Astronomy 45. Introduction to Astrophysics

Problem set 1 Due Friday, February 14

1. The synodic period of a planet (S) is defined as the time interval between successive oppositions or conjunctions, whereas the sidereal period (P) is the amount of time necessary to make a complete orbit relative to the background stars.

a) Derive the following relationships between the synodic and sidereal periods

$$\frac{1}{S} = \frac{1}{P} - \frac{1}{P_\oplus}, \quad \text{for inferior planets}$$

$$\frac{1}{S} = \frac{1}{P_\oplus} - \frac{1}{P}, \quad \text{for superior planets,}$$

where $P_\oplus$ is the sidereal period of Earth. (Hint: it might be easier to work in the rotating frame of reference in which Earth is stationary.)

b) Which planet in the Solar system has the shortest synodic period and why? Compute this period (in days) using the fact that $P_\oplus = 365.26$ days, and the following table.

Planet	Period (yr)	Planet	Period (yr)
Mercury	0.2408	Saturn	29.4577
Venus	0.6152	Uranus	84.0139
Earth	1.0000	Neptune	164.793
Mars	1.8809	Pluto	248.54
Jupiter	11.8622		

2. Using the understanding of synodic periods and/or rotating frames from the previous problem:

a) Calculate the time it takes Venus to transit (cross) the Sun, if it crosses at an apparent latitude on the Sun's disk of 42°N. You can take the angular diameter of the Sun, as seen from Earth, to be 32 arcminutes. The period of Venus' orbit is 0.615 years.

b) Two observers on Earth are separated by a North-South distance of 8000 km. How different are the apparent latitudes on the Sun's disk at which they see Venus cross? That is, if the N observer sees $42.0000°$N, what does the S observer see.

c) What is the difference in absolute time between when the N observer sees Venus first touch the Sun, and when the S observer sees this. That is, if it occurs for the N observer at 11:00:00.000, when does it occur for the S observer (in the same time zone?) (You can assume that Venus is a point for this estimate, if you want.)

3. In 1672, an international effort was made to measure the parallax angle of Mars at the time of the opposition, when it was closest to Earth.

a) Consider two observers who are separated by a baseline equal to Earth's diameter. If the difference in their measurements of Mars' angular position is $33.6''$, what is the distance between Earth and Mars at opposition?

b) If the distance to Mars is to be measured to within 10%, how closely must the clocks used by the two observers be synchronized? (Hint: Use the average orbital velocities of Earth and Mars, you should have enough information in this problem set to compute them. Can the Earth's rotation be ignored in this problem?)

4. Proxima Centauri is the closest star to the Sun and is a part of a triple star system. It has the epoch 1950.0 coordinates $(\alpha, \delta) = (14^h 26.3^m, -62°28')$, while the brightest star in the system, α Centauri is located at $(\alpha, \delta) = (14^h 39.6^m, -60°49.8')$.

a) What is the angular separation between the two stars?

b) If the distance to Proxima Centauri is 4.3 lyr, what is the projected distance between the two stars? The distance to α Centauri is roughly 4.4 lyr. What is the distance between the two stars?

c) The apparent visual magnitudes of the three stars in a triple system are 0.0, 1.3, and 11.0 (α Centauri being the brightest and Proxima Centauri the dimmest). What is the total apparent magnitude of the system? What is the total flux observed in the visual band?

d) Compute the absolute magnitudes of the three stars (it is necessary to make some assumption about the distance to the third star). Based on this result, what are their approximate spectral types and masses?