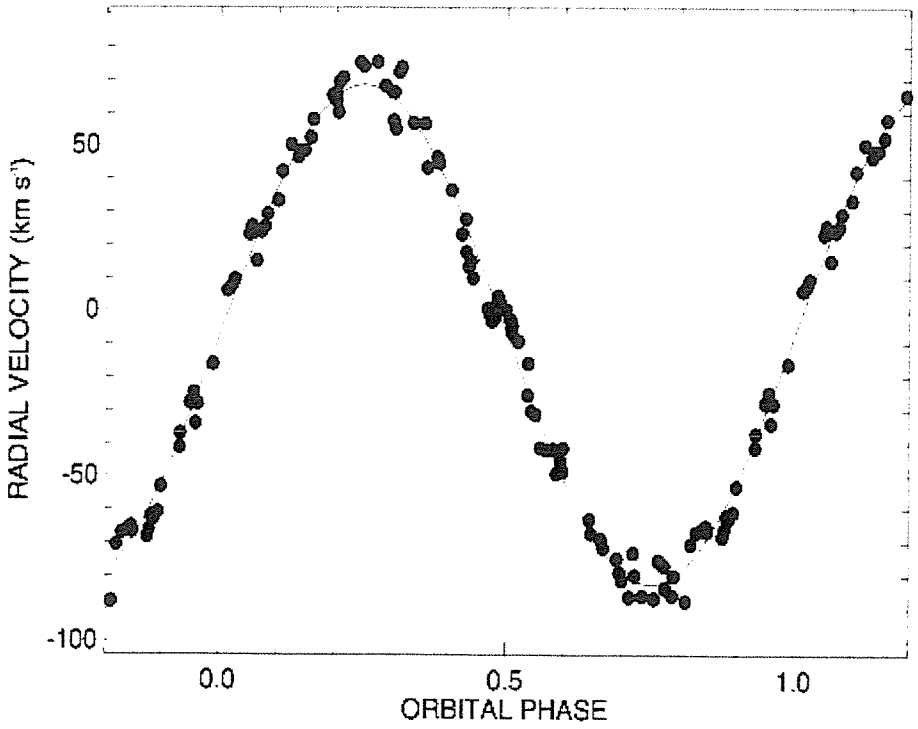
ASTR 205: Stellar Astronomy
Class Assignment 5: Feb 15 2019

1. A **real** single-lined spectroscopic binary has the radial velocity curve shown below. The period is 5.6 days and the radial velocities are indicated in units of km/sec along the y-axis. The visible star is an O-supergiant with a mass of 19.2 solar masses. A recent study suggests that the orbit of the binary is inclined by 48 degrees to the line of sight. Provide as much information as you can about this system including the velocity of this star in its orbit, an estimate of the radius of its orbit, an estimate of the mass of the unseen component, some comments about the nature of the unseen component, and anything else you can learn about the system.



$P = 5.6^d = 4.8 \times 10^5$ sec.

Observed $V_r = 75$ km/sec.

Corrected for inclination:

$$\frac{75}{\sin 48} = 101 \text{ km/sec.}$$

∴ circumorbit $= 101 \times 4.8 \times 10^5 = 4.8 \times 10^7$ km

∴ Radius orbit $= \frac{4.8 \times 10^7}{2\pi}$

$= 7.7 \times 10^6$ km.

$1 AU = 1.5 \times 10^8$ km

∴ Separation $= .05\ AU = 11\ R_\odot$

(eg Mercury $= 0.39\ AU$)

Estimate mass under component use Mass Function

$$PV_1^3/2\pi G = \frac{M_2^3 \sin^3 i}{(M_1 + M_2)^2}$$

M_2 is unseen star - probably not correct $M_1 << M_2$ so can ignore M_1 and $\sin i$ use full expression

$\sin^3 i =$ 19.2 $M_\odot$ =

$V_1 = 75{,}000$ m/sec. masses in kg.

$$\frac{(4.8\times10^5)\times(7.5\times10^4)^3}{2\pi\times 6.67\times10^{-11}} = \frac{M_2^3\times 0.41}{(3.8\times10^{31}+M_2)^2}$$

(~~1.47 $\times10^{33}$~~)

∴ ~~4.8 $\times10^{29}$~~

$$1.2\times10^{30} = \frac{M_2^3}{(3.8\times10^{31}+M_2)^2}$$

To solve:

If ignore M_1 then $M_2 = 1.2\times10^{30}$
not realistic

Guess at solutions

e.g. 15 $M_\odot$ = 3×10^{31}

then RHS 2.8×10^{30} (too big)

e.g. 10 $M_\odot$ = 2×10^{31}

then RHS = 2.3×10^{30} still bit large.

Last try 8 $M_\odot$ = 1.6×10^{31}

then RHS = 1.4×10^{30} close

So mass unseen ≃ 8 $M_\odot$
(Real value ≃ 14)

∴ Black hole.