Cosmology, Clusters, and Chemistry: How Supernovae Trace and Shape the Universe

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The LSST will discover over one million supernovae during its 10-year survey. This overwhelming compendium of stellar death throes will allow for novel techniques and insights to be brought to bear in our study of the evolution of the Universe, large-scale structure, supernova explosion physics, and star formation and evolution. The LSST sample of hundreds of thousands of well-studied Type Ia supernovae (SNe Ia) will allow the current generation of SN Ia cosmology experiments to be replicated several hundred times in different directions and regions across the sky for a stringent test of homogeneity and isotropy. Subsamples as a function of redshift, galaxy type, environment, and supernova properties will allow for a detailed investigation of supernova evolution and the relationship between supernovae and the processing of baryons in galaxies, which is one of the keys to understanding galaxy formation. Such large samples of supernovae, supplemented by additional follow-up observation will reveal details of supernova explosions both from the large statistics of fiducial classes of supernovae and the extra leverage and perspective of the outliers. The skewness of the brightness distribution of SNe Ia as a function of redshift will encode the lensing structure of the massive systems traversed by the SN light on the way to us on Earth. There will even be enough SNe Ia to construct a SN Ia-only baryon acoustic oscillation measurement that will provide independent checks on the more precise galaxy-based method as well as allowing for a SN Ia-only constraint on both Ω_M and Ω_Λ. Taken together with SN Ia BAO measurements, this will allow SNe Ia alone to constrain σ_8, Ω_M, and the properties of dark energy over the past 10 billion years of cosmic history.

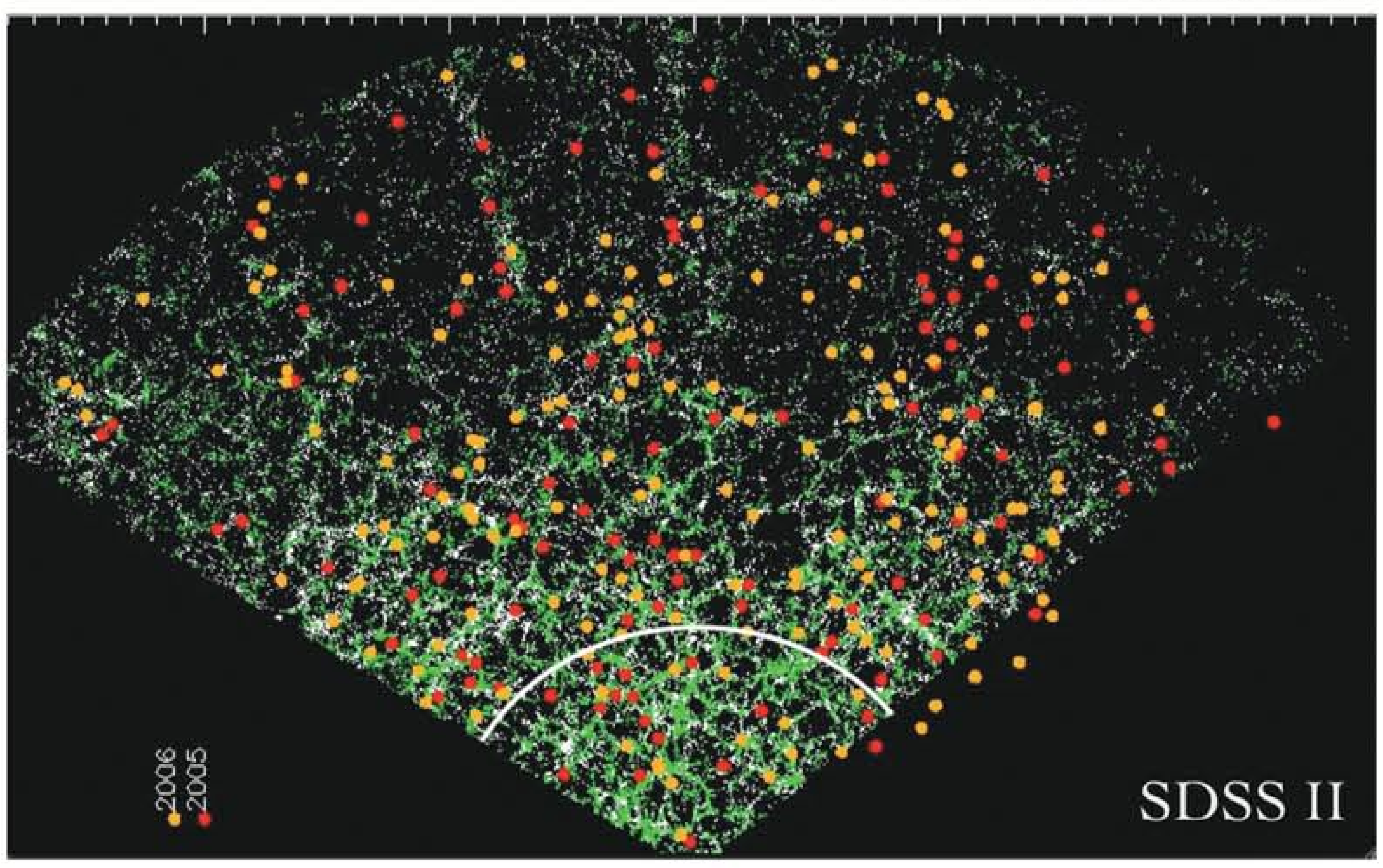
Cosmology: Expansion, Dark Energy
Homogeneity & Isotropy
Structure:
SN Ia BAO, Cluster tracing
Lensing:
Weak and Strong, Dark Matter
Chemistry: redshift, metallicity,
SN composition, dust creation
Photo-z: SN + Galaxies
Rates: type, z, SFR, IMF, gal density
Progenitors:
Galactic SNe, precursors
Stellar Evolution:
Pre-SN outbursts, Populations

Supernova Cosmology

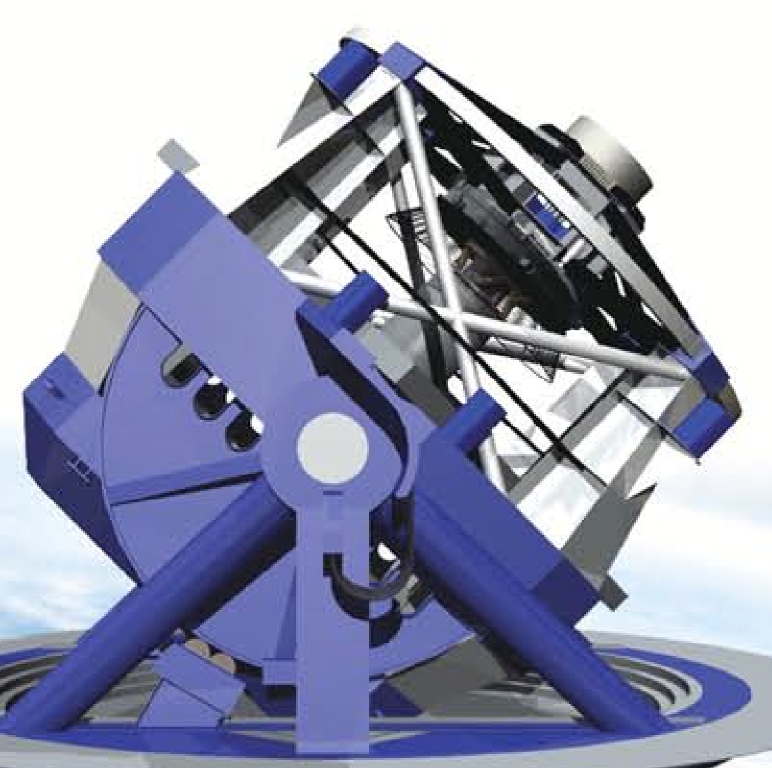
The LSST Supernova sample will finally explore the limits of supernova cosmology. From the well-known Type Ia Supernovae, to the possibility of using other types of supernovae as distance indicators and tracers, these explosive deaths of stars will illuminate the Universe from the present time to at least 10 billion years into the past. There will be of order one million supernovae found during the 10-year LSST survey. New precision SN Ia cosmology will be enabled by the detailed comparison of supernovae of identical properties from the same star formation and metallicity environments.

Supernovae Trace Large Scale Structure

Supernovae trace galaxies and thus large scale structure, as seen in the image from the SDSS II project shown below (the white line is z~0.1, the rough lower limit for LSST). This enables cross-correlations and independent BAO analyses The million supernovae of all types will allow for probing of structure from the large scale to the cluster scale.

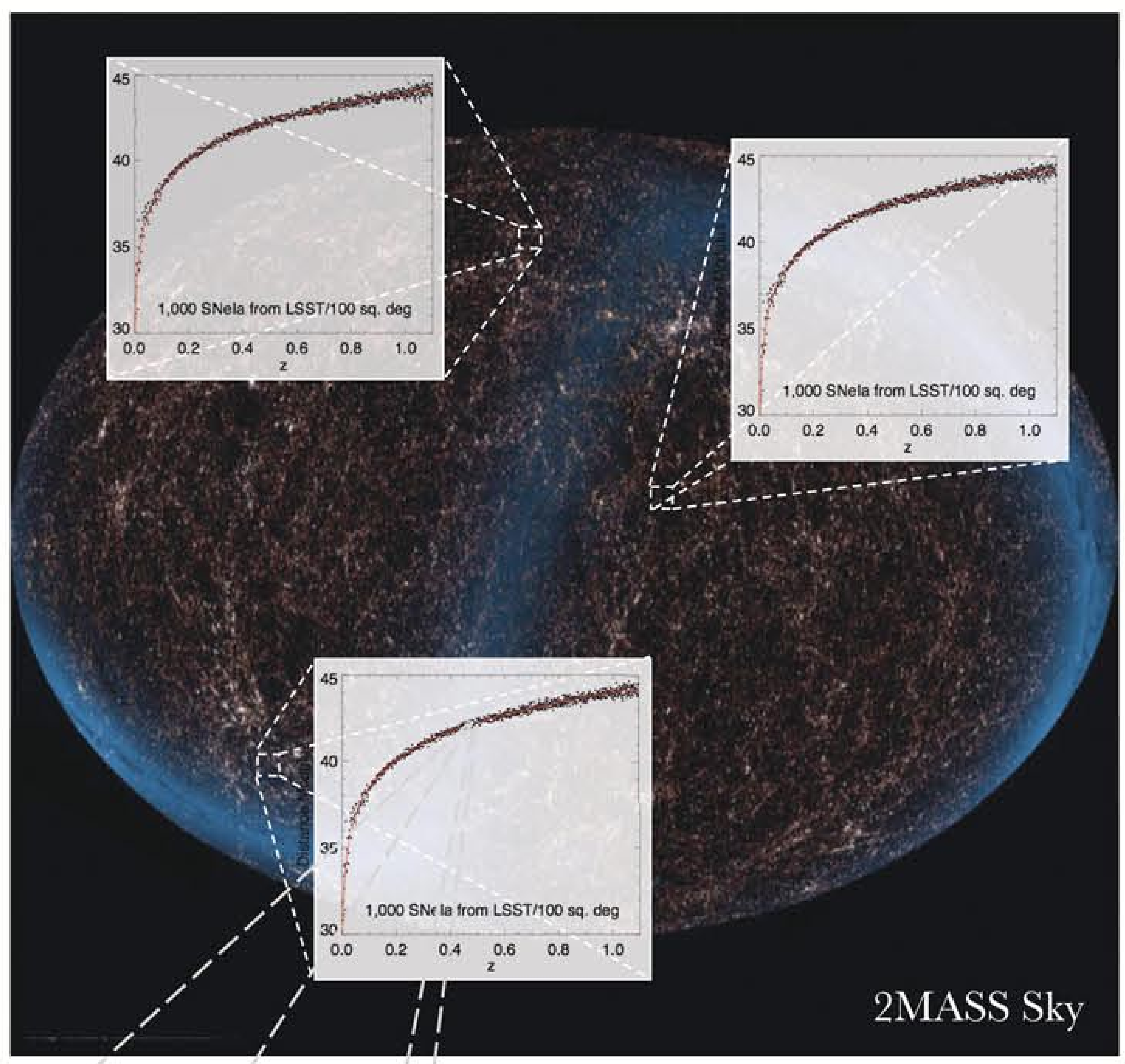


Supernovae will trace the distribution, star formation history, and composition of galaxies.



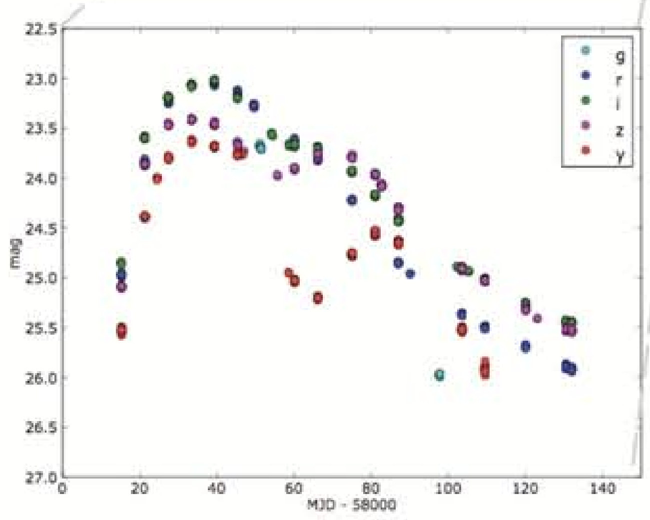
Isotropy and Homogeneity

Supernova are individually useful events for measuring distances in the Universe. In contrast with the statistically powerful approaches of BAO and weak lensing each individual SN Ia gives a relative luminosity distance to a particular point in the spacetime of the Universe. With the hundreds of thousands of well-sampled SNe Ia from LSST, we will be able to measure the expansion of the Universe in different directions and subregions as illustrated in the figure to the left.



SNeIa from LSST will independently measure the expansion of the Universe in different directions and combinations on the sky.

LSST Supernova Lightcurve



Lightcurve of a SNIa at z ~ 0.5 in the LSST dataset. There will be 25,000 such high-quality lightcurves in each year of the survey between 0.1 < z < 0.9. The brightest SNeIa will be visible years later and allow for detailed studies of the interaction of the SN ejecta and ISM.

While the redshifting of the incoming light will reduce the number of useful filters at high redshift, a special deep-drilling cadence and the y filter will allow LSST to obtain high-quality lightcurves of SNeIa out to z~1.1 across a subset of 500 square degrees in the survey.

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