# PRELIMINARY RESULTS OF MODELING OF LIGHT CURVES OF WW AND

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ABSTRACT. In this work we present the preliminary results of modeling of Olson's Iybv light curves of an Algol-type binary WW And. A model of a binary star containing an accretion disk around the primary star is deployed. We present a solution for the mass ratio fixed at q=0.20.

**Key words:** Stars: binary, accretion disks

Table 1: Absolute parameters of WW And

| hot star | cool star |
|---|---|
| $i=80\overset{\circ}{.}4$ | |
| $q$=0.10 | |
| $T_1$=9500* | $T_2$=4359 |
| $R_1$=2.04 | $R_2$=9.45 |
| $M_1$=2.84 | $M_2$=0.28 |

* - not adjusted

## Introduction

WW And is a long period (P=23.3 days) eclipsing binary star. The earliest spectroscopic study of the system was done by Wyse(1934) and Struve(1946). The latter study confirmed Wyse's speculation of H$\alpha$ been in emission. Struve estimated spectral types of components to A5 and F3 and derived mass function f(m)=0.048 $M_\odot$. Until 1993, only fragmentary photographic photometry of WW And has been published. Elias (1993) reported tentative discovery of radio emission from this system.

Recently Olson and Etzel (1993) published five-colour, uvbyI photometry of WW And. The authors obtained also CCD spectra of H$\alpha$, H$\beta$, MgII and OI lines. The photometric data allowed Olson and Etzel to improve value of the period of WW And (P=23.285213 days). The primary minimum is partial and of about 0.6mag depth in the yellow filter. The light curves show clear ellipticity effect indicating one component been significantly distorted. The CCD spectra, covering wavelengths from 6400 to 6700 angstroms, revealed strong, double-peaked H$\alpha$ emission at all phases and times, suggesting existence of an accretion disk around the hotter component. Olson and Etzel also obtained the radial velocity curve of the cool component, determining mass function f(m)=2.21 $M_\odot$, $K_2$=97km/s, and $\gamma$=-14km/s.

The authors solved the photoelectric Iybv light curves using the latest version of the Wilson-Devinney code. First, they attempted to find a semidetached solution but failed. Finally they argue that a good fit to observations can be achieved only if potentials of both stars were allowed to be free parameters. They conclude that a model with both components been well within their Roche lobe can describe observations. Simultaneously, spectroscopy shows that a permanent accretion disk exists in the system. Taking the photometric and spectroscopic solutions into account, Olson and Etzel computed the absolute parameters of components of WW And (Table 1).

In this paper we present a preliminary solution of modeling of Iybv light curves using a code that accounts also for presence of an accretion disk in a binary system. For comparison, also a search for a solution within a standard Roche lobe model is made.

## Modeling of the light curves

From all individual points, the normal ones were calculated, 73 in each light curve. These points were used to obtain a solution both within the Roche model (ver. 1993 of the Wilson-Devinney code, Wilson 1993) and accounting also for existence of an accretion disk around the primary, hotter component. Details of the latter computer model were given in Zoła (1991) and Zoła (1992). However, in both approaches the Monte Carlo search method was used instead of the differential correction one, included in the DCMP code.

First we performed computations to search for the best fit using the LC program along with the Monte Carlo search method. Also, the third light was set as a free parameter. Domains to be search for other parameters were set as wide as possible. Computations were done until the difference between the best and worst elements in the search array was less than 1 percent. We achieved solution for similar parameters to those derived by Olson and Etzel, apart from the

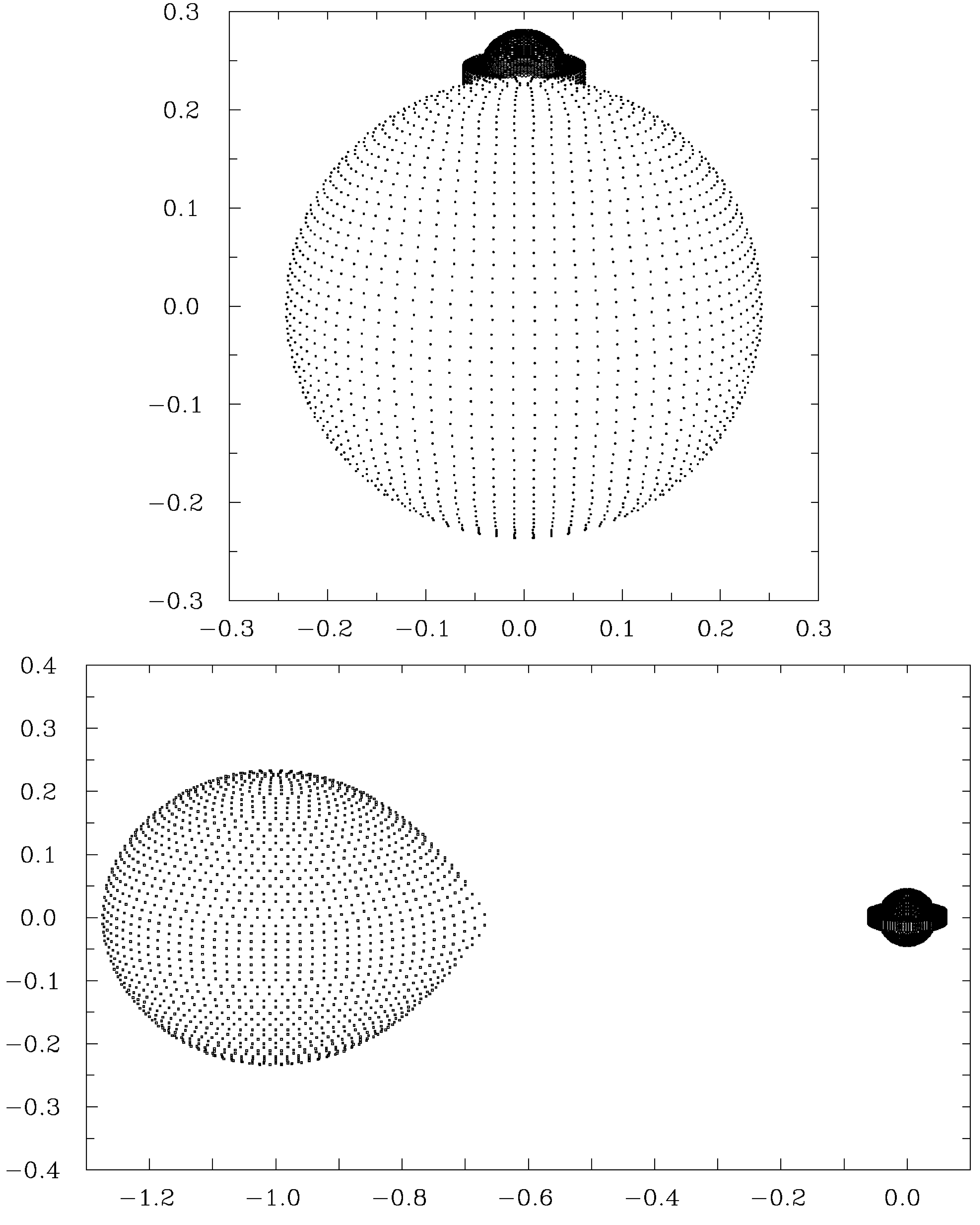


Figure 1. Projections of the system onto the plane of view at the main minimum (phase 0) and at phase 0.25. The co-ordinates are marked in units of the orbital separation.

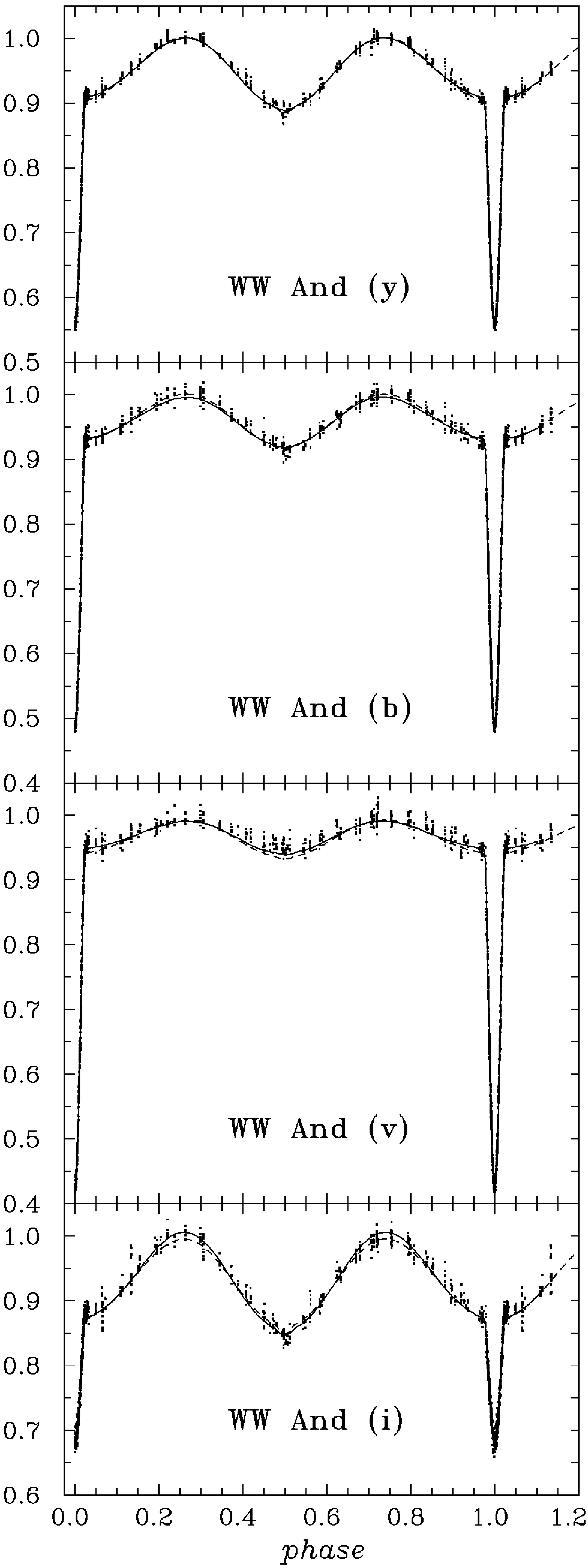


Figure 2. Observational versus theoretical light curves of WW And in the filters *ybvi*.

primary component temperature, which was obtained $T_1$=12000K (Olson and Etzel assumed it to be 9500K), and the third light which in our solution amounts to 14, 10, 6 and less than 1 percent of the total light for I, y, b and v light curves, respectively. The secondary star was also found to be marginally smaller than its Roche lobe.

Next the computations were proceeded by using a computer model that accounts also for effects from a disk around the primary star. The preliminary computations were done for a fixed mass ratio $q$=0.20. It was assumed that there is no third light in the system and the mass losing star exactly fills its Roche lobe. Again, the iterations were stopped when difference between the best and worst elements of the search array was less than 1 percent. The model of WW And as viewed at phases 0.0 and 0.25 is presented in Fig. 1. The theoretical light curves, obtained in both approaches, plotted against the observational data are shown in Fig. 2.

## Conclusions

It is possible to obtain a reasonably good fit to observations both within the standard Roche model and within a model which includes an accretion disk around the mass gainer. Although, the quality of the fit (measured by the sum of residuals) is slightly better for the former model, the theoretical light curves are almost undistinguishable, except for the $I$ light curve, near the maxima. However, both these light curves fit observations within the observational errors/intrinsic scatter of the data (see Fig. 2).

A thorough search is being done also for other mass ratio values, between 0.05-0.50. The preliminary results show that the radius of the disk, partly obscuring the hotter star, is about 0.06 A (an orbital separation), independently of the $q$ value. The disk contribution to the total light is significant, from about 20 percent for $I$ light curve to about 50 percent for $v$ one.

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