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On the Photometric Detection of Eclipse on Variable Star AO Serpentis

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ABSTRACT

This research is on the Photometric observation of Variable star AO Ser so as to observe and report the eclipse phenomenon. The target was observed with the 0.4m SBIG optical telescope from Las Cumbres Obervatory Global Telescope Network remotely. The photometric analysis was done using SAO Image Viewer (DS9) and IRIS software which enabled us to plot the light curve the deduce eclipses. Results from our photometric analysis revealed that AO Ser is an eclipsing binary variable star with significant flares. Theaverage values of from the analysis of the V-filter of AO Ser, gaveA1 = 1.35, A2 = 0.229, D1 = 187×10³hrs (51.94secs), D2 = 78.4×10³hrs (21.7secs) and d1 = 25.4×10³hrs (7.055secs), d2 = 0hrs (0secs) while the B-filter gaveA1 = 0.64, A2 = 0.143, D1 = 184×10³hrs (51.11secs), D2 = 76.5×10³hrs (21.25.0secs) and d1 = 25.0×10³hrs (6.944secs), d2 = 0hrs (0secs) respectively.The value of d2 = 0secs were the same both for V and B Filters observation, demonstrating that the primary ccandidate of AO Ser is smaller than its secondarycompanion, hence the secondary component was not totally eclipsed. The results from our photometric data showed that AO Ser is an eclipsing star with an average surface temperature of 9447K classifying the source as a red giant.

KEYWORDS: *photometry, red giant, eclipse, variable Stars*

INTRODUCTION

Variability of AO Serpentis (AO Ser) was first published by Hoffmeister (1935) and classified as an eclipsing binary variable star. AO Ser is a star in the constellation of Serpens. It's a variable star classified as a red giant that is undergoing pulsations, which means its size and brightness are constantly changing. Sometimes it will get from us, so the light we are seeing right now left the star hundreds of years ago (Rucinski, et al. 2008).

LITERATURE

AO Ser had been extensively studied by previous investigators (Brancewiez and Dworak, 1980; Kreiner et al. 2001; Hoffman 2009 ; Yang et al. 2010) with surface temperature estimate of 9960 K (Cox, 2000), 8770 K (Zavros et al. 2008), 9480 K (Yang et al. 2010) and 7800 K (Alton et al. 2012). (Chika et al., 2022), (Chisom et al., 2022). Koch and Koch (1962) revised AO Ser orbital period to 0.87934745 days. Wood and Forbes (1963) derived a cubic ephemeris with a period decrease, based only on 39 photographic or visual light minimum times with much larger error. Hoffman (2009) determined the mass ratio to be 0.178. Percy and Kim (2014) found an oscillation with a period and amplitude of 1.12 h and 0.02 mag in the B band, respectively, through frequency analysis. The main purpose of this study is to observe AO Ser with V-filter and B-filter. Plot the light curves and estimate the surface temperature from photometric measurement to determine the eclipse event.

METHOD

Photometric Observation

The data acquisition of AO Ser was from the Las Cumbres Observatory Global Telescope through remote observations from Rivers State University, Port Harcourt Nigeria. The data reduction and analysis was downloaded after completion and subjected through DS9 for decompression.

Photometric Application of Iris for Stellar Identification and light curve data generation.

IRIS was used to obtain the instrumental magnitudes within the framework of the study for the variable star AO Ser before light curve production. This was done by first installing the windows version 5.59 of the photometric IRIS software on the AstroLab computer and prepared the system for the data analysis. We ensured that all calibrated images have been obtained and saved in a folder on the desktop as earlier decompressed by DS9 before launching the IRIS software from the desktop of the AstroLab computer and activating the file menu for parametric settings to calibrate the data working path from the DS9 folder on the desktop to invoke all calibrated files into the IRIS memory. The working path was initiated from the setting menu and the DS9 image working directory was invoked by right clicking the folder, followed by AO1-1.fit representing the variable star FIT Image. The properties of the folder followed by the location were activated and the location identity (description) copied before subsequently closing the AO1-1.fit window properties to migrate back to IRIS. The file menu was launched, followed by settings to paste the AO1-1.fit location properties in the IRIS working path which inform the IRIS software where our image is located in the computer which constitute our device working path.

However, the decompressed images in DS9 were labelled AO1-1.fit, AO2-1.fit, AO3-1.fit, AO4-1.fit…………AAOn-1.fit, where n=1,2,3,4,5………… n+1. When furthermore clicked 'OK' when the working path was properly calibrated into the computer memory.

RESULTS

Light curves for eclipses in AO Ser

Figure 4.3, 4.4, 4.5 and 4.6 is the background separation of AO Ser for V and B filters, all representing eclipses.

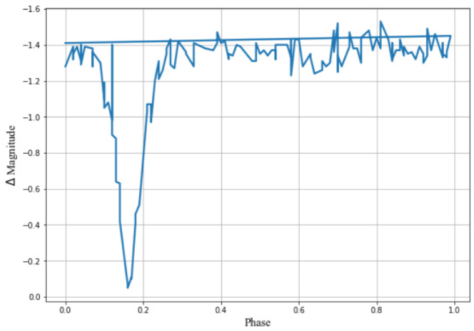

Fig. 4.1. The light curve of ΔMagnitude vs Phase of AO Ser revealing the presence of eclipse in AO Ser – C1 for V and B filters

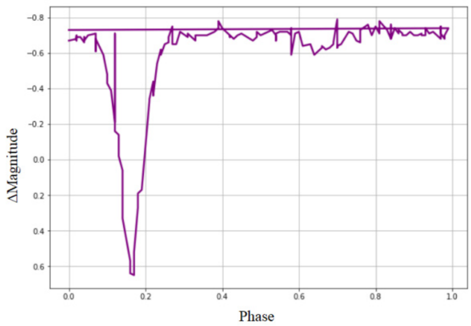

Fig. 4.2. The light curve of ΔMagnitude vs Phase of AO Ser revealing the presence of eclipse in AO Ser – C2 for V and B Filters.

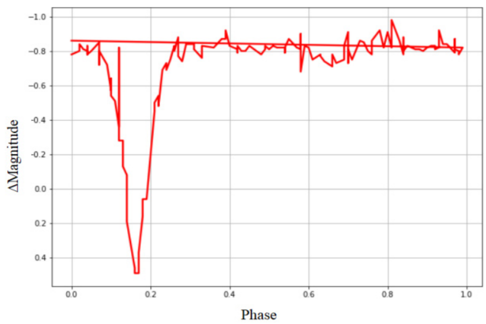

Fig. 4.3. The light curve of ΔMagnitude vs Phase of AO Ser revealing the presence of eclipse in AO Ser – C3 for V and B Filters.

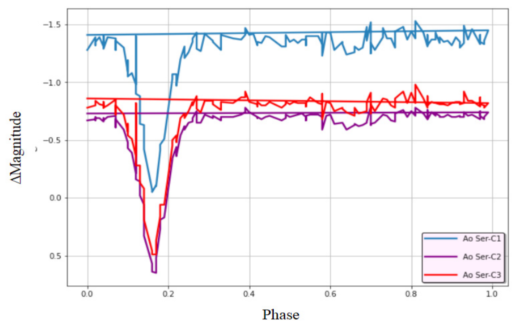

Fig. 4.4. Light curve of ΔMagnitude vs Phase of AO Ser for background separation of AO Ser – (C1,2,3) in V and B Filters.

Photometric Estimation of Variable Stars Surface Temperature

Table 4.1 is the results of photometric eclipse estimated from the light curve of AO Ser, Table 4.2, 4.4 and 4.6 are the results of photometric surface temperatures of AO Ser, WW Cnc and CZ Aqr respectively from Ballesteros and Zombeck equations. Table 4.3, 4.5 and 4.7 are the results of luminosity temperature of variable stars AO Ser, WW Cnc and CZ Aqr respectively from Ballesteros equations.

Table 4.1. The estimated values for the depth of the primary and secondary eclipse in AO ser

V-Filter	A1 (km)	A2 (km)	D1×10^3 (hrs)	D2×10^3 (hrs)	d1×10^3 (hrs)	d2×10^3 (hrs)	Period (days)
AO Ser – C1	1.34	0.235	188	77.5	25.2	0	
AO Ser – C2	1.37	0.221	187	79.1	27.3	0	
AO Ser – C3	1.35	0.230	186	78.5	23.7	0	
Average	1.35	0.229	187	78.4	25.4	0	0.879±0.01
B-Filter							
AO Ser – C1	0.87	0.138	189	76.9	26.3	0	
AO Ser - C2	0.79	0.148	188	77.2	23.5	0	

AO Ser - C3	0.82	0.142	174	75.5	25.1	0	
Average	0.64	0.143	184	76.5	25.0	0	0.879±0.01

Table 4.2. Results of Temperatures of AO Ser obtained using Ballesteros and Zombeck equations.

JD (Days)	B(mag)	V(mag)	B-V(ma)	BE(k)	ZE(k)
2459352.63	-12.83	-12.80	-0.03	9256	9272
2459352.43	-12.96	-12.88	-0.08	9152	9344
2459352.61	-13.60	-13.51	-0.09	9714	9921
2459352.52	-13.82	-12.75	-0.07	9486	9312
Average	-13.23	-13.16	-0.07	9447	9462

DISCUSSION

Light Curve for eclipse detection in AO Ser

To produce the light curve of AO Ser, a plot of the stellar magnitude (ΔMagnitude) vs Stellar Phase was generated for AO Ser data using python version 3.9 revealing the presence of eclipse in the background separation of comparative star C1 from the target star decompressed as AO Ser – C1 through the V and B Filter (Figure 4.1). The longest peak on the light curve indicates the duration of primary eclipse at 52.2 secs and B-filter at 52.5secs, duration of totality in primary eclipse estimated V-filter at 21.5secs and B-filter at 21.4secs. The smaller peaks in the Figure 4.3 represents the duration of totality in secondary eclipse estimated for V-filter = 7.0secs, B-filter = 7.3secs and duration of totality in secondary eclipse for both filters = 0 represent no total obscurity because the secondary stellar companion is bigger than its primary companion as shown on Table 4.1.

The light curve of Stellar (ΔMagnitude) vs Stellar Phase of AO Ser on Figure 4.4 is revealing the presence of eclipse in the background separation of comparative star C2 from the target star decompressed as AO Ser – C2 through the V and B Filter (Figure 4.2). The longest peak on the light curve indicates the duration of primary eclipse at 52.2 secs and B-filter = 52.2secs, duration of totality in primary eclipse estimated V filter = 22.0secs and B-filter = 20.1secs. The smaller peak represents the duration of totality in secondary eclipse estimated V filter = 7.8secs, B filter = 6.5secs and duration of totality in secondary eclipse for both filters = 0 represent no total obscurity because the secondary companion is bigger than its primary candidate.

Figure 4.3 shows the light curve of the stellar magnitude (ΔMagnitude) vs Stellar Phase of AO Ser revealing the presence of eclipse in the background separation of comparative star C3 from the target star decompressed as AO Ser – C3 through the V and B Filters. The longest peak on the left light curve indicates the duration of primary eclipse of V filter = 51.7 secs and B filter = 48.3secs, duration of totality in primary eclipse estimated V-filter = 21.7secs and B-filter = 21.0secs. The smaller peak represents the duration of totality in secondary eclipse estimated V filter = 7.8secs, B filter = 6.6secs and duration of totality in secondary eclipse for both filters = 0 represent no total obscurity because the secondary companion is bigger than its primary candidate.

Figure 4.4 shows the light curve of the average values for stellar magnitude (ΔMagnitude) vs Stellar Phase of AO Ser revealing the presence of eclipse in the background separation of combined comparative star C1,2,3 from the target star decompressed as AO Ser – C1,2,3 through the V and B Filters. From the analysis of the V-filter of AO Ser, theaverage values of A1 = 1.35km, A2 = 0.229km, D1 = 187×10^{3}hrs (51.94secs), D2 = 78.4×10^{3}hrs (21.7secs) and d1 = 25.4×10^{3}hrs (7.055secs), d2 = 0hrs (0secs) respectively. For the B filter, the averagesof A1 = 0.64km, A2 = 0.143km, D1 = 184×10^{3}hrs (51.11secs), D2 = 76.5×10^{3}hrs (21.25.0secs), d1 = 25.0 ×10^{3}hrs (6.944secs) and d2 = 0hrs (0secs).The value of d2 = 0secs were the same both for V and BFilters observation, demonstrating that the primary companion of AO Ser is bigger than its secondarycompanion hence the secondary component was not totally eclipsed. The physical meaning of this scenario is that the secondary star cannot totally eclipse the main sequence primary companion of the binary star.The results for all eclipsesare shown clearly in the Table 4.1, hence it can be concluded that AO Ser is an eclipsing-binary star as reported by *Chika et al.,* 2022

Stellar Surface Temperature Detection

Table 4.1 is the results for all estimated values for the depth of primary and secondary eclipses for AO Ser. By using the Zombeck (1990) and equation Ballesteros (2012) equations, the surface temperatures of AO Ser was calculated. The B-V observation index was estimated at -0.07 for AO Ser (Table 4.2). Similary, using the Ballesteros and Zombeck equations, an average stellar temperature of 9447K was estimated for AO Ser (Table 4.2). The estimation derived using Ballesteros (2012) and Zombeck (1990) equations shows that AO Ser has an average surface temperature ranging from (9467 ± 40)K – (9447 ± 40)K see (Table 4.2) for primary stellar component. These results agrees with Cox,(2000); Rovithis-Livaniou.,(2020); Yang *et al.,*(2013); Alton *et al.,* (2012) and Chika *et al.,* (2022). Stars at these range of temperatures are classified as Red-giant stars having an orange-yellow appearance. The results obtained in from this study shows that all the variable stars belong to theRed-giant spectral class. Furthermore, the estimated average absolutemagnitude (M) ofAO Ser was estimated at-13.16for the V Filter. Also for B filter,AO ser average absolute tempreture was estimated at -13.23 see (Table 4.2).

CONCLUSION

From the analysis of the V-filter of AO Ser, theaverage values of A1 = 1.35km, A2 = 0.229km, D1 = 187×10^3hrs (51.94secs), D2 = 78.4×10^3hrs (21.7secs) and d1 = 25.4×10^3hrs (7.055secs), d2 = 0hrs (0secs) respectively. For the B filter, the averagesof A1 = 0.64km, A2 = 0.143km, D1 = 184×10^3hrs (51.11secs), D2 = 76.5×10^3hrs (21.25.0secs), d1 = 25.0 ×10^3hrs (6.944secs) and d2 = 0hrs (0secs).The value of d2 = 0secs were the same both for V and B Filters observation, demonstrating that the primary companion of AO Ser is bigger than its secondary companion hence the secondary component was not totally eclipsed. The B-V observation index was estimated for AO Ser at -0.07(Table 4.2) while the average stellar temperature of 9447K was estimated for AO Ser (Table 4.2) using the Zombeck equation. The results show that AO Ser is a hot star. The estimation derived using Ballesteros (2012) and Zombeck (1990) equationsalso shows that AO Ser has an average surface temperature ranging from (9447 ± 40)K – (9467 ± 40)K (Table 4.2) classifying the star as a Red giant.

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REFERENCES

1. Alton, K. B.,& Prisa, A. (2012), in Warner B. D., Buchleim R.K., Foote J. L., Mais D., eds, Proc. Soc. Astron. Sci. Annual Symposium. Vol. 31, Symposium on Telescope Science. Society for Astronomical Sciences, Rancho Cucamonga, CA, 127
2. Ballesteros, F.J. (2012) New insights into black bodies, Europhysics Letters Association, 97 34008.
3. Brancewiez, H.K. & Dworak, T.Z. (1980), Acta Astron., 30,501
4. Catelan, M., and Smith, H. (2015), Pulsating Stars, 1st ed., Wiley-VCH, Berlin: Cambrige University Press.
5. Chika C. Onuchukwu, Michael C. Onu, Frances N. Anekwe (2022), Photometric Study of an Eclipsing Binary Star AO Serpentis, Astronomical Society of Nigeria (PASN) 000, 1–10
6. Chisom. S. Ejiofor, C. C. Onuchukwu & F. N. Anekwe, (2022), Photometric Study of an Eclipsing Binary Star CZ Aqr, Publication of the Astronomical Society of Nigeria (PASN) 000, 1–10
7. Hoffman, D. I. (2009), PhD thesis, New Mexico State University, New Mexico.
8. Hoffmeister, C (1935), Astronomische Nachrichten, 255 (22) 401
9. Koch, J.C., and Koch, R.H. (1962), AJ, 67, 462
10. Percy, J. R., and Kim, R.Y.H., (2014), JAAVSO, 42, 267.
11. Rucinski, S.M; et al. (2009), in IAU Trans 4 (27A), Reports on Astronomy 2006-2009., ed. K.A. Vander Hucht. Cambridge; Cambridge University. Press, 260.
12. Wood, B.D., and Forbes, J.E. (1963). AJ, 68, 257
13. Yang, P., L. Bi, B.A. Baum, K.-N. Liou, G.W. Kattawar, M.I. Mishchenko, and B. Cole, (2010): Spectrally consistent scattering, absorption, and polarization properties of atmospheric ice crystals at wavelengths from 0.2 to 100 µm. J. Atmos. Sci., 70, 330-347
14. Zavros P; Rovithis-Livaniou H, (2006), CCD Observations of the Algol-type Binary AO Serpentis, AIP Conference Proceedings 848, 447–450
15. Zombeck, M (1990) Calibration of MK spectral types. Handbook of space Astronomy and Astrophysics (2nd ed) Cambridge University press.

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