Review of *Periods of 25 Variable Stars in the Small Magellanic Cloud*

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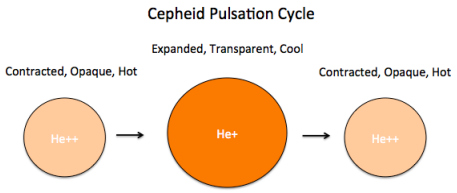
Abstract

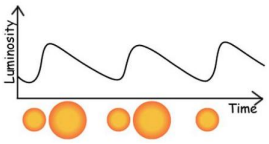
In Periods of 25 Variable Stars in the Small Magellanic Cloud, *Leavitt and Pickering suggest a logarithmic relationship between the period and luminosity of a cepheid variable. We validate that the logarithmic fit performs best and provide a slight improvement by taking the mid apparent magnitude as opposed to the max or min in isolation.*

I. Summary

At the start of the 20th century, stellar parallax was the best method available for measuring the distance from Earth to stars outside the solar system. The large distances to these other stars relative to the radius of the Earth's orbit set an upper bound on distances that this method could resolve. The average radius of the Earth's orbit is $\sim 1.5 \times 10^{-5} ly$, whereas the distance to the next closest star is $\sim 4.4 ly$ and to the center of the Milky Way is $\sim 2.5 \times 10^{4} ly$. Even with contemporary experimental precision, stellar parallax can only resolve distances below $\sim 300 ly$.

In 1912, Leavitt and Pickering found a relationship that helped establish a new way to measure the distance to stars via cepheid variables [Leavitt and Pickering, 1912] . Cepheid variables are large, bright stars which are 4-20 times the size of the Sun and can be up to 100,000 times more luminous. These stars evolve through regular contraction and expansion phases governed by an outer layer of Helium ions and produce a pulsing luminosity signature.

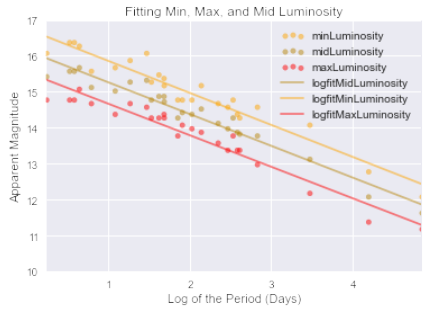




By restricting their focus to the cepheid variables from the Small Magellanic Cloud, all of which are approximately the same distance to Earth, Leavitt and Pickering noticed a logarithmic relationship between the period and the luminosity of these stars.

II. Data Analysis

As the title of their paper suggests, Leavitt and Pickering provide 25 cepheid variable data points. Each point includes the max and min apparent magnitude of the star and the period measured in days. The logarithmic fit significantly outperforms low degree polynomial candidates. By fitting the mid of the two extrema for each star, we were able to noticeably reduce the mean standard error of the fit. The first plot below shows the fits, the second shows the residuals, and the final plot summarizes the distribution and fit.



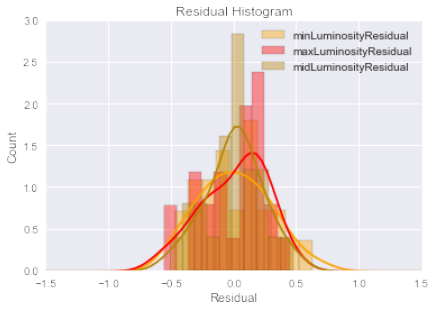


Table 1: *Distribution and Fit Summary*

Lum.	Mean	Std. Dev.	Fit MSE
Max	13.86	1.01	.22
Min	15.04	1.04	.23
Mid	14.45	1.01	.17

III. Impact

After this discovery astronomers measured the distance to the Small Megalomanic Cloud through stellar parallax. With this in hand they were able to measure the distance to other cepheid variable stars by measuring their periods and comparing absolute and apparent luminosities. In 1923, Edwin Hubble used this technique to show that various nebulae were not part of the Milky Way and that the universe contains a vast multitude of galaxies, most billions of lightyears away. Henrietta Leavitt's discovery of the period-luminosity relationship was instrumental in mapping out the universe.

References

[Leavitt and Pickering, 1912] Leavitt, H. S. Pickering, E. C. (1912). Periods of 25 Variable Stars in the Small Magellanic Cloud *Harvard Observatory Circular 173*