. This supernova, in the nearby galaxy ESO 467-G051 (z=0.006), was discovered and followed up by the All Sky Automated Survey for SuperNovae (ASAS-SN). We obtained well-sampled LCOGTN BVgri and Swift UBVW1M2W2 optical and near-UV light curves and several spectra in the early photospheric phases. The supernova is ~1.6 kpc above the disk of ESO 467-G051, an edge-on disk galaxy. The large projected distance from the disk and non-detection of H-alpha emission from MUSE IFU observations of the explosion site are in conflict with the standard environment of core-collapse supernova progenitors and suggests the possible scenario that the progenitor received a kick in a binary interaction. We will present analysis of the optical light (including bolometric) curves and spectra, from which we derive a distance from the Photospheric-Magnitude-Method (PMM) for Type II-P SNe and physical properties of the SN explosion (Ni^56 mass, explosion energy, and ejected mass). We also discuss the low oxygen abundance of the host galaxy derived from the MUSE data and compare it with the supernova spectra, which is also consistent with a low metallicity progenitor.

18.-
SESSION: 05
NAME: Sergey Moiseenko
AFFILIATION: Space Research Institute, Moscow
TITTLE: Development of Magneto-Differential-Rotational Instability in MagnetoRotational Supernova explosion.
ABSTRACT:
We represent results of 2D simulations of development of the Magneto-Differential-Rotational Instability in MagnetoRotational Supernova explosion. At the initial stage of the amplification of the magnetic field its growth is linear. Later the exponential growth of all components of the magnetic field show the development of special type of Magneto-Rotational-Instability (Tayler-type instability). We call it Magneto-Differential-Rotational-Instability(MDRI).

19.-
SESSION: 05
NAME: Tomás Müller
AFFILIATION: Pontificia Universidad Católica
TITTLE: Physical Parameters of Type II Supernovae
ABSTRACT:
The understanding of core-collapse supernovae is crucial for learning more about the evolution of massive stars an their deaths. In particular, most theoretical simulations of core-collapse in massive stars fail to produce supernova explosions. We extract physical parameters from a sample of multicolor light curves and spectra of Type II supernovae (13 from Galbany et al. 2015 and 4 from other studies in the literature) using the global fitting technique of Pejcha & Prieto (2015). The fitting yields physical parameters, such as the distance modulii, reddenings, and 56Ni masses, that we compare with previous works. We study the distribution of 56Ni masses, ejecta masses, and explosion energies of a sub-sample of well-observed Type II supernovae retrieving some known correlations, but also paying special attention to the 56Ni mass distribution and comparing it with theoretical models of core-collapse with the neutrino mechanism. Depending on the theoretical model and mass upper limit for supernova progenitors, we obtain similar distributions. As future work, we would like to shed more light into the conclusion by Pejcha & Thompson 2015 and Sukhbold et al. 2015 that there is no single mass below which all stars explode turning into a neutron star and above which black holes form, but rather there is a more complex behavior.

20.-
SESSION: 05
NAME: Tatsuya Nakaoka
AFFILIATION: Hiroshima University
TITTLE: Extended UV-NIR observations of Type IIP supernova 2014cx from two days after the explosion
ABSTRACT:
SN 2014cx is a type IIP supernova (SNe IIP), which show strong Balmer lines in its optical spectrum and a plateau in its optical light curve. This SN is one of the earliest discovered SNe IIP and we successfully obtained multi-band data covering UV to NIR wavelengths from only two days after the explosion. From its spectral energy distribution, we derived blackbody temperature and radius as an approximation of the photospheric temperature and its radium. They are 25000 K and 2600 R_sun, respectively, at two days after the expected explosion date. By extrapolating the derived slope of the expanding radius, we can estimate the radius at 0 days, that is, the radius of the progenitor star. Although it should contain significant uncertainties, it is interesting that the derived radius, about 500 R_sun, is comparable with that independently estimated by adopting the semi-analytic light curve model of SNe IIP (Popov 1993). The characteristics of the light curve and spectra in its early phase are mostly consistent with those of typical SNe IIP, e.g., SNe 2012aw and 1999em, except for the slightly shorter plateau phase (78 days). The length of the plateau phase is about ten percent shorter than the average of IIP SNe, and the semi-analytic model gives the hydrogen envelope mass of the progenitor, about 6 M_sun. This is nearly half as massive as those of typical SNe IIP, and we suggest that the progenitor is less massive or has lost its hydrogen envelope before the current SN explosion.

21.-
SESSION: 05
NAME: MinaPak
AFFILIATION: Korea Astronomy and Space Science Institute (KASI), Korea University of Science & Technology (UST)
TITTLE: Caltech Core-Collapse Program Near-Infrared Analysis of Young Supernovae
ABSTRACT:
We analyse optical and near-infrared photometric data for ten core-collapse supernovae obtained from the Caltech Core-Collapse Supernova Program. Infrared data are from the observations of Palomar 5-m Wide Field Infrared Camera, while the optical data are from publicly available data of previous studies. We conduct simple blackbody fittings to the spectral energy distributions and, when necessary, use modified blackbody fittings. We obtain physical parameters of the supernovae and perform systematic investigations that might indicate dust formation in the supernova environments.

22.-
SESSION: 05
NAME: Hajime Sotani
AFFILIATION: National Astronomical Observatory of Japan
TITTLE: Evolution of gravitational wave spectra from protoneutron stars
ABSTRACT:
We examine the spectra of gravitational waves radiating from protoneutron stars after bounce of core-collapse supernova, where we adopt the relativistic Cowling approximation. To calculate the frequencies of photoneutron stars, we construct the stellar models with the assumption that the protoneutron stars would be quasi-static at each moment. Solving the eigenvalue problem numerically, we obtain the frequencies. Then, we find that the frequencies of f-mode are almost independent from the distributions of electron fraction and entropy per baryon, but depend on the mass and radius of protoneutron stars. In addition, the frequencies are almost proportional to the average density of protoneutron stars, whose proportional constant is completely different from that for cold neutron stars. Thus, combining the observations for the so-called g-mode oscillations around protoneutron stars, one could determine the radius and mass of protoneutron stars via the observation of f-mode oscillations. We will also show the results how the frequencies depend on the progenitor mass and equation of state.

23.-
SESSION: 05
NAME: Maximilian Stritzinger
AFFILIATION: Aarhus University
TITTLE: Unveiling the nature of the peculiar supernova 2016adj born within the dust lane of Centaurus A
ABSTRACT:
Supernova 2016adj was discovered by the BOSS supernova search on 08.6 February 2016 and classified by the Carnegie Supernova Project on 09.2 February 2016 as a Type Ib supernova. Given this supernova was discovered near maximum, exhibits peculiar spectral properties compared to standard SN IIb/Ib, and is located in the prominent dust lane of the nearby galaxy Centaurus A, we initiated a comprehensive optical and near-IR follow-up campaign using facilities at the Las Campanas Observatory. We will present our initial data set and efforts to constrain the host reddening and the explosion parameters of supernova 2016adj.

24.-
SESSION: 05
NAME: Francesco Taddia
AFFILIATION: Stockholm University
TITTLE: Rare long-rising Type II supernovae resembling SN 1987A
ABSTRACT:
After the explosion of the compact blue supergiant progenitor of supernova (SN) 1987A, only a few transients were observed to resemble that famous event. We contributed to the study of these rare SNe with observations performed by the Carnegie Supernova Project (CSP), the Caltech Core-Collapse Project (CCCP) and the Palomar Transient Factory (PTF). Here we present these 1987A-like SNe, in particular their photometrical and spectroscopical properties, as well as the derived progenitor and explosion properties. These SNe show a remarkable variability in the early emission, which we interpret as due to a wide range of (compact) progenitor radii.

25.-
SESSION: 05
NAME: Katalin Takáts
AFFILIATION: Universidad Andres Bello/ MAS
TITTLE: Searching for the progenitor of the Type II-P SN 2009ib
ABSTRACT:
SN 2009ib was a Type II-P supernova (SN) that exploded in NGC 1559. The host galaxy of the SN was observed by the Hubble Space Telescope in 2001, which gave us the opportunity to look for the progenitor of the SN directly. These HST images, however, are not particularly deep and the galaxy is relatively far for this kind of analysis, therefore our study resulted in several open questions. We applied for time with the HST and obtained new, post-explosion images in 2015, which allow us to find answers to at least some of the questions. I'll present the results of of our analysis of both the pre- and post-explosion images and discuss the progenitor and the environment of SN 2009ib.

26.-
SESSION: 05
NAME: Schuyler Van Dyk
AFFILIATION: IPAC/Caltech
TITTLE: Direct Progenitor Identifications for Recent Core-Collapse Supernovae

ABSTRACT:
I will report our group's results on attempts to identify directly the progenitors of some recent core-collapse supernovae in pre-explosion archival image data.

27.-
SESSION: 07
NAME: Regis Cartier
AFFILIATION: University of Southampton
TITTLE: Early Observations of SN 2015F: Detection of Persistent High-Velocity C II
ABSTRACT:
We present photometry and time-series spectroscopy of the nearby type Ia supernova SN2015F over −16 days to +80 days relative to B-band maximum light, obtained as part of the Public ESO Spectroscopic Survey of Transient Objects (PESSTO). SN2015F is a slightly sub-luminous SN Ia, a decline rate over the 15 days after maximum light in the B-band of Δm15(B) = 1.35 +/- 0.03 mag, placing it in the region between normal and SN 1991bg-like events. The velocity evolution of the Si II 6355 line indicates that SN 2015F is a low-velocity gradient SN Ia. The spectra exhibit photospheric C II 6580 absorption until -4 days. In the earliest spectra at < −10 days, high-velocity Ca II is particularly strong at expansion velocities of ~23000 km/s, but is almost undetected by maximum light. At early times we also find evidence for iron-peak elements (Fe II, Co II, Ti II) expanding at velocities > 13500 km/s, suggesting mixing in the outermost layers of the SN ejecta. Intriguingly, we detect an absorption feature at ~6800 AA that persists until maximum light, with the most likely explanation being detached high-velocity Cii. This high-velocity carbon seems to be confined in a relatively narrow region in velocity space at ~18500 km/s. The detection of high-velocity C II suggests that the outermost layers (> 18000 km/s) of SN 2015F are mostly unburned.

28.-
SESSION: 07
NAME: Suhail Dhawan
AFFILIATION: ESO, Garching
TITTLE: Near Infrared and bolometric properties of fast-declining SN Ia indicate sub-Chandra progenitors
ABSTRACT:
Dedicated searches for Type Ia supernovae (SN Ia) have discovered several classes exhibiting photometric and spectroscopic peculiarities. In this study, we characterise the diversity in the near infrared (NIR) and bolometric properties of the class of SN Ia with fast optical decline rates (delta_m15 > 1.6 mag) and compare them to normal (delta_m15 < 1.6) SN Ia. Fast-declining show a large range of peak bolometric luminosities (L_max differing by upto a factor of ~8). The SNe appear to be split into two groups based on their L_max. All fast-declining SN Ia with L_max < 0.3 egs are spectroscopically classified as 91bg-like and show only a single NIR peak. SNe with L_max > 0.5 egs appear to smoothly connect to normal SN Ia. The total ejecta mass values for SNe with enough late time data are < 1 Msun, indicating a sub-Chandrasekhar mass progenitor for these SNe.

29.-
SESSION: 07
NAME: Tiara Diamond
AFFILIATION: NASA Goddard Space Flight Center
TITTLE: Post-maximum and Late-time Near-infrared Spectroscopy of SN 2014J
ABSTRACT:
We present post-maximum and late-time near-infrared spectroscopic observations of the Type Ia supernova SN 2014J. The proximity of this supernova allowed for high S/N data in the J and K band regions well into the nebular phase. The late-time emission lines in these regions are less blended than features in the optical, which enable us to make comparisons to predictions

from models. The spectra show numerous strong iron and cobalt emission features throughout the 0.8 − 2.5 μm region. As the spectrum ages, the cobalt features fade as would be expected from the decay of 56Co to 56Fe. The data are shown with synthetic spectra from spherical delayed-detonation models. The [Fe II] emission line at 1.644 μm, which only has minimal blending from neighboring features, can be used as a probe of the progenitor channel. The line width is sensitive to the central density of the white dwarf prior to the explosion due to electron capture in the early stages of burning, which increases as a function of density. The evolution of this line allows for investigation of magnetic fields in the ejecta, and the effects of the magnetic fields on the emission line profile increase with time. By helping to constrain possible progenitor channels and explosion scenarios through observational signatures during the nebular phase, using the 1.644 μm emission line at late times is extremely complimentary to other current work investigating Type Ia SNe.

30.-
SESSION: 07
NAME: Georgios Dimitriadis
AFFILIATION: University of Southampton
TITTLE: Late time evolution of SN Ia SN2011fe
ABSTRACT:
We present the late-time light curve evolution of the nearby type Ia supernova (SN Ia) SN2011fe over 200-1300 days after maximum, monitored by the Palomar Transient Factory, and combined with external photometric and spectroscopic data. Our analysis reveals a sudden change in the ionisation state of the supernova at ~500 days, consistent with an infrared catastrophe, causing a shift of the emitted flux from the optical wavelengths to near infrared ones. Moreover, the extremely late light curve evolution reveals the presence of Nickel-57, with a mass consistent with explosions models of relatively low Nickel-56 synthesized masses, possibly pointing to double degenerate progenitor scenarios. We will demonstrate the importance of late time, multi-wavelength studies of SNe Ia for probing the explosion physics of the phenomenon, and discuss the implication of them for the long-standing progenitor problem.

31.-
SESSION: 07
NAME: Xiangcun Meng
AFFILIATION: Yunnan Observatories, CAS
TITTLE: A common-envelope wind model for SNe Ia
ABSTRACT:
We propose a new version of the SD model in which a common envelope (CE) is assumed to form when the mass-transfer rate between the CO WD and its companion exceeds a critical accretion rate. Our models are quite robust and may share many of the virtues of other models.

32.-
SESSION: 07
NAME: Nidia Morrell
AFFILIATION: Las Campanas Observatory, Carnegie Observatories
TITTLE: Optical spectroscopy of Type Ia supernovae by the Carnegie Supernova Project and more
ABSTRACT:
We present an extensive set of optical spectra of type Ia supernovae (SNe Ia) obtained by the Carnegie Supernova Project (CSP) between 2009 and 2014, along with additional spectroscopic observations mainly gathered during the course of the Calan-Tololo survey, starting in 1981. This work intends to be a continuation of the first release of CSP SNe Ia optical spectroscopy by Folatelli et al. (2013). From these data we derive spectroscopic parameters such as expansion velocities and pseudo equivalent widths for

selected SNe Ia features and compare their behavior at maximum light as well as their correlation with photometric properties such as decline rates and colors. The present work involves 450 spectra of 264 SNe Ia obtained by the CSP and not published in Folatelli et al. 2013 and 180 spectra of 44 SNe Ia obtained prior to the CSP campaigns.

33.-
SESSION: 07
NAME: Patrick Neunteufel
AFFILIATION: Rheinische Friedrich-Wilhelms-Universität Bonn
TITTLE: He ignitions on Carbon-Oxygen White Dwarfs - Donor Driven accretion processes, Effects of Rotation and Dynamo Action
ABSTRACT:
Type Ia supernovae (SNe Ia) have been an important tool for astronomy for quite some time; however, the nature of their progenitors remains somewhat mysterious. Recent theoretical studies indicated the possibility of producing thermonuclear detonations of carbon-oxygen white dwarfs (CO WDs) at masses less than the Chandrasekhar mass through accretion of helium-rich matter. This talk will present results obtained through detailed evolutionary modeling, using preexisting data on WD detonation conditions in line with the double detonation scenario, of candidate progenitor He star+CO WD systems, as well as evolutionary modeling of He accretion on rotating sub-Chandrasekhar mass WDs with magnetic fields. The viability of sub-solar mass He donor and WD system, discounting magnetic fields and rotation as major contributors to the observed rate of SNe Ia, SNe Iax and white dwarf deflagrations is discussed. The effects of rotation and magnetic fields on the evolution and ignition state of He-accreting CO WDs are examined, particular emphasis being placed on the effect of the Tayler-Spruit dynamo when compared with non-magnetically induced rotational instabilites. The ability of dynamo action to negate the effects viscous heating induced through non-magnetic rotational instabilities is discussed and placed into context.

34.-
SESSION: 07
NAME: Ian Remming
AFFILIATION: University of Chicago
TITTLE: The internal structure and propagation of magneto-hydrodynamical thermonuclear flames
ABSTRACT:
We present general equations for non-ideal, reactive flow magneto-hydrodynamics (RFMHD) in the form best suited for describing thermonuclear combustion in high-density degenerate matter of Type Ia supernovae. From the general RFMHD equations, we derive the one-dimensional ordinary differential equations describing the steady-state propagation of a planar thermonuclear flame front in a magnetic field. The physics of the flame is first studied using a simple case of one-step Arrhenius kinetics, a perfect gas equation of state, and constant thermal conductivity coefficients. After that the equations are solved, the internal flame front structure is calculated, and the flame velocity and thickness are found for carbon-oxygen degenerate material of supernovae using a realistic equation of state, transport properties, and detailed nuclear kinetics. The magnetic field changes the flame behavior significantly as compared to the non-magnetic case of classical combustion. (1) The magnetic field influences the evolutionarity of a flame front and makes it impossible for a flame to propagate steadily in a wide range of magnetic field strengths and orientations relative to the front. (2) The speed of the flame can be diminished or enhanced by up to several factors relative to the non-magnetic laminar flame speed. (3) For high density burning, the magnetic field creates an environment in which multiple flame solutions can exist for the same fuel conditions.

35.-
SESSION: 07
NAME: Kevin Wilk
AFFILIATION: University of Pittsburgh PITT PACC
TITTLE: Influence of Fixed 56Ni Mass with Varying Total Mass on Type Ia Supernovae
ABSTRACT:
I present our work on Type Ia supernovae models with fixed 56Ni mass but with varying total mass (two sub-Chandrasekhar, Chandrasekhar, and super-Chandrasekhar). We ran these models from day one until day 400. We highlight the differences in both light curve/energy evolution and spectral evolution. The sub-Chandrasekhar model light curves evolve faster than higher mass models, reaching maximum earlier (by 2-3 days) and having shorter half light widths (by 3-4 days). These models fall under the broadline classification as defined by Branch et al. (2006), and they do not show high velocity features due to Ca II at maximum; instead they show Si II 6355 at higher velocity compared to the Ca II NIR triplet. Given that these models have the same energy input from nuclear decay, I will show that some of the spectral differences occur to due to the elemental mass and density difference between different models.

36.-
SESSION: 08
NAME: Jennifer Andrews
AFFILIATION: University of Arizona
TITTLE: High Resolution Spectroscopy of Interacting SNe Within the First Few Weeks
ABSTRACT:
Type IIn SNe are characterized by their narrow hydrogen emission lines, created as the expanding SN shock runs into pre-existing circumstellar material. We have been using high resolution spectroscopy (1200 l/mm) with Bluechannel on the MMT to observe a large sample of IIn SNe in order to probe their progenitor characteristics and CSM properties. By observing the strong, narrow Halpha emission lines within the first few weeks to months after explosion in the high resolution regime it is possible to measure, or at least constrain, the wind speed and mass-loss rates of the progenitor. This is of extreme interest since it gives insight into the mechanisms of the violent, eruptive mass-loss and instability of the stars that end their lives as IIn SNe; a subject to which we are still largely in the dark. Here we present a sample of Halpha emission lines of 20 Type IIn SNe before the radioactive decay phase. Even with a wide range of maximum luminosity, environment, and observation date we are able to draw important inferences about the progenitor systems to these uncommon but extremely interesting events.

37.-
SESSION: 08
NAME: Barnabas Barna
AFFILIATION: University of Szeged
TITTLE: Comparative spectroscopic analysis of Type Iax SNe
ABSTRACT:
As we have shown in the case of SN 2011ay (Szalai et al. 2015), strong blending with metal features (those of Fe II, Ti II, Co II) could make the direct analysis of the broad spectral features of SNe Iax very difficult, even during the early phases. The effect of strong blending also makes the ‘quick-look’ velocity estimates uncertain; for example, measuring the absorption minimum of the ~λ6200 feature and assuming that it is due to purely Si II λ6355 might underestimate the photospheric velocity, because of the effect of blending with Fe II and Co II. Here we present the results of a comparative spectroscopic analysis of several SNe Iax, which is based on spectral modelling carried out with SYN++/SYNAPPS parameterized resonance scattering codes as well as with the 1D Monte Carlo radiative transfer code TARDIS.

38.-
SESSION: 08
NAME: Regis Cartier
AFFILIATION: University of Southampton
TITTLE: The nature of LSQ15adm: a circumstellar interacting SN
ABSTRACT:
Type Ia supernovae displaying signatures of interaction with circumstellar material around their progenitor systems (dubbed Ia-CSM) are a very rare class of supernova explosion, but provide some of the best evidence for 'single degenerate' progenitors. However, a core collapse origin has also been proposed for these controversial SNe. Only a handful of them have been discovered before peak brightness, and studied using high-resolution spectra. I will present detailed observations of LSQ15adm, a Ia-CSM at z=0.0735, discovered by LSQ, and classified by PESSTO before peak brightness, that has been observed in immense detail by PESSTO and CSP, including high-resolution spectra. This SN reached an optical absolute magnitude of ~ -20.7, ~1.5 magnitude brighter than a normal SN Ia. Our observations strongly suggest a Type Ia origin.

39.-
SESSION: 08
NAME: Griffin Hosseinzadeh
AFFILIATION: LCOGT/UCSB
TITTLE: Type Ibn Supernovae Have Uniform Light Curves But Two Spectral Subclasses
ABSTRACT:
Type Ibn supernovae are a small yet intriguing class of explosions whose spectra are characterized by low-velocity helium emission lines. The prevailing theory has been that these are the core-collapse explosions of very massive stars embedded in helium-rich circumstellar material. We report optical observations of six new Type Ibn supernovae, bringing the sample size of such objects in the literature to 22. In order to characterize the class as a whole, we analyze the photometric and spectroscopic properties of the full sample of 22 supernovae. Unlike the more common Type IIn supernovae, whose interaction with hydrogen-rich circumstellar material has been shown to generate a wide variety of light curve shapes, we find light curves of Type Ibn supernovae to be surprisingly more homogeneous and faster evolving. We divide early spectra of Type Ibn supernovae into two subclasses, those showing only a blue continuum with narrow P Cygni lines and those that resemble the archetype SN 2006jc. These may indicate differing optical depths of circumstellar material and potentially different mass loss histories. Alternatively, the two subclasses could arise from an observational bias or a viewing angle effect.

40.-
SESSION: 08
NAME: Satoru Katsuda
AFFILIATION: ISAS/JAXA
TITTLE: Multi-Epoch X-Ray Observations of Very Luminous Type IIn Supernovae, SN2005ip, SN2005kd, and SN2006jd
ABSTRACT:
We present relatively deep, multi-epoch X-ray observations of very luminous Type IIn supernovae, SN2005ip, SN2005kd, and SN2006jd, using Chandra, XMM-Newton, Suzaku, and Swift. Significant X-rays have been detected from the three sources for several years after the explosions. The X-ray spectra can be well represented by either a single-component or double-components thermal emission model. Interestingly, we found that the X-ray spectra gradually soften with time, which is only seen for another Type IIn SN2010jl. The spectral evolution is most likely caused by decreasing absorbing materials; the hydrogen column densities are initially estimated to be as high as N_H ~ 1e23 cm^{-2}, and then decreases to the level of that in our galaxy (N_H ~ 1e20 cm^{-2}) within several years. This indicates that the SN went off in a dense circumstellar medium and that the forward shock has overtaken it, and that the progenitors had experienced massive eruptions <~1,000 years before the SN explosions (assuming a wind speed of 100 km/s and a shock speed of 10,000 km/s). Based on the X-ray luminosities as well as

the absorption column densities, we can find extremely large mass-loss rates of roughly 0.01 M_sun/year, in agreement with those seen for luminous blue variable stars.

41.-
SESSION: 08
NAME: Miho Kawabata
AFFILIATION: Hiroshima University
TITTLE: Long-term Optical/NIR Observations of type Iax supernova SN 2014dt
ABSTRACT:
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 (>~1 mag), bluer continuum (i.e. hotter photosphere) and slower expansion velocity. Recently, they are called ""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 started follow-up observation with the 1.5m Kanata telescope at Higashi-Hiroshima observatory, the 51cm telescope in Osaka Kyoiku University and the 8.2m Subaru telescope. We successfully monitored the tails of the light curves in detail, well beyond 410 days after the maximum light. The time and band (optical to near-infrared) coverages of the obtained data are superior to those of previously observed SNe Iax. 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. We constrain the explosion model suggested for SNe Iax with the derived explosion parameters, e.g., ejecta mass and kinetic energy.

42.-
SESSION: 08
NAME: Felipe Olivares E.
AFFILIATION: Universidad Andrés Bello
TITTLE: Search for correlations within the GRB-SN phenomenon
ABSTRACT:
I explored the whole sample of associations between gamma-ray bursts (GRBs) and supernovae (SNe) in search for correlations. The existence or lack of correlations between different parameters and observables are explained in the context of the explosion physics and progenitors. I also assess the validity of the stretch-luminosity relation of the SN component as a cosmological tool.

43.-
SESSION: 08
NAME: Mariana Orellana
AFFILIATION: UNRN & CONICET
TITTLE: Hydrodynamic modeling of Superluminous Supernovae: application to the unprecedentedly bright ASASSN-15lh
ABSTRACT:
We use our radiation hydrodynamic code in order to simulate magnetar powered Superluminous Supernovae (SLSNe). As previously proposed, we assume that the central rapidly rotating magnetar deposits all its rotational energy into the ejecta. The magnetar luminosity and spin-down timescale are adopted as the free parameters of the model.
For the case of ASASSN-15lh (or SN 2015L), which has been claimed as the most luminous SN ever discovered, we have found physically plausible magnetar parameters can reproduce the overall shape of the bolometric light curve (LC) provided the progenitor mass is relatively large (i.e. an ejected mass of approx 6 M_sun). We note the ejecta hydrodynamics of this event is

dominated by the magnetar input. This and other numerical experiments lead us to conclude that the hydrodynamical modeling is necessary in order to derive the properties of magnetars driven SLSNe and to characterize their stellar progenitors.

44.-
SESSION: 08
NAME: Elena Sorokina
AFFILIATION: Sternberg Astronomical Institute, Moscow University
TITTLE: Hydrogen-poor superluminous supernovae as explosions inside circumstellar envelopes: multi-color numerical modeling.
ABSTRACT:
A number of Type I superluminous supernova (SLSN) events have been discovered recently. However, their nature remains debatable. One of the most promising ideas is the shock-interaction mechanism, but only simplified semi-analytical models have been applied so far. We simulate light curves for several SLSN-I models enshrouded by dense, non-hydrogen circumstellar (CS) envelopes, using a multi-group radiation hydrodynamics code STELLA that predicts not only bolometric, but also multicolor light curves. We demonstrate that the bulk of SLSNe-I including those with relatively narrow light curves like SN 2010gx or broad ones like PTF09cnd can be explained by the interaction of the SN ejecta with CS envelope, though the range of parameters for these models is rather wide. Moderate explosion energy (2-4 foe) is sufficient to explain both narrow and broad SLSN-I light curves, but ejected mass and envelope mass differ for those two cases. Only 5 to 10 Msun of non-hydrogen material is needed to reproduce the light curve of SN 2010gx, while the best model for PTF09cnd is very massive: it contains almost 50 Msun in the CS envelope and only 5 Msun in the ejecta.

45.-
SESSION: 09
NAME: Petr Baklanov
AFFILIATION: ITEP, Moscow, Russia
TITTLE: Type IIP supernovae as primary distance indicators in cosmology
ABSTRACT:
I will review briefly primary distance indicators for cosmology, and in particular the Expanding Photosphere Method (EPM) for supernova distance measurements. The EPM allows us to directly determine the distance up to hundreds Megaparsecs and the EPM-distance does not depend on any steps of the cosmological distance ladder. The EPM suggests that the supernova photospheric flux can be expressed via a simple formula involving an important correction factor. The theoretical modelling of SN IIP by Eastman(1996) and Dessart(2005) has revealed the correlation between the correction factor for EPM and the color temperature of a supernova. The best-fit polynomials of the correlation are in qualitative agreement in both papers, however, the values of the correction factor are systematically larger for Dessart approximation, than for Eastman approximation. That is why, the EPM-distance difference can reach up to 40% for the same object! Using the self-consistent numerical simulations with our radiation hydrodynamics code STELLA we have obtained diagrams of dependence of the correction factor on the color temperature from the initial phase of explosion up to the nebular stage. Our approach to the numerical simulations differs radically from Dessart methods, nevertheless, at the phase of free expansion our best-fit polynomials are surprisingly close to the ones obtained from Dessart modelling. This result is an additional argument for a ``long'' scale of the EPM-distances.

46.-
SESSION: 09
NAME: Thomas de Jaeger
AFFILIATION: MAS/Universidad de Chile
TITTLE: Cosmology from Type II Supernovae: a bright future
ABSTRACT:

The coming era of large photometric wide-field surveys, which will increase the detection rate of supernovae by orders of magnitude. Such numbers will prohibit spectroscopic follow-up in the vast majority of cases, and hence methods must be deployed which can proceed using solely photometric data. Using two different methods we construct a Hubble diagram of Type II supernovae (up to 0.2-0.4 redshift) which combines three different samples: the Carnegie Supernovae Project I (CSP), the Sloan Digital Sky Survey (SDSS), and the SuperNova Legacy Survey (SNLS). I will present a new method to standardise SNe II. Using the Photometric Colour Method (PCM) we correct the apparent magnitude by two photometric observables, one corresponding to the slope of the plateau and the second a colour term. Using more than 75 SNe we are able to reduce the scatter in the Hubble diagram from ~0.58 mag to ~0.38 mag. For a subset of SNe II with spectroscopic data, we also performed the Standard Candle Method (SCM), where we correct the apparent magnitude for the expansion photospheric velocity. Using the SCM and more than 60 SNe with a redshift range of 0.01-0.20 we obtained an intrinsic dispersion in the Hubble diagram of 0.29 mag which it is correspond to 13% in distance uncertainty. For both methods we tried to constrain the cosmological parameters, but uncertainties are high due to the lack of high redshift supernovae. However, this work shows that SNe II have a bright future in cosmology.

47.-
SESSION: 09
NAME: Lluís Galbany
AFFILIATION: Universidad de Chile
TITTLE: Standardization of type II supernova light-curves with statistical methods
ABSTRACT:
SNII are the most common and homogeneous set of SNe and, although they are on average 1.2 mag intrinsically fainter than SNIa, their use as independent cosmological distance indicators has been already demonstrated. The main advantages of SNII as cosmological probes over SNIa reside on the simplicity of their hydrogen dominated atmospheres and low-density surrounding media, and on the understanding of the explosion mechanism and progenitor stars. A variety of approaches to standardize their light curves have been presented and the uncertainty in the distance determination has been reduced to ~0.3 mag, which is only a factor of two greater than that achieved using SNIa. Most of the reported methods to standardize SN II (except de Jaeger+15) require at least one spectroscopic observation for each SN. We present a Principal Component Analysis (PCA) of the light-curves of a sample of more than 250 nearby type II supernovae (SNII) compiled from several sources. Using the explosion epoch and the epoch of maximum brightness as references we extracted the common properties of these light--curves and searched for correlations to some physical parameters and morphological parameters. We also created SNe II light-curve templates that are used for standardizing these objects, construct Hubble diagrams, and determine cosmological distances. The uncertainty of this purely photometric method is competitive to other previous attempts that required at least one epoch of spectroscopy.

48.-
SESSION: 09
NAME: In Sung Jang
AFFILIATION: Seoul National University
TITTLE: The TRGB calibration of Type Ia Supernovae and the Hubble Constant
ABSTRACT:
Type Ia supernovae (SNe Ia) are a powerful distance indicator for external galaxies in the cosmic expansion dominated field (D>100Mpc). Their bright luminosity with a small luminosity dispersion enabled us to determine cosmological parameters including the Hubble constant. A precise calibration of SNe Ia is expected to provide a better understanding of modern cosmology. However, the current luminosity calibration of SNe Ia depends strongly on Cepheid variables, Population I indicator, showing a sizable scatter. The Tip of the Red Giant Branch (TRGB) is another precise distance indicator for resolved galaxies. We present the TRGB distances to seven SNe Ia host galaxies based on the archival Hubble Space Telescope image data. By

combining the TRGB distances derived in this study with optical light curves of SNe Ia in the literature, we calibrate the absolute peak luminosity of SNe Ia and derive a value of the Hubble constant. We discuss the cosmological implications of our results.

49.-
SESSION: 09
NAME: Myung Gyoon Lee
AFFILIATION: Seoul National University
TITTLE: The Limit of TRGB Distance Estimation for Supernova Host Galaxies
ABSTRACT:
The Hubble tension between the traditional distance ladder and the cosmic microwave background measurements is getting more acute with the advent of recent results of the Planck mission. Resolving this discrepancy is one of the most important and difficult problems in modern cosmology. Type Ia supernovae (SNe Ia) are at the forefront of the traditional distance latter, and the current calibration of the peak luminosity of the SNe Ia is mainly based on Cepheid variable stars. One of the steps to resolve the Hubble tension is to calibrate SN Ia using another precise indicator. The tip of the red giant branch (TRGB) is an excellent independent standard candle for this problem. The TRGB has several advantages over Cepheids. The TRGB is a Population II indicator so that it can be used for any types of resolved galaxies, enabling to use a larger sample of SN host galaxies. The TRGB method is getting more powerful and efficient as deep high resolution images of resolved galaxies from Hubble Space Telescope became available. In this study, we present the current limit of TRGB distance estimation for resolved galaxies hosting SNe Ia as well as SNe II-P, and discuss future prospects of the TRGB in the era of the James Web Space Telescope.

50.-
SESSION: 09
NAME: Bonnie Zhang
AFFILIATION: Australian National University
TITTLE: Constraining the cosmic distance scale with Type Ia supernovae
ABSTRACT:
We review the present landscape of cosmology with Type Ia supernovae (SNe Ia) and outline new directions with a focus on two vital Australian-led projects: OzDES, the spectroscopic counterpart to the Dark Energy Survey, expected to secure ~3000 redshifts of SNe Ia host galaxies up to z~1.2, and the SkyMapper Supernova Survey, a non-targeted all southern sky search at low redshift ($z < 0.1$). Our efforts in combining these complementary samples build on recent progress, with the present gold standard SN Ia sample and analysis, the SNLS-SDSS Joint Lightcurve Analysis (JLA), constraining the dark energy equation-of-state w to ~5%. We also draw on lessons learned, particularly the importance of having a uniform, well sampled and precisely calibrated low redshift anchor, and the significant contribution of calibration uncertainties to the error budget. The challenges we face in reducing and estimating uncertainties include rigorous cross-calibration of these surveys, quantifying statistical contributions from the lightcurve fitter SALT2, and performing accurate corrections for peculiar motion at low redshift. I will give an overview of current work in using SNe Ia to unify the cosmic distance scale, with a focus on these challenges. From measuring the Hubble constant and anchoring the SN Ia magnitude zero point using nearby supernovae, to tracing the universe's expansion history and the evolution of dark energy, precision and attention to detail are of the utmost importance.

51.-
SESSION: 10
NAME: Joseph Anderson
AFFILIATION: ESO Chile
TITTLE: The All-weather MUse Supernova Integral field Nearby Galaxies (AMUSING) survey
ABSTRACT:

The AMUSING survey uses the wide-field integral field spectrograph MUSE to observe large numbers of supernova host galaxies. The survey aims to further our understanding of supernova progenitors and explosions through analysing their host environments within galaxies. MUSE combines a large spectroscopic FOV of 1'x1' with high-spatial sampling together with the power of being mounted to the VLT 8m telescope. Such observations allow us to investigate multiple stellar population properties, such as age, metallicity, extinction, star formation rate, etc, thus constraining the parent progenitor populations of different supernova types. In this contribution the main aspects of the survey will be summarised, new science available with such an instrument will be highlighted and we present a few preliminary science results.

52.-
SESSION: 10
NAME: Hanindyo Kuncarayakti
AFFILIATION: MAS/DAS, UChile
TITTLE: IFU study of SN explosion sites within 30 Mpc
ABSTRACT:
The progenitors of SNe are still not very well understood. Direct detections of SN progenitors in the recent years have provided important clues on the physical characteristics of the progenitors. However, these are rare and it is difficult to increase the statistics due to the limited availability of high-quality pre-explosion images. Furthermore, most detections are of type II SNe, leaving the progenitors of H-poor SNe relatively less well constrained. Initial mass and metallicity are considered as the most important drivers of massive star evolution, and these can be derived from the immediate environment of the SN. By performing statistical studies on the SN environments, one may derive useful constraints on the progenitors. Integral field spectroscopy of more than 100 nearby SN sites within ~30 Mpc has been obtained using multiple IFU spectrographs in Hawaii and Chile, providing the identification of the parent stellar populations of the SN progenitors and the estimates of their age and metallicity. While focusing in the optical, this study also utilizes AO-assisted near-IR IFU in order to better resolve the explosion sites and characterize the star formation history. By studying the SN environment and parent stellar population, we aim to investigate how mass and metallicity influence the diversity of the SNe and their progenitor populations.

53.-
SESSION: 10
NAME: Mercedes Molla
AFFILIATION: CIEMAT
TITTLE: On the Dependence of Type Ia SNe Luminosities on the Metallicity of Their Host Galaxies
ABSTRACT:
The metallicity of the progenitor system producing a type Ia supernova (SN Ia) could play a role in its maximum luminosity, as suggested by theoretical predictions. We present an observational study to investigate if such a relationship exists. Using the 4.2 m William Herschel Telescope (WHT) we have obtained intermediate-resolution spectroscopy data of a sample of 28 local galaxies hosting SNe Ia, for which distances have been derived using methods independent of those based on SN Ia parameters. From the emission lines observed in their optical spectra, we derived the gas-phase oxygen abundance in the region where each SN Ia exploded. Our data show a trend, with an 80% of chance not being due to random fluctuation, between SNe Ia absolute magnitudes and the oxygen abundances of the host galaxies, in the sense that luminosities tend to be higher for galaxies with lower metallicities. This result seems likely to be in agreement with both the theoretically expected behavior and with other observational results. This dependence MB–Z might induce systematic errors when it is not considered when deriving SNe Ia luminosities and then using them to derive cosmological distances.

54.-
SESSION: 10
NAME: Takashi Nagao
AFFILIATION: Kyoto University
TITTLE: The non-standard extinction law toward SNe Ia and circumstellar dust
ABSTRACT:
Type Ia supernovae (SNe Ia) show non-standard extinction laws; R_V < 2 in contrast to the typical Galactic value of R_V~3 (e.g. Nobili & Goobar 2008). As a possible interpretation, it has been shown that multiple scattering of SN photons by circumstellar (CS) dust may lead to the unusual extinction law (Wang 2005; Goobar 2008). In this study, we systematically study effects of multiple scattering on extinction laws for a bright point source (i.e., SN) surrounded by CS dust. In doing this, we adopt various dust models and compute resulting values of R_V, by performing Monte Carlo radiation transfer simulations. We have found that R_V becomes lower for the CS dust with a higher ratio between mass extinction coefficients in the B and V bands, and with a lower ratio between albedos in the B and V bands. We have also found that such optical properties leading to low R_V require small silicate and polycyclic aromatic hydrocarbons (PAHs). In other words, we have found that a value of R_V does not always become lower by the effects of multiple scattering but depends sensitively on the properties of CS dust, and therefore the extinction laws toward SNe Ia could be used to constrain the properties of dust grains in the CS environments. In addition to these general relations in a steady-state approximation, we also discuss time-dependent effects relevant to the case of SNe, including the effects of time evolution of source flux and color.

55.-
SESSION: 10
NAME: Giuliano Pignata
AFFILIATION: Universidad Andres Bello/ Millennium institute for astrophysics
TITTLE: Supernova rates from the SUDARE survey
ABSTRACT:
We present Supernova rates per unit volume computed from the data collected by the Supernova Diversity and Rate Evolution (SUDARE) experiment. We monitored the Cosmic Evolution Survey (COSMOS) and Chandra Deep Field South (CDFS) fields in the g, r, i filters with the VLT Survey Telescope (VST) between 2011 and 2015. The rates of SNe of different type will be also correlate with the main parameters of the host galaxies.

56.-
SESSION: 10
NAME: Alessandro Razza
AFFILIATION: Universidad de Chile/Millennium Institute of Astrophysics
TITTLE: Extinction laws toward Type Ia supernovae with integral field spectroscopy.
ABSTRACT:
Accurate measurements of the extinction along the line-of-sight of Type Ia supernovae (SN Ia) are essential for determining distances in observational cosmology. Extinction curves, parametrized by the total-to-selective extinction ratio Rv, have been found steeper than the standard Rv = 3.1, with unusual low values inferred from SN Ia photometric observations, revealing peculiar dust properties of the interstellar medium (ISM) and possible presence of circumstellar dust. The favorable possibility of resolving spatially the stellar population at the SN location with integral field spectroscopy (IFS), provides a valuable tool to measure thoroughly the extinction and derive the dust composition before/after the explosion, both locally and in the entire galaxy. Accordingly, we select SN host galaxies where IFS from CALIFA and AMUSING surveys are available with the scope of mapping the overall host galaxies dust properties and measuring directly the extinctions at SN sites.
For this purpose, the optical spectra and UV/NIR photometry are fitted with STARLIGHT spectral synthesis code where the best combination of single stellar populations (SSPs) from synthetic spectra is determined. Results are then compared with those

retrieved from SN photometry information alone and from other methodologies such as extinction estimates from HII emission lines (Balmer decrement) and ISM lines (NaI).

57.-
SESSION: 10
NAME: Ósmar Rodríguez
AFFILIATION: Universidad Andrés Bello
TITTLE: Type II supernovae as distance indicators at near-IR wavelengths
ABSTRACT:
We investigate the potential of Type II supernovae (SNe II) as distance indicators at near-IR wavelengths. For this, we work with a set of nine SNe II from the Carnegie Type II Supernova survey. We construct a near-IR Hubble diagram (HD), measuring distances with the method described in Rodríguez, Clocchiatti & Hamuy (2014). We obtain H0(J,H)=(65.2+-3.2, 65.9+-3.2) km/s/Mpc, in agreement with the last results of the Planck experiment. The dispersion of 0.12 mag in the HD indicates a distance precision of 6%, comparable to the current precision of SN Ia distances. This result is confirmed by the inclusion of seven SNe II from the literature to the analysis, showing that SNe II are more standardizable at near-IR than at optical wavelengths.

58.-
SESSION: 10
NAME: Patricia Tissera
AFFILIATION: UNAB
TITTLE: The impact of SNIa for galaxy formation
ABSTRACT:
We studied the SNIa rate in galaxies formed within the current cosmological paradigm. Our simulations follow the formation of galaxies including their star formation history and chemical enrichment. Chemical patterns of the Milky Way bulge are used to set constraints to the different models for the lifetime of SNIa progenitors (DTD). We investigate the existence of possible correlations between the specific SNIa rate and the assembly history of galaxies. We carried out the analysis by using different DTDs.

59.-
SESSION: 10
NAME: Lingzhi Wang
AFFILIATION: CASSACA/NAOC
TITTLE: Investigation of absorption lines from SN hosts via 3D IFS
ABSTRACT:
Narrow absorption lines from supernova environments are a powerful probe to understand stellar populations as well as intervening material in the line of sight. IFU data cubes can help us understand the origin of these lines throughout the galaxy by: a) fitting the continuum to stellar population models to extract the narrow lines contribution from stellar age and metallicity and b) constraining dust characteristics of the intervening material from the remaining contribution of the narrow lines after removal of the stellar part. We then compare the inferred host dust properties with the ones at the local SN exploding position to constrain the nature of the nearby SN material. Here we present the investigation of the narrow absorption lines from CALIFA and MUSE, and also compare the results with the SN spectra and with global SN host spectra.