REVISED EPHemerIS FOR THE ECLIPSING BINARY PP Lac

ABSTRACT: PP Lac is a variable discovered by W.J. Miller; it was at first classified as "EW or RR?", but later Figer and Rolland, by visual observations made by GEOS, found it to be an EW-type eclipsing binary and gave the first ephemeris.

In this paper, 128 minima observed visually by GEOS members from 1976 to 1988, plus 18 minima observed by BBSAG, are analysed. On the basis of these data, a more precise ephemeris can be computed:

\[ \text{Min I (or II) = JD Hel 2442903,235 + 0,401 161 50} \pm 2 \pm 48 \]

It has been impossible to discriminate the primary minimum from the secondary one.

RESUME: PP Lac est une étoile variable découverte par W.J. Miller et d'abord classifiée comme "EW ou RR?". En 1977, des observations visuelles effectuées par le GEOS, permirent à A. Figer et R. Rolland de conjecturer qu'il s'agissait d'une binaire à éclipses du type EW et de donner une première éphémérie.

Dans cet article, on analyse 128 minima observés visuellement par le GEOS de 1976 à 1988 et 18 minima observés par le BBSAG. Ces observations permettent de calculer une éphémérie plus précise:

\[ \text{Min I (ou II) = JD Hel 2442 903,235 + 0,401 161 50} \pm 2 \pm 48 \]

Il n'a pas été possible de différencier le minimum principal du minimum secondaire.

RIASSUNTO: La variabile PP Lac fu scoperta da W.J. Miller, ed inizialmente classificata come "EW o RR?". Successivamente, Figer e Rolland, tramite osservazioni GEOS, stabilirono trattarsi di una binaria ad eclisse di tipo EW e ne fornirono la prima ephemeride. In questo articolo sono analizzati 128 minimi osservati visualmente da membri del GEOS tra il 1976 ed il 1988, unitamente a 18 minimi pubblicati dalla BBSAG. Sulla base di questi dati e' stato possibile calcolare la seguente ephemeride:

\[ \text{Min I (o II) = JD Hel 2442 903,235 + 0,401 161 50} \pm 2 \pm 48 \]

Non e' risultato possibile distinguere il minimo principale da quello secondario.

RESUMEN: PP Lac es una estrella variable descubierta por W.J. Miller y clasificada en principio como "EW o RR?". En 1977, las observaciones visuales efectuadas por el GEOS, permitieron a A. Figer y R. Rolland concluir que se trataba de una binaria a eclipses del tipo EW y dar una primera efiemeride. En este articulo, se analizan 128 mínimos observados visualmente por los miembros del GEOS de 1976 a 1988 y 18 mínimos observados por el BBSAG. Estas observaciones permiten calcular una efeméride más precisa:

\[ \text{Min I (o II) = DJ Hel 2442 903,235 + 0,401 161 50} \pm 2 \pm 48 \]

No ha sido posible distinguir el mínimo principal del mínimo secundario.
Revised ephemeris for the eclipsing binary PP Lac

Introduction

PP Lac was discovered by W. J. Miller on photographic plates taken at Castel Gandolfo during 1948 - 1955 in the Cygnus star cloud.

Miller and Wachmann [1] found a range from 11.1 to 12.0 p and a period of about 0.5 d; the classification proposed was EW or RR.

The star was added to GEOS observing programme in 1976. Figer and Rolland [2],[3] classified the star as EW, finding a period of 0.4011 d. The classification was made on the basis of the shape of light curve, but it was impossible to discriminate between the primary and the secondary minima. Thus, an uncertainty still remains about the classification of the star.

The most recent edition of GCVS [4] gives the following elements:

EW/KW. 11.1 - 12.0 p; min II 12.0

Min I = JD $2445598.438 + 0.4011E$ .

In this paper, all visual observations made by GEOS will be analyzed (including those which led to the papers of Figer and Rolland [2],[3]). In order to obtain a more precise ephemeris, assuming that the star is an EW-type variable.

Observations

Visual observations were carried on by GEOS members until 1988. Most of observations were made using Argelander's method.

Fig. 1 shows the field of the variable and the comparison stars used. The magnitudes of the comparison stars had been roughly estimated by Figer and Rolland [3]. As the aim of this paper is to find a new ephemeris, and not to analyze the range of variation, the lack of precision in the values of magnitude of comparison stars does not represent a problem.
The light curves obtained by each observer during each night of monitoring were examined in order to find times of minimum of the variable. Some of these light curves are shown in figs. 2-5. Minima were determined by the tracing-paper method.

A total of 128 minima from 17 observers was collected. Table 1 shows all observers (identified by a three-letter abbreviation) and the number of observed minima.

<table>
<thead>
<tr>
<th>Observer</th>
<th>Site</th>
<th>abbr.</th>
<th>n. of minima</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Figer</td>
<td>Paris</td>
<td>FGR</td>
<td>88</td>
</tr>
<tr>
<td>A. Maraziti</td>
<td>Catanzaro</td>
<td>MRZ</td>
<td>20</td>
</tr>
<tr>
<td>Ph. Raincourt</td>
<td>Nantes</td>
<td>RAL</td>
<td>12</td>
</tr>
<tr>
<td>P. Wils</td>
<td>Niel</td>
<td>WLS</td>
<td>11</td>
</tr>
<tr>
<td>R. Boninsegna</td>
<td>Dourbes</td>
<td>BNN</td>
<td>2</td>
</tr>
<tr>
<td>M. Penna</td>
<td>Asti</td>
<td>MPN</td>
<td>2</td>
</tr>
<tr>
<td>C. Romoli</td>
<td>Altopascio</td>
<td>RML</td>
<td>2</td>
</tr>
<tr>
<td>P. Baruffetti</td>
<td>Massa</td>
<td>BFF</td>
<td>1</td>
</tr>
<tr>
<td>G. Boistel</td>
<td>Nantes</td>
<td>BLT</td>
<td>1</td>
</tr>
<tr>
<td>J.F. Le Borgne</td>
<td>Toulouse</td>
<td>FLB</td>
<td>1</td>
</tr>
<tr>
<td>S. Ferrand</td>
<td>Bougival</td>
<td>FND</td>
<td>1</td>
</tr>
<tr>
<td>A. Grycan</td>
<td>Toulouse</td>
<td>GRY</td>
<td>1</td>
</tr>
<tr>
<td>P. Guiraudou</td>
<td>Montpellier</td>
<td>GUI</td>
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<td>E. Le Saout</td>
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<td>L. Maurin</td>
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<tr>
<td>C. Pampaloni</td>
<td>Firenze</td>
<td>FMP</td>
<td>1</td>
</tr>
<tr>
<td>L. Rivas</td>
<td>Valencia</td>
<td>RVS</td>
<td>1</td>
</tr>
</tbody>
</table>

In addition to these minima, 18 more minima published by BBSAG [5] have been analyzed. A linear regression on these 146 minima leads to the following ephemeris:

\[
\text{Min I (or II) = JD } 2442903.235 + 0.40116150 \cdot E + 48 \pm 12 \pm 148
\]  

(98% level of confidence for error bars)

The ephemeris refers to primary or secondary minimum because, once more, it was impossible to discriminate between them (as we will see later).

Table 2 lists all minima showing the O-Cs with respect to
this ephemeris. Residuals are comparable with intrinsic accuracy of visual observations; it results $\sigma_{o-c} = 0.010^d$ which is a typical value for a short period variable observed visually. Only one minimum lies beyond $\pm 3\sigma$, which is a further confirm of reliability of visual observations.

In order to check the ephemeris (1), the composite light curves obtained by the two more productive observers are shown in figg. 6.7. Each dot represents the moving average over an interval of 0.04 period; each interval is shifted by 0.02 period with respect to the previous one. The reason of using moving averages is to filter observing errors without affecting the general shape of the curve.

The shape of these curves is consistent with the hypothesis of an EW-type variable. Both curves show a difference between the two minima, but these differences are too small to be considered significant. The phases of minima are very close to 0.00 and 0.05, which confirms the validity of ephemeris (1).

Conclusion

A revised ephemeris for PP Lac has been calculated, assuming the EW classification for the star. This conjecture will be checked in a following paper by means of photoelectric observations planned by GEOS members at Jungfraujoch Observatory.

Antonio Maraziti

Bibliography

fig. 1.

fig. 2.

PP Lac - RAL
30 Jul 1958