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Protecting Humans from Cosmic Radiation Using Magnetic Shields

Would you like to set foot on Mars one day? Humans have dreamed about exploring other planets, moons, and asteroids for decades, but the furthest we've gotten is Earth's own moon. You can probably imagine some of the challenges we'd face on the months-long journey to Mars: having enough food, oxygen, and water; keeping astronauts fit and sane; and being able to communicate with home are just a few! But one of the biggest challenges for the engineers and scientists working to make that trip possible is **cosmic radiation**, high-energy particles like protons, neutrons, and electromagnetic waves that travel through our solar system.

This harmful cosmic radiation can come from different sources, including the solar wind, solar storms, and galactic cosmic rays. The **solar wind** is a constant stream of charged protons and electrons coming from the outer layers of our sun's atmosphere. Just like storms here on Earth have very powerful and sometimes dangerous winds, too much solar wind can lead to **solar storms** when the sun is very active, accelerating particles to high energies by its powerful magnetic fields. Finally, **cosmic rays** are extremely high-energy particles coming from catastrophic processes outside of our solar system, like massive black holes and dying stars (supernovae).

All these high-energy particles are bad news for astronauts, because they pack enough punch to rip electrons away from atoms in the body's cells, damaging DNA and other molecules that keep the cells in their bodies running. But why don't you have to worry about getting zapped by cosmic rays on your way to school? On Earth, our planet's **magnetosphere** helps to deflect most of that high-energy radiation away. Acting like a giant magnet, the Earth's core is constantly generating a magnetic field around itself. **Figure 1** shows the shape of our magnetosphere shield and how it protects us from most of the charged particles coming in from space.

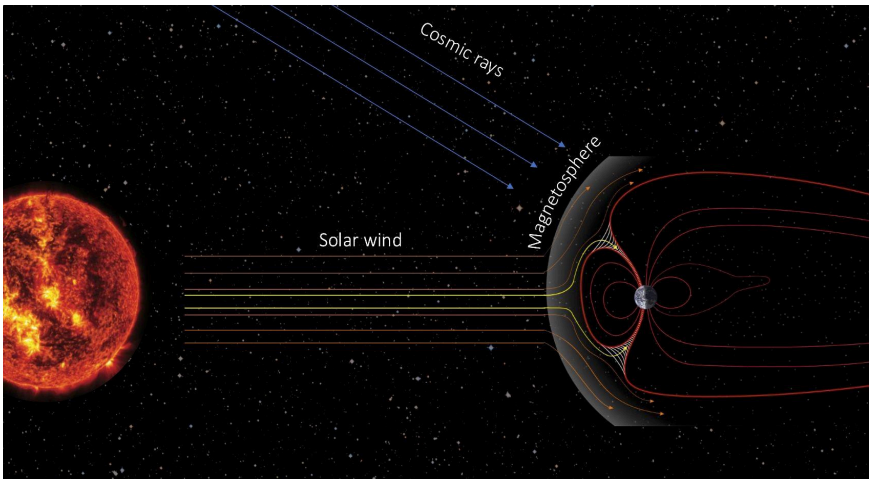

Figure 1. Earth's magnetosphere deflecting cosmic radiation. The magnetosphere allows humans and other life on Earth to exist without being severely damaged by particles in solar storms and radiation like cosmic rays. *Source: Adapted from Sarrecen, NASA/SDO, NASA/Aaron Kaase*

Without the protection of Earth's giant magnetic field, how would you shield astronauts and Mars explorers from cosmic radiation? One possibility: just cover up! Thick walls of metal or even water can absorb some of that harmful radiation, but they need to be bulky and heavy—a bad combination for expensive space travel, where every added pound can cost thousands of dollars. NASA is looking for more efficient answers, and scientists like Dr. Elena D'Onghia are working hard to come up with solutions.

Dr. D'Onghia's team has developed a design for future spacecraft that could protect astronauts from cosmic radiation! Just like how Earth's magnetosphere shields us from incoming radiation, their proposal would use a magnetic field to deflect high-energy particles and other radiation. By sending an electric current through specialized coils around the astronauts' habitat, we can create an electromagnetic shield without heavy materials or thick walls. **Figure 2** shows one possible design for these coils and how they could surround the astronomers' habitat.

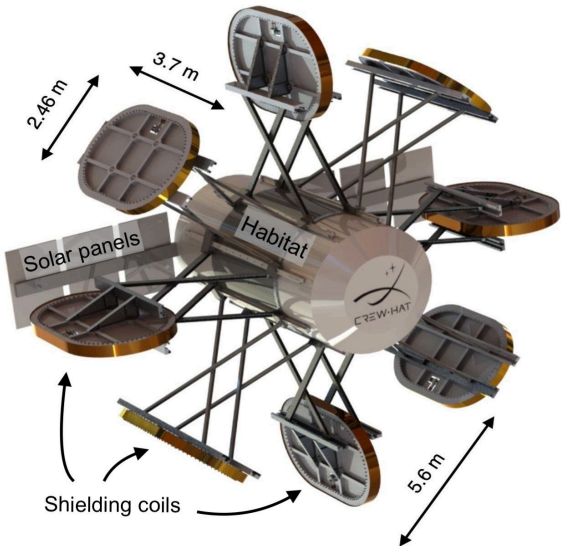

Figure 2. Design rendering of the CREW HaT magnetic shield device. Solar panels keep the eight shielding coils powered to protect an astronaut crew in the central habitat.
Source: Adapted from Elena D'Onghia/NASA

As you can see, some clever engineering lets us take our own magnetic shield with us as we leave our home planet and travel into space! **Electromagnetic shielding** is also important for many other applications on Earth, from keeping our electronics secure to containing the radiation inside your kitchen microwave. Scientific projects like CREW HaT often help develop advanced technology that we end up using back home.

References

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BiteScientist Profiles

The STARs initiative at the University of Connecticut is an organization focused on improving the retention and experience of students from historically excluded groups in physics. Each year, they work in groups alongside mentors to create their own lessons on fundamental topics in physics to bring to local high schools. STARs members Danya Alboslani, Isabella Bruzzese, Nina Bolard, Taevis Kolz, and Brook Thibodeau developed and tested the electromagnetism lesson plan in 2024 with Mr. Thomas Longyear and his awesome class at Hartford Public High School.

Elias Oakes is a graduate student in physics at the University of Connecticut. His research looks at clouds of gas in galaxies outside the Milky Way to better understand how stars form. His favorite thing about astronomy is learning and talking about how the universe works. In his free time, he loves hiking, cooking, and traveling to explore new places.

As a chemist at MIT, **Shannon Morey**'s thesis work focused on creating novel and complex molecules, called synthetic polypeptides. Shannon has been teaching high school physics and chemistry since 2014 and is currently working at Abbott Lawrence Academy in Lawrence, MA. She is a co-founder of BiteScis and the 2022 MA STEM Teacher of the Year.