What is the Temperature of Space?

9-12 National Science Standards - Key Concept(s):

Physical Science: Structure and Properties of Matter, Interaction of Energy and Matter.

Summary:

Objects in space, including astronauts, are subject to extreme temperature differences. This short video and accompanying notes explain the physical properties that make this so. They also present the measures that NASA

engineers must take to protect spacewalking astronauts from extremely hot temperatures.

Featured Imagery Component:

NASA 60 second video feature, “What Is the Temperature of Space?” To

view this clip, please visit: http://brainbites.nasa.gov/tempspace/

Post-Video Discussion:

What are some general factors that can influence the temperature of objects in space?

Why might an object’s temperature be different in space than on Earth?

How is heat transferred in space? How do an object’s physical properties determine its temperature in space?

What are the advantages and disadvantages of constructing space materials with metals?

How does NASA reduce the temperature hazards that confront spacewalking astronauts?

1. Although the vacuum of space has no temperature, objects traveling through space do. The International Space Station (ISS) has many different temperatures in various locations and these temperatures are constantly changing.

There are many factors responsible for these varying temperatures. Two of the

more significant factors are that the ISS is made of many different materials and it is constantly moving between sunlight and shade. In fact, ISS orbits Earth once every 90 minutes with a “day” and “night” occurring during each orbit.

2. The temperatures that objects experience in space are often quite extreme compared to what the same objects would experience here on Earth. For

instance, NASA’s bulky white spacesuits that astronauts wear on spacewalks can have a temperature difference of up to 275 degrees F from one side to the other. This can happen if an astronaut has one side of the suit facing the sun with the other side facing deep space.

3. Three types of heat transfer generally exist: radiation, convection, and conduction. Radiation is the only method of heat transfer for objects in a vacuum, so a spacesuit’s physical properties (specifically its optical properties) will heavily influence its temperature. One optical property of a material is known as solar absorptivity, or α. is the fraction of incident solar light absorbed by a surface.

Another optical property is called IR emissivity, or ε. This refers to when materials passively reject energy by emitting radiation in the infrared wavelengths (IR). In space, an insulated surface pointed at the sun will warm up until the absorbed incident solar energy is balanced by the emitted IR energy.

Therefore, the optical ratio α/ε becomes critical to determining how hot an object could get in space. www.nasa.gov

4. NASA engineers like to construct space materials with metals because t

hey are strong and resist penetration by micrometeoroids. While bare metals

usually have a relatively low α, they have a much lower ε, producing favorable

α/ε ratios. When continuously orbiting the sun, some bare metals can reach temperatures above 260 degrees Celsius (500 degrees Fahrenheit). These extremely hot temperatures can be hazardous to astronauts performing spacewalks,

also known as Extra Vehicular Activities (EVAs).

5. To reduce the temperature hazards to astronauts performing EVAs, bare metals outside the ISS and other spacecraft will have special coatings or blankets on them. These cautionary measures typically tend to keep “touch temperatures” between 120 degrees Celsius and -129 degrees Celsius. Transparent Teflon tape is sometimes applied over bare metals to replace their extremely low ε with a high

ε while retaining the metals’ relatively low α.

This can result in a much lower α/ε and a steady state temperature for the metal of about -23 degrees Celsius (-10 degrees F) in constant sun.

Suggested Activities:

Heat and Temperature

<http://coolcosmos.ipac.caltech.edu/cosmic_classroom/light_lessons/thermal/index.html>

Overview:

When we discuss infrared and infrared astronomy we refer to infrared as being primarily thermal radiation or radiation due to heat. In this module, we introduce the concepts of heat and temperature, heat transfer and detection. We also introduce several examples of what we can learn by detecting heat and measuring temperature and include links to related classroom lesson plans and activities.

Meteorology Guide http://www.nasa.gov/audience/foreducators/topnav/m

aterials/listbytype/Meteorology\_Guide.html

Barometer Basics:

A Structured-Inquiry Activity, Page 23-26:

Conceptual Theme:

To develop a basic understanding of the interrelationship between temperature and pressure and the structure of a device made to examine this relationship.

Content:

Developing basic information relating to temperature and pressure and its importance to the study of meteorology.

Constructing a Barometer:

A Structured Inquiry Activity; Page 27-30

Conceptual Theme:

To develop a basic understanding of the relationship between temperature and pressure and that a barometer can be constructed to detect this relationship.

Content:

Developing basic information relating to how temperature change affects a mechanical response in a barometer, to record such changes and the importance

of this instrument to the basics of meteorology.

Angle of Light Rays and Surface Distribution:

A Structured-Inquiry Activity, Page 19-22:

Conceptual Theme:

To develop basic understanding of interrelationship between the angle of light rays and the area over which the light rays are distributed and the potential to affect changes in the temperature of materials.

Content:

Developing basic information that relates to the angle of incidence (angle at which light rays strike the surface) of light rays, understanding the difference in the area of distribution of the light rays, and eventually projecting this information to surface

temperature differences on the Earth.

Additional Resources:

Frequently asked questions: Science topics <http://www.nasa.gov/centers/kennedy/about/information/science_faq.html>.