NEW ANALYSIS OF II PEG 1977 LIGHT CURVE

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Abstract. The solution of the inverse photometric problem for spotted stars obtained on the basis of the analytical solution of the direct problem is applied to II Peg 1977 light curve. The geometric parameters of the spot configuration so obtained are unambiguously determined in contrast to the cases when analysis of the light curve is done on the basis of numerical modelling. A comparison between both methods has been carried out.

1. Introduction

Photometric variations attributed to starspots contain useful information on the physical characteristics (size, location, effective temperature) of the spots. The extraction of this information could help for the explanation of the physical processes in the spotted stars and of their evolutionary status.

So far the analysis of the observational light curves is done on the basis of numerical mouldings (Vogt, 1981a, hereafter referred to as Paper I; Poe and Eaton, 1985; etc.). But such solution of this inverse problem suffers from strong ambiguity – i.e., each observational light curve can be reproduced with many spot configurations (for instance in Paper I is given a method for unambiguously determining of the spot temperature but there the geometrical modeling is quite nonunique).

The ambiguity problem could be lessened in a considerable degree if the solution of the inverse problem is done on the basis of the analytical solution of the respective direct problem. Such treatment of principle is given by Kjurkchieva (1987, hereafter referred to as Paper II).

We apply for the first time this solution of the inverse problem to the 1977 light curve of II Peg (Vogt, 1981b) because of the following considerations: (a) this RS CVn-type one-line binary does not eclipse and, therefore, its light variations are due entirely to the spots; (b) the II Peg 1977 light curve satisfies the compulsory requirement of the discussed solution – to have a flat section (Figure 1); (c) this light curve has a simple form – one extremum per cycle. That means II Peg had one spot in this season. In this case the extremum was a minimum: i.e., the spot was cooler than the surrounding photosphere; (d) in addition, the minimum was symmetrical and this allows to suppose reasonably that the spot had circle shape. Just to such spots the solution in Paper II is applicable.

2. Analysis of II Peg 1977 Light Curve

Because the temperature modeling in Paper I is totally decoupled from the geometric one, and because it gives unambiguous results which agree very well with the spectral
temperature determination, we will consider $T^{sp}$ as already well-determined quantity and we will direct our efforts to the geometric analysis only.

In order to determine the spot geometric parameters it is necessary the following quantities from the observational light curve to be measured (Paper II):

(a) The phase $\phi_1$ in which the light curve course (i.e., the functional dependence type) changes. It is, in fact, the moment in which the spot begins to hide behind limb of the visible hemisphere.

(b) The phase $\phi_2$ of the flat section beginning (as the initial one is adopted the extremum phase).

(c) The brightness difference $\Delta m = m_0 - m_\phi$ between the flat section and the phase $\phi$ determined from the equation

$$\cos \phi = (\cos \phi_1 + \cos \phi_2)/2.$$  \hspace{1cm} (1)

In the concrete case for the II Peg 1977 light curve (Figure 1) these quantities have the values

$$\phi_1 = 0.13, \quad \phi_2 = 0.41, \quad \Delta m = -0''06.$$  \hspace{1cm} (2)

Then by use of the results from Paper II we can determine the angular spot size from the equation

$$\text{dex}(\Delta m/2.5-1) = 0.5E(2-3 \cos \alpha + \cos^2 \alpha) + 3(F - E)(\alpha - \sin \alpha \cos \alpha)/\pi,$$  \hspace{1cm} (3)

where

$$E = (I_{0p}^{sp}/I_0^{sp} - u^{sp})/(3 - u^{sp}), \quad F = (I_{0p}^0/I_0^0 - 1)/(3 - u^{sp}).$$  \hspace{1cm} (4)

The polar distance $\beta$ of the spot centre and the inclination $i$ of the rotational axis of