Supernovae

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- Supernovae (Photometric and Spectroscopic Evolution, Rates)
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1.1 ICRANet participants

- Carlo Luciano Bianco
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- Luca Izzo
- Massimo Della Valle

1.2 Past collaborators

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- Roberto Gilmozzi (ESO, Garching, Munchen)
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- Piero Madau (Santa Cruz, California University)
- Nino Panagia (STScI, Baltimore)
- Saul Perlmutter (Lawrence Berkeley National Laboratory, University of California)
- Sumner Starrfield (Arizona State University)
- Robert Williams (STScI, Baltimore)

1.3 Ongoing collaborations

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- Guido Chincarini (Bicocca University, Milano) and the SWIFT team
- Filippo Frontera (Ferrara University)
- Roberto Gilmozzi (ESO, Garching, Munchen)
- Filippo Mannucci (INAF-Arcetri, Firenze)
- Dani Maoz (Tel-Aviv University)
- Francesca Matteucci (Trieste University, Trieste)
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- Nino Panagia (STScI, Baltimore)
- Andrea Pastorello (Queen's University, Belfast)
- Martin Henze (MPE-Garching)
- Evan Scannapieco (Arizona State University)
- Robert Williams (STScI, Baltimore)
- Bruno Leibundgut (ESO)
- Adam Riess (STScI & Hopkins University)

1.4 Sabatical Visits, 2005-2010

- European Southern Observatory, Munchen (2005)
- STScI, Baltimore, (2005)
- KAVLI Institute, Santa Barbara (2006, 2007)
- Tokyo University (2006)
- Dark Cosmology Center, Niels Bohr Institute, Copenhagen (2007)
- Aspen Center for Physics (2007)
- Queen's University, Belfast (2007)
- European Southern Observatory, Munchen (2008-2009)

1.5 Students

- Luca Izzo (IRAP PhD, Italy)
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2 Brief description

My research field concern the study of several classes of transient phenomena such as: supernovae, gamma-ray bursts and novae .

Gamma-ray bursts and their Afterglows. My interest in this area started in 2000 when I became member of the SWIFT follow-up team. Most efforts were (and still are) devoted to the study of the connection between Supernovae and GRBs. Currently, I'm PI of a VLT proposal *A spectroscopic study of the Supernova/GRB connection* aimed at following the spectroscopic evolution of nearby SN-GRB associations. This project is carried out in collaboration with other members of SWIFT follow-up team. I point out 4 highlights from this programme, occurred in 2008/2011: i) the discovery of a transition object (SN 2008D/XRF 080109) between GRBs and standard Core-Collapse SNe; ii) the detection of a GRB-SN at z=0.53 and iii) the discovery of GRB 090423 at z=8.1 that is the farthest GRB ever (spectroscopically) confirmed; iv) the discovery and the follow-up of a new case of association between GRBs and SNe, i.e. GRB100316D/SN 2010bh, which takes advantage of the performances of X-shooter at VLT.

Supernovae. Photometric and the spectroscopic study of all types of SNe (Ia, Ib/c, II-linear, II-plateau) near maximum light and at late stages and their theoretical modeling. The observations at maximum provide us with the necessary data for using SNe (Ia and II) as standard candles. The observations at later stages allow one to discriminate among different energy sources (i.e. radioactive decay, pulsar, light-echo), to model the mechanisms of the explosion, and to shed light on the nature of the progenitor (In collaboration with N. Panagia and the Padova and Belfast SN groups.)

Supernovae at high z. The study of Supernovae has been extended to objects at high-z. The search for SNe at high z is twofold important. On the one hand the evolution of the SN rate with redshift contains unique information on the star formation history of the universe, the IMF of stars and the nature of the progenitors in Type Ia events. On the other hand SNeI-a at $z \sim 1 - 1.5$ are valuable tracers of cosmological models . Both aspects are currently investigated both on observational and theoretical grounds. We currently have an ESO proposal at VLT, "SN rate at high redshift and the composition of the universe" (PI B.Leibundgut in collaboration with P. Rosati, D. Maoz. S. Blondin, M. Postman and A. Riess) which has been awarded with 40h at VLT.

Search for obscured Supernovae. The "true" value of the SN rate is considerably underestimated because of extinction. This problem can be partially solved by observing in the infrared. We have started two NIR SN searches in ultra-luminous galaxies, the former at NTT and TNG the latter with HST-NICMOS (In collaboration with F. Mannucci, R. Maiolino and G. Cresci).

Search for environmental effects on the properties of type Ia SNe. This is a long-term project (in collaboration with F. Mannucci, Nino Panagia, R. Gilmozzi and F. Matteucci) aimed at throwing light on the still unknown origin of the progenitors of type Ia Supernovae. Our results have been reported in 10 papers so far published (since 2005), see items 5 and 8.

Novae. The systematic study of extragalactic novae in galaxies of different Hubble types has shown, that nova frequency (number of nova outburst per year) depends on the Hubble type of the parent galaxy. In particular, we find that spiral galaxies are more prolific nova producers, by a factor about 4, in units of K-band luminosity, than ellipticals and S0's. We show that this result could be explained by assuming that novae in late– and early–type galaxies originate from two different classes of progenitors. This result has been recently confirmed by X-ray monitoring of Super-Soft sources observed in M31 (see item 2 and 3).

The use of the maximum magnitude *vs.* rate of decline relationship, calibrated on the nova population of M31 and LMC, has allowed us to re-define the distance scale from the Local Group up to Fornax cluster and to measure the Hubble constant. The distance moduli so derived compare very well (i.e. within 0.2 mags) with those obtained via Cepheids, thus demonstrating that classical novae are indeed good distance indicators perfectly suitable to calibrate the absolute magnitude at maximum of type Ia occurred in early type galaxies. In collaboration with R. Gilmozzi we have explored the possibility to use nova stars as standard candles for measuring the cosmological parameters, with an Extremely Large Telescope (40m). High resolution spectroscopic observations carried out with Bob Williams, Elena Mason and A. Ederoclite on a sample of galactic Novae have shown the existence of stationary material, coming from the secondary star, around the circumburst area. Implications for Nova (and possibly SN-Ia) progenitors are under investigations.

Cosmological Parameters with GRBs. Observations of SNe-Ia in the range of redshift $z \approx 0.3 \div 1.3$ (Perlmutter et al. 1998; 1999; Riess et al. 1998; 2004; Schmidt et al. 1998) have shown that their peaks magnitude appear (at $z \sim 0.5$) dimmer than expected by ~ 0.2 mag. This result has been taken as evidence for the existence of a "cosmic jerk", then suggesting that the Universe may accelerate its expansion. On the other hands the cosmological interpretation rely on the lack of evolutionary effects on progenitors of type Ia SNe. Recent results on SNe-Ia progenitors, which imply the existence of two different classes of progenitors for SNe-Ia (Della Valle & Panagia 2003,

Della Valle et al. 2005, Mannucci et al. 2005, 2006, 2007, Sullivan et al. 2006, Aubourg et al. 2007) occuring in different environments and at different redshift, may cast some doubts on this assumption. In addition recent versions of the Hubble diagramm for SNe-Ia (e.g. Wood-Vasey et al. 2006) display peculiar distributions of the residuals, which are also suggestive for the presence of systematics. This situation calls for an independent measurement of the cosmological parameters besides the one obtained via SNe-Ia. We show that GRBs can be used to measure Ω_M (see Amati et al. 2008; Della Valle & Amati 2008).

3 Publications 2011

1. *Supernovae and Gamma-ray Bursts: a Decade of Observations*, Della Valle, M. 2011 IJMPD, 20, 1745

In this paper I have shortly reviewed the observational status of the Supernova and Gamma-ray bursts connection, including some of the most recent cases: the discovery of the association between GRB 081007 and SN 2008hw at z=0.53 and SN 2008D associated with GRB 080109, a borderline object that may link GRBs with "standard" core-collapse events.

2. *X-ray monitoring of classical novae in the central region of M 31. II. Autumn and winter 2007/2008 and 2008/2009*, Henze et al. 2010, A&A, 533, 52

This is the second paper of the series devoted to the study of Classical novae (CNe) in M31. CNe represent the major class of supersoft X-ray sources (SSSs) in the central region of our neighbouring galaxy M 31. We performed a dedicated monitoring of the M 31 central region with XMM-Newton and Chandra between Nov 2007 and Feb 2008 and between Nov 2008 and Feb 2009 respectively, in order to find SSS counterparts of CNe, determine the duration of their SSS phase and derive physical outburst parameters. We systematically searched our data for X-ray counterparts of CNe and determined their X-ray light curves and spectral properties. We detected in total 17 X-ray counterparts of CNe in M 31, only four of which were known previously. These latter sources are still active 12.5, 11.0, 7.4 and 4.8 years after the optical outburst. From the 17 X-ray counterparts 13 were classified as SSSs. Four novae displayed short SSS phases (¡ 100 d). Based on these results and previous studies we compiled a catalogue of all novae with SSS counterparts in M 31 known so far. We used this catalogue to derive correlations between the following X-ray and optical nova parameters: turn-on time, turn-off time, effective temperature (X-ray), t2 decay time and expansion velocity of the ejected envelope (optical). Furthermore, we found a first hint for the existence of a difference between SSS parameters of novae associated with the stellar populations of the M 31 bulge and disk. Additionally, we conducted a Monte Carlo Markov Chain simulation on the intrinsic fraction of novae with SSS phase. This simulation showed that the relatively high fraction of novae without detected SSS emission might be explained by the inevitably incomplete coverage with X-ray observations in combination with a large fraction of novae with short SSS states, as expected from the WD mass distribution. In order to verify our results with an increased sample further monitoring

observations are needed.

3. *Nova M31N 2007-12b: supersoft X-rays reveal an intermediate polar?*, Pietsch, W. et al.2011, A&A, 531, 22

In the central part of M 31, a high number of optical novae can be targeted within the field of view of the XMM-Newton EPIC and Chandra HRC-I X-ray detectors. A special monitoring program of the area has allowed us to investigate supersoft emission of individual novae in detail and perform a statistical analysis of the sample. For the He/N nova M31N 2007-12b, we aimed to constrain the time of appearance of a supersoft source (SSS) and the duration of the SSS state as well as determine the spectral and time variability while the source was bright. We analyzed XMM-Newton EPIC and Chandra HRC-I observations of our monitoring program performed at intervals of ten days and added results of a XMM-Newton target of opportunity observation and Swift XRT observations. We performed source detection, determined long-term time and spectral variation of M31N 2007-12b, and searched for shorter-term time variability in the individual observations when the source was bright, using fast Fourier and folding techniques to analyze periodicities. The SSS emission started between 21 and 30 d after the optical outburst and ended between 60 and 120 d after outburst, making M31N 2007-12b one of the few novae with the shortest SSS phase known. The X-ray spectrum was supersoft and can be fitted with a white dwarf (WD) atmosphere model with solar abundances absorbed by the Galactic foreground. The temperature of the WD atmosphere seems to increase at the beginning of the SSS phase from 70 to 80 eV. The luminosity of M31N 2007-12b during maximum was at the Eddington limit of a massive WD and dropped by 30% in the observation 60 d after outburst. The radius of the emission region is 6×10^8 cm. In the four bright state observations, we detected a stable 1110 s pulsation, which we interpret as the WD rotation period. In addition, we detect dips in three observations that might represent a 4.9 h or 9.8 h binary period of the system. Conclusions: Nova envelope models with $< 50\%$ mixing between solar-like accreted material and the degenerate core of the WD can be used to describe the data. We derive a WD mass of 1.2 $M_\odot$, as well as an ejected and burned mass of 2×10^{-6} $M_\odot$ and 0.2×10^{-6} $M_\odot$, respectively. The observed periodicities indicate that nova M31N 2007-12b erupted in an intermediate polar (IP) system. The WD photospheric radius seems to be larger than expected for a non-magnetic WD but in the range for magnetic WDs in an IP system.

4. *Prospects for true calorimetry on Kerr black holes in core-collapse supernovae and mergers*, van Putten, M. et al. 2011 PhRvD, 83, 4,

Observational evidence for black hole spin down has been found in the normalized light curves of long gamma-ray bursts in the BATSE catalog. Over the duration T90 of the burst, matter swept up by the central black hole is susceptible to nonaxisymmetries, producing gravitational radiation with a

negative chirp. A time-sliced matched filtering method is introduced to capture phase coherence on intermediate time scales, τ, here tested by the injection of templates into experimental strain noise, $h_n(t)$. For TAMA 300, $h_n(f) \sim 10^{-21} Hz^{-1/2}$ at f=1kHz gives a sensitivity distance for a reasonably accurate extraction of the trajectory in the time-frequency domain of about D0.07-0.10 Mpc for the spin down of black holes of mass $M = 10 - 12 M_\odot$ with $\tau = 1s$. Extrapolation to advanced detectors implies D35-50 Mpc for $h_n(f) \sim 2 \times 10^{-24} Hz^{-1/2}$ around 1 kHz, which will open a new window to rigorous calorimetry on Kerr black holes.

5. *Nearby supernova rates from the Lick Observatory Supernova Search - IV. A recovery method for the delay-time distribution* Maoz, D. et al. 2011, 412, 1508

Recovery of the supernova (SN) delay-time distribution (DTD) - the SN rate versus time that would follow a hypothetical brief burst of star formation - can shed light on SN progenitors and physics, as well as on the time-scales of chemical enrichment. Previous attempts to reconstruct the DTD have been based either on comparison of mean SN rates versus redshift to cosmic star-formation history (SFH), or on the comparison of SN rates among galaxies with different mean ages. Here, we present an approach to recover the SN DTD that avoids the averaging and loss of information of other schemes. We compare the SFHs of individual galaxies to the numbers of SNe discovered by a survey in each galaxy (generally zero, sometimes one SN, rarely a few). We apply the method to a subsample of 3505 galaxies, hosting 82 type-Ia SNe (SNe Ia) and 119 core-collapse supernovae (CC SNe), from the Lick Observatory Supernova Search (LOSS), that have SFHs reconstructed from Sloan Digital Sky Survey (SDSS) spectra. We find a $> 2\sigma$ SN Ia DTD signal in our shortest-delay, 'prompt' bin at < 420 Myr. We identify and study a systematic error, due to the limited aperture of the SDSS spectroscopic fibres, that causes some of the prompt signal to leak to the later bins of the DTD. After accounting for this systematic error, we demonstrate that a prompt SN Ia contribution is required by the data at the $> 99\%$ confidence level. We further find a 4σ indication of SNe Ia that are 'delayed' by > 2.4 Gyr. Thus, the data support the existence of both prompt and delayed SNe Ia. We measure the time integral over the SN DTD. For CC SNe we find a total yield of 0.010 0.002 SNe per $M_\odot$ formed, in excellent agreement with expectations, if all stars more massive than 8 Msun lead to visible SN explosions. This argues against scenarios in which the minimum mass for core-collapse SNe is $> 10 M_\odot$, or in which a significant fraction of massive stars collapse without an accompanying explosion. For SNe Ia, the time-integrated yield is 0.0023 0.0006 SNe per $M_\odot$ formed, most of them with delays < 2.4 Gyr. Finally, we show the robust performance of the method on simulated samples, and demonstrate that its application to already existing SN samples, such as the full LOSS sample, but with complete and unbiased SFH estimates for the sur-

vey galaxies, could provide an accurate and detailed measurement of the SN Ia DTD.

6. *The Afterglows of Swift-era Gamma-Ray Bursts. II. Type I GRB versus Type II GRB Optical Afterglows*, Kann, A. et al. 2011, ApJ, 734, 96

Gamma-ray bursts (GRBs) have been separated into two classes, originally along the lines of duration and spectral properties, called "short/hard" and "long/soft." The latter have been conclusively linked to the explosive deaths of massive stars, while the former are thought to result from the merger or collapse of compact objects. In recent years, indications have been accumulating that the short/hard versus long/soft division does not map directly onto what would be expected from the two classes of progenitors, leading to a new classification scheme called Type I and Type II which is based on multiple observational criteria. We use a large sample of GRB afterglow and prompt-emission data (adding further GRB afterglow observations in this work) to compare the optical afterglows (or the lack thereof) of Type I GRBs with those of Type II GRBs. In comparison to the afterglows of Type II GRBs, we find that those of Type I GRBs have a lower average luminosity and show an intrinsic spread of luminosities at least as wide. From late and deep upper limits on the optical transients, we establish limits on the maximum optical luminosity of any associated supernova (SN), confirming older works and adding new results. We use deep upper limits on Type I GRB optical afterglows to constrain the parameter space of possible mini-SN emission associated with a compact-object merger. Using the prompt-emission data, we search for correlations between the parameters of the prompt emission and the late optical afterglow luminosities. We find tentative correlations between the bolometric isotropic energy release and the optical afterglow luminosity at a fixed time after the trigger (positive), and between the host offset and the luminosity (negative), but no significant correlation between the isotropic energy release and the duration of the GRBs. We also discuss three anomalous GRBs, GRB 060505, GRB 060614, and GRB 060121, in light of their optical afterglow luminosities.

7. *No quantum gravity signature from the farthest quasars*, Tamburini, F. et al. 2011, A&A, 533, 71

Strings and other alternative theories describing the quantum properties of space-time suggest that space-time could present a foamy structure and also that, in certain cases, quantum gravity (QG) may manifest at energies much below the Planck scale. One of the observable effects could be the degradation of the diffraction images of distant sources. We searched for this degradation effect, caused by QG fluctuations, in the light of the farthest quasars (QSOs) observed by the Hubble Space Telescope with the aim of setting new limits on the fluctuations of the space-time foam and QG models. With this in mind we have developed a software that estimates and compares the phase

variation in the interference patterns of the high-redshift QSOs, taken from the snapshot survey of HST-SDSS, with those of stars that are expected to not be affected by QG effects. We used a two-parameter function to determine, for each test star and QSO, the maximum of the diffraction pattern and to calculate the Strehl ratio. Our results go far beyond those already present in the literature. By adopting the most conservative approach where the correction terms, that describe the possibility for space-time fluctuations cumulating across long distances and partially compensate for the effects of the phase variations, are taken into account. We exclude the random walk model and most of the holographic models of the space-time foam. Without considering these correction terms, all the main QG scenarios are excluded. Finally, our results show the absence of any directional dependence of QG effects and the validity of the cosmological principle with an independent method; that is, viewed on a large scale, the properties of the Universe are the same for all observers, including the effects of space-time fluctuations.

8. *Five supernova survey galaxies in the southern hemisphere. II. the supernova rates*, Hakobyan, A. et al. 2011, Astrophysics, 54, 301

Based on the database compiled in the first article of this series, with 56 SN events discovered in 3838 galaxies of the southern hemisphere, we compute the rate of supernovae (SNe) of different types along the Hubble sequence normalized to the optical and near-infrared luminosities as well as to the stellar mass of the galaxies. We find that the rates of all SN types, show a dependence on both morphology and colors of the galaxies, and therefore, on the star-formation activity. The rate of core-collapse (CC) SNe is confirmed to be closely related to the Star Formation Rate (SFR) and only indirectly to the total mass of the galaxies. The rate of SNe Ia can be explained by assuming that at least 15% of Ia events in spiral galaxies originates in relatively young stellar populations. We find that the rates show no modulation with nuclear activity or environment. The ratio of SN rates between types Ib/c and II shows no trend with spiral type.

9. *The Type IIP SN 2007od in UGC 12846: from a bright maximum to dust formation in the nebular phase*, Inserra et al. 2011, MNRAS, 417, 261

Ultraviolet, optical and near-infrared observations of the Type IIP supernova (SN) 2007od, covering from maximum light to late phases, allow detailed investigation of different physical phenomena in the expanding ejecta. These data turn this object into one of the most peculiar SNe IIP ever studied. The early light curve of SN 2007od is similar to that of a bright IIP, with a short plateau, a bright peak ($M_V = -18$ mag), but a very faint late-time optical light curve. However, with the inclusion of mid-IR observations during the radioactive tail, we derive an ejected mass of ^{56}Ni of $M(^{56}Ni)$ $\sim 2 \times 10^{-2} M_{\odot}$. By modelling the bolometric light curve, ejecta expansion velocities and blackbody temperature, we estimate a total ejected mass of

$5 - 7.5 M_{\odot}$ with a kinetic energy of at least 0.5×10^{51} erg. The early spectra reveal a boxy H profile and high-velocity features of the Balmer series that suggest the possible interaction of the ejecta with a close circumstellar matter (CSM). The interaction with the CSM and the presence of dust formed inside the ejecta are evident in the late-time spectra. The episodes of mass-loss shortly before explosion, the bright plateau, the relatively small amount of ^{56}Ni and the faint [O I] emission observed in the nebular spectra are consistent with a super-asymptotic giant branch progenitor $M \sim 9.7 - 11 M_{\odot}$.

10. *T Pyxidis 2011*, Izzo et al. 2011

We have observed with the 3.5m Galileo Telescope the last outburst of the Recurrent Nova T Pyx. A paper is currently under drafting. Here below we report the preliminary report included in IAUC 9205:

Izzo et al. report on their spectroscopic observation of T Pyx with the Telescopio Nazionale Galileo (+ SARG; range 462-795 nm; resolution 57000) obtained on Apr. 14.89 UT. A preliminary analysis shows that the spectrum is dominated by Balmer, N II, and Na I emission lines. H_{α} and H_{β} are flanked by blue-shifted P-Cyg profiles, and the mean expansion velocity derived from the minimum of the P-Cyg absorptions is about 1800 km/s. The measured FWHM of Balmer lines is about 1200 km/s. The Na I interstellar lines appear saturated, thus suggesting a high absorption/reddening.

11. *X-ray variability with WFXT . AGNs, transients and more*, Paolillo, M. et al. 2011, MSAIS, 17, 97

The Wide Field X-ray Telescope (WFXT) is a proposed mission with a high survey speed, due to the combination of large field of view (FOV) and effective area, i.e. grasp, and sharp PSF across the whole FOV. These characteristics make it suitable to detect a large number of variable and transient X-ray sources during its operating lifetime. Here we present estimates of the WFXT capabilities in the time domain, allowing to study the variability of thousands of AGNs with significant detail, as well as to constrain the rates and properties of hundreds of distant, faint and/or rare objects such as XRF/faint GRBs, Tidal Disruption Events, ULXs, Type-I bursts etc. The planned WFXT extragalactic surveys will thus allow to trace variable and transient X-ray populations over large cosmological volumes.

12. *The fast and faint SN 2010bh connected to GRB 100316D*, Bufano, M. et al. 2011, ApJ, submitted

We present the spectroscopic and photometric evolution of the nearby (z = 0.059) spectroscopically confirmed supernova, SN 2010bh, connected with a soft/long Gamma Ray Burst (a.k.a. X-ray flash), GRB 100316D. An intensive follow- up of SN 2010bh was performed at the ESO Very Large Telescope (VLT), using X- shooter and FORS2 instruments. Thanks to the detailed tem-

poral coverage and the extended wavelength range (300 - 2500 nm), we obtained an unprecedentedly rich spectral sequence among the Hypernovae, which makes SN 2010bh one of the best studied representatives of this SN class. We found that SN2010bh has a more rapid rise to the maximum (8.0 1.0 days) and a fainter absolute peak luminosity (Lbol $\sim 310^{42}$ ergs) than those of previously observed SN events connected with GRBs. Our estimate of the ejected ^{56}Ni mass is 0.12 ± 0.02 $M_{\odot}$. From the broad spectral features we measured large expansion velocities, higher than those of SNe 1998bw (GRB 980425) and 2006aj (GRB 060218). The light curve shape and photospheric expansion velocities of SN 2010bh suggest that we witnessed a relatively high energy explosion with a small ejected mass ($E_k \sim 10^{52}$erg and $M_{ej} \sim 3M_{\odot}$).

13.*Electromagnetic priors for black hole spindown in gravitational-wave searches from supernovae and long GRBs*, van Putten, M., Della Valle, M., Levinson, A. 2011, A&A, in press

Some of the core-collapse supernovae appear hyper-energetic, some of which are aspherical and associated with long GRBs. In this paper we use observations of electromagnetic emission from core-collapse supernovae and GRBs to impose constraints on their free energy source as a prior to searches for their gravitational wave emissions. Therefore we review these events on the basis of a finite efficiency of converting spin energy to magnetic winds powering supernovae. We find that some of the hyper-energetic events cannot be powered by spindown of rapidly rotating proto-neutron stars by virtue of their limited rotational energy. They can, instead, be produced by spindown of black holes with a distinct prospect for gravitational-wave emissions of interest to LIGO, Virgo and the LCGT.

14. *Evidence for Type Ia Supernova Diversity from Ultraviolet Observations with the Hubble Space Telescope*, Wang et al. 2011, arXiv1110-5809

We present ultraviolet (UV) spectroscopy and photometry of four Type Ia supernovae (SNe 2004dt, 2004ef, 2005M, and 2005cf) obtained with the UV prism of the Advanced Camera for Surveys on the Hubble Space Telescope. This dataset provides unique spectral time series down to 2000 Angstrom. Significant diversity is seen in the near maximum-light spectra ($\sim$ 2000–3500Å) for this small sample. The corresponding photometric data, together with archival data from Swift Ultraviolet/Optical Telescope observations, provide further evidence of increased dispersion in the UV emission with respect to the optical. The peak luminosities measured in uvw1/F250W are found to correlate with the B-band light-curve shape parameter dm15(B), but with much larger scatter relative to the correlation in the broad-band B band (e.g., $\sim$ 0.4 mag versus $\sim$ 0.2 mag for those with $0.8 < \Delta(m)15 < 1.7$ mag). SN 2004dt is found as an outlier of this correlation (at $> 3\sigma$), being brighter than normal SNe Ia such as SN 2005cf by $\sim$ 0.9 mag and 2.0 mag in the uvw1/F250W and uvm2/F220W filters, respectively. We show that differ-

ent progenitor metallicity or line-expansion velocities alone cannot explain such a large discrepancy. Viewing-angle effects, such as due to an asymmetric explosion, may have a significant influence on the flux emitted in the UV region. Detailed modeling is needed to disentangle and quantify the above effects.