AN INTRODUCTION TO GENETIC ALGORITHMS FOR NUMERICAL OPTIMIZATION

Solutions for Exercises of Section 4

Exercise 1:

I obtained a best-fit solution using both the GA2 and GA3 versions of `PIKAIA`. GA3 was run for 2500 generations, but GA2 required 5000 to consistently produce a fit with $\chi^2 \leq 1.5$. Here again creep mutation seems to help. Default values were used for all other input parameters.

The following Table lists the parameters of my best-fit solution to the ρCrB data, as well as the orbital parameters originally determined by Noyes *et al.* 1997

Orbital parameters for ρCrB

Parameter	Units	Best-fit	Noyes *et al.* 1997
P	days	39.858	39.645±0.088
τ	HJD	245.11	413.7±8.2
ω	degree	129.64	210±74
e		0.1378	0.028± 0.040
K	m s^{-1}	64.544	67.4±2.2
V_0	m s^{-1}	-45.607	not listed

My best fit solution has a reduced $\chi^2 = 1.414$; examination of the solution's convergence reveals that some troublesome numerous secondary minima exist, with $\chi^2 = 1.66$ and $\chi^2 = 1.90$. These have eccentricities $e \simeq 0.6$ and 0.7, which would lead to significantly different physical interpretation as to the unseen planetary companion. The Figure below is a plot of the ρCrB data, together with the best-fit solution.

There are clearly significant differences differences between my best-fit solution and the Noyes *et al.* solution. They have to do with the the fact that the Noyes *et al.* dataset does not include the group of data at JD-2450000$\simeq$ 380, and three data with high residuals were omitted from the final analysis; I just took all data and errors at face values and carried out the fit on the whole dataset. As a further exercise you might want to repeat the analysis using only the data retained by Noyes *et al.*

The difference in the times of periastron passage τ are in part an artefact of the zero-point definition for time; adding 4 times the period to my best-fit τ yields $\tau = 404.54$, which falls within the one-σ estimates given by Noyes *et al.* The large estimated errors on ω and τ reflect the difficulty of estimating ω and τ for a nearly circular orbit.

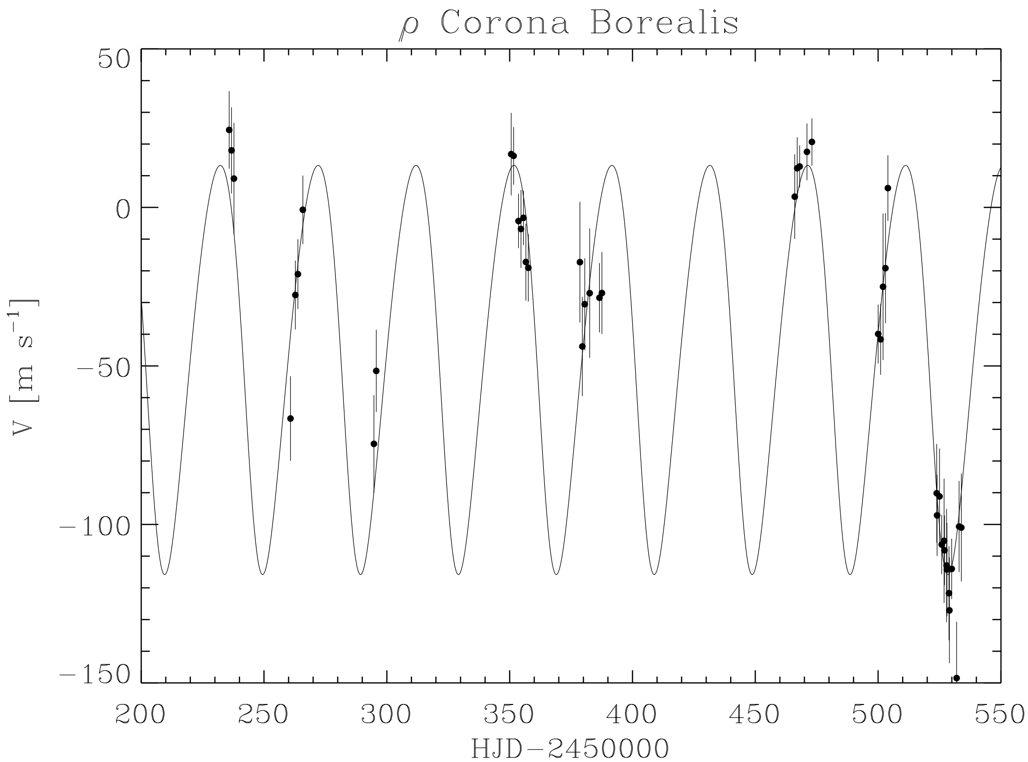

Figure 4.1: Data and best-fit solution for the star ρCrB. Because the orbit is nearly circular ($e \simeq 0.1$), the radial velocity curve is very nearly sinusoidal.

Exercise 2:

Think a bit about a circular orbit, versus an elliptical one. In a circular orbit there is no aphelion nor perihelion; this means that from the point of view of fitting an elliptical orbit to velocity data arising from a circular orbit, the fit is completely degerenate with respect to longitude of perihelion ω and time of perihelion passage τ; any point along the orbit can serve as perihelion, *provide that the time of perihelion passage be adjusted accordingly.* Put otherwise, with a circular orbit there is an infinite set of (ω, τ) pairs that lead to the exact same velocity curve.

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