Impact on Hubble's Constant due to Linear and Nonlinear Period-Luminosity Relations from OGLE II/OGLE III Measurements

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Motivation:

Increased precision in the measurement of Hubble's Constant is vital for the testing and determination of parameters in the dark energy equation-of-state [1].

Mounting evidence for the nonlinearity of the Large Magellanic Cloud (LMC) Cepheid period-luminosity (P-L) relation suggests that using the linear P-L relation could result in an inaccurate value for Hubble's Constant [2].

We will use both linear and nonlinear Cepheid P-L relations for several magnitude functions to calibrate distances to Type Ia supernovae and then use this information to derive and compare the values of Hubble's Constant.

P-L Relations Using the Wesenheit and μ_0 Functions:

The Wesenheit I magnitude is calculated using $W_I = I - 1.55(V-I)$ and the Wesenheit V is calculated using $W_V = V - R(V-I)$, where *R* is 2.45 or 2.55 [3].

For the μ_0 function, magnitude is calculated using $\mu_0^V = \mu_V - 2.45(\mu_V - \mu_I)$ or by using $\mu_0^I = \mu_I - 1.55(\mu_V - \mu_I)$ [3].

Applying a linear regression fit to these magnitudes versus log of the period yields relations of the form $a_{mag}\log(P) + b_{mag}$. For the nonlinear P-L relation, Cepheids with periods greater than ten days are fit seperately from those with shorter periods [3].

Calculating Hubble's Constant Using Linear and Nonlinear Cepheid P-L Relations:

Given the observed magnitudes of Cepheids in galaxies that hosted Type Ia supernovae and using the derived P-L relations to calculate absolute magnitude for each Cepheid based on their observed period, we can find the distance to the host galaxies [2].

Using these distances, we can find the absolute magnitude of the supernovae, M_V. Hubble's Constant, H_0, can then be found with the equation $\log(H_0) = 0.2\mathrm{M}_V + a_V + 5$, where $a_V = 0.697$ [2,4].

Here we have results for H_0 from OGLE II and OGLE III linear and nonlinear P-L relations for the μ_0^V magnitude function.

Galaxy	OGLE II Linear	OGLE II Nonlinear	OGLE III Linear	OGLE III Nonlinear
NGC 3370	75.9	75.3	79.3	86.1
NGC 3982	73.2	72.8	76.3	81.6
NGC 4536	73.5	73.1	76.6	81.8
NGC 4639	77.8	76.8	81.4	89.9

Here are H_0 results for the W_I magnitude function.

Galaxy	OGLE II Linear	OGLE III Linear	OGLE III Nonlinear
NGC 3370	77.2	77.6	77.7
NGC 3982	74.3	74.6	74.8
NGC 4536	74.6	75.0	75.2
NGC 4639	79.0	79.3	79.4

Conclusions:

The μ_0^V magnitude function produces larger differences between OGLE II and OGLE III and between linear and nonlinear $H_0's$ than the Wesenheit magnitude function.

The discrepancy between the $H_0's$ calculated using OGLE II and OGLE III measurements could be due to the different reddening corrections applied.

References

[1]Riess, A. G., et al. 2009, submitted

[2]Ngeow & Kanbur, 2006, Astrophys.J.642:L29-L32

[3]Ngeow, “Cepheid Distances to the Four SN Ia Hosted Galaxies...”, 2009

[4]Riess, A., Li, W., Stetson, P., et al., 2005, ApJ, 627, 579