STARSPOT MODELLING WITH PC-S AT KONKOLY OBSERVATORY

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Abstract

A review is given on the computational aspects of starspot modelling at Konkoly Observatory. Different programs are used for spot modelling, demonstration and physical background visualization of single spotted variables and eclipsing binaries. An important part of this lecture is a computer show.

INTRODUCTION

Modelling the light variations of certain groups of stars with a small number of circular (or non-circular) relatively dark areas on the stellar surface (spots) is a widely accepted method. Long traditions exist in this field at the Konkoly Observatory: K. Oláh has been modelling late-type stars, and B. Vető is working on Be and Bp stars. We use a number of programs running on IBM PC compatible machines for modelling, demonstration and visualization.

DISCUSSION

I. **Visualization.** Astronomers not (or not yet) familiar with this field are often asking questions like: Why do you think that those stars are spotted? Why do you use circular spots, and why only one or two of them? What extent are you confident in those spot parameters? I will not answer this questions now (see Friedeman, Gürtler, 1975; Budding, 1977; Oláh, 1986, 1987; Hempelmann, Schöneich, 1987), I will only present two programs, written by Katalin Oláh, for visualizing those problems. One of them demonstrates the effect of using different spot-to-surface flux ratios, limb darkening coefficients and inclinations. With the help of the other one can vary the spot parameters, and watch the effect of this on the model-curve. This can help of finding good initial values for modelling programs too.

II. **Modelling.** Three programs are currently used.

a.) SPOT. This is written and used mainly by Katalin Oláh. The original version run on PDP machines, and later it was modified for PC-s. Based on the analytic method of E. Budding (Budding, 1977), it uses a multidimensional grid-search method for minimization of chi-square differences. Minimized variables are the spot coordinates

and radii.

b.) SPOTTER. This is a program written by E. Budding and modified by M. Zeilik and M. Rhodes (Budding, Zeilik, 1987; Zeilik, Budding, Rhodes, Cox, 1989), and used in conjunction with FITTER, an eclipsing binary light curve fitting program. One can approximate the "clean" eclipsing binary and spotted star light curves successively. It is based on the same analytic approach as the previous one, and the method of minimization is a step-by-step parabolic fit for each variable combined with a vector search. Each model parameter can be minimized.

c.) MULTIPAF. The program is written by A. Hempelmann and W. Schöneich, and was transported to PC-s by us. It is used by B. Vető. The underlying method is surface integration (Hempelmann, Schöneich, 1987). The spot coordinates, flux ratios and the reference intensity is minimized for different spot radii.

The first program is written in Pascal, the others in FORTRAN. On test data each of them gave the same results with tolerable differences. A single run of SPOT and SPOTTER take a few minutes on a PC 386-AT computer equipped with math co-processor (MULTIPAF is much slower). SPOT is very easy-to-use, and not too sensitive to the initial spot parameters.

III. **Demonstration.** Two programs are presented, one of them (FIGURE) displays the light curve of the star, and the star itself, the other program (DRW) shows an eclipsing binary system with spots (optionally) on both components. With saving the graphic screens on disk files, a movie can be created.

The programs written in the Konkoly Observatory will be available with an user's manual soon.

ACKNOWLEDGEMENT

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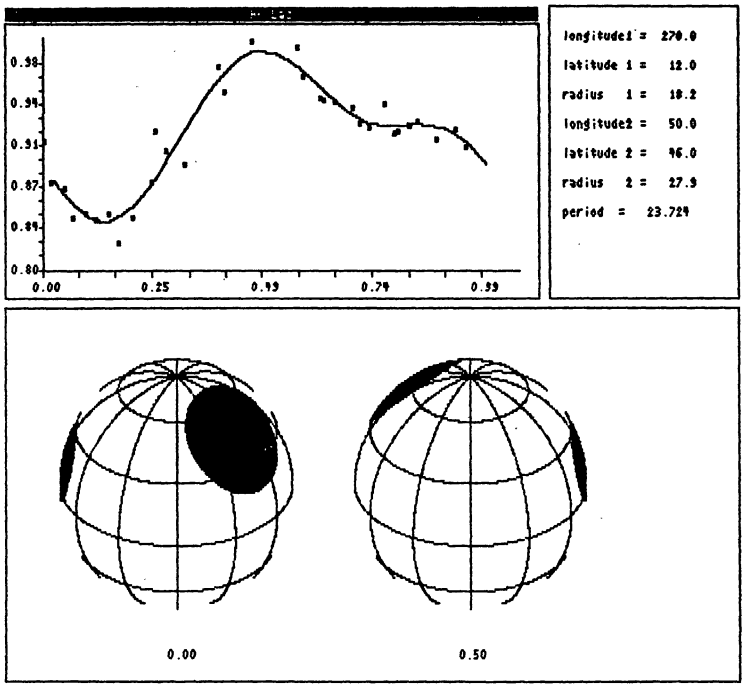

Figure 1. The light curve, the fitted spot parameters and stellar surface of HK Lacertae. See Oláh et al., 1986. An output of FIGURE.

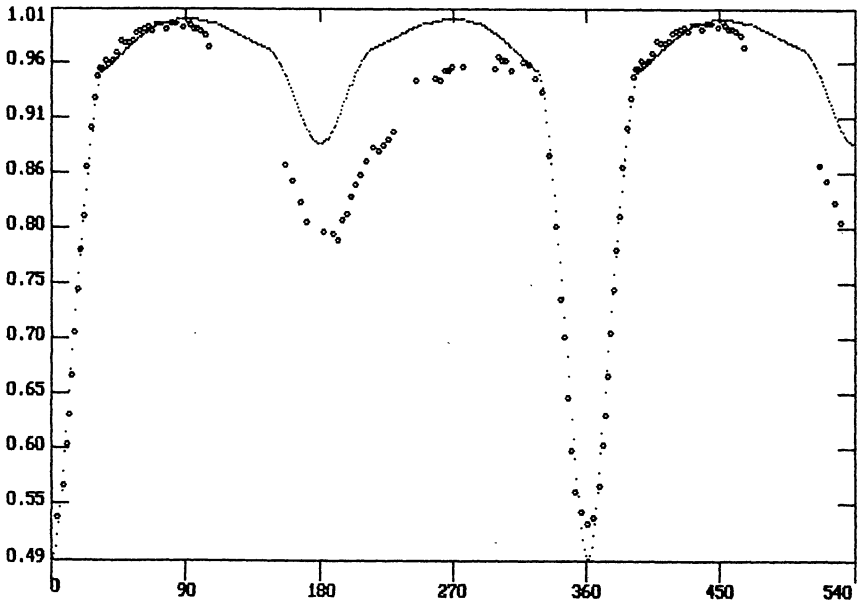

Figure 2. The observed (small circles) and model (line) light curve of SV Camelopardalis (Budding, Zeilik, 1987). An output of the FITTER.

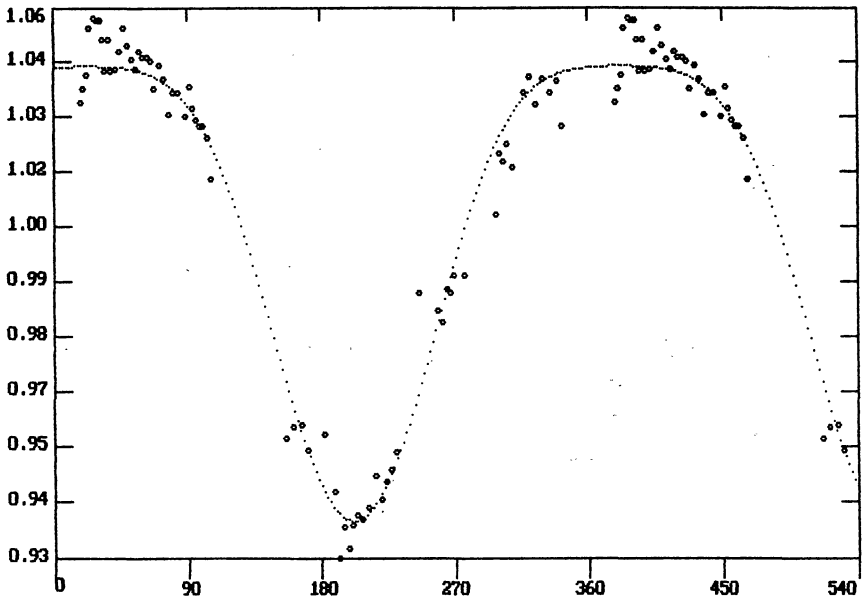

Figure 3. The "spot" light curve (the difference of the clean - i.e. the effect of the spot is removed - and the observed light curve) of SV Cam. An output of SPOTTER.

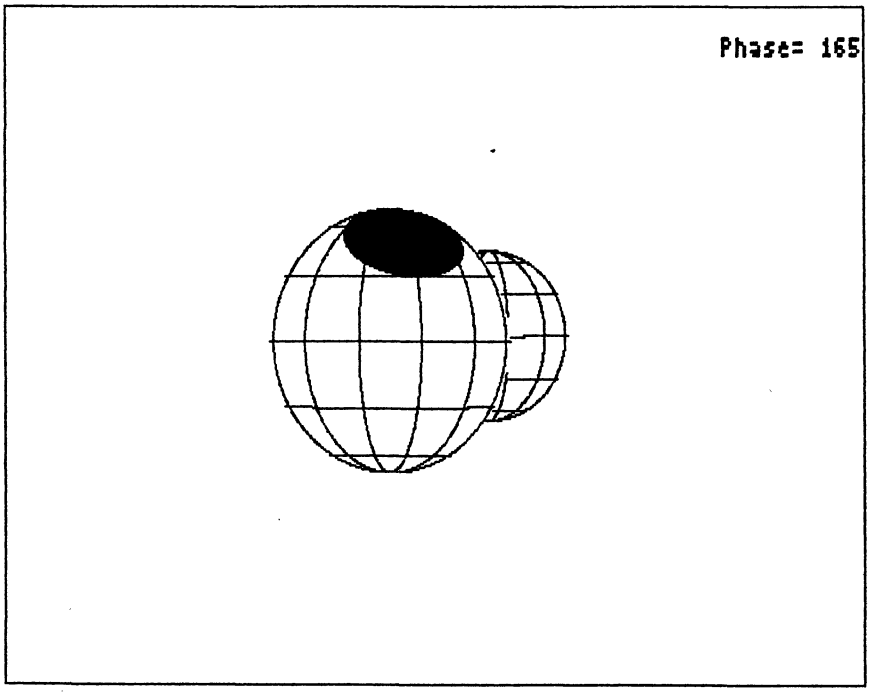

Figure 4. The view of the SV Cam during the secondary eclipse. An output of DRW.