Near-infrared SN Ia Cosmology in the LSST era

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The problem

Optical samples of SN Ia for cosmology have reached their limit to constrain the nature of the dark energy (DE) because of the systematic uncertainties.

• More optical data doesn’t mean better DE constraints.

• **Optical** light is dimmed and **reddened** by **dust** in the host galaxy, the Milky Way, and the extragalactic medium.
A solution: NIR observations!

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- SN Ia observed in **NIR** are much more standard candles than in optical wavelengths, even when you correct the optical light curves for light curve shape.

Previous works:

- Wood-Vasey et al. 2008
- Mandel et al. 2009 (BayeSN code)
- Burns et al. 2011 (SNooPy code)
- Friedman et al. 2015
- Avelino et al. 2017, in prep
• Near infrared (NIR) light is much less sensitive to dust than the optical wavelengths. Then the systematic uncertainty due to dust is reduced.

• SN Ia observed in NIR are much more standard candles than in optical wavelengths.

• **NIR** light curves have a **second maximum** that allow to have a brighter SN for longer compared with the optical bands and can help in photometric classification.
A solution: NIR observations!

Improvement in the precision and accuracy of the photometric distance modulus of individual SN by combining optical + NIR data.

- Previous work has shown that it is possible! (Mandel, Narayan & Kirshner 2011 [BayeSN code])
A potential Optical+NIR program

1. Discover supernovae using LSST.

2. Determine the type of supernova and its redshift $z$ (either photometric or spectral classification).

3. If it is a SNIa and $z \sim 0.5$ then get NIR data with WFIRST to obtain rest frame YJ bands.

4. Fit the optical (LSST) + NIR (WFIRST) photometric data to determine the distance modulus of each SN Ia.

5. Constrain the dark energy using the Hubble diagram.
Filters overlaps

Bandpasses overlap at $z=0.5$

$z=0.5$
Filters overlaps

Bandpasses overlap at $z=0.8$

Wavelength (Angstroms)

$z=0.8$
Optical+NIR program

We are already learning how to do it now and with real data!

RAISIN = SN IA in the IR

“Tracing cosmic expansion with SN Ia in the Near Infrared”

Robert Kirshner (PI), Arturo Avelino, Kaisey Mandel, Peter Challis, Andrew Friedman and the RAISIN team

• Expanding Universe like raisins in a bread
Takeaway for LSST

• SN Ia observed in NIR are much more standard candles than in optical wavelengths and less affected by dust.

• Combine optical + NIR data to obtain more accurate distance modulus than from optical data only!

• NIR LC can help in SNIa classification.