

Supernovae: The LSST Revolution

Daniel Scolnic (U Chicago)

Thermonuclear Explosions: What Questions Will LSST Answer about Type Ia Supernovae?

Type Ia Supernovae continue to be one of the premier tools to measure cosmological parameters, yet many underlying questions about the physics of the explosions remain unanswered. These issues have not yet stopped the progress from using Type Ia supernovae to measure distances, but the status quo will likely not continue much longer. We continue to find puzzles about relationships between supernovae and host galaxy properties and odd properties of the dust around SNe. As LSST finds an order of magnitude more supernovae than any other survey, these large statistics make it necessary that we understand these mysteries to improve cosmological measurements and at the same time the large statistics will make it possible. This will be challenging; we are firmly in the era of photometric samples with contamination from core collapse supernovae. In this talk, I will go over the most exciting and unique contributions to the study of SNIa that LSST will make and discuss where we must focus our efforts today to optimize the impact of the survey.

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Maria Drout (Carnegie Observatories)

Unusual Explosions in the Era of LSST

The recent advent of wide-field time domain surveys has led to the discovery of a wide array of transient phenomena whose observed properties challenge the parameter space easily explained by traditional supernova models (e.g. the thermonuclear explosion of a white dwarf or the iron core-collapse of a massive star). In some cases these unusual explosions represent intrinsically rare events, while in others they represent abundant phenomena whose observed populations have remained relatively small due to detection challenges with 'traditional' survey cadences and depths. However, in all cases, their discovery offers us a means to probe uncertain stages in the evolution of stars and physics of stellar explosions. In this talk, I will review the landscape of unusual astronomical explosions, open questions, and what is required in order to make progress in the era of LSST.

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Melissa Graham (U Washington)

LSST Project Data Products

In this talk I will give a brief update on the status of the LSST project and present the preliminary plans for the commissioning phase observations. I will then provide an overview of the LSST Data Management system, with an emphasis on the data products that will be most relevant to the supernova community. I will also discuss the anticipated timeline for Special Programs proposals (e.g., deep drilling), and the plans for processing these data by the Data Management team and by community members using the LSST Science Platform.

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Ori Fox (STScI)

Supernovae and their Progenitor Systems (or lack thereof)

Despite the robust empirical supernova (SN) classification scheme in place, the underlying progenitor systems remain ambiguous for many subclasses. The most straightforward constraint relies on a detection of the progenitor star in high-resolution pre-explosion images. Such a direct identification is typically not feasible, however, even with modern telescopes such as Hubble. Instead, astronomers are forced to rely on supernova “forensics,” where the surrounding circumstellar medium can yield direct clues about the mass loss from the star in the years leading up to the SN explosion. Although progenitor discussions have historically considered mostly single star systems, I will focus a significant portion of the discussion on the impact binary stars may have on our understanding of these results.

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Tony Piro (Carnegie Observatories)

Supernova Light Curves Now and into the Future

One of the exciting developments in recent years is the explosion of early data on supernovae soon 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 looking for a stellar companion. I will then discuss how future transient surveys can be used to continue to advance our understanding of these explosions and their progenitors.

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Lucy Frey (LANL)

Supernovae Simulation at LANL

Our LANL astrophysics group is actively developing multiple code pipelines for supernovae simulations, and is collaborating with projects including LSST, PTF, and Swift to use our simulations to classify and analyze observational data. We have simulated many different types of SNe including Types Ia, Ib-c, II, superluminous SNe, and SNe with various kinds of circumstellar material. To make robust comparisons to observed SNe, we are building a relational database of simulations and observations, which will also permit sensitivity studies and code-to-code comparisons.

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Matthieu Roman (LPNHE)

Environmental dependence of supernova light-curves

Type Ia supernovae have proved to be a successful probe of dark energy thanks to their property of standardizable candle allowing us to construct a supernova Hubble diagram with very low scatter through a two-parameter empirical light-curve correction. However, 0.15 magnitude intrinsic luminosity variation remains once corrections are applied, leaving plenty of room for a third variable correlating to Hubble diagram residuals. Indeed, the standardization process does not entirely capture the physical processes at play leading to the triggering of the explosion, and does not take into account the evolution of progenitor properties through history. In an attempt to link host galaxy properties to supernova light-curves, numerous independent studies have shown that host galaxy stellar masses significantly correlate with light-curve standardization parameters, and that Hubble diagram residuals correlate to global properties of the host galaxy. I present a consistent set of measurements of the properties of the global and local environments of Type Ia supernovae in the largest spectroscopic sample to date. Our sample includes the full Supernova Legacy Survey data (SNLS) as well as the SDSS data and a number of well-measured low-redshift supernovae. While the analysis is still blinded regarding cosmology, preliminary results can be obtained which cast a new light on the environmental dependence of supernova luminosity.

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Patrick Kelly (UC Berkeley)

Putting the Strongly Lensed SNe Discovered by LSST to Work

Imaging and spectroscopy of the hundreds of multiply imaged supernovae (SNe) detected by the Large Synoptic Survey Telescope (LSST) will make it possible to (1) measure the Hubble constant, (2) improve galaxy-cluster mass modeling techniques, (3) probe the ejecta structure of SNe, and (4) study faint and luminous SN populations at high redshift. Identifying and then following up strongly lensed SN candidates rapidly will be important to using the expected sample of strongly lensed SNe as powerful tools. I will discuss strategies, including the use of adaptive optics facilities, that will make it possible to take advantage of this new class of events.

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Arturo Avelino (Harvard-Smithsonian CfA)

Near-infrared SN Ia Cosmology

Observations of SN Ia in the near infrared (NIR) are a promising way to construct an accurate cosmic expansion history to constrain the properties of dark energy. SN Ia are more nearly standard candles in NIR than in optical bands, while dust absorption is less of a problem at NIR wavelengths. This allows to investigate the dark energy properties in a way that is less sensible to systematic errors due to the variations in the intrinsic brightness of SN Ia or the properties of dust in the host galaxies. Based in our experience in the RAISIN program, I will discuss the idea of making LSST+WFIRST observations of SN Ia in the rest-frame optical and NIR to derive accurate cosmic distances and improve knowledge of the dark energy equation of state.

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Stefano Valenti (UC Davis)

LSST Cadence and Supernova Science

I will present the status of the LSST cadence (today) focusing on how this will impact the Supernova science. I will start presenting the default LSST cadence (minion 1016) highlighting the key points of the LSST Observing strategy paper. While the need for a rolling cadence for transient studies has been, so far, well received by the LSST team, there is still room for improvements and input from the transient community. I will highlight the Supernova science that can be accomplished with the current cadence (and/or the rolling cadence) and finish with my point of view on the Supernova science that, at the moment, could still be a challenge with the current cadence.

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Saurabh Jha (Rutgers U)

LSST Cadence for Supernova Cosmology

The LSST Dark Energy Science Collaboration Supernova Working Group is significantly engaged in developing metrics and proposed cadences for the LSST main survey (wide, fast, deep) and extragalactic deep drilling fields. Our goal is to significantly increase the number of LSST supernovae with well-measured light curves. This goal has strong synergy across a wide range of supernova science cases, well beyond SN Ia cosmology. I will present our proposals and findings, and advocate that the broad supernova community work together to ensure that LSST “celestial cinematography” is all that we want it to be.

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Christopher Stubbs (Harvard U)

New Results on Alternative Scheduler/Cadence

We have implemented an illustrative alternative scheduler for LSST, that emphasizes i) taking observations close to the meridian, ii) obtaining the two visits per night in distinct passbands, and iii) achieving uniform depth from the South celestial pole up to a declination of +20 over the duration of the survey. The detailed sequence of observations is informed by the anticipated LSST dome and telescope agility constraints. This is one version of a “rolling cadence” observing program. I will present preliminary results using the MAF framework, in comparison to OpSim results.

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Edo Berger (Harvard U)

Nature's Biggest Explosions: Past, Present, and Future

Somewhere in the universe a massive star ends its life in a cataclysmic explosion every second. These explosions play a critical role in shaping the Universe: they are responsible for the creation and dispersal of the chemical building blocks of stars, planets, and life; they give birth to exotic objects such as neutron stars and black holes; and some are so powerful that they can be used to illuminate the infant universe. In this talk I will review the history, present, and exciting future of how we study nature's biggest explosions.

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Rosanne Di Stefano (Harvard-Smithsonian CfA)

Type Ia Supernovae: how the nature and state of the progenitor affects pre-explosion and post-explosion signatures that might be detectable with LSST

Although we know that Type Ia supernovae are exploding white dwarfs, the exact natures of the pre-explosion astrophysical systems inhabited by the white dwarfs is still a subject of intense research. It is important to link the theory of progenitor models with possible observable signatures. For example, are there precursor events potentially detectable by LSST? In addition, post explosion signatures are very sensitive to the progenitor model, and LSST may be able to break the degeneracy among models. Because it will discover large numbers of Type Ia supernovae, LSST may even find evidence that nature uses multiple pathways to Type Ia supernovae.

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Matteo Cantiello (Flatiron Institute)

Open Questions in Massive Stars Evolution

I will review the current status of our understanding of massive stars evolution, emphasizing both recent progress and areas where we still lack a physical picture of the dominating processes at work. Will discuss possible ways to move forward, stressing the emerging synergies between theoretical and computational efforts, and the new observational probes.

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Brian Nord (Fermilab)

AstroEncoder: Applications of Deep Learning to Cosmological Data

Current and future cosmology surveys will provide data sets unprecedented in size and precision with which to measure dark energy, dark matter and the early universe through probes like strong gravitational lensing, supernovae, and the cosmic microwave background. First, we'll discuss the challenges posed by astronomically big and complex data, and the potential for machine learning. Then, I will present a variety of successful applications of deep learning techniques to astrophysical and cosmological data, including classification and measurement. We'll conclude with a discussion of the key issues for the application of deep learning in cosmology.

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Or Graur (Harvard-Smithsonian CfA)

The Dark Energy Spectroscopic Instrument survey and LSST

Beginning in 2018, the Dark Energy Spectroscopic Instrument (DESI) survey will obtain spectra of several tens of millions of galaxies. DESI will run in parallel with LSST, which brings up the possibility of an active collaboration between the two projects. How can the two surveys work together and complement each other to advance transient science? I will present the work of the DESI Time Domain Working Group and solicit ideas and joint action items.