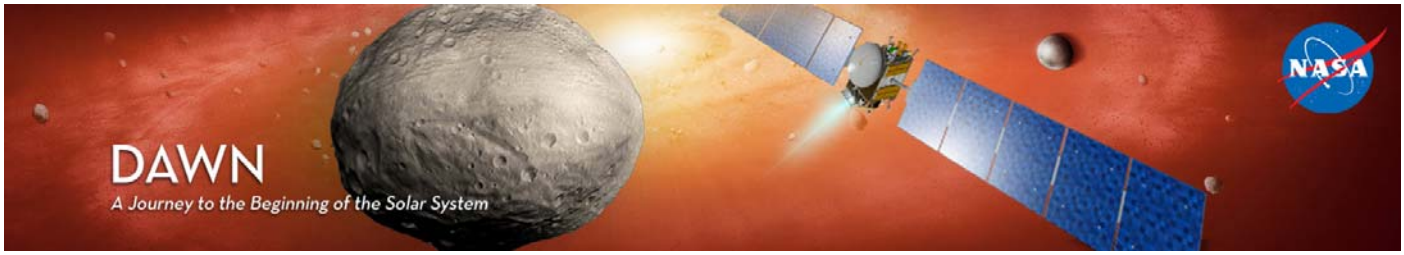

Interactions of Energy and Matter: Dawn Instrumentation

Gravity Mapping: Measuring Mass Concentration

STUDENT ACTIVITY

Words in bold and italics may be found in the Dawn Dictionary (http://dawn.jpl.nasa.gov/dictionary/index.asp) on the Dawn Mission website.

In this activity you will use some simulated, but realistic, data that correlates with a shape model and simulated surface of Vesta (see Figure 1), one of the asteroids that the instruments on the Dawn spacecraft will be mapping. These data includes the ***latitude*** and ***longitude*** coordinates of data points at which a change in the ***line-of-sight velocity*** of the spacecraft was determined by ***Doppler shifts***. By mapping and connecting data points having the same ***velocity***, we can identify areas of relatively high and low ***mass concentrations***.

Useful Terminology for This Activity

Longitude: The imaginary lines drawn through the North and South Poles of a body, such as the Earth or Vesta. Their angular distance (in degrees) is measured from a prime meridian (designated **0** in Figure 1 above) with positive values going east and negative values going west.

Latitude: The imaginary lines that denote the distance north or south of the equator of a body. Their angular distance (in degrees) is measured from the equator of Vesta (designated **0** on the left side in Figure 1 above) with positive values going north and negative values going south.

Line of sight velocity: The component of the velocity of a body, such as a spacecraft, that is parallel to a line from an observer or reference point to that body.

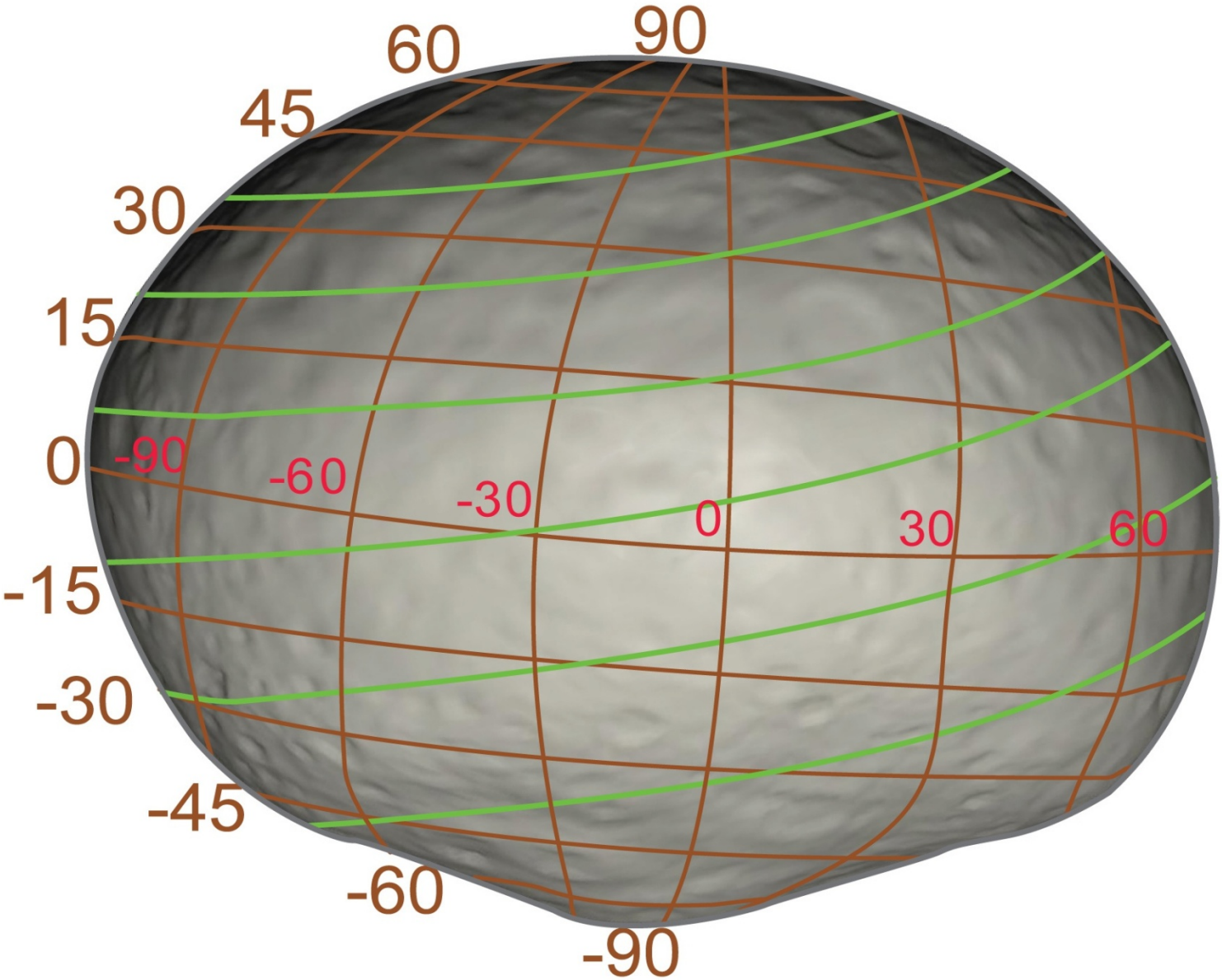

Figure 1. Shape model and simulated surface features of Vesta.

Table 1.

Area 1			Area 2		
Line of Site	Longitude	Latitude	Line of Site	Longitude	Latitude
velocity m/s	degrees	degrees	velocity m/s	degrees	degrees
195	12	3	195	-95	15
(green)	2	-1	(green)	-90	8
	-8	-15		-75	7
	-2	-25		-60	8
	12	-30		-50	13
	30	-20		-48	15
	40	-15		-40	23
	30	-5		-45	30
				-60	35
200	10	-2		-75	34
(yellow)	2	-8		-90	30
	0	-20		-93	20
	15	-25			
	25	-15	190	-90	20
	28	-10	(turquoise)	-83	15
	25	-5		-75	10
	15	-2		-60	12
				-50	15
203	9	-7		-48	20
(orange)	7	-15		-50	25
	12	-17		-60	30
	15	-14		-75	28
	14	-8		-80	25
206	11	-13	185	-60	22
(red)	9	-14	(blue)	-75	25
	13	-16		-80	18
	12	-14		-77	12
				-60	13
				-55	18
			182	-63	17
			(purple)	-62	20
				-65	21
				-76	18
				-74	17

Procedure

1. Make a ***gravity*** map of the surface of Vesta by plotting the data points in Table 1 on a full-size copy of the Figure 1, which shows latitude and longitude lines on a model surface of Vesta. Use different colored pen/pencils for each of the different spacecraft velocities. Plot the data points and connect those points with lines using the following color scheme:
   195 m/s — green
   200 m/s —yellow
   203 m/s — orange
   206 m/s — red
   190 m/s — turquoise
   185 m/s — blue
   182 m/s — purple

Starting with the center of each area, fill in the area defined by the lines with the color of the lines. For example, color the area enclosed by the red lines red. Then use the orange pen to fill in the area between the red lines and the orange lines. In the other area, fill the enclosure outlined by purple lines with the purple. Then fill the area between the purple and the blue lines with blue.

2. Now, just as scientists do, you need to analyze the data. Record your answers in the space below each question and be ready to defend your answers in the follow-up class discussion.

After studying the locations where the spacecraft changed line-of-sight velocities, interpret these velocity changes (or Doppler shifts in radio signals) in terms of increasing or decreasing mass concentrations by answering the following questions relating to

a) Area 1—defined by -8 to 40 degrees longitude and +3 to -30 degrees latitude.
   1) How does the line-of-sight velocities change as you move from the outer to the inner regions of this area?

   2) What does this change indicate regarding the mass concentration in this area with respect to that on either side of the area.

   3) What *might* this change in mass concentration indicate in terms of the ***topography*** of the area with respect to that on either side of the area?

   4) Why might the change in line-of-sight velocities of the spacecraft *not* be an indicator of a change in the topography of Vesta's surface in this area?

b) Area 2—defined by -40 to -95 degrees longitude and +35 to +7 degrees latitude.
   1) How does the line-of-sight velocities change as you move from the outer to the inner region of this area?

2) What does this change indicate regarding the mass concentration in this area with respect to that on either side of the area?

3) What *might* this change in mass concentration indicate in terms of the topography of the area with respect to that on either side of the area?

4) Why might the change in line-of-sight velocities of the spacecraft *not* be an indicator of a change in the topography of Vesta's surface surface in this area?

c) Can you make any inferences about the Dawn spacecraft's line-of-sight in the space between the two areas of Vesta's surface for which we have no data measurements?
Why or why not?

What additional information would you need to know before you could make inferences regarding this space?