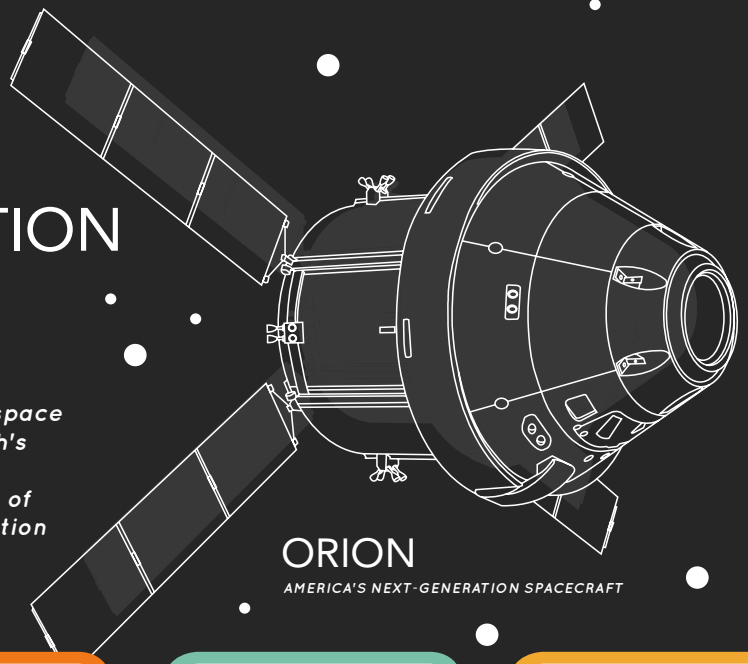
TYPES OF RADIATION *in Space*

The radiation environment of deep space is very different from that at Earth's surface or in low-Earth orbit. For people outside the protection of Earth's magnetic field, space radiation is a serious hazard.



ORION

AMERICA'S NEXT-GENERATION SPACECRAFT

This type of radiation is emitted as immense clouds of high-energy charged particles thought to originate from supernovas.

This type of radiation occurs when charged particles become trapped in Earth's magnetic field and spiral around inside the field.

Solar energetic particles are released by the Sun in solar particle events. This can result in sudden, intense storms.

Ultraviolet radiation is less energetic. Particles impart energy on to the atoms and molecules with which they interact, but do not strip off electrons.

IONIZING

NON-IONIZING

GALACTIC COSMIC RADIATION

CAN NOT BE PROTECTED AGAINST

TRAPPED RADIATION

ONLY INSIDE EARTH'S MAGNETIC FIELD

SOLAR ENERGETIC PARTICLES

EASIEST TO PROTECT FROM

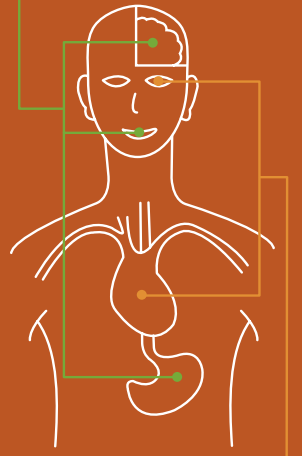
ULTRAVIOLET RADIATION

LIGHT FROM THE SUN

RADIATION EFFECTS ON HUMANS

ACUTE

- Felt almost immediately when a large dose of radiation is accumulated in a short amount of time
- Causes nausea, vomiting fatigue, and central nervous system diseases, which can lead to changes in motor function and behavior



CHRONIC

- Effects can be experienced decades after exposure
- Results from an accumulated dose of radiation over a long period of time
- Causes increased risk of cancer, cataracts and vision impairment, degenerative cardiac disease

Challenges of Spaceflight: Dealing with Space Radiation

Orion, America's next-generation spacecraft, will take astronauts to destinations beyond low-Earth orbit and thus outside the protective shield of Earth's atmosphere and magnetic field. Without the protection Earth provides, the crew and systems of Orion will be exposed to the full spectrum of space radiation. To prepare for the effects of that exposure, scientists and engineers are working now to develop methods to protect them.

THE DIFFERENCES BETWEEN RADIATION ON EARTH AND IN SPACE

Radiation on Earth

On Earth's surface, we are protected from most of the radiation of the universe and the Sun by our atmosphere and magnetosphere.

Non-ionizing Radiation

Non-ionizing radiation refers to a less energetic – but still harmful – radiation in which particles impart energy on to the atoms and molecules with which it interacts, but does not strip off electrons. One form of non-ionizing radiation is ultraviolet, or UV, radiation, which you may be familiar with – we use sunscreen on Earth to shield ourselves from harmful UV rays.

Radiation in Space

Ionizing Radiation

There are several forms of ionizing radiation in space. Ionizing radiation deposits energy onto the atoms and molecules with which it interacts, causing electrons to be lost. The resulting ions, or charged particles, give this form of radiation its name.

One form of ionizing radiation is galactic cosmic radiation. This type of radiation is thought to come from supernovae, or exploding stars. While this radiation is low intensity, the particles associated with galactic cosmic radiation have a high level of energy and cannot be shielded with current spacecraft design technologies.

NP-2014-03-001-JSC

The second form is trapped radiation, which occurs when radiation becomes trapped in Earth's magnetic field. This type of radiation is not a problem outside of Earth's magnetic field.

Finally, solar energetic particles are released by the Sun in what are called solar particle events. This type of radiation is lower in energy, and is easier to protect astronauts and electronics from with shielding materials.

EFFECTS OF SPACE RADIATION ON HUMANS

Space radiation can cause radiation sickness and other health problems. These effects are classified as either acute, which have immediate impacts on humans, or chronic, which affect humans over longer periods of time.

Acute Effects

Acute effects can be felt almost immediately when a large dose of radiation is accumulated in a short amount of time. These effects can include acute radiation syndrome, which causes nausea, vomiting and fatigue.

Chronic Effects

Chronic effects are the results of an accumulated dose of radiation over longer periods of time. Chronic effects include an increased risk of cancer, for example. The onset of these diseases can happen decades after the exposure to radiation occurs.

COUNTERMEASURES

NASA protects astronauts from radiation in several ways during spaceflight. One that requires no special equipment is to limit the time humans spend exposed to radiation. For example, spacewalks are scheduled so that they do not occur during times of intense solar activity. Also, NASA limits the amount of radiation astronauts are exposed to during their careers. Every astronaut is required to wear a dosimeter during missions to keep track of the radiation to which they have been exposed.

Spacecraft are built with materials that act as shields against radiation. Some of the best materials available are those that have a high concentration of hydrogen atoms, such as water. Most spacecraft include a place with additional radiation shielding where the astronauts can shelter in place during solar particle events.

ORION'S SPACE RADIATION PROTECTION

Orion is designed for both short missions to nearby destinations and long-distance missions to Mars that will last more than three years. As the average long-duration spaceflights for Americans have lasted about six months and have taken place entirely within low-Earth orbit, NASA must be prepared to deal with significantly more radiation than astronauts have experienced in the past.

Orion will use the mass that is already on board to protect its crew by creating a temporary shelter in the aft bay of the spacecraft, which is the inside portion closest to the heat shield. This location minimizes the amount of equipment to move around while maximizing the amount of material that can be placed between the crew and the outside environment. The mass that will be used includes supplies, equipment and launch and re-entry seats, as well as water and food. By using the items already on board, the astronauts benefit from additional shielding without adding to Orion's mass.

Radiation Sensors Flying on Orion

The Orion spacecraft will have three "passengers" equipped with radiation sensors flying on Artemis I. The Moonikin, a male-bodied manikin, will be equipped with two radiation sensors. Also on board are two female-bodied model human torsos, called phantoms, also equipped with sensors. "Zohar" and "Helga," named by the Israel Space Agency (ISA) and the German Aerospace Center (DLR), will support the Matroshka AstroRad Radiation Experiment (MARE). MARE will provide valuable data on radiation levels during missions to the Moon, and assess a new radiation-shielding vest for crew. Data from all three "passengers" will help NASA protect astronauts from radiation during future crewed missions.