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HW 03: AN ECLIPSING BINARY IN THE LMC

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1. AN ECLIPSING BINARY IN THE LMC

1.1. *1.1 Orbital Size, Sum, Stellar Masses*

$$a_1 = \frac{K_1 P_1}{2\pi} \tag{1}$$

$$OrbitalSize = (a_1 + a_2) \tag{2}$$

Equation refsemi had the input parameters of semi-amplitude (K), period (P). The orbital size calculated was 1.3068 AU with equation 2. The total sum of the stellar masses, found with Kepler's law was 6.4789 $M_\odot$.

1.2. *1.2 Mass Ratio and Individual Masses*

The mass ratio from the division of K_2 and K_1 was found to be 1.0312. Using the sum of stellar masses and the mass ratios, the masses of each individual star was 3.1896 $M_\odot$ and 3.2893 $M_\odot$.

1.3. *1.3 Angular Sizes and Distance to the LMC*

$$\kappa + 5 \log \phi = 2.76 + 0.252(V - K) \tag{3}$$

The Barnes-Evans equation in equation 3 gave two phi values of 0.0887° and 0.0795° for the apparent magnitudes 14.895 and 15.446, respectively.

$$\tan \theta = r/D \tag{4}$$

Equation 4 was used to calculate the angular sizes (D) of the two stars. From the physical sizes 26.06 $R_\odot$ and 19.76 $R_\odot$, the respective distances were 16829.52625 $R_\odot$ and 14247.6664 $R_\odot$.

2. 2.0 ELLIPTICAL ORBITS

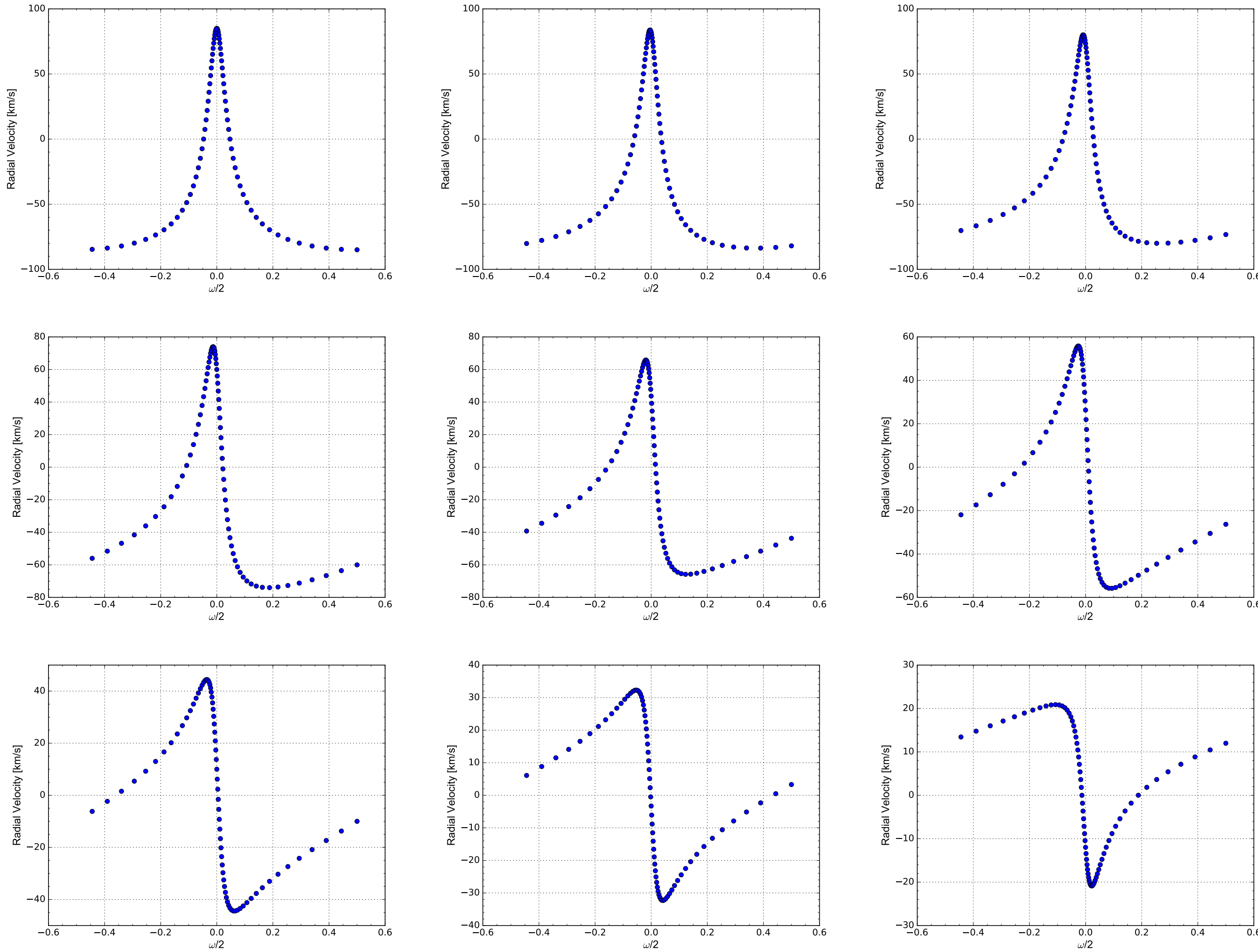

Figure 1. Elliptical orbits for increasing true anomaly of 5° and periastron of 20° increments.

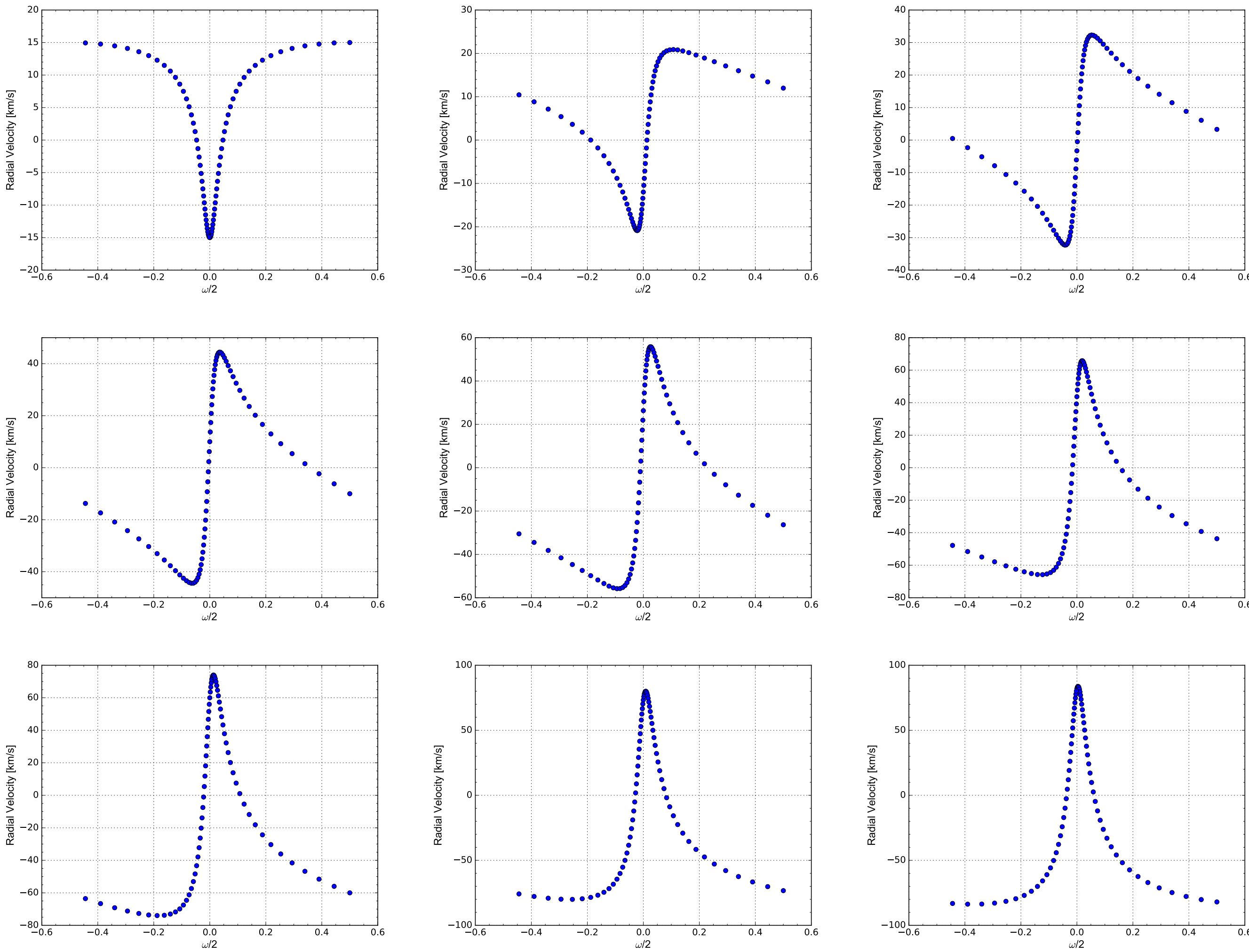

Figure 2. Elliptical orbits for increasing true anomaly of 5° and periastron of 20° increments.

3. 3.0 PERIOD SEARCH USING RADIAL VELOCITY DATA

The heliocentric radial velocity data is provided in table 1 in the appendix.

3.1. *Method of Lafler and Kinman*

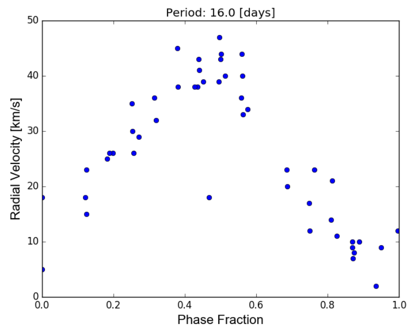

Figure 3. The best period plot using period increments from 3 to 40 days.

$$\Theta = \frac{\sum_i (m_i - m_{i+1})^2}{\sum_i (m_i - \bar{M})^2} \tag{5}$$

Figure 3 was generated using the Lafler and Kinman method, equation 5, to find the period. The period that yielded the lowest Θ value was 16.0 days. The 16 day period yields a semi-amplitude radial velocity of 46.6146 km/s. This is compared to the SIMBAD radial velocity for NGC 2346, which was 47 km/s.

3.2. *Lomb-Scargle Method*

The Fast Lomb-Scargle method outlined in *gatspy* yielded a period between 3 and 40 days of 15.9925318331. This result agrees within 0.1 of the Lafler and Kinman method, which produced a period of 16 days.

4. APPENDIX

```
import datetime
import numpy as np
import matplotlib.pyplot as plt
from astropy.stats import sigma_clip
from numpy import mean
from astropy.io import fits as fits
from astropy import units as u
from astropy.coordinates import SkyCoord
from matplotlib.patches import Rectangle
from astropy.coordinates import Angle
from scipy import ndimage
from astropy import units as u
import ccdproc
import pyfits
from matplotlib.colors import LogNorm
from astropy.stats import LombScargle
import astropy.units as u
from gatspy import periodic

JD = []
V = []

JD = np.genfromtxt("rv2346.dat", usecols = 0)
V = np.genfromtxt("rv2346.dat", usecols = 1)

#period = np.arange(15, 17, 0.1)
#period = np.arange(16, 17, 0.0000000000001)
'''
for i in period:
  plt.clf()
  phase_frac = (JD - JD[0])\%i/i
  plt.plot(phase_frac, V, "o")
  plt.xlabel('Phase Fraction', fontname="Arial", fontsize = 16)
  plt.ylabel('Radial Velocity [km/s]', fontname="Arial", fontsize = 16)
  plt.title("Period: "+str(i)+" [days]")
  plt.show()
'''
plt.clf()
model = periodic.LombScargleFast(fit_period=True)
model.optimizer.period_range = (3.0, 40.0)
model.fit(JD, V, None)
print(model.best_period)
```

Listing 1. Python example

Table 1. Radial Velocities.

Julian Date	Radial Velocity [km/s]
43138.66	5.0
43140.654	23.0
43141.829	26.0
43142.775	26.0
43143.702	36.0
43144.758	38.0
43146.664	43.0
43147.651	40.0
43200.559	10.0
43878.7	30.0
43879.778	32.0
43880.731	45.0
43881.689	43.0
43881.717	41.0
43882.698	44.0
43883.673	33.0
43885.651	20.0
43886.657	12.0
43887.661	21.0
43888.647	8.0
43890.668	18.0
43892.643	15.0
43893.675	26.0
43894.682	35.0
43914.591	39.0
43915.598	36.0
43920.569	9.0
44137.879	39.0
44138.859	40.0
44139.868	34.0
44142.869	23.0
44143.874	11.0
44144.87	10.0
44145.861	9.0
44265.633	38.0
44266.6	47.0
44267.625	44.0
44269.615	23.0
44270.628	17.0
44271.608	14.0

Table 1 continued on next page

Table 1 *(continued)*

Julian Date	Radial Velocity [km/s]
44272.585	7.0
44273.631	2.0
44274.603	12.0
44276.607	18.0
44277.571	25.0
44377.486	38.0
56967.004	29.0
56970.135	18.0

NOTE—Heliocentric radial velocity against Julian Date. Note that the number 2400000 is subtracted from the provided Julian Date.