Metallicity effects in infra-red Cepheid light curves

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ABSTRACT

A critical component in evaluating cosmological models is the extra-galactic distance scale and crucial to a firm foundation for the extra-galactic distance scale is the metallicity dependence of the Cepheid Period-Luminosity (PL) relation. As a prelude to studying the metallicity dependence of the infra-red Cepheid PL relation, we present a study of the non-linear structure of Cepheid light curves in the Large Magellanic Cloud (LMC). We use both Fourier analysis and Principal Component Analysis to study this structure and show that PCA is a much more efficient way of studying light curve structure than Fourier analysis.

INTRODUCTION

- Knowledge of accurate distances is crucial in Astrophysics. A fundamental element of this is the Cepheid PL relation (Ngeow and Kanbur 2006).
- Cepheid stars are intrinsically variable stars which beat, like a heart, with a very regular variation of their light output - their light curve, and a characteristic period which varies from 2 days to 100 days.
- This period of oscillation is related to a star's intrinsic luminosity - the PL relation. Hence observation of a star's apparent luminosity and its period of oscillation yields the absolute luminosity.
- Thus the difference between the star's absolute and apparent luminosity is related to its distance from us.
- It is of considerable interest to know how the PL relation $M = a + b \log P$ varies with metallicity or environment.
- Related to this is the way the structure of a Cepheid light curve varies with environment.
- This project deals with the structure of Cepheid light curves in the infra-red and provides a comparison of the structure between Galactic and LMC Cepheids.

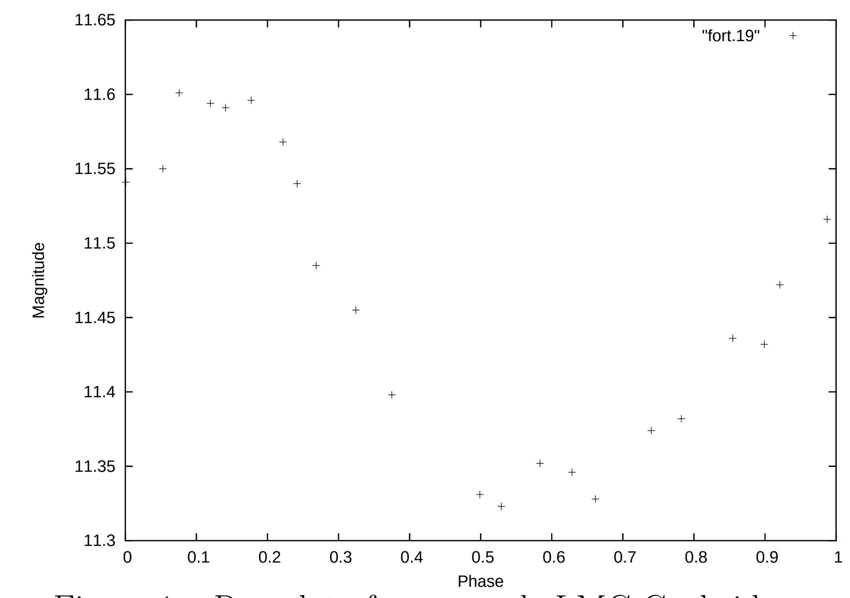

Figure 1 – Raw data for a sample LMC Cepheid.

THE DATA

- We use published data for Cepheids in the infra-red from the Galaxy and LMC.
- Here we perform a Fourier analysis (Ngeow et al 2003) of 92 Cepheids in the LMC in the JH and K wavebands.
- Fit a Fourier series of the form,

$$A_0 + \sum_{i=1}^{i=N} (A_k sin(k\omega t + \phi_i),$$

to the datapoints.

- Analyze the data for each Cepheid, in each waveband, and determine both the best order of the Fourier fit and the Fourier parameters themselves.

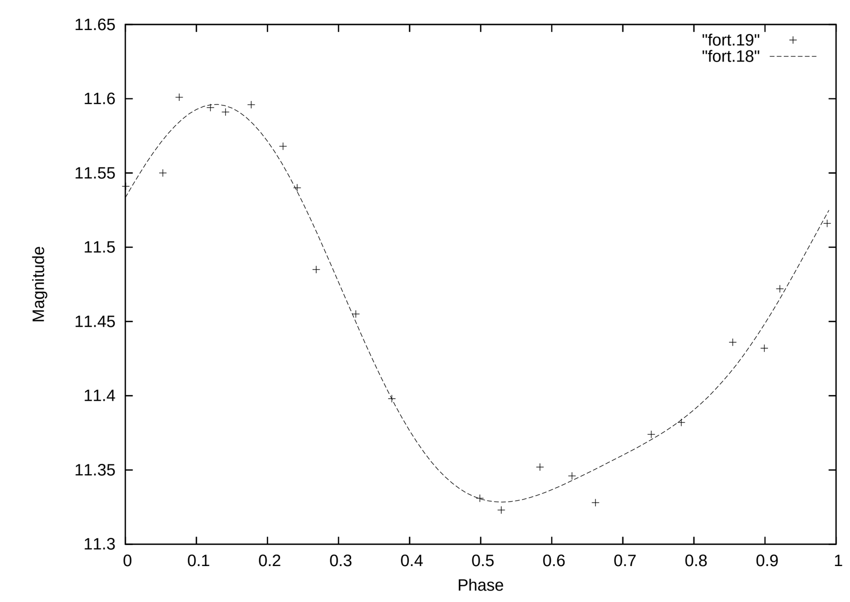

Figure 2 – Fourier fit to the raw data for the sample Cepheid.

PRELIMINARY RESULTS & CONCLUSION

- Example results of the Fourier decomposition for LMC Cepheids are shown in Figures 1 and 2.
- The output from the Fourier decomposition are used to perform Principal Component Analysis (PCA).
- PCA (Kanbur et al 2003, Kanbur and Mariani 2004) is a way of reducing the dimensionality of the data. Whereas some 18 parameters are needed to describe the light curve structure, only about 9 are needed in PCA.
- We do this for both Galctic and LMC Cepheids. Figure 2 displays the results.
- In figures 3-4, solid and open symbols represent Galactic and LMC Cepheids respectively.
- The PCA plot provide much structure, but perhaps of greatest difference is a possible difference between Galaxy and LMC in the second Principal Component in the J and H bands.

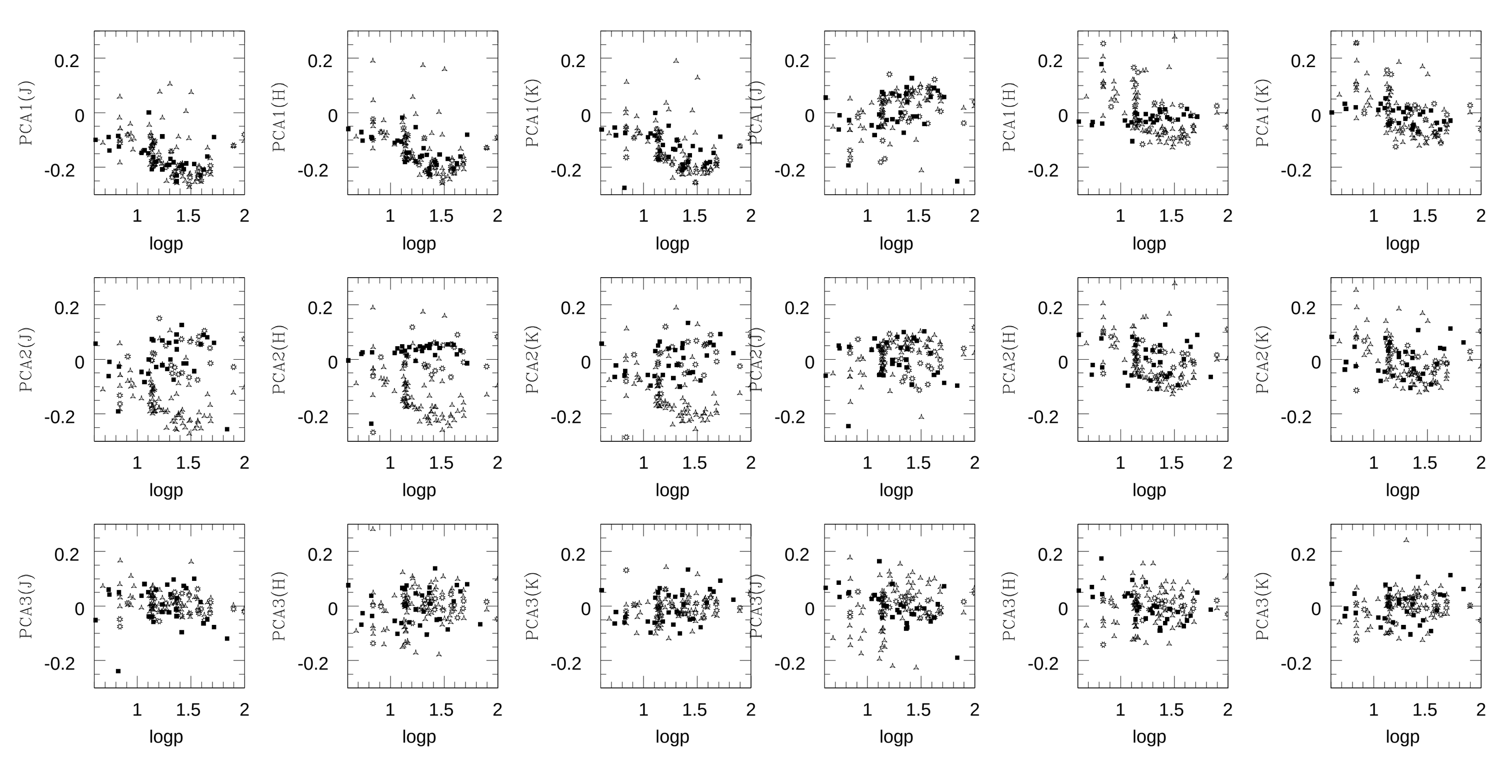

Figure 3 – PCA without removing the average term. Figure 4 – PCA with average term removed.

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