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Calibrating Type Ia SNe Using the Planetary Nebula Luminosity Function

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Abstract. Using the [O III] 5007 Planetary Nebula Luminosity Function (PNLF) distance indicator, we can double the number of known distances to nearby Type Ia SNe, and hence improve their zero point calibration while searching for systematic offsets in SN Ia luminosities between young populations (spiral galaxy) and old populations (ellipticals). We report three new PNLF distances and two new lower limits for five galaxies (NGC 524, 1316, 1380, 1448, & 4526) that have hosted well-observed Type Ia SNe. From the PNLF, we find a Hubble constant of 75 km/s/Mpc, whereas we derive H_0=72 from Cepheids and H_0=73 from SBF.

Keywords. Hubble Constant, supernovae, galaxies, distances

Type Ia SNe are excellent distance indicators over great cosmological distances, provided that the relationship between maximum magnitude and decline rate is taken into account (Phillips *et al.* (1999)). However, it has been historically difficult and controversial to calibrate the zero point for this distance indicator, and to assess the presence of systematics between old and young populations that can impact measurements of dark energy. Unfortunately, there are only $\sim$ 5 SN Ia that satisfy the two criteria of having excellent photometry, and having accurate distances, and these are all in spiral galaxies (Riess *et al.* (2005)) because Cepheid variables only arise in the young stellar populations of spirals. Thus, systematic errors are lost in the small number statistics of the few reliable SN Ia calibrators, and the impact of the parent populations' properties cannot be assessed at all.

We can improve the SN Ia zero point calibration, while testing for systematics across galaxy types, by using a galaxy distance technique that works well for elliptical and spiral galaxies. The Planetary Nebula Luminosity Function method is about the only choice that can be applied to both spiral and elliptical types, and is suitable for galaxies as distant as 20 Mpc.

So far, we have observed 5 galaxies in this program using the Magellan Clay 6.5-m and WIYN 3.5-m telescopes. We identify candidate planetary nebulae using the on-band – off-band technique and the semi-automated classification scheme of Feldmeier *et al.* (2003).

We have applied the [O III] λ5007 Planetary Nebula Luminosity Function (PNLF, Jacoby *et al.* (1992)) distance indicator to 3 galaxies (NGC 1316, 1380, & 4526) that have hosted well observed SN Ia. We also derive lower limits to the distances of two galaxies: NGC 524 and 1448. For these two galaxies, we failed to obtain images that

Table 1. SN Ia and their host galaxies

SN	Galaxy	Nr PN	Distance (Mpc)
1980N	NGC 1316	45	18.5 ± 1.3
1992A	NGC 1380	44	16.7 ± 1.2
1994D	NGC 4526	94	13.6 ± 1.2
2000cx	NGC 524	0	>20.9
2001el	NGC 1448	0	>15.8

are sufficiently deep that PNe can be detected. Table 1 summarizes our results for all 5 galaxies.

We update the Cepheid distances to the 13 PNLF calibrator galaxies for recently derived metallicity and P-L corrections. We also apply an adjustment to both PNLF and Surface Brightness Fluctuation (SBF, Jacoby *et al.* (1992)) distances for the systematically higher reddening in the calibrating spiral galaxies relative to the target elliptical galaxies. This reddening offset is small, about E(B-V)=0.02 and compensates for the $\sim 7\%$ offset in distances observed between these 2 methods.

In addition to the optical SN light curves, we also apply a new, higher accuracy, IR approach to dealing with internal dust in the SN Ia light curves. We then derive a Hubble constant and compare our results against those from the Cepheid and SBF calibrations of SN Ia host galaxies.

The PNLF data are consistent with a Hubble constant of 75 km/s/Mpc, whereas we derive H_0=72 from Cepheids and H_0=73 from SBF. Thus, if there is a systematic difference in the SN Ia descending from old stars in ellipticals relative to the SN Ia descending from younger stars in spirals, that difference is not likely to be larger than ~ 0.08 mag. This is much smaller than the signature of dark energy at z$\sim$1 of $\sim$0.25 mag, further supporting arguments *against* an evolutionary contribution to the variations in SN Ia luminosity as a function of redshift.

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