Supernova Surveys

Bruno Leibundgut
ESO
One-slide SN 1987A

  - inner ejecta resolved and mapped in [Si I] and [Fe II] as well as He I lines
Some past supernova surveys

- **Historical surveys**
  - **Zwicky/Caltech/Palomar/POSS**
    - first systematic searches with the 18” Schmidt
    - only provider of SNe for a long time
  - **Asiago (Rosino)/Zimmerwald (Wild)**
    - spawned from the Caltech search
  - **Rev. Evans, McNaught**
    - extremely successful amateur searches
  - **Las Campanas search (Tammann/Sandage – 1984-1986)**
    - very limited success (20 SNe in 2 years)
    - no rate paper every published
  - **Berkeley automated search**
    - first automated search (from Leuschner Observatory)
  - **Calan/Tololo SN search (Maza/Hamuy/Phillips/Suntzeff - 1990s)**
    - successful search with photographic plates and CCD follow-up observations
    - coordinated spectroscopy
    - basis for SN cosmology by providing the nearby sample (Hamuy et al. 2006)
Nearby supernova surveys

• Nearby – z<0.03
  → mostly focused on prominent, large galaxies
  → “stellar explosions → look where the stars are”
  – amateurs
    • many, over long periods
    • well organised (e.g. finding charts, networks, Web pages)
    • still find interesting objects, often find them early
  – LOSS/LOTOS
    • KAIT (first Leuschner then Lick)
    • running for over 15 years (11 years with KAIT – Weidong Li)
    • >1000 SNe discovered – all types
    • best nearby sample for SN rates
    • results are being published
      – Smith et al. 2010, Leaman et al. 2010, Li et al. 2010ab
Lick Observatory Supernova Search

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Leaman et al. 2010
Li et al. 2010
Nearby SN surveys

• Nearby (cont.)
  – Center for Astrophysics
    • follow-up of interesting objects – all types
    • active for the past 2 decades
    • many individual and peculiar objects
    • most extensive nearby SN Ia sample
      – critical for the cosmology (e.g. Riess et al. 1999, Jha et al. 2003, Hicken et al. 2009)
  – Carnegie Supernova Project – CSP
    • nearby and distant SN follow-up
    • all types
    • including on IR light curves
      – Hamuy et al. 2006, Phillips et al. 2007, Folatelli et al. 2010
Nearby SN surveys

- **ROTSE-III**
  - Akerlof et al. 2003

- **SN Factory**
  - see talk by Childress
  - 600 SNe in two years
  - mostly unpublished

- **Quest (Palomar/La Silla)**
  - continuation of SN Factory search in southern sky

- **CHASE**
  - new search providing mostly bright supernovae (e.g. 2010ev)

- **Catalina Real-Time Transient Survey**
  - covers 26000 °
  - 62 SNe in six months
  - publish events through VOEvents
    - Drake et al. 2009
Nearby SN surveys

- **Palomar Transient Factory**
  - see Mark Sullivan’s talk
  - >500 SNe in one year
    - most not reported to IAU
    - several peculiar objects detected
      - Avishai Gal-Yam’s talk
    - ‘unbiased’ statistics

- **PanSTARRS-1**
  - started this year
  - expect 26000 core-collapse SNe year\(^{-1}\)
    - most not reported
      - Young et al. 2008
Distant SN surveys

- **Intermediate 0.03<z<0.3**
  - **SDSS**
    - see Bob Nichol’s talk
      - Kessler et al. 2009
  - **CSP**
    - Freedman et al. 2009

- **Distant z>0.3**
  - **Danish distant SN Search**
    - Danish 1.54m telescope on La Silla
    - two year search
      - 1 Type Ia (Norgaard-Nielsen et al. 1989), 1 Type II (Hansen et al. 1989)
  - **Supernova Cosmology Project**
    - several projects (NOAO, AAT, CTIO 4m)
    - started 1991
  - **High-z SN Search Team**
    - CTIO 4m
    - started 1995
      - Schmidt et al. 1998, Riess et al. 1998, Tonry et al. 2003
Distant SN surveys

- CFHT SN Legacy Survey
  - CFHT+MegaCam
    - 4 filters, six years, rolling search all year
    - Astier et al. 2006, Howell et al. 2006, Sullivan et al. 2006ab and many more
  - ESSENCE
    - 2 filters, six years, search during 3 months per year
- GOODS HST SN Search/SHOES/PANTS
  - highest-z SNe Ia so far (z>1.2)
Some thoughts on current status

- Current SN discovery rate substantial
  - During the past decade more SNe were observed than during the millennium before (half-point is late 2003)
  - Current searches are extremely effective
    - not all supernovae are reported to the IAU any longer
    - effectively much higher statistics in the last few years
- Most reported supernovae are classified
Nearby supernovae

- More bright supernovae discovered
Surveys targeting SN progenitors

- **SPY**
  - search for white dwarf binaries that will merge within a Hubble time
- **VLT-FLAMES Survey of Massive Stars**
- **Smartt/VanDyk HST/Keck/VLT programs to detect massive stellar progenitors**
- **X-ray surveys**
  - Roelofs et al. 2008 – failed in this case, but still promising
  - X-ray all sky surveys – eROSITA?
Direct observations of SN progenitors

- White dwarf: $M \approx 10\text{mag}$
- Giant: $M \approx -4\text{mag}$

Observable distances (assume $m=26$)
- White dwarf: $D \approx 16\text{kpc}$ (100kpc for $m=30$)
- Giant: $D \approx 10\text{Mpc}$ (60Mpc for $m=30$)

Poelarends et al. 2008

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$m=30$

350Mpc

280Mpc

220Mpc

180Mpc

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Poelarends et al. 2008
Supernova Progenitor survey

- ~1000 white dwarfs checked for radial velocity changes → search close binaries
  - are there double degenerate white dwarfs in the solar neighbourhood?
  - discovered ~100 double degenerate systems

Napiwotzki et al. 2007
Geier et al. 2010
Other searches for SN signatures

• \(\nu\)-surveys
  – heavily discussed in the \(\nu\) community
  – science case for various current and future \(\nu\) detectors (e.g. AMANDA or ICECube)

• IR surveys (VVV, VIDEO, UltraVista)
  – just started – too early to tell
Future surveys

• Several searches/surveys continue:
  – Amateurs, LOSS, CfA, CHASE, PTF, PanSTARRS-1

• New surveys
  – SkyMapper
    • 1.35m telescope, 4 filters, 1250 ° ‘rolling’
    • expect ~400 SNe per year
    • IR follow-up organised
    • to start seriously next year
  – GAIA transient sources
    • expect ~6000 transients during mission
Future distant surveys

- **CANDELS/CLASH**
  - part of two HST multi-cycle treasury programs
  - \(z > 1.5\) SNe for rates
    - see Enikö Regös’ talk
      - Riess et al.

- **DES**
  - several hundred SNe Ia
    - see Bob Nichol’s talk
      - Bernstein et al. 2008

- **PanSTARRS-4/LSST**
  - >100,000 supernovae per year

- **EUCLID/JDEM**
  - **EUCLID**: SNe not main driver (weak lensing and BAO)
    - details by Bob Nichol
  - **JDEM**: BAO and supernovae
  - expect several thousand SNe
Cosmology - do we need more?

• Already in hand
  – >1000 SNe Ia for cosmology
  – constant $\omega$ determined to 5%
  – accuracy dominated by systematic effects
    • reddening, correlations, local field, evolution

• Test for variable $\omega$
  – required accuracy $\sim$2% in individual distances
  – can SNe Ia provide this?
    • can the systematics be reduced to this level?
    • homogeneous photometry?
    • further parameters (e.g. host galaxy metallicity)
    • handle $>$100000 SNe Ia per year?
More supernovae

• Increase in interesting supernovae
  – many more general searches
    • remove paradigms
  – possible through the technological progress
    • detectors, data storage, data handling and processing
  – Need to keep the overview

• Improved understanding
  – hints on explosion physics
  – statistical samples
    • progenitor environments – ‘short fuse’ required
    • rates → clues on progenitor systems
More supernovae

• (Do we need a definition of what is a supernova?)
• Do we need a central SN database?
  – collect all SN discoveries?
  – IAU database outdated and not capable to supported most new searches
• Follow-up observations
  – classification
  – critical to explore the physics
    • explosions
    • nucleosynthesis
    • asymmetries
    • peculiarities
    • masses