

# Verification of Cepheid Variable Distance Measurements Using Roxy's Ruler

Bruce Rout

## Abstract

There has been some controversy over the validation of using the period/luminosity relationship of Cepheid variables to measure the distance to galaxies[2]. We present here a statistical analysis of distance variations for 21 galaxies between Cepheid variables and Roxy's Ruler. The analysis shows there is no systemic error in Measurements to galaxies using Cepheid variables and that such measurements are valid within well defined degrees of error.

Leavitt discovered a period/luminosity relationship for Cepheid variables that has since been used a distance measure[1]. We compare this distance measure, which we refer to as a Cepheid measurement, on 21 galaxies as presented by Ferrarese et al[3], to distance measures of the same galaxies using Roxy's Ruler. This comparison is shown in Table 1.

Other distance measurements such as super nova luminosity peaks and water maser measurements have been used. Herrnstein's distant measurement to NGC 4258 has been validated by Roxy's Ruler with a high degree of precision[4].

Graph 1 is histogram of the normalized measurement differences and appears as a Gaussian distribution centered at 0 with a normalized standard error of .183.

Graph 3 is a presentation of a linear fit between Cepheid measurements and Roxy's Ruler showing a discrepancy from matching a one to one linear fit by less than 2%.

## **Error**

Cepheid variable distances have been calibrated by using such variable stars observed within the Large Magellanic Cloud. The LMG subtends about  $7^\circ$  of arc. As a result, a calibration of variable stars randomly distributed within the LMG would invoke an error of 12.2%. Other errors such as in the measure of periodicity and luminosity would add to this error. An absolute total error estimate of 5% in rotational velocity and angular measure of arc length between spiral arms along the major axis of measured galaxies is also given. Therefore a standard error of 18.3% between the measures using Cepheid Variables and Roxy's Ruler is deemed within acceptable parameters.

Table 1:

Name	Velocity of Spin (Kps)	Delta R (minutes of arc)	Roxy's Ruler distance (Mpc)	m-M	Cepheid Distance (MPc)	Per Cent difference
NGC 7331	225	1.26	11.03	30.89	15.07	-36.61
NGC 4725	210	1.47	10.09	30.57	13.00	-28.90
NGC 3319	130	1.98	12.14	30.78	14.32	-17.95
NGC 4321	260	0.87	13.82	31.04	16.14	-16.80
NGC 4535	140	1.52	14.70	31.10	16.60	-12.92
NGC 3368	220	1.39	10.19	30.20	10.96	-7.64
NGC 1365	50	3.51	17.80	31.39	18.97	-6.58
NGC 4414	230	0.75	17.99	31.41	19.14	-6.40
NGC 4639	200	0.72	21.61	31.80	22.91	-6.00
NGC 224	241	17.66	0.73	24.44	0.77	-5.31
NGC 3627	190	1.64	10.01	30.06	10.28	-2.67
NGC 4536	125	1.63	15.36	30.95	15.49	-0.85
NGC 3031	140	6.06	3.68	27.80	3.63	1.42
NGC 3351	220	1.33	10.63	30.01	10.05	5.53
NGC 2090	150	1.46	14.26	30.45	12.30	13.71
NGC 4548	157	1.04	19.09	31.04	16.14	15.44
NGC 925	120	2.31	11.26	29.84	9.29	17.51
NGC 2541	95	2.18	15.07	30.47	12.42	17.62
NGC 5457	190	1.66	9.93	29.34	7.38	25.67
NGC 3198	151	0.99	20.83	30.80	14.45	30.61
NGC 598	130	19.09	1.26	24.64	0.85	32.66

Histogram of Percent Difference between Cepheid Measure and Roxy's Ruler

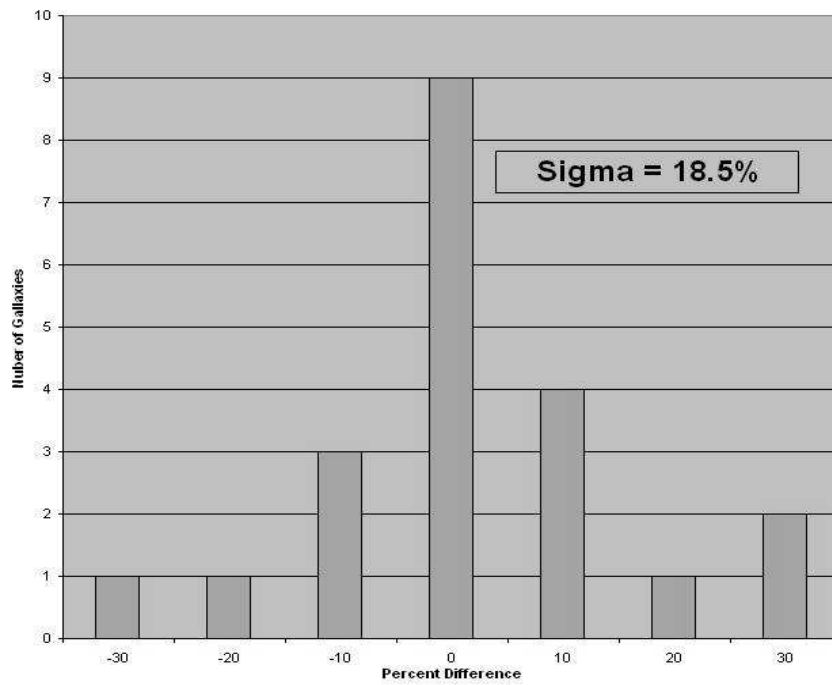


Figure 1: Graph 1: A histogram of the differences in measure between Roxy's Ruler and Cepheid Variable measurements.

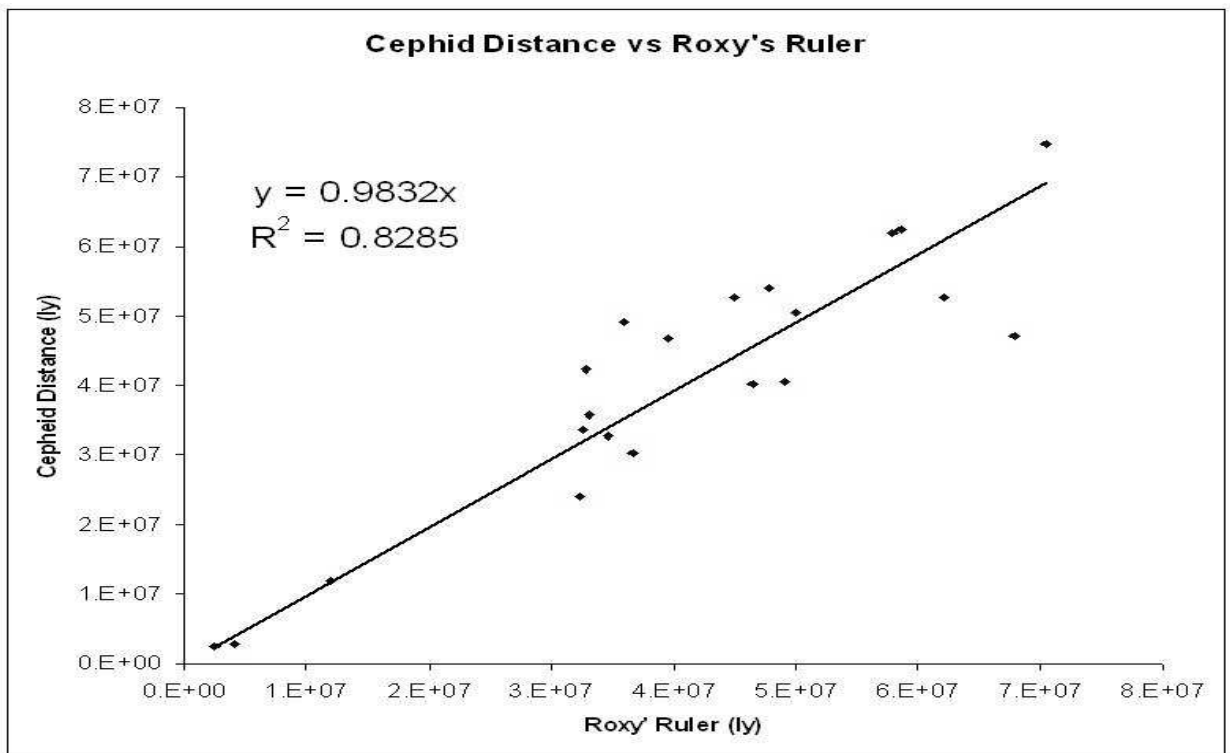


Figure 2: Graph 2: Cepheid distance vs. Roxy's Ruler.

## References

- [1] Leavitt, Henrietta S. *1777 Variables in the Magellanic Clouds*. Annals of Harvard College Observatory. LX(IV) (1908) 87-110
- [2] Allen, Nick. *The Cepheid Distance Scale: A History*. <http://www.institute-of-brilliant-failures.com/>
- [3] Laura Ferrarese, Holland C. Ford, John Huchra, Robert C. Kennicutt, Jr., Jeremy Mould, Shoko Sakai, Wendy L. Freedman, Peter B. Stetson, Barry F. Madore, Brad K. Gibson, John A. Graham, Shaun M. Hughes, Garth D. Illingworth, Daniel D. Kelson, Lucas Macri, Kim Sebo and N. A. Silberman. *A Database of Cepheid Distance Moduli and Tip of the Red Giant Branch, Globular Cluster Luminosity Function, Planetary Nebula Luminosity Function, and Surface Brightness Fluctuation Data Useful for Distance Determinations*. The Astrophysical Journal Supplement Series Volume 128, Number 2, Citation: Laura Ferrarese, et al 2000 ApJS 128 431.
- [4] Rout, B., *A Comparison of Distance Measurements to NGC 4258*, viXra:0911.0016, Nov., 2009.