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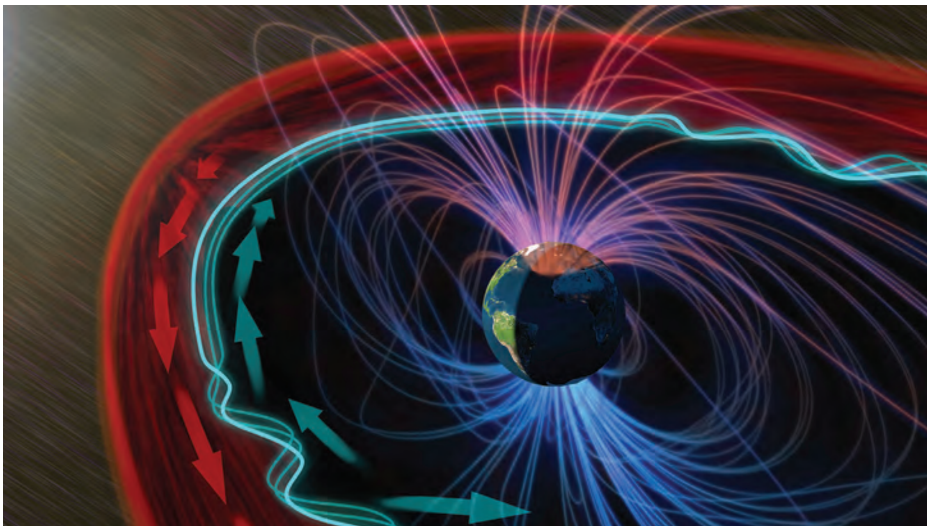
Eavesdropping on the Vibrations of Earth's Magnetic Bubble



A magnetic bubble protects our planet from most of the radiation that streams from the Sun. However, turbulent solar winds can strike the magnetic field, causing it to resonate like a harp string. Credit: Martin Archer/Emmanuel Masongsong/NASA Goddard Space Flight Center

Our solar system is not silent nothingness. It's buzzing with charged particles expelled from the Sun and lofted along by solar winds. Gusty and energetic solar winds can send ultralow-frequency waves quivering along the magnetic field lines that surround our planet—just like a harp string when plucked.

These haunting melody is too low in pitch for us to hear, but researchers have turned the sounds into something audible and are now asking the public to help listen to the din of space (see bit.ly/space-weather-sonification).

"We're hoping that the wisdom of the crowd, combined with our highly tuned human sense of hearing, will help us pick out the features of these waves," said Martin Archer, a space physicist with Imperial College London and one of the scientists behind the project, Heliophysics Audified: Resonances in Plasmas (HARP).

By classifying the different types of vibrations, the researchers hope to get a better picture of how they influence Earth's magnetic field.

Sounding Out the Notes

Stunning aurorae, seen dancing across skies near the poles, provide one illustration of how plasma energy carried by solar winds can interact with Earth's magnetic field, or magnetosphere.

Beyond creating colorful light displays, waves generated when our magnetosphere is struck by solar winds also contribute to disruptive space weather, which can pose a risk to satellites, telecommunications, and astronauts.

Characterizing plasma waves could help improve predictions of space weather hazards. But studying them has proved challenging in the past because even computers struggle to separate out the many simultaneous vibrations among the background noise of space.

"These plasma waves are really complicated," said Wen Li, an astronomer at Boston University who is not involved in the HARP project. "Even after decades of study, we still have a lot of questions about how they work."

One unknown the researchers hope to explore is why some plasma waves interact with their space environment more strongly than others. "Audio analysis could add a new dimension to our understanding of these waves," Li said.

To amplify the sound of plasma waves for human ears, the researchers used a technique called sonification to speed up years of electromagnetic measurements collected by NASA's THEMIS mission (Time History of Events and Macroscale Interactions during Substorms), which deployed five satellites to fly through Earth's magnetosphere in 2007.

Back in 2018, Archer trialed a small-scale version of the project with high school students, who identified a series of solar storms

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reverberating within Earth's magnetosphere. Each storm sounded like a loud crunch, followed by whistles that steadily lowered in pitch as the magnetic field lines readjusted.

"Space scientists had barely discussed sounds like this before," Archer said. The storms "leapt out at us when we listened to the data but were easy to miss in the plots."

Since that discovery, with the backing of NASA, the HARP team has worked with

Stunning aurorae, or northern and southern lights, are caused by solar winds interacting with Earth's magnetic field. These interactions can also trigger vibrations that with the right tools can be amplified for us to hear. Credit: NASA's Marshall Space Flight Center, CC BY-NC 2.0 (bit.ly/ccbync2-0) sound experts to create an interface that allows people to highlight and comment on the waveforms. The researchers are asking volunteers to listen to the audio and describe what they hear—whether the sound is a formless static noise or pure tone, for instance.

Borrowing techniques used by musicians was fundamental to the project, said Archer, who has a background in radio and as a DJ. "It struck me that these data might be better suited to our ears," he continued.

"Hearing these waves really brings them to life," said David Sibeck, a heliophysicist at NASA Goddard Space Flight Center and a THEMIS mission scientist who is not involved in the HARP project. The huge bank of data gathered by the mission has been a challenge for scientists to analyze by themselves, Sibeck said.

Aside from being a way to engage the public in space science endeavors, asking folks to listen to the data also brings scientific benefits. Humans excel at disentangling competing sounds, even set against background noise, Archer explained, offering an example: "Take our ability to filter out conversations at a cocktail party."

An Ear on Space

One of the team's goals is to identify the properties of each plasma wave. Just like the strings of a harp, each wave resonates and interacts with its surrounding space differently. Certain plasma waves are thought to play a role in forming the giant donut-shaped radiation belts, or Van Allen belts, within Earth's magnetosphere. These belts, which contain highly charged particles, are a major hazard for astronauts and spacecraft because of their high radiation levels.

Current theories suggest that plasma waves can energize the charged particles in these belts, making them more hazardous. Stronger plasma waves with larger amplitudes are thought to be more effective at transferring energy between particles, said Li, "but we are still unsure exactly how this process works."

Observations from HARP could help scientists understand that energy transfer, according to Sibeck. "We really won't know which waves are important until we survey them all," he said.

The public contribution will be crucial to the success of the project, Archer said.

By **Erin Martin-Jones** (@Erin_M_J), Science Writer

Raising Hazard Awareness at the Foot of Nyiragongo

Students in Goma, Democratic Republic of the Congo, play the board game Hazagora to learn about volcanic hazard resilience. Credit: Blaise Mafuko Nyandwi

Memories of the glow emanating from the top of the Democratic Republic of the Congo's Mount Nyiragongo volcano have not been forgotten by those living nearby. At the volcano's summit is a lava lake that lights up the night sky like a beacon. In May 2021, an unexpected lava flow came down Nyiragongo's flank, pouring into the outskirts of the nearby Congolese city of Goma as residents fled in the dark.

Now, researchers are studying ways of educating residents about the hazards of living near one of the world's most dangerous volcanoes. The scientists presented their research at the European Geosciences Union General Assembly 2023 (bit.ly/prepared-community).

As a child in Goma, Blaise Mafuko Nyandwi grew up with towering Nyiragongo as a backdrop and watched the red glow of its lava every night. Now a volcanologist at the University of Goma, he knows from experience that people living in the city still do not know how volcanoes work and may therefore be unprepared to react during future eruptions.

"Volcanic eruptions cannot be prevented, so mitigation strategies are needed to reduce impact," said Mafuko, lead researcher of the new study. Mitigation can mean making the nearby population aware and ready to react, he added.

With the ever present threat in the region, situated in the Virunga Volcanic Province of East Africa, Mafuko and his colleagues worked with 435 sixteen-year-old students from 12 high schools in Goma to test how well two extracurricular activities raised awareness of geological risk: playing the board game Hazagora and visiting the Virunga Volcano Museum.

Gaming and Exploring the Way to Awareness

On the fictional island of Hazagora, players develop a society regularly hit by earthquakes, volcanic eruptions, floods, and landslides. Five to 10 players, representing the island's mayor, a fisherman, a lumberjack, a farmer, and a tour guide, must figure out how to survive disasters by making trade-offs among protective measures. Players use their annual income to provide for their families' basic needs but can also stockpile supplies and reinforce or protect infrastructure, for instance.

The game, originally developed by researchers at Vrije Universiteit Brussel in Belgium, includes information sheets on geo-