The approximation of RR Lyrae and eclipsing binary light curves using cubic polynomials

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Abstract We describe the method of cubic polynomials in approximating the light curves of RR Lyrae stars and eclipsing binaries. We detail some advantages of this method over existing techniques and apply the method to HST RR Lyrae data in the halo of M31. We show that this method eliminates virtually all ringing effects, and that at least for RRc stars, all the parameters of the fit can be related to pulsation physics. We report a number of additional periodicities not found in the data previously: 23 RRc stars, 29 RRab stars and 3 multiperiodic stars. We also discuss the use of this method to detect eclipsing binaries.

1 Introduction

RR Lyrae variables are pulsating horizontal branch stars with low mass and metal content. The light curves of RR Lyrae variables are often approximated from their sampled observations by applying Fourier analysis or cubic spline interpolation. However, Fourier fitting can lead to excessive ringing, and cubic splines require continuity of the second derivative. Here we fit cubic polynomials to observed RR Lyrae data and compare the resulting fitted light curves with existing methods.

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2 Cubic Polynomials

The method of cubic polynomials is achieved by fitting piecewise continuous polynomials to different parts of the light curve. Using two cubic polynomials requires five parameters: period, shift (the phase at which first observation occurs), maximum, minimum, and the proportion of the curve that is decreasing. In the case of three cubics, there are ten parameters. In order to model continuous pulsation, the slope must zero at each end. Parameters should be chosen to minimize Sum of Squares Error (SSE). Importantly, this method allows for an estimation of pulsation period.

3 Triple Mode RR Lyraes?

We applied the method of cubic polynomials to HST observations of RRab stars in the Andromeda Halo (Brown et al 2004). We fit one period, and then saw if the residuals from this fit would admit another period. We tried this independently for both bands, $F606W$ and $F814W$. We used the F test to check if fitting subsequent periods lead to a significant reduction in the SSE. The table below presents our evidence for possible triple mode RR Lyraes in M31. The F test is very strongly significant, indicating that a fit with three periods is consistent with the data for stars V1, V90 and V95 in both bands.

Star	P1	P2	P3	Band	F	sig(%)	N
V1	0.3816	0.5104	0.2182	F606W	4.44	99.3	75
				F814W	4.16	99.1	91
V90	0.3533	0.4747	0.2025	F606W	12.3	99.9	93
				F814W	4.74	99.6	99
V95	0.3615	0.4854	0.2872	F606W	5.55	99.8	101
				F814W	2.55	94	115

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References

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