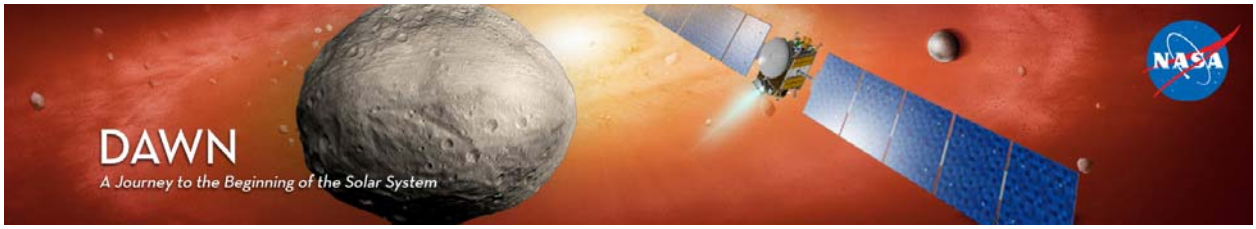

Interactions of Energy and Matter: Dawn Instrumentation

Student Script: VIR PowerPoint

STUDENT SCRIPT TO ACCOMPANY VIR POWERPOINT

This text is designed to accompany the PowerPoint presentation that describes the design and function of the Visible and Infrared Spectrometer (VIR) that is part of the Dawn Spacecraft Instrumentation Package. This information will help you answer the questions in the VIR Student Report Sheet. The bold, italicized words can be found in the Dawn Dictionary at http://dawn.jpl.nasa.gov/dictionary/index.asp.

> ***Note: Some of the slides in this presentation include some animation effects. The instruction to {click} indicates that you should use either a keystroke or a mouse depression to advance the animation.***

Slide 1
VIR is one of the scientific instruments in the payload of the Dawn spacecraft. The Dawn Mission is designed to increase our understanding of the conditions and processes that were happening during the solar system's earliest epoch. Surface mineralogical data from VIR will give scientists a better understanding about how two large asteroids, Vesta and Ceres, evolved.

{click to Slide 2}
The VIR is a ***Visible*** and ***Infrared Imaging Spectrometer***. In this section, we will be learning more about the VIR, including what it does and how it does it.

{click to Slide 3}

Write your answers to the following questions on your *VIR Student Report Sheet*:

What region of ***electromagnetic radiation*** (EMR) from Ceres and Vesta will the VIR measure?

What frequency and wavelength regions of EMR are classified as visible radiation?

What frequency and wavelength regions of EMR are classified as infrared radiation?

How does the ***energy*** of visible and infrared compare with the energy of the rest of the EMR waves?

{click to Slide 4}

What will the VIR do when Dawn gets to Vesta and Ceres?

{click}
The Visible and InfraRed (VIR) imaging spectrometer will measure the mineralogical composition of the surfaces of Vesta and Ceres. Using a combination of visible and infrared ***radiation***, it will;

{click}

- image the surfaces of Vesta and Ceres and determine the spatial distribution of the various mineralogical types found there;

{click}

- determine the physical texture and nature of surface particles, which can provide information about the conditions under which Vesta and Ceres were formed; and

{click}

- determine the mineral composition of surface materials, including silicates, hydrates and other minerals, in the geological context.

{click to Slide 5}
The VIR spectrometer is designed to investigate both visible and infrared regions of the electromagnetic spectrum because the minerals that compose the surface of Vesta and Ceres show ***absorption bands*** in both regions.

The VIR

{click}
weighs 27 kg, and has three modules:

{click}
the optical system, which we will examine more thoroughly in the next few slides;

{click}
the proximity electronics, which interface with the main electronics and drive the radiation detectors, the scan mirror and the cover mechanism;

{click}
and the cryocooler, which maintains the temperature of the instrument between 70 and 75 K so the detectors can operate.

{click to Slide 6}
This is a diagram of the VIR Optical System.

The system combines a ***Shafer telescope***,

{click}
which is lightweight and very compact, with an ***Offner grating spectrometer***,
{click}

in a single ***optical head***. One advantage of this unique instrument arrangement is that it makes the VIR is very compact, measuring only

{click}
22 cm

{click} {click}
by 20 cm.

Reflected light

{click}
from the asteroid's surface enters the Shafer telescope, and strikes the primary mirror,

{click}
also called the scanning mirror. This design utilizes the beryllium technology first introduced by Ferrari to make Formula 1 cars lighter in weight. Beryllium's thermal and mechanical characteristics make the mirror weigh less than an equivalent mirror made of aluminum. The beryllium mirror is also less flexible and less sensitive to temperature changes than an equivalent aluminum mirror.

{click}
The telescope also uses five aluminum mirrors mounted on an aluminum optical bench. Aluminum was used because it has a low density, high reflectivity, and high durability.

Write your answer to the following question on your *VIR Student Report Sheet*:

What interactions of matter and energy are described in this explanation of VIR?

{click to Slide 7}
Focused light from the telescope enters the Offner spectrometer through

{click}
a slit and travels through a

{click}
spherical glass convex ***diffraction*** grating. The grating bends the visible and infrared waves coming into the telescope to create a spectrum of the radiation.

Because VIR measures both visible and infrared reflected radiation, two different groove densities are etched on a single grating. The central 30% of this enlarged image of the grating

{click}
is etched with a higher groove density. That is, there are more lines per millimeter. This generates the high spectral resolution needed in the visible channel.

{click}
The infrared channel, which utilizes the outer 70% of the grating, is etched with a lower groove density. The larger IR collecting area compensates for the lower solar radiation in this region.

Write your answer to the following question on your *VIR Student Report Sheet*:

What do the diffraction gratings (matter) do to the visible and infrared rays (energy) after they enter the VIR?

{click to Slide 8}
VIR uses two radiation detectors, a silicon ***charge-coupled device***,

{click}
or CCD,

{click}
to detect and image visible radiation in wavelengths from 0.25 to 1 micrometer and

{click}
a mercury cadmium telluride IRFPA, short for ***Infrared Focal Plane Array***,

{click}
to detect radiation in the infrared region from 0.95 to 5 micrometers. The IRFPA is cooled to 70 K by the cryocooler. The CCD is operated at 155 K and is mounted directly on the spectrometer. For a review of how units of measurement compare to each other, see the Wavelength Conversion Factors chart at
http://dawn.jpl.nasa.gov/DawnClassrooms/3_instrument/pdfs/Wavelength_Conversion_Factors.pdf

Write your answer to the following question on your *VIR Student Report Sheet*:

Why is it necessary to use two radiation detectors?

{click to Slide 9}
VIR shares a data processing unit, a DPU, with another instrument on Dawn, the Framing Camera, to save payload mass. The DPU produces spectroscopic graphs like the one shown here, in which the

{click}
percentage reflection is plotted against

{click}
the radiation wavelength.

In the part of the graph labeled “visible light”

{click}
the red line

{click}
is the spectrum for red sandstone, an Earth rock that reflects more red light than blue light. This is the reason that red sandstone appears red to us.

Andesite

{click}
and basalt, volcanic rocks common on Earth,

{click}
don't reflect any one color of light much more than any other color so they appear dark gray or black to our eyes. Based on the connection between ***HED meteorites*** and spectra of Vesta obtained from space-based telescopes, scientists expect to find basaltic rock on Vesta.

Because the color of rock in visible light does not indicate the kinds of minerals that are present in the rock, the VIR will also measure reflected radiation in the

{click}
infrared region of the electromagnetic radiation spectrum.

The "dips" or "troughs" in the infrared spectrum can help us identify the minerals that are present in the rock. At what wavelengths do sharp troughs appear in the sandstone spectrum?

That's right, at

{click}
1.4

{click}
1.9 and

{click}
2.2 microns.

Do you see that the spectrum from limestone, another common Earth rock, shows the same troughs at 1.4 and 2.2 microns, but not at 1.9 microns?

The dips in the spectra at these wavelengths indicate that water is present in both sandstone and limestone. This also indicates that they are sedimentary rocks that formed underwater.

At what wavelengths are there smooth dips in the andesite and basalt spectra?

That's right, at

{click}
0.9 and

{click}
1.0 microns. These smooth troughs are indications that iron and magnesium are present in these rocks.

With clues like these, scientists can determine the chemical and mineral makeup of a rock—which then become clues to the puzzle of the geologic history of the rock.

{click to Slide 10}
VIR is one of the instruments on the Dawn Spacecraft that will utilize the interactions of energy

and matter to collect scientific data about Vesta and Ceres.

{click}

Write your answers to the following questions on your *VIR Student Report Sheet*:
What interactions of matter and energy are described in this explanation of VIR's output?

Are there any other interactions of matter and energy that were described in this PowerPoint explanation of VIR?