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Amplitude and Period Changes in the δ Sct Star AN Lyncis

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Abstract. We report a study of time-dependent behaviour of the light variations in the δ Sct star AN Lyn, based on an analysis of new time-series CCD observations and existing data. The amplitude of the main frequency increased from 1994 to 2000 at a rate of 0.006 mmag/yr. The light variation of AN Lyn can be explained currently by amplitude variability mixed with multiperiodic pulsation. With the extended data base, results on XX Cyg are also reported.

1. Introduction

AN Lyn is a medium-amplitude (ΔV=0$^{\rm m}$.18), multiperiodic δ Sct star (Rodríguez et al. 1997a,b, hereafter R97a,b). R97b found three frequencies f_1=10.1756, f_2=18.1309 and f_3=9.5598 c d^{-1} along with the harmonics $2f_1$ and their interaction terms f_1+f_2 and $2f_1+f_2$. The main frequency (f_1) corresponds to the second overtone of radial pulsation (R97a). However, the peculiarity in the asymmetric light curves of AN Lyn is dominated by the main frequency and is not due to multiperiodicity. The presence of amplitude variations of f_1 was indicated from season to season. To study further the amplitude variability of AN Lyn, observations were carried out with a CCD lightcurve survey photometer on the 85-cm telescope at the Xinglong Station of the Beijing Astronomical Observatory (China) in 2000. We obtained a sum of 2937 Johnson V differential measurements (120-s bins, 129 hours) on 21 nights spanning 62 days. Based on all the available data, a comprehensive analysis for AN Lyn was made.

2. Analysis

Our new V data were analyzed together with the 926 y measurements of R97a,b. Owing to an amplitude modulation of f_1, the peak at f_1 is larger than the theoretical one resulting from a signal having a constant amplitude. This modulation also caused higher noise in the region around f_1. The higher noise in the region lower than 5 c d^{-1} mostly reflects the effects from instrumental drifts, the motion of images on the CCD chip and atmospheric changes (e.g., sky transparency irregularities and scintillation noise). In addition, the effects of arbitrary zero-point adjustments and possible intrinsic stellar variability cannot be separated for lower frequencies ($<$ 10 c d^{-1}). Hence, we stop searching for frequencies in the low-frequency region and an attempt was made to de-noise in this region.

Similar to the low-frequency filtering applied in XX Pyx (Handler et al., 2000), we first go back to re-check the constancy of the comparison stars in the investigated frequency range through analyzing the amplitude spectrum of the time series of the comparison stars. We found no frequency caused by the comparisons is needed to be removed from the differential data of the variable. Therefore, the main sources of noise should come from instrument drifts and other sources. Then we tried to pick out the frequencies lower than 10 c d^{-1} with S/N<4 in the variable's data, and remove them. Last, we failed to detect any new frequencies.

Amplitude variability was investigated by applying wavelet and Fourier transforms. The wavelet amplitudes are well in agreement with the Fourier amplitudes: $0\overset{m}{.}0673$, $0\overset{m}{.}0675$, $0\overset{m}{.}0718$ and $0\overset{m}{.}0807$ for the years 1994, 1995, 1996 and 2000, respectively. We derived that the amplitude of f_1 of AN Lyn was increasing from 1994 to 2000, following a linear relation $V = -0\overset{m}{.}25 \pm 0.02 + (6\overset{m}{.}37 \pm 0.39) \times 10^{-6} \times$ (HJD − 2400000.0) with $\sigma = 0\overset{m}{.}00165$, which indicates a mean increasing rate of about $6\overset{m}{.}37$ per million years. Our results do not suggest the variability of the main frequency. However, there is a discrepancy between the results from the Fourier and from the O–C methods. By appending 53 times of maximum light determined from the present light curves, we cannot see period changes from the distribution of the O–C residuals.

3. Results

On a time base of six years, our analysis shows that the amplitude of the main frequency of the δ Sct star AN Lyn increased from 1994 to 2000 at a rate of 0.006 mmag yr^{-1}. The peculiar light variations of AN Lyn are caused by amplitude variability and multiperiodicity.

In addition, based on the existing data and our new time-resolved CCD photometric data of XX Cyg, a metal-poor, high-velocity Pop. II monoperiodic ($P_0 = 0\overset{d}{.}1348652 \pm 0.0000001$) SX Phe star, we obtained the Fourier amplitudes of 336.5, 318.5, 314.6, 325.0, and 340.1 mmag for 1974-76, 1980, 1984-87, 1996 and 1999-00, respectively. A linear-fit to the variations results in $V = 0\overset{m}{.}82 \pm 0.29 - (1\overset{m}{.}0 \pm 0.6) \times 10^{-5} \times$ (HJD − 2400000.0), which indicates a decreasing rate of about 0.01 mmag yr^{-1}. A parabola fit to the 101 times of maximum light suggests a slow continuous period increase at a rate of 6.55×10^{-10} d yr^{-1} ($\Delta P/P = 6.32 \pm 0.3 \times 10^{-8}$), which agrees with $10.4 \pm 4.0 \times 10^{-8}$ determined by two-segment linear fits shown by Kiss & Derekas (2000).

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References

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