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AN IMPORTANT FEATURE OF THE ORBITAL-PLANE ORIENTATIONS FOR BINARIES

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SUMMARY: We find that any really close concentration of positions of poles of orbital planes for binaries is not affected by the corresponding positions of "mirror poles" for the same orbital planes. Namely, strong concentrations of positions of the true poles imply a complete isotropy in the distribution of the corresponding positions for the mirror poles.

Key words. binaries: visual

1. INTRODUCTION

It is well known that a reliable knowledge of the orbital-plane orientation exists for few binaries only. The impossibility of an unambiguous determination of the orbital-plane poles is due to the fact that the quadrant of the ascending node of the orbit is unknown. Therefore, we approach the problem by assuming both solutions for the ascending-node position (Ω, i.e. $\Omega + 180°$). One of the two obtained poles is true, the other one is not; it is the so-called "mirror" pole. Our starting assumption is: if there is any special property in the orientation of poles, i.e. in that of orbital planes, then this property will also be in the approach with two solutions. This is due to the fact that the probability of obtaining the correct node position from the catalogue values of Ω is equal to the probability that the node position should be corrected by 180°.

Using the Sixth Catalog of Orbits of Visual Binary Stars (Hartkopf and Mason 2003) we calculate the positions of orbital-plane poles for 1400 binaries, thus yielding the positions for 2800 poles (1400 poles with Ω and 1400 poles with $\Omega + 180°$ as input data).

The distribution of obtained positions of the poles approaches an isotropic one. The only thing seen from it is a division of these positions into two groups. This is due to the convention that for the ascending node one always assumes $\Omega < 180°$. The global view of the distribution (Figs. 1, 2 and 3) really indicates a complete isotropy. The concentrations of the pole positions towards small regions of the sphere yield no significant contrast compared to the surrounding background.

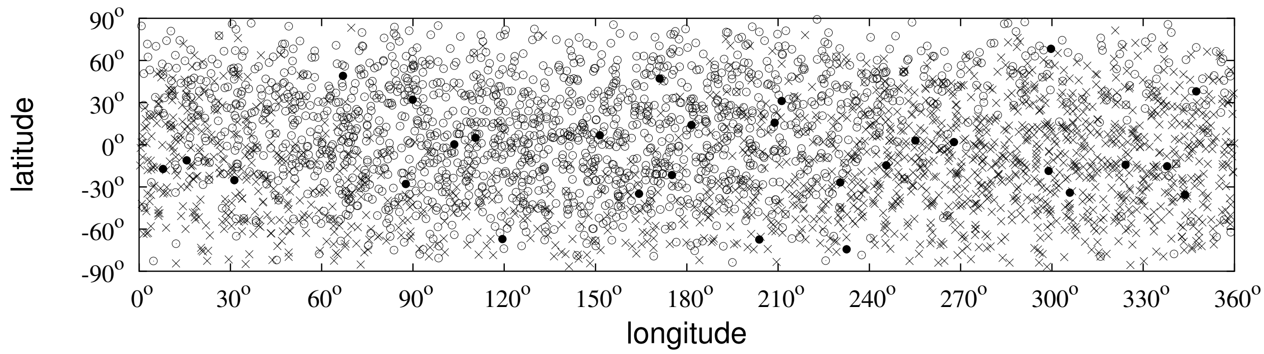

Fig. 1. *(Top) the global view of the distribution for calculated poles: true ones (○), mirrors (×) and binaries with known ascending nodes (●); (middle) distribution of all poles in longitude; (bottom) distribution of all poles in latitude.*

The formulae for calculating the poles of orbital planes for binaries with regard to the change in the input data (Ω or $\Omega + 180°$) must yield different values for the pole positions, resulting in their different distributions. However, the effect of the changed distributions and their densities (change in the input data concerning Ω) cannot be clearly seen from the formulae only. Therefore, we introduce a special example, i.e. we compare two fields of the pole-position density: one for the true poles and one for the corresponding "mirrors". More precisely, we select the poles from the Sixth Catalog of Orbits of Visual Binary Stars for which the positions are highly concentrated, to calculate afterwards the corresponding "mirrors". The comparison of the density fields clearly shows that any existence of a real group of highly concentrated poles is not affected by the density field of the "mirrors".

The present study is aimed at demonstrating that any true distribution of poles cannot be masked by the corresponding distribution of the "mirror poles". This fact is important in the present approach since the pole orientation is derived from an ambiguous solution.

Fig. 2. *(Top) distribution of the true poles in longitude; (bottom) distribution of the mirror poles in longitude.*

Fig. 3. *(Top) distribution of the true poles in latitude; (bottom) distribution of the mirror poles in latitude.*

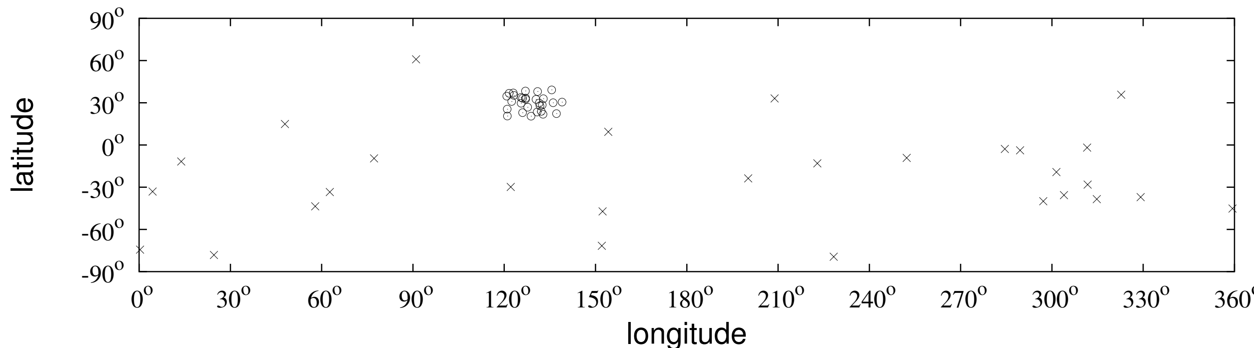

Fig. 4. *Calculated poles from the region around $l = 130^\circ\!.8$, $b = 30^\circ\!.2$: true ones ($\circ$) and mirrors ($\times$).*

Fig. 5. *The density-field function $\Phi(l_j, b_j)$ in 3D.*

2. AN EXAMPLE OF A TRUE POLE CONCENTRATION REGION

As it can be seen from Fig. 1 (also Popović et al. 2003) around the position $l = 130^\circ\!.8$, $b = 30^\circ\!.2$ there is a strong concentration of the poles. This is the reason to choose this position with its immediate surroundings ($\Delta l = \pm 10^\circ$, $\Delta b = \pm 10^\circ$) as a "true concentration region". By separating the stars with the orbital poles in this region it is possible to calculate also the positions of the "mirror poles". In Fig. 4 we present the calculated poles: "true" and "mirror" ones. It becomes immediately clear that, if there is any strong concentration of true poles, the concentration of their "mirrors" will be spread out.

Since the input data are the catalogue node positions (according to the convention always less than 180°) the "mirror positions" appear in an isotropic form, but only to the limits allowed by that convention.

The density field is examined mathematically by using a function $\Phi(l_j, b_j)$ defined as the sum of the squares of cosines (Eq. (1) - Popović 1993) for the angle obtained by connecting each pole position $(l_\circ, b_\circ)$ with n network points (l_j, b_j) in the galactic coordinate system with resolution of 1°.

$$\Phi(l_j, b_j) = \sum_{i=1}^{n} \cos^2 x_{ji} =$$

$$= \sum_{i=1}^{n} [\sin b_j \sin b_{\circ i} + \cos b_j \cos b_{\circ i} \cos(l_{\circ i} - l_j)]^2. \quad (1)$$

In Fig. 5 the density-field function $\Phi(l_j, b_j)$ is presented in a 3-dimensional form.

For this way of considering the problem one may also ask the following question: How high is the probability for a concentration of false poles, i.e. of "mirror poles"? The answer is: This probability is low. The reason is: if there are n realistic isotropies in the distribution of pole positions, then in $n-1$ cases they will also generate an isotropy in the distribution of mirror-pole positions, whereas in only one case this will not occur. Thus the existence of possible concentration areas of pole positions should be treated as a reality in the approach of ambiguous calculation of orbital poles.

3. CONCLUSION

The analysis presented in this paper clearly indicates that the selected field of high concentration for orbital planes of binaries has not also as a direct consequence a high concentration of the corresponding positions of their "mirror poles". In other words, the positions of the "mirrors" do not contribute to the increasing of the density of the true poles.

An alternative formulation of the conclusion may be: if in the general distribution of poles centres of high concentration of their positions are conspicuous, then they are realistic to a high probability.

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ЈЕДНА БИТНА КАРАКТЕРИСТИКА ОРИЈЕНТАЦИЈЕ ОРБИТАЛНИХ РАВНИ ДВОЈНИХ ЗВЕЗДА

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Оригинални научни рад

У раду је показано да на евентуалне реалне високе концентрације положаја полова орбиталних равни двојних звезда не утичу одговарајући положаји "полова огледала" ових орбиталних равни. Наиме, високе концентрације положаја реалних полова повлаче потпуну изотропију у расподели одговарајућих положаја "полова-огледала".