Mercury's Rotational Period: Exercise 20

Lab Procedure

1. Choose one of the time delayed signals in Figure 20-2 and calculate the distance beyond the sub-radar point (d) that the beam has traveled.

$d = 1/2 * c * \Delta t =$ ______________________ Equation 1

$c = 3.0 \times 10^8$ m/s (speed of light)
Δt = delay time in microseconds (10^{-6} s)

2. In Figure 20-3 the lengths x and y are given by

$x = R - d$ Equation 2

$y = (R - x)^{1/2}$ Equation 3

where R is the radius of Mercury = 2.420×10^6 m. Calculate x.

$x = R - d = 2.420 \times 10^6 -$ ___________________ = ____________________

Use the result for x to find y.

$y^2 = (2.420\mathrm{x}10^6\mathrm{m})^2 - ($____________________$)^2 =$ ____________________ m^2

Take the square root of your result above to get y.

$y = ($___________________$)^{1/2} =$ _______________________

3.Using the previously selected signal from Figure 20-2 find V . the observed line-of-sight component of the rotational velocity at some point indicated in Figure 20-3. the Doppler equation is generally stated in terms of a change in wavelength (λ) relative to the "rest wavelength (λ), but it can also be stated in terms of the frequency (f)

$$V_o = \frac{\Delta f}{f} c$$ Equation 4

where Δf is the change in frequency

f is the frequency of the signal = $4.30 \times 10^8\ \mathrm{s}^{-1}$ (hertz)
V_o is the observed velocity
c is the speed of light (radar wave, 3×10^8 m/s).

Examine the selected radar signals in Figure 20-2 and mark with a pencil the points to the left and right of center where the relative power begins to drop down to the baseline. read off the frequency change (Δf) as accurately as you can. Disregarding algebraic signs (+, -) add the frequency changes for the two shoulders together and divide by two. **The actual frequency shift (Δf), is half the value obtained from Figure 20-2 as this is a reflected signal and the radar pulse is shifted "going in" and again in "coming out."** Calculate V_o in meters per second.

$$\Delta f = \frac{\Delta f}{2} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ s^{-1}(hertz)$$

$$V_o = \frac{\Delta f}{f} c = \frac{\text{-------------------------}}{4.3 \times 10^{8}\ s^{-1}}\ s^{-1} * 3 \times 10^{8} m/s = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ m/s$$

4. From the line-of-sight component V_o , calculate V, the foreshortened rotational velocity. Inspect Figure 20-3 and note that the triangle containing x, y, and R is similar to the triangle containing V_o and V. Hence,

$$\frac{V}{V_o} = \frac{R}{y} \qquad \text{Equation 5}$$

Calculate V from equation 5. The result is the true rotational velocity in meters per second.

$$V = V_o \frac{R}{y} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \text{ m/s}$$

Insert your values for y, R, and V_o

5. Calculate Mercury's rotational period by dividing V into the circumference of Mercury = 1.520×10^{7} meters.

Period = 1.520×10^{7} meters /__________________ = ____________________ seconds

Since the above period is in seconds and we want it in days divide the period by the number of seconds in one day (3600 seconds/hour * 24 hours/day = 86,400 seconds/day).

Period (days) = ______________________/86,400 = _______________________ days

Calculate the percent error given that the actual rotational period of Mercury is 56.6 days.

Percent Error = _______________________ %

Discussion Questions

1. What are some possible reasons why Schiaparelli observed an 88 day rotation period?

2. In order to minimize the motions of the two planets (motion along the line of sight), what would be the ideal time to make this set of observations? Explain.

3. Venus' rotation is considerably slower than Mercury's. If this method was used on Venus, would the frequency change be larger or smaller than that for Mercury? (Keep in mind that the planets are not the same size.) Explain.