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METHODOLOGY OF NUMERICAL OPTIMIZATION FOR ORBITAL PARAMETERS OF BINARY SYSTEMS

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The use of a numerical method of maximization (or minimization) in optimization processes allows us to obtain a great amount of solutions. Therefore, we can find a global maximum or minimum of the problem, but this is only possible if we used a suitable methodology. To obtain the global optimum values, we use the genetic algorithm called PIKAIA (P. Charbonneau) and other four algorithms implemented in Mathematica. We demonstrate that derived orbital parameters of binary systems published in some papers, based on radial velocity measurements, are local minimum instead of global ones.

Six parameters are need to obtain the relation between the radial velocity curve and the orbital elements. The orbital parameters are: the orbital period (P), the time of periastron passage (τ), the longitude of the periastron (ω), the orbital eccentricity (e), the orbital velocity amplitude (K), and the system's radial velocity (V_0).

Numerous numerical methods have been used to infer these parameters from the observed radial velocity, we treat this fitting problem as a nonlinear least-squares minimization problem.

In order to perform the optimization fit, first a data set of the radial velocity are obtained V_j^{obs} based on the time (t_j), with its respective error estimate (σ_j). The adjustment becomes by nonlinear least-square minimization, here we used the statistical estimator χ^2. The function to optimize is defined by the following expression:

$$\chi^2(P,\tau,\omega,e,K,V_0) = \frac{1}{N-6}\sum_{j=1}^{N}\left(\frac{V_j^{\mathrm{obs}} - V(t_j;P,\tau,\omega,e,K,V_0)}{\sigma_j}\right)^2 .$$

The normalization factor $1/(N-6)$ indicates if ours $\chi^2 \lesssim 1$ the fit is acceptable, where 6 corresponds the number of degrees of freedom (parameters) of the fit and N is the number of observations. V_j^{obs} is the observed radial velocity and $V(t_j;P,\tau,\omega,e,K,V_0)$ is the radial velocity in the time t_j giving for the estimate parameters.

TABLE 1

Parameters	Carrier(2001)	This work
$P[HJD]$	49.699 ± 0.016	49.707
$\tau[HJD] - 2450000$	1993.39 ± 0.19	1993.01
ω [Radians]	5.6845 ± 0.029	5.6081
e	0.393 ± 0.008	0.409
$K[\mathrm{km}^{-1}]$	9.95 ± 0.17	9.724
$V_0[\mathrm{km}^{-1}]$	0.33 ± 0.08	0.073
χ^2	**1.0358**	**0.6654**

We make a comparison with the parameters found by Carrier (2002) for HD141929. Using the data set and the parameters published by Carrier (2002), we found the following in Table 1.

The χ^2 calculated by Carrier (2002) corresponds to a local optimum and that our χ^2 has a high probability to be a global optimum. We can affirm this with great confidence, because our methodology guarantees the obtaining of the global optimum.

Our methodology can be summarized as follows:

- To change the **randomseed** whenever the algorithm (e.g.,PIKAIA) is used.
- Among the options our algorithm owns, is to use an amount of iterations in each execution. We recommend to use a suitable value, whose number will depend to the amount of data that is used.

This methodology not only must be used for this work, but also must be used in any other processes where we want to find a global optimum.

A future work is to find the confidence limits of the fit parameters by us.

REFERENCES

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