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RESEARCH PAPER

Photometric analysis of SW Lac short period binary star

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A B S T R A C T:
In this research, the short period binary system named (SW Lac) have been chosen to be analyzed with U,B and V light curves with the PHOEBE program .The geometrical and physical parameters have been obtained and compared with previous results of papers. The present result indicated that the selected system is over contact also the absolute parameters have been obtained with suitable results as compared with previous results of previous papers. The O'Connel effect ratio have been obtained by using the methods of integration ,summation method also compared with the exact method the results of O'Connel effect ratio with integration method and summation methods are near with the result of difference in magnitude with exact method .The roche lobe radii and bolometric magnitude have been obtained with suitable results.

KEY WORDS: Light curve, Binary Stars, SW Lac, W UMa .
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1. INTRODUCTION:

EW stars, or W UMa-type variable stars, are over-contact eclipsing binary systems that have orbital periods between 0.2 day and 1 day. Each component is a main sequence star (i.e. it burns hydrogen in its core) with spectral type ranging from A to K. Both the spectral type and the color of an EW star do not change during the orbital cycle. This implies that the common envelope is optically thick and has a nearly uniform temperature. Temperature differences of only a few hundred Kelvin are found between the two components . There is a large scale energy transfer from larger, more massive component to the smaller, less massive one, roughly equalizing surface temperatures over the entire system and applied to the early-type eclipsing binary Beta Lyrae. (Lucy, 1968), was the first to apply the Roche model to eclipsing binary stars-more specifically it was applied to the W UMa stars. In the short-period, dumb-bell shaped binary, both stars are in contact or overflowing the Roche lobes. The equality of the effective temperatures of both components is one of the discriminating characteristics of the contact binaries of W UMa-type, it was initially one of the most difficult properties to explain and led to development of the successful "contact model" (Lucy, 1968).The investigation of W UMa is one of the most important tasks in eclipsing binary research in general the two components of those systems have masses of the order of a solar mass a less. (Binnendijk, 1970),divided the W UMa binaries into two subclasses based on observational characteristics, referred to as the A- and W-type systems with the division as follow: A-type class: A-type systems usually possess components with earlier spectral type (typically from A to G), higher luminosity, larger mass, and a smaller mass ratio . W UMa stars are easily recognized by their light curves with near equal minima and continuous light variation. Variability ranges from a few tenths to slightly over a magnitude. Deeper primary minimum due to the transit eclipse of the larger, more massive, hotter

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component.(Wilson, 1978)reported that eight A-type systems with accurately determined parameters all had larger than zero-age main sequence radii, i.e., that they were all evolved. .. The degree of contact is larger and a thick common envelope is present (Van Hamme, 1982). Although W UMa stars are thought of as contact binaries, a satisfactory theory for origin, structure, and evolution of the class is not complete. Some theories suggest the possibility that W-type systems evolve into A-type through mass exchange. The term, "contact binary," however, seems to have had had slightly different meanings to Kuiper and to Kopal. Although W UMa stars are thought of as contact binaries, a satisfactory theory for origin, structure, and evolution of the class is not complete-type class: W-type systems are generally composed of stars of later spectral type (from F to K). In the W-type W UMa stars, the deeper primary minimum corresponds to the occultation eclipse of the smaller, less massive component. Stars in the W-type systems are generally closer to the zero age main sequence ZAMS (celestial object zero age main sequence, a star that has just become a main sequence i.e. a star that has begun burning hydrogen in its core)than the A-type class. The secondary components of the W-type systems have radii larger than normal ZAMs (celestial object zero age main sequence, a star that has just become a main sequence i.e. a star that has begun burning hydrogen in its core) of about the same mass .A- and W-type systems are usually assumed to be in slightly different states of evolution. We used this light curves of Fig12 (a, b, c) to analyze and extracting data of binary star SW Lac for (U,B,V) filters of light curve.

1.1A description of SW Lac

SW Lac (BD +37°4717, HD 216598, HIP 113052, TYC 3215 -1746 -1)is one of its varying orbital periods and lighting curve anomalies, contact binary stars are among the most frequently observed and analyzed in research. (Hilditch et al., 1988) .It is a suitable candidate for W type of W UMa systems, showing short period of the light period (approximately 0.3207209 d). SW Lac is well-known contact binary is Strong luminance and changing light curves have been used to analyze the brightness curves. Miss Ashall has found the photometric variations of SW Lac using plates collected at Harvard Observatory. SW Lac has a spectrum class of G5 (Essam et al., 2014) and is a member of the W-type subcategory of W UMa binaries (Zhai and Lu, 1989) . We will talk about PHOEBE computer simulations to evaluate the light curve of SW Lac for three filters: the U, B, and V bands of light curve.

2.1Study of the light curve

The physics of Eclipsing binaries software, PHOEBE, was released under the GNU public license. It is modeling software for eclipsing binaries which uses the Wilson-Devinney code. The Wilson-Devinney code, WD code, computes a synthetic model of an eclipsing binary which is based on the Roche model. The inverse problem is solved using differential corrections. At PHOEBE's core, the modeling engine is running on WD-2003, the next layer consists of the incorporations of all scientific, numerical and technical extensions. At the outermost layer there is an user interface, serving as a bridge between the user and the model (Prša, 2006).The differential corrections method was first proposed by Euler (1755). It's based on replacing partial derivatives with finite differences and is one of the most straight forward numerical methods to determine the best fit (Prša, 2006).PHOEBE offers the user five options for the system's configuration: general system with no constraints, a detached system, semi-detached system, double-contact, and two over-contact configurations: W UMa-type and one where the components are not in thermal contact. The model type selected adds constraints depending on the configuration. And one where the components are not in thermal contact. The model type selected adds constraints depending on the configuration. The underlying WD code can be driven through either the scripter or the PHOEBE Differential Corrections Minimization window. After each iteration, the DC Minimization window displays the parameter name, the original value, the correction amount, the corrected value and the standard deviation of the corrected value (Prša, 2006) . The fitting tab contains functions and parameters that define and support minimization algorithms. Finally, the plotting tab from this tab we can plot light curve and the radial velocity of the stars also we can plot the shape of the star from this tab (Prša, 2006)

1.3 The O'Connel effect ratio for SW Lac

In numerous binary star light curves, variations in the height of Max_1 and Max_2 are visible. One of early investigations on this phenomenon was done, but more recent research (Davidge and Milone, 1984) has revealed relationships between the O'Connell effect and system factors. One theory for the O'Connell effect has been the starspots hypothesis. Other theories include absorption by the gas stream (O'Connel1951) , atmospheric circulation, and others (Zhou and Leung, 1990).The O'Connel effect is an asymmetry in the photometric light curve certain close eclipsing binary stars. This is contrary to expectations that the observed luminosity of an eclipsing binary should be the same when its components switch positions every half period. The maximum following the primary minim is nearly always brighter than the preceding one. This is called the positive O'Connell effect, the reverse case is referred to as the negative O'Connell effect. The difference increases with the ellipticity of the stars, and the differences in their sizes and densities also increase. Also, spectral differences have been observed between subsequent maxima. Moreover, the origin 2021 program is used which is a proprietary computer program for interactive scientific graphing and Analyzing. It produced by origin corporation, and runs on windows, It has inspired several platforms independent. Origin primarily GUI software, a GUI graphical is a system of interactive visual components for computer software. A GUI displays objects that convey information, and represent actions that can be taken by the user. The objects change color, size, or visibility when the user interacts with them. With a spreadsheet front end. Unlike popular spreadsheets like Excel, Origin's worksheet is column oriented.

$$\mathrm{OER} = \frac{\sum_{i=1}^{n/2}(\mathrm{I^{-}}_{\mathrm{bin(i)}} - \mathrm{I_{minI}})}{\sum_{i=n/2+1}^{n}(\mathrm{I^{-}}_{\mathrm{bin(i)}} - \mathrm{I_{minI}})} \quad \ldots\ldots\ldots\mathbf{1}$$

Equation of oconnell effect ratio (OER) summation

$\mathrm{I^{-}}_{\mathrm{bin(i)}}$: The average intensity at each bin.

$\mathrm{I_{minI}}$: The intensity at primary minimum

$$\Delta m = m_2 - m_1 \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\mathbf{2}$$

Equation of exact method (difference in magnitude)

m_2 : The magnitude at secondary maximum.

m_1 : The magnitude at primary maximum

$$\mathrm{OER} = \frac{\int_{0.0}^{0.5}(\mathrm{I_{\theta}} - \mathrm{I_{0.0}})d\theta}{\int_{0.5}^{1.0}(\mathrm{I_{\theta}} - \mathrm{I_{0.0}})d\theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\mathbf{3}$$

$\mathbf{I_{\theta}}$: The intensity at phase $\boldsymbol{\theta = 0.0}$ to $\boldsymbol{\theta = 0.5}$

Equation of O'Connel effect ratio by using integration

$\mathbf{I_{0.0}}$: The intensity at point 0.0

2.SW Lac Investigation light curves by using program

Utilizing PHOEBE heritage, analyze systematically the light curve of an eclipsing binary (SW Lac) using the software involving input data information. Data in Data tabstarting by entering name of star (SW Lac) then enter the name of star again then there are two columns in first column choose phase and in the second column choose magnitude then after choose both the filter type and the model after that click on ok .for plotting tab synthetic and observed light curve have been plotted we see the plot of synthetic and observed light curve of SW Lac of (UBV)filters of Fig.1(a),Fig.2(a) and Fig.3(a) synthetic and observed light curve of three filters respectively as shown below. To obtain the geometrical and physical parameters first we use the model overcontact binary not in thermal contact. For U filter of SW Lac again we fixed mass ratio on (1.180) also we adjusted following parameters: orbital inclination(i),the non -dimensional potential(Ω_1), the effective temperature of the first and secondary component(T_1),(T_2)and, limb darkening parameters: orbital inclination(i),the non-dimensional potential(Ω_1),the effective temperature of the first and secondary component(T_1),(T_2)and the limb-darkening coefficient for primary and secondary, component(X_1),(X_2)and the relative luminosity of(L_1),primary star and secondary star surface albedo(A_1),(A_2) After some iteration we get the best match between synthetic and observed light curve as Shown in Fig.1 (b). Also for B filter of SW Lac mass ratio is fixed and adjust bling this parameters limb darkening for primary and secondary component(X_1),(X_2) and the relative luminosity of the primary (L_1) component , primary star and secondary star surface albedo(A_1),(A_2) after some iteration we get the best match between synthetic and observed light curve as shown in Fig.2(b). Finally, for SW Lacof V filter the mass ratio is fixed at 1.1701 this model and for a given mass has the following adjustable parameters: orbital inclination (i), then non –dimensional potential(Ω_1),the effective temperature of the first and secondary Component (T_1), (T_2) and the limb-darkening coefficient primary and secondary component(X_1), (X_2) The relative luminosity of the primary(L_1) . After some iteration one gets the best match between synthetic and the observed light curve as shown In, Fig.3 (b).For mesh shape one uses this parameters (colatitude-longitude-radius-Temperature. The spot parameters for primary and secondary components are shown in Table (1).The (Fig.5 a, b, c) shows the un spotted model shape of SW Lac at different phases. The Fig. (6,7,8) show spotted model of SW Lac at different phases. The output parameters for unspotted model of SW Lac (UBV) filters with comparison with other previous papers are shown in Table (6) below. Also, the best fit parameters of SW Lac for unspotted model three filters (UBV) are shown in Table (2). the best match between synthetic and observed light curve for unspotted model for SW Lac. One A cool spot parameters is added on the primary star as shown in Table (1) and the light curve after spot parameter added is shown in Figs .(9a,10a,11a).After adjustment ,temperature factor for primary spot which allowed to vary the output parameters of fitting tab by clicking on calculate as one sees the output parameters of SW Lac in Table (3). after removing the temperature factor and keep adjustment on other parameters one gets the best match between synthetic and observed light curve of SW Lac as sown in Figs.(9b,10b,11b,) for U,B and V filters, and the best fitting parameters for spotted model are shown in Table (5). The absolute parameters are Determined for SW Lac system as shown in Table (7).

2.1 Graph mesh plot

Mesh plot is a shape of the star itself as it is common envelope. So, mesh plots certainly depend on the geometrical configuration, but they don't show any one, for example, orbit themselves or the Roche equipotential. The solution of light curve indicates that the system is Overcontact. Positioned in orbit it will depend on all, physical circumstances present in the system, so if the system is detached, you will see near circular meshes; if semi-detached, one will see a teardrop shape; if contact, then it will see a common envelope. So, mesh plots certainly depend on the geometrical configuration, but they don't show one, example, orbit themselves or the Roche equipotential. The solution of light curve indicates that the system is overcontact.

2.2 Spot analysis

The equivalents of sun spots on other stars are called star spots. Because they are too small to produce discernible changes in luminosity, spots the sizes of sunspots are exceedingly difficult to find on of stars .The identified star spots, which can encompass up to 30% of the stellar exterior and are 100 times larger than that on the sun, are generally bigger than those of the sun. The modeled spots are represented in Table (1). By entering spot parameters in the spot tab (cool spot) affect has been seen the change in the first light curve part so did not fit all the bands of the light curve, but have good fitting in second part of the light curve.

3. Results

The results for unspotted model of best fit parameters have been shown in Table (2) which are near to each other for three filters ,the results of output parameters for spotted model of binary star SW Lac have been shown in Table (3) which results of output parameters are near to result of previous study except the result of limb darkening for primary and secondary component of binary star are taken from previous result which are (0.442,0.473 for B filter and 0.399,0.923 for V filter) Bolometric magnitude and Roche lobe radius have been shown in Table (4) the best fit parameters for spotted model of SW Lac for three filters have shown in Table (5) also the results for output parameters of SW Lac for unspotted model have been shown in Table (6) is the absolute parameters near to each other for three filters have been determined by using Equations (4) to (8) and compared with previous result, which approximately closer to results other research. The results of output parameters of spotted model and unspotted model in very good agreement with each other. The spot model effects on light curve and unspotted model light curve have been shown in Figs. (9a,10a, 11a) for spotted model and Figs. (1a,2a,3a) for unspotted model which are different from each other because of the spot model effect on the light curve asymmetry between primary and secondary maxima the light curve figure after adding third light which are shown in Figs. (4.a, 4.b) . The O'Connel effect ratio have been determined by using Equation (1) to (3) results of exact method is (0.078), integration method (0.589) and for Summation method is (1.12) Whereas the results of integration is closer than result of summation method when compared with result of O'Connel effect ratio by using exact method .The first contact angle and type of eclipse have been shown in Table (8).

3.1 First contact angle

The following formula can be used to determine first contact angle.

$$\theta 1 = sin^{-1} * \sqrt[2]{(r1+ r2)^2 * csc^2(i) - cot^2(i)} \text{.....(11)}$$

$$a = \frac{r_1}{(r_1+r_2)} \text{...(12)}$$

$$c = \frac{\text{Cos (i)}}{(r1+r2)} \text{...(13)}$$

$r1$ and $r1$: denotes Fractional radii and i: the inclination angle of the orbital plane to the celestial sphere

3.2 The binary SW Lac system's absolute parameters

The absolute parameters can be determined using Equations (4) to (8) (Awadalla and Hanna, 2005) Matlab program was used in the application. Applying formulas from these two articles of references (Paczynski, 1971, Gürol et al., 2015)we calculate the bolometric magnitudes and roche lobe radius that used Software managed using Matlab from equations (9-13)

$$A^3 = 74.5 * p^2 * (M1 + M2) \text{.................................(4)}$$

Equation of Kepler's third law. P : The orbital period in days.

M1 and M2 are the masses of the components in solar mass

$$M_1 = 1/1+q \ \ M, \ \ M_2 = \frac{q}{1+q} M \text{.................................(5)}$$

Equation of mass of each component of binary star system.

M1 and M2: are the masses of the components in solar mass

M: the solar mass, q: mass ratio for the components of binary star system.

$$R1 = A * r1 \ , R2 = A * r2 \text{..............................(6)}$$

Equation of the absolute radii and the relative radii of the components.

A: Separation between components expressed in solar radii R1 and R2: The absolute radii in solar radii

$$Q = \frac{M2}{M1} \text{...(7)}$$

Mass ratio between secondary and primary component.

$L_1 = R_1^2 * T_1^4 , L_2 = R_2^2 * T_2^4$……………..........(8)

Equation of luminosity and radius relation L_1 : The luminosity of primary component L_2: The luminosity of secondary component R_1:The absolute radius of primary component R_2:The absolute radius of secondary component T_1:The effective temperature of primary component T_2:The effective temperature of secondary component

$M_{bol1,2} = 4.75 - 5\log(\frac{R_{1,2}}{R_\odot}) - 10\log(\frac{T_{1,2}}{T_\odot})$………......(9)

Equation of bolometric magnitude.

$\frac{r1}{A} = 0.38 + 0.2 \log(M1/M2) \quad For \quad 0.3 < M1/M2 < 2$ ……………………………………………………………(10)

Equation of roche lobe radius

3.3 The O'Connel ratio results

The O'Connel effect ratio of SW Lac results are shown below by using three ways for determining O'Connel effect ratio which are (exact method, integration method and summation method) resulted from three methods are for three filters(exact result is (Δm) 0.078, OER by integration method is 0.589, OER by summation methodis1.12). An equal quadrature light level, namely the O'Connell effect ,is found in many eclipsing binaries and explained by several physical mechanism ,such as the presence of additional orbital mass(also known as third light),a hot spot due to the impact from mass transfer between the component, a cool spot that may be connected with magnetic activity with the same nature as solar magnetic spots, and the circulation effect

4- Discussion

Photometric solution has been obtained by solving U, B and V filters of the light curve spectral type of SW Lac binary star K0Vv C which means a main sequence star (orange dwarf) and it has luminosity V that is based on the width of certainabsorption lines in the stars spectrum ,which vary with the density of the atmosphere and so distinguish giant star from dwarfs. in an effort to advance understanding the impact of the third light on the O'Connell and fitting the illumination curves, a new light curve has been run with PHOEBE solution with the third light source for (U,B,V)filters of SW Lac, the parameters are found to be decrease slightly so the third light had slightly effect on the O'Connell effect as shown in Fig.4(a) and Fig.4(b) of SW Lac B filter of SW Lac After adding a cool spot on the primary component for u filter the light curve has a change and variation in the light curve brightness in the phase interval(-0.4 to -0.25) which affect the first part of the light curve and has no effect onthe second part of the light curve so the cool spot parameter model has one reason on the O'Connell effect in this work because there is the change in brightness between two maxima of the light curve and compared with other light curve of the same binary star . One sees that the change in maxima (Δm) is changes a year to another year so it means that one reason to O'Connell effect is the spot parameter on either component OER also the primary cool spot have been added to B,V filters and the light curve of the V filter has been changed and the cool spot affect the second part of light curve in the range 0.20-0.40 of phase axes decrease brightness also affect the brightness of primary and secondary minimum in the range -0.5 of the phase axes ,for B filter the light curve has been changed and the cool spot affect the second part of the light curve in the range 0.20-0.30 of phase axes and the secondary minimum in 0.5 on phase axes of the light curve so the cool spot is one reason of O'Connell effect forV,B filters.(O'Connel effect ratio)method of summation, OER method of integration are (1.12),(0.589), respectively the results are near to exact a unique type of summing. The result of (Δm) which is(0.078) that means Δm > 0 and for summation method OER>0 and OER>0 for integration method ,basically one has seen the OER method for integration result has near than OER method of summation due to the fact that integrate could be thought about as. The photometric solution in Table (2) and Table (4) indicate that the binary star SW Lac is W UMa

overcontact binary star and for U filter the mass ratio

Is (1.197),B filter(1.197) ,V filter(1.191) the mass ratio is close to spectroscopy q_{Sp} = 0.776. The effective temperature more mass component for U filter(5430.6) is greater than the effective temperature of less massive component and for B filter the effective temperature of primary components(5587.49) which is greater than secondary component of binary star system ,also the effective temperature of V filter for primary component is (5657.7) which is greater than effective temperature of secondary component which means the greater components have large luminosity and light by Stefan Boltzmann law. The absolute parameters of SW Lac binary are compared star for three filters (U,B,V)in Table (7),Table (4) with other previous paper and the results are near to each other in the solution of lightcurve of spotted model for out parameters the parameters for U ,B and V filter as seen from Table (3).The output parameters of secondary effective temperature ,the primary star surface albedo ,the limb darkening for primary and secondary componentare far when compared to unspotted model parameters as seen in Table (4).while other parameters of spotted model for three filters are near to the output parameters of unspotted model the best fit parameters for B filter for both models spotted and unspotted are near to each other for V filter all parameters are near for both models except the primary star gravity brightening.

5. Conclusion

The analysis of light curve of short period binary star SW Lac has been obtained for three filters (UBV) .The O'Connell effect ratio has been done by using integration method which is closer than Summation method. The effect of spot model on the light curve asymmetry O'Connell effect is greater than effect of third light on the light curve asymmetry of SW Lac binary star. Spot areas on the cooler component has less massive component gives satisfactory fit of the light curves secondary part ,the solution of the light curve showed that the system is overcontact system with a small temperature difference between the components (ΔT =66.7) which indicates thermal contact between the components.

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Conflict of Interest

According to the authors, there is no conflicts of interest.

Table 1.The spot parameters solution for SW Lac (UBV) filters.

Parameters	Primary SpotFor U filter(Jeonget al., 1994)	Primary spot for B filter(Jeonget al., 1994)	Primary spotfor Vfilter(Jeonget al., 1994)
Colatitude	20.0°	20.0°	20.0°
Longitude	67.89°	302.44°	291.27°
Radius	20.42°	22.63°	22.63°
Temperature Factor(K)	0.8436	0.7997	0.8149

Table2. The Best Fit Parameters of SW Lac for (UBV) Filters for unspotted model.

Parameters	SW Lac(V) filter	SW Lac(B)filter	SW Lac(U)filter
Inclination(i)	81.88°	83.80°	81°
Temperatureeffect of secondary star K(T_2)	5345	5498	5320

Temperature effect of primary Star K (T_1)	………..	5448	5430
Primary star gravity brightening(GR1) unit less	0.62	0.97	0.72
Secondary star gravity brightening(GR2) unit less	0.62	0.97	0.72
Limb darkeningcoefficient for primary star(X_1)		0.532	0.542
Limb darkeningcoefficient for secondary star(X_2)		0.563	0.553

Table 3. The output parameters of spotted model of SW Lac

Parameters	SW Lac(U)	SW Lac(B)	(Essamet al., 2014)	SW Lac(V)	(Essamet al., 2014)
Temperature factor spot K	1.43	1.128	0.7500	0.7632	0.7500
Mass ratio(q)	1.213	1.142	1.217	1.131	1.25
Inclination in degrees(i)	82.75	81.17	80.948	79.33	80.817
Temperature effect of primary star in K(T_1)	5404.38	5460.91	5371	5638.43	5379
Temperature effect of secondary star K(T_2)	5446.16	5444.54	5529	5303.27	5521
Surface potential of primary star(**PHSV)**	3.798	3.704	3.919	3.709	3.91
Limb darkening for secondary star(X_2)	0.3695	0.473	0.803	0.399	0.664
Limb darkening for primary star(X_1)	0.4784	**0.442**	0.777	0.923	0.638
Primary starsurface albedo(ALB_1) unit less	0.57	0.215	0.500	1.196	0.500

Secondary starsurface albedo(ALB_2) unit less	………	0.153		0.116	0.500
Primary stargravity brighteningGR1 unit less	0.34	………		……….	
Secondary stargravity brighteningGR2 unit less	0.70	……….		………	

Table 4. Bolometric magnitudes and Roche –lobe radii:

Nameof Star	Rochelobe radii $\frac{r_1}{a}$	M_{bol1} (mag)	M_{bol2} (mag)
SW Lac	0.3628	4.4067	9.9182

Table 5.The best fit parameters for spotted model SW Lac

Parameters	SW Lac(u)	SW Lac(B)	SW Lac(V)
Inclination(i)	83	85.45	82.95
Temperature effect of primary star in K(T_1)	5349		
Temperature effect of secondary star K(T_2)	5400		5450
Primary starsurface albedo(ALB_1) unit less	0.54		
Primary stargravity brighteningGR1 unit less	0.55	0.45	0.75
Secondary stargravity brighteningGR2 unit less	………..	0.45	0.75

Table (6): The out parameters of unspotted model of SW Lac.

Parameters	SW Lac(U)	SW Lac(B)filter	SW Lac(V) filter
Mass ratio(q)	1.197	1.197	1.191
Temperature effect of primary star in K(T_1)	5430.6	5587.49	5657.7
Temperature effect of secondary star K(T_2)	5363.9	5501.77	5268.8
Surface potential of primary star(PHSV)	3.801	3.855	3.723
Inclination in degrees(i)	81.80	79.39	81.37
Primary starsurface albedo(ALB_1) unit less	0.380	1.309	…………….
Limb darkeningfor primary star(X_1)	0.674	0.719	0.83
Limb darkeningfor secondary star(X_2)	0.674	0.609	0.14
Relative luminosity ofprimary star	5.283	33.699	10.694
R_{pole}(primary)	0.3610	0.3596	0.3855
R_{pole}(secondary)	0.1297	0.1253	0.1287
R_{side}(primary)	0.3819	0.3796	0.4134
R_{side}(secondary)	0.1300	0.1255	0.1289
R_{back}(primary)	0.4248	0.4192	0.4799
R_{back}(secondary)	0.1303	0.1258	0.1239

Table 7. Absolue parameter (using solar units) of the system:

Name of Star	R_1	R_2	M_1	M_2	T_1	T_2	L_1	L_2	Q	A	Type	References
SW Lac	0.7117	0.2557	0.4552	0.5448	0.92514	0.91378	0.3711	0.0456	1.1968	1.9715	W	(Awadalla and Hanna, 2005) ,
SW Lac	1.090	0.976	1.240	0.964	1.05622	0.99388	0.971	0.953	0.85	2.43		(Gazeas et al., 2005)

Table (8):The first Contact angle and Type of eclipse

Name Of Star	θ_1	a	c	Type of eclipse
SW Lac	1.5707°	0.3653°	0.7623°	W

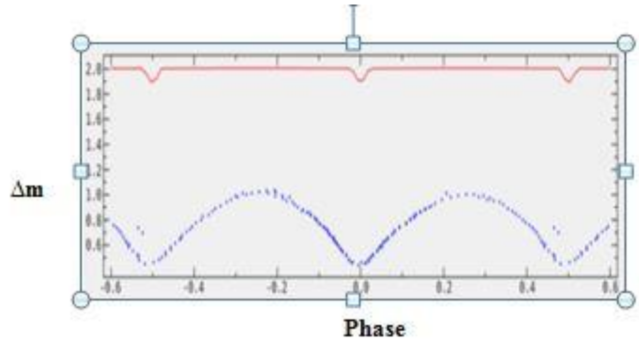


Fig.1 (a): Synthetic and observed light curve of SW Lac U filter.

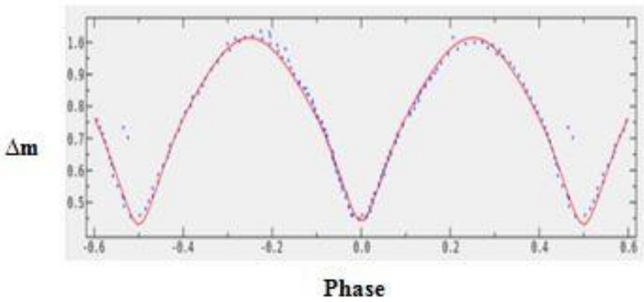


Fig.1 (b): The best match between synthetic and observed light curve of SW Lac U filter.

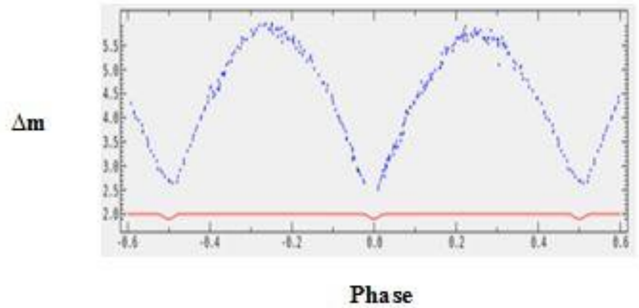


Fig.2 (a): Synthetic and observed light curve SW Lac B filter.

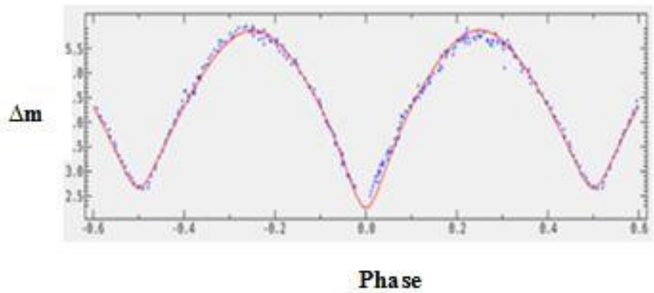


Fig.2 (b):The best match between synthetic and observed light curve of SW Lac B filter

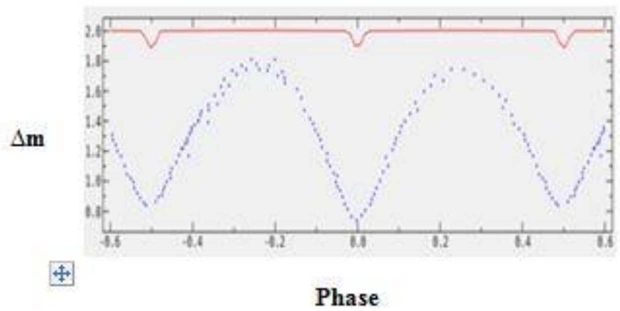


Fig.3 (a): Synthetic and observed light curve of SW Lac V filter.

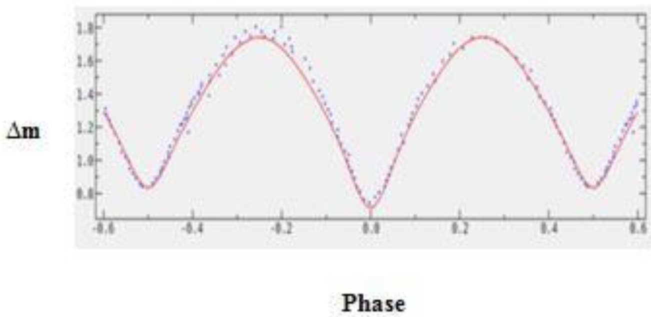
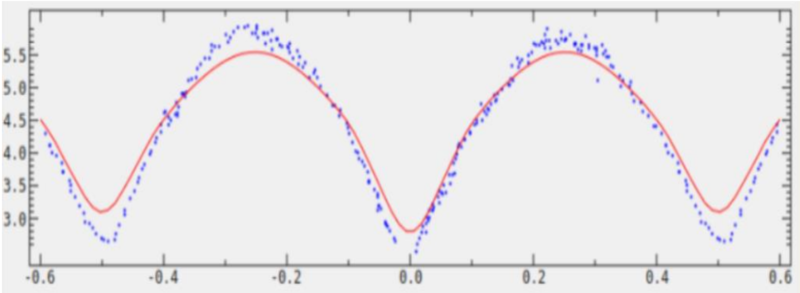


Fig.3 (b):Best match between synthetic and observed light curve of SW Lac V filter

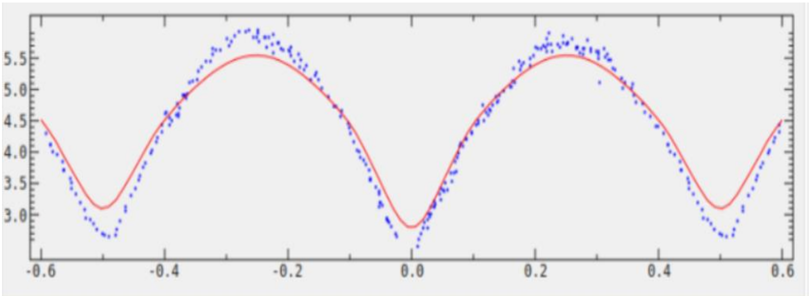
Δm



Phase

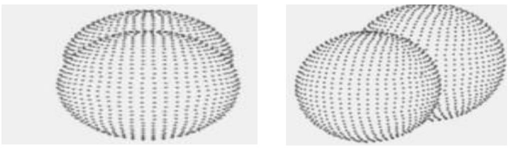
Fig.4 (b):SW Lac plot of B filter with third light

Δm



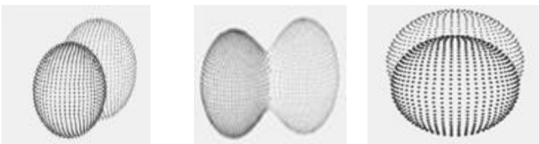
Phase

Fig.4(a): SW Lac plot of B filter without third light



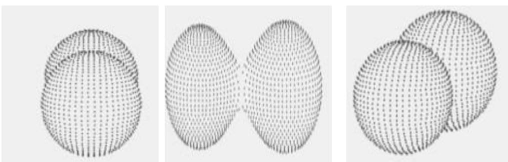
Phase=0.0 **Phase=0.45**

Fig.5(a):The mesh plots of SW Lac V filter .



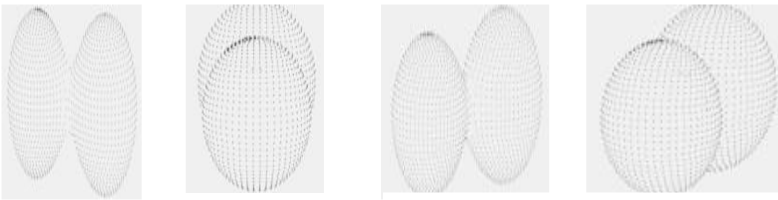
Phase=0.45 **Phase=0.30** **Phase=0.50**

Fig.5(b): The unspotted model (mesh plots)of SW Lac U filter



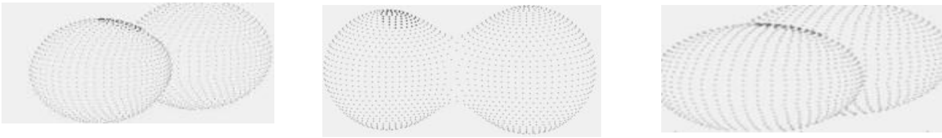
Phase=0.0 **Phase=0.25** **Phase=0.45**

Fig.5(c):The unspotted model(mesh plots)of SW Lac B Filter



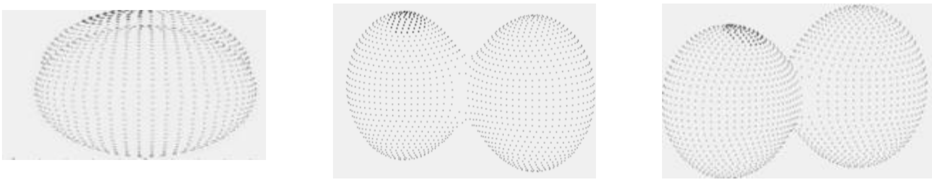
Phase=0.20 **Phase=0.50** **Phase=0.35** **Phase=0.45**

Fig.6: The spotted model of SW Lac (U) filter



Phase=0.25 **Phase=0.40** **Phase=0.45**

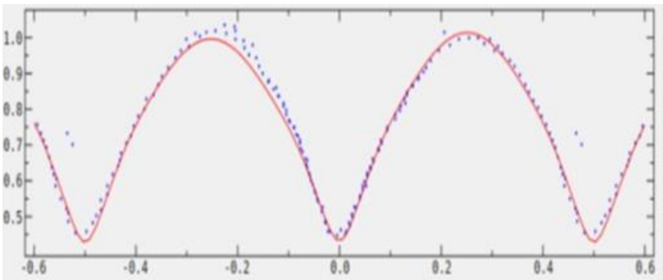
Fig.7: The spotted model of SW Lac (B) filter



Phase=0.0 **Phase=0.20** **Phase=0.35**

Fig.8:The spotted model of SW Lac(V)filter

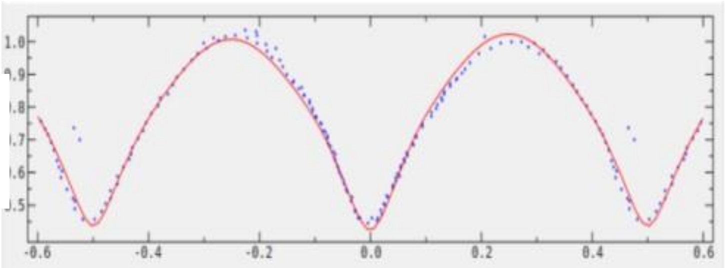
Δm



Phase

Fig.9 (a): Synthetic and observed light curve afteradding spot parameters of SW Lac (u)filter

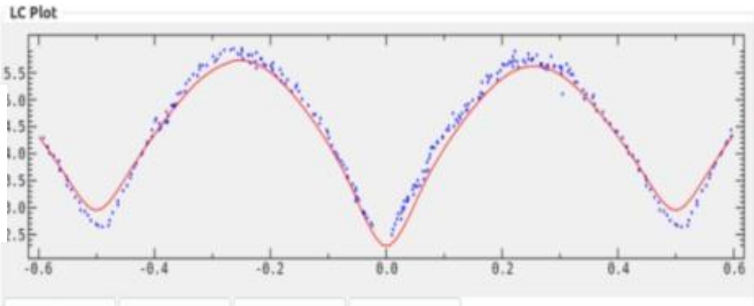
Δm



Phase

Fig.9(b):The best match between synthetic and observed light curve the spotted model of SW Lac (u) filter

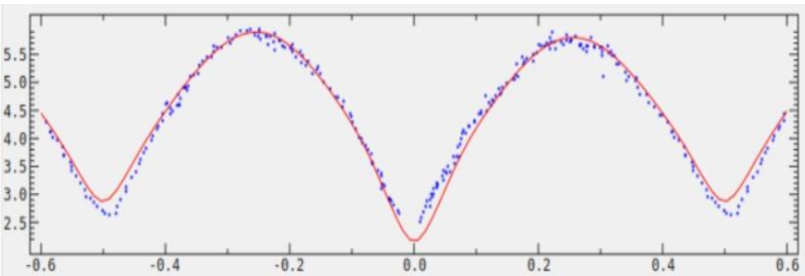
Δm



Phase

Fig.10 (a): Synthetic and observed light curve after adding spot parameters(B) filter

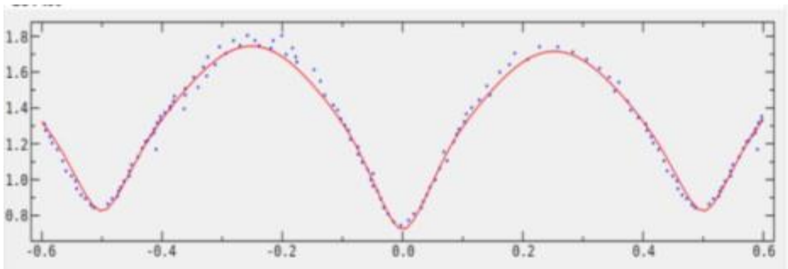
Δm



Phase

Fig.10 (b): The best match between synthetic and observed light curve ofthe spotted model of SW Lac (B) filter

Δm



Phase

Fig.11 (a): Synthetic and observed afteradding spot parameters SW Lac (V) filter

Δm

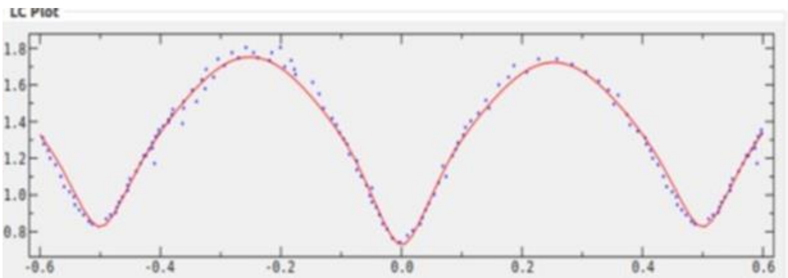
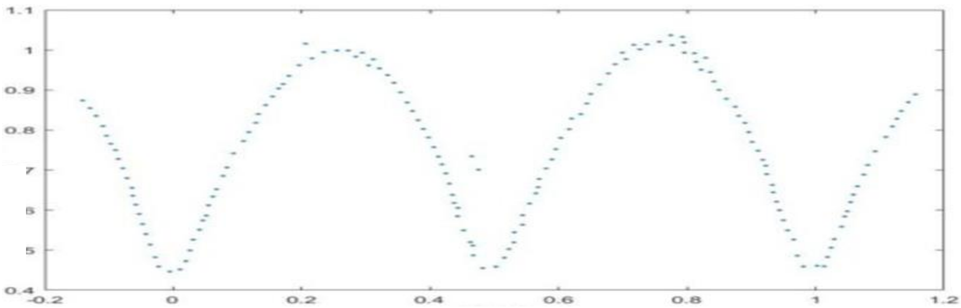


Fig.11(b): The best match between syntheticand observed light curve of the spotted model of SW Lac (V) filter

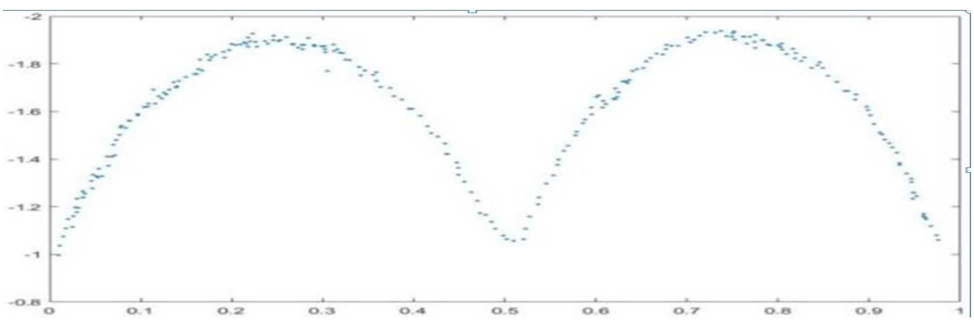
Δm



Phase

Fig.12 (a): Light curve of SW Lac (U) filter (Maceroni et al., 1983)

Δm



Phase

Fig.12(b)Light curve of SW Lac (B) filter (Muthsam and Rakos, 1974)

Δm

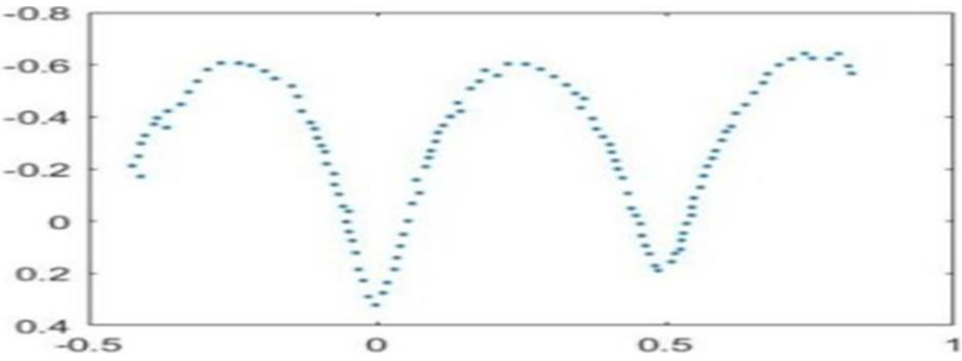


Fig.12 (c) :Light curve of SW Lac V filter (Mikolajewska and Mikolajewski,1981)

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