Peculiar velocities with type Ia supernovae from the Nearby Supernova Factory

XIIth Rencontres du Vietnam - Large Scale Structure and Galaxy Flows

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SNfactory

Time Series of Type Ia Supernovae
- ~200 SNe for classic cosmology
- ~ redshift [0.03 ; 0.08]
- ~15 spectra per SNe
- median first phase -4.6 days
SNfactory

Synthesize Light Curves in any filter system

Pereira et al. 2013
SNfactory

Test the accuracy of current K-corrections (effect on $w \sim 3\%$)

Saunders et al. 2015

Pereira et al. 2013
SNfactory

Twinning
dispersion as low as 0.07 mag

Fahkouri et al. 2015

Pereira et al. 2013
SNfactory 3D Spectroscopy

Local Environment and SNe Observed Simultaneously
Astrophysical Bias in Cosmology

Rigault et al. 2013, 2015
Rigault et al. in prep.
Correct Astrophysics for Accurate Cosmology ($H_0$)

Still debated (Riess et al. 2016 to be checked)
Measuring Bulk Flows with SNfactory

Analysis of 279 SNe (z < 0.1) from Union2 and SNfactory

128 SNe
p = 0.027

Bulk flow:
243 ± 88 km/s

0.015 < z < 0.035

Feindt et al. 2013
Constraining “Dark Flow”

Adapted from: Planck Collab. (2014), A&A 561, A97

\[ \Lambda \text{CDM} \]

NB: 95% limits shown

Planck (AP)
Planck (uMMF)
Feindt et al. (2013)

Adapted from: Planck Collab. (2014), A&A 561, A97
Attractor Model for Shapley

Spherical attractor model

- Single attractor at location of Shapley supercluster disfavored at $\sim2\sigma$
- Sloan Great Wall could provide required additional mass

Feindt et al. 2013
New bulk flow study in prep.

- SNfactory sample size doubled
- Based on minimum variance weights (Watkins et al. 2009)
Zwicky Transient Facility
ZTF Field of View

HSC, 1.7 deg$^2$

DES, 2.5 deg$^2$

PTF/iPTF, 7.3 deg$^2$

ZTF, 47 deg$^2$

PS1, 7 deg$^2$

LSST, 9.6 deg$^2$
Survey speed increased by an order of magnitude:
- 3750 deg$^2$/hour (3π in 8 hours)
- Observation in g, R and I
- Expecting ~1800 well-sampled multi-color SN Ia lightcurves (0.03 < z < 0.08)

<table>
<thead>
<tr>
<th></th>
<th>PTF</th>
<th>ZTF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Area</td>
<td>7.26 deg$^2$</td>
<td>47 deg$^2$</td>
</tr>
<tr>
<td>Overhead Time</td>
<td>46 sec</td>
<td>&lt;15 sec</td>
</tr>
<tr>
<td>Optimal Exposure Time</td>
<td>60 sec</td>
<td>30 sec</td>
</tr>
<tr>
<td>Relative Areal Survey Rate</td>
<td>1x</td>
<td>14.7x</td>
</tr>
<tr>
<td>Relative Volumetric Survey Rate</td>
<td>1x</td>
<td>12.3x</td>
</tr>
</tbody>
</table>
ZTF Bulk Flow Prediction

Simulation of ZTF-like survey
(Feindt et al. in prep.)

- 1800 SNe Ia at Dec. > -20°
- Redshift 0.03 < z < 0.08
- Bulk flow/shear fits in spheres up to z = 0.08
- Bulk flow constraints almost at size of ΛCDM prediction
- Shear constraints require southern data

Further planned ZTF analysis:
- PV power spectrum;
growth factor $f \sigma_8$

Adapted from: Planck Collab. (2014), A&A 561, A97
## Conclusions

**The Nearby Supernova Factory** has obtained
~200 SN Ia time series

- Improve SNe Ia as standard candles
- Correct astrophysical biases \((w, H_0)\)
- Measure bulk flows out to \(z < 0.1\)

**The Zwicky Transient Facility** will obtain
~1800 SN Ia lightcurves

- Constrain bulk flows at \(z < 0.08\) at < 100 km s\(^{-1}\) precision
- Extend SN Ia PV studies to shear, growth factor etc.
SNfactory

Understand the SN Ia progenitor(s) (*simulations*)

Roepke et al. 2012

Pereira et al. 2013
ZTF Shear Prediction

Median uncertainty of first shear eigenvalue

\[ \sigma_{\lambda_1} \text{ [km s}^{-1} \text{ Mpc}^{-1}] \]

- 1800 ZTF SNe
- 2400 ZTF SNe
- 1800 ZTF + 600 southern SNe
Galaxies are more Star Forming at Higher Redshift

Could impact $w$ by a few %
The Local Perspective

Global

Spiral, Star forming Galaxies

Locale

Star forming Environments — Young stars

Passive Environments — Old(ger) stars

Ulrich Feindt
Correct Astrophysics for Accurate Cosmology

Access Better Standard Candles
– Confirmed par Kelly et al. (2014) –

Strong Reduction of the Systematic Uncertainties

Rigault et al. (2013)