National Aeronautics and Space Administration

JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

EZIE

Electrojet Zeeman Imaging Explorer

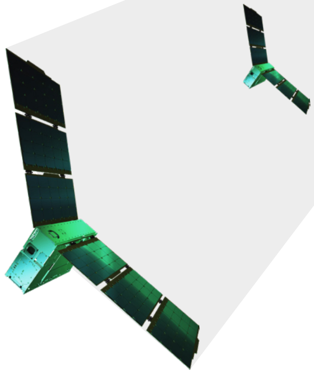
PRESS KIT

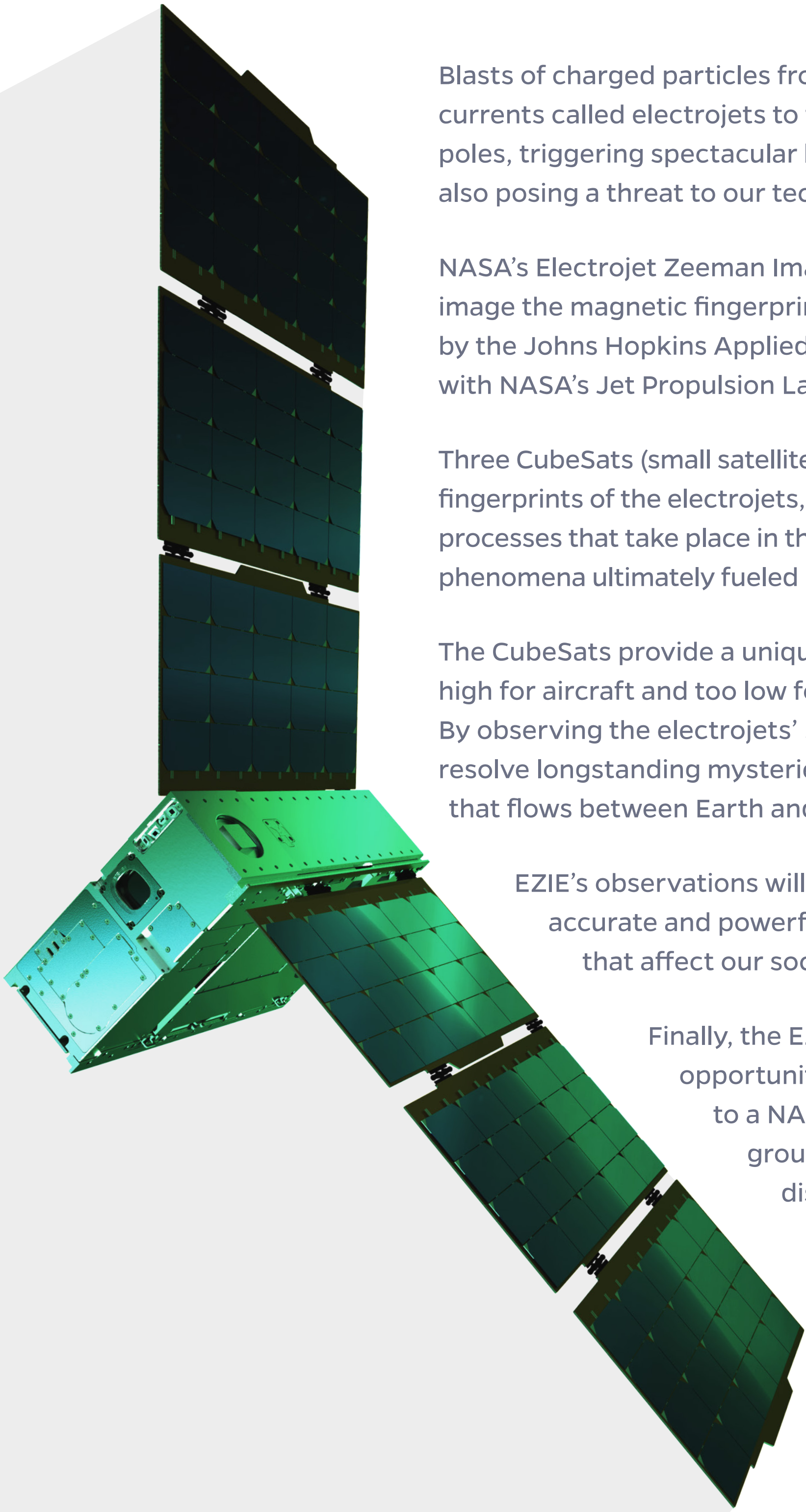
> “EZIE is a small mission with a big science return.”

Jason Kalirai, Johns Hopkins APL Space Formulation Mission Area Executive

Table of Contents

Introduction





Blasts of charged particles from the Sun can cause intense electrical currents called electrojets to flow in our upper atmosphere over the poles, triggering spectacular light shows associated with the aurora but also posing a threat to our technology both in space and on the ground.

NASA's Electrojet Zeeman Imaging Explorer (EZIE) is the first mission to image the magnetic fingerprint of these auroral electrojets. EZIE is led by the Johns Hopkins Applied Physics Laboratory (APL), in collaboration with NASA's Jet Propulsion Laboratory and Blue Canyon Technologies.

Three CubeSats (small satellites) will fly pole to pole to image the magnetic fingerprints of the electrojets, thereby providing insights into the physical processes that take place in the near-Earth space environment — phenomena ultimately fueled by the Sun — including the auroras.

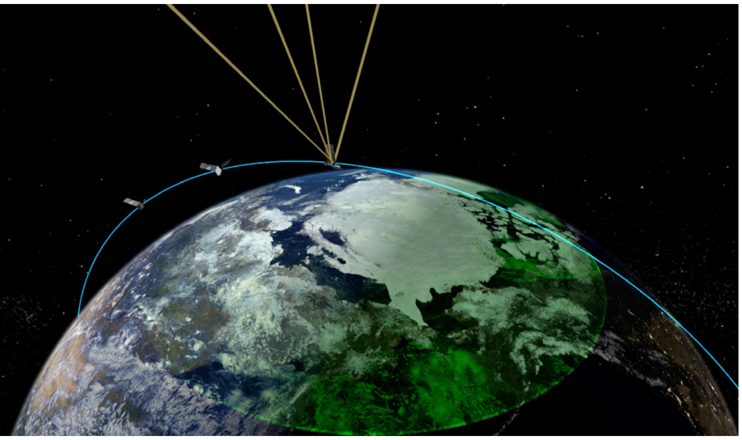
The CubeSats provide a unique view of the electrojets, which flow too high for aircraft and too low for traditional satellites to directly measure. By observing the electrojets' structure and evolution, scientists can resolve longstanding mysteries about the vast electrical current circuit that flows between Earth and the surrounding space.

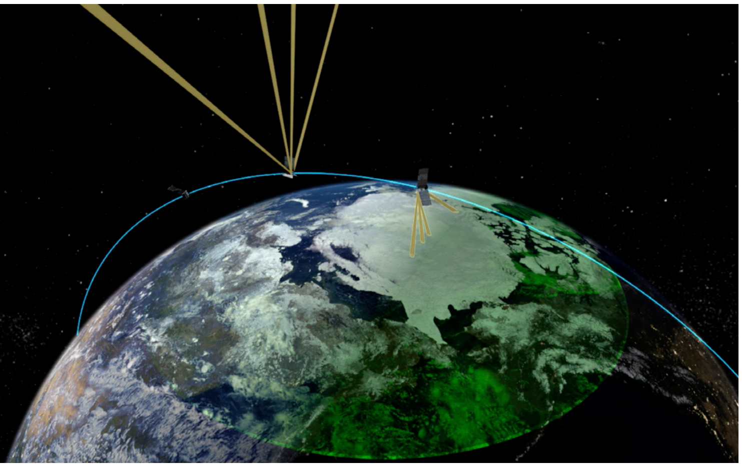
EZIE's observations will also help researchers develop more accurate and powerful models to predict space weather events that affect our society.

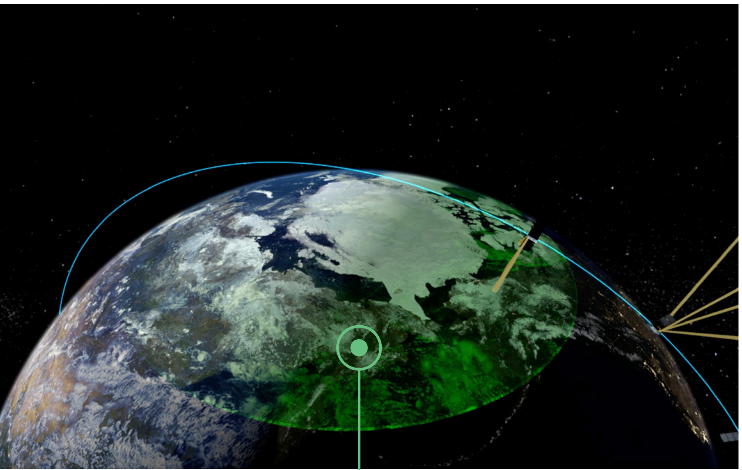
Finally, the EZIE mission will provide an unprecedented opportunity for students and teachers to contribute to a NASA mission through the EZIE-Mag ground magnetometer kits that will be freely distributed to students and teachers across the United States.

THREE THINGS TO KNOW

About EZIE







1

EZIE Maps Electrical Currents From Afar

The electrojets sit roughly 65 miles (100 kilometers) above the Earth's surface, pushing roughly 1 million amps of electrical charge around the poles every second.

The trio of EZIE CubeSats will fly 260–370 miles (420–590 km) above Earth's surface. Each of the satellites will carry a low-power, miniaturized instrument to map the electrojets. With the CubeSats lined up like pearls on a string, EZIE will travel between Earth's poles using differential drag to adjust the spacing between the spacecraft. The spacing will be between 2 and 20 minutes to reveal how the electrojets evolve.

Although EZIE will fly well above the electrojets, the satellites will observe emissions from oxygen molecules located some 10 miles (16 kilometers) below the electrical currents. The electrojets create a magnetic field that leaves a "fingerprint" in the oxygen emissions, known as the Zeeman effect, which EZIE is designed to measure precisely.

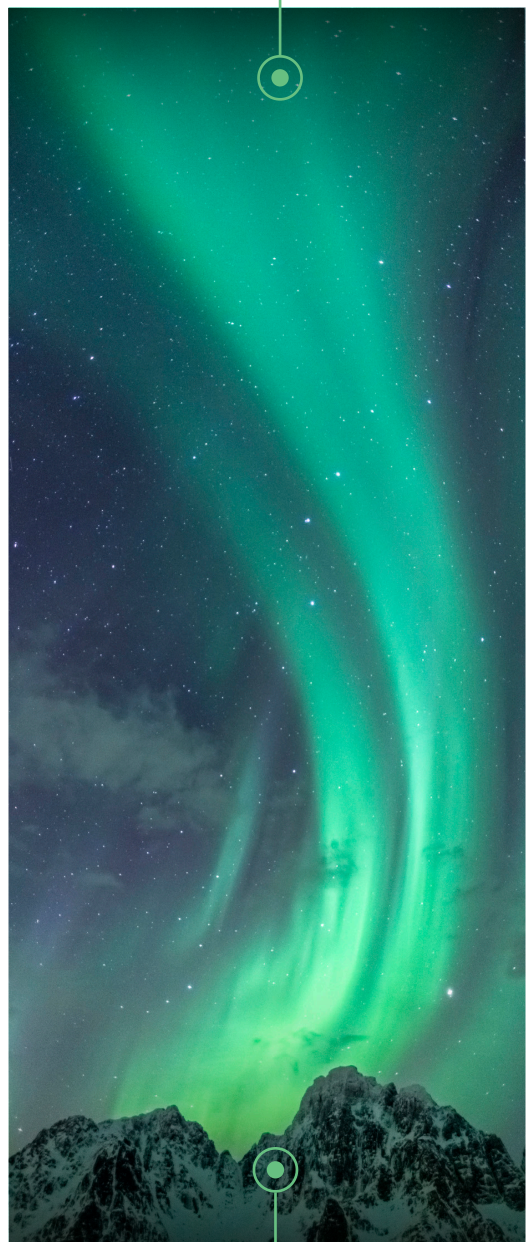
2

EZIE Will Help Protect Our Technology on Earth

Space weather refers to the conditions in the near-Earth space environment that affect our society. It includes a range of phenomena, from aurora to geomagnetic storms, that are ultimately fueled by the Sun itself. Every second, up to 2 million metric tons of charged particles stream from the Sun at 1 million miles per hour. This solar wind would be harmful to life if not for Earth's protective magnetic field and atmosphere.

The Sun itself is highly variable, at times experiencing intense activity. This activity includes massive explosive events that can generate coronal mass ejections — giant bubbles of superheated plasma that expand as they move away from the Sun. When such ejections are directed at Earth and interact with Earth's atmosphere, they generate spectacular space weather conditions.

When many of us think of space weather, we picture one of its most well-known effects — the stunning displays that are visible mostly at Earth's northern and southern poles, known as the aurora borealis and aurora australis, respectively. But space weather can have more adverse effects — disrupting communication, damaging spacecraft, impairing our power grid or even delivering enhanced radiation doses to astronauts in space.



The EZIE mission will play a key role in developing a better understanding of the processes that affect space weather. By revealing how the electrojets are structured and how they evolve, not only will scientists learn how these currents connect Earth and space, but the data will help researchers create more accurate and powerful models for predicting space weather events.

3

Students Are Participating in the Mission

Before launch, the EZIE team is making and freely distributing approximately 700 magnetometer kits (nicknamed EZIE-Mags) to teachers and students across the United States. Schools and educators can apply for a kit on the eziemag.jhuapl.edu website.

EZIE-Mag kits will let students build their own science-quality magnetometer. The lunchbox-sized instrument suites allow students and teachers to monitor the magnetic signature produced by the vast Earth–Space electrical current system. Data collected from all EZIE-Mags will appear on the ezie.jhuapl.edu/ website.

The combination of EZIE's exploration of the electrojets and the data collected by EZIE-Mag will allow students, teachers and other users to monitor how the current system behaves in real time. And the chance to work with science-quality ground magnetometers creates new opportunities for students who are interested in pursuing science, technology, engineering and mathematics (STEM) careers.

Media Services

Media Contacts

NASA

Sarah Frazier
NASA Heliophysics Division
sarah.frazier@nasa.gov

Johns Hopkins APL

Brett Molina
Public Affairs
240-280-9362
Brett.Molina@jhuapl.edu

Michael Buckley
Public Affairs
443-567-3145
Michael.Buckley@jhuapl.edu

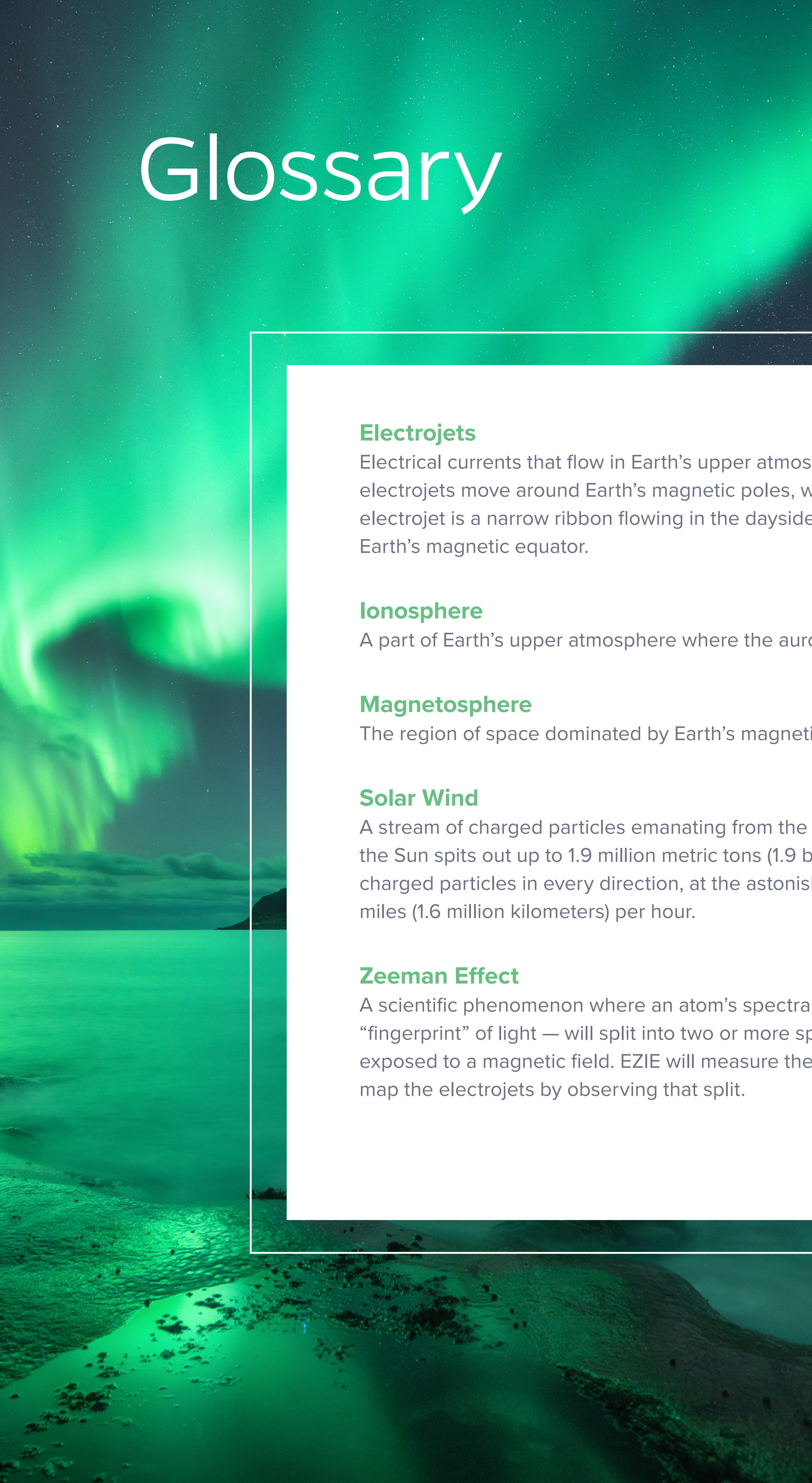
Products and Events

News Releases, Features and Status Reports

News, updates and features about the EZIE mission can be found at ezie.jhuapl.edu/ and science.nasa.gov/mission/ezie/.

Video and Images

EZIE mission videos, animations and images are available in the EZIE gallery (ezie.jhuapl.edu/media) and on NASA's Scientific Visualization Studio website (svs.gsfc.nasa.gov/14542).



Glossary

Electrojets
Electrical currents that flow in Earth's upper atmosphere. Auroral electrojets move around Earth's magnetic poles, while the equatorial electrojet is a narrow ribbon flowing in the dayside ionosphere near Earth's magnetic equator.

Ionosphere
A part of Earth's upper atmosphere where the auroral electrojets flow.

Magnetosphere
The region of space dominated by Earth's magnetic field.

Solar Wind
A stream of charged particles emanating from the Sun. Every second, the Sun spits out up to 1.9 million metric tons (1.9 billion kilograms) of charged particles in every direction, at the astonishing speed of 1 million miles (1.6 million kilometers) per hour.

Zeeman Effect
A scientific phenomenon where an atom's spectral line — a unique "fingerprint" of light — will split into two or more spectral lines when exposed to a magnetic field. EZIE will measure the magnetic fields and map the electrojets by observing that split.

MISSION
Overview

To the naked eye, Earth seems isolated from its celestial neighbors. Even the nearest of them, the Moon, is some 240,000 miles (386,000 kilometers) away. Our planet is anything but isolated, however.

Invisible to our eyes is an intricate system of interweaving magnetic field lines. They fuse and break, and guide waves of charged particles and energy through space, sometimes creating spectacular light shows around the poles and other times disrupting our technology.

This system consists of three interacting parts: the solar wind, Earth's magnetosphere and Earth's ionosphere.

Solar energy and particles flowing in Earth's upper atmosphere create 100,000-mile-long (161,000-kilometer-long) electrical circuits flowing along magnetic field lines. These currents are caused by complex processes in the magnetosphere, many of which scientists are still trying to understand.

An important piece of that circuitry are the auroral electrojets — electrical currents flowing high above Earth's poles.

The EZIE mission is the first to map these electrical currents. By observing the electrojets' structure and evolution, scientists can resolve outstanding mysteries about what generates the current that flows between Earth and space. The observations will also help researchers build more accurate and powerful models to predict space weather events that affect our increasingly technological society.

MISSION

Science

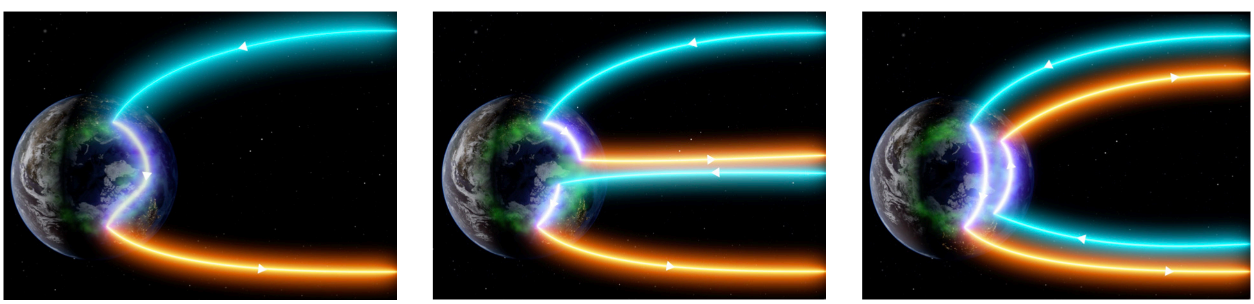
Earth's auroral electrojets are electrical currents traveling around the planet's magnetic poles. From roughly 65 miles (100 kilometers) above the surface, the electrojets push roughly 1 million amps of electrical charge around the poles every second, making them responsible for some of the largest magnetic disturbances on the ground.

The auroral electrojets are just a small part of a vast electrical circuit flowing between the magnetosphere and Earth's upper atmosphere. When drawn, the circuit resembles an enormous wedge-like structure, which scientists call the substorm current wedge. These structures are essentially massive power cords, stretching over 100,000 miles (160,000 kilometers) between Earth's ionosphere and its magnetosphere.

Although they're just a small portion of the huge wedge-like system, the auroral electrojets produce a strong magnetic field that scientists can use to monitor how the entire wedge-like system behaves.

Scientists have measured the electrojets' magnetic field for more than a century with ground-based magnetometers. They know it's fundamental to understanding the wedge system and how the magnetosphere releases energy.

But they're still debating what the overall system looks like and how it evolves. In the nearly 50 years since the substorm current wedge model was published, teams have proposed a steady stream of new but conflicting models of the current wedge system. The proposed structures generally fall into three categories (pictured from left to right below): a single wedge system, two wedges with opposite flows and two overlapping wedges.



EZIE's aim is to test which — if any — proposed structure is correct. The mission will also provide insight into the physics of our magnetosphere — knowledge that would apply to any magnetized planet in the universe.

EZIE

Spacecraft

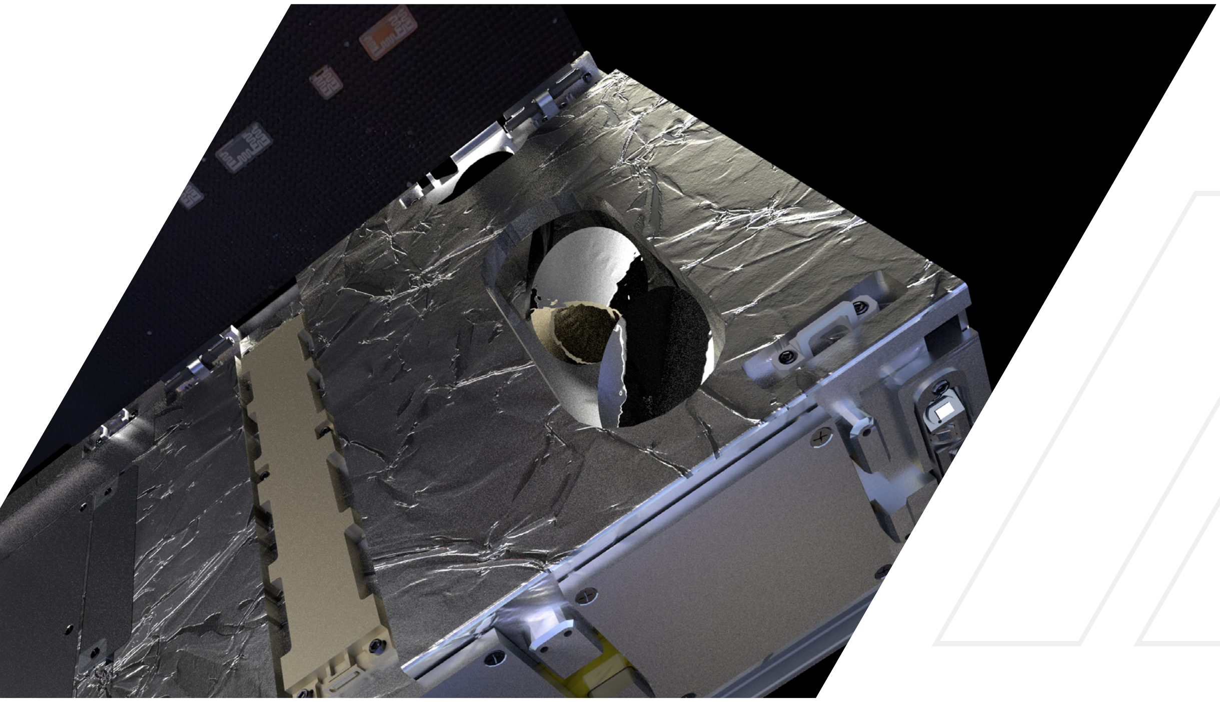
NASA's EZIE mission will use three small solar-powered satellites that have been innovatively designed to include a low-power, miniaturized instrument for measuring the auroral electrojets.

Lined up like pearls on a string, the three CubeSats will fly 260–370 miles (420–590 kilometers) above Earth's surface, moving from pole to pole.

During each orbit, each spacecraft will produce a map of the electrojets, providing detailed views over space and time to determine the electrojets' structure and evolution. They partly do this by changing the spacing between themselves. Typically, such adjustments would require a propulsion system, but the EZIE spacecraft won't have that.

Instead, while traveling at about 5 miles (8 kilometers) per second, the spacecraft will be able to turn individually, using the drag experienced while flying through Earth's upper atmosphere to change how they're spaced. This will either bring one or more spacecraft closer together or space them farther apart. Consequently, the spacecraft will fly over the same region from 2 to 10 minutes after each other.

EZIE's CubeSat trio will fly high above the electrojets, which flow just 65 miles (105 kilometers) above Earth's surface. But EZIE is actually eyeing oxygen molecules located 13 miles (20 kilometers) below the electrojets.



That’s because the electrojets create a magnetic field around them that leaves a signature in light released by the oxygen molecules — a magnetic “fingerprint” that EZIE is designed to look for.

The oxygen molecules release a photon in the microwave wavelength with a frequency of 118 gigahertz. Although this light is invisible to our eyes, EZIE can “see” it using a spectrometer — an instrument that separates and collects light as individual wavelengths.

When near the magnetic field around the electrojets, however, that 118-gigahertz line splits apart — a phenomenon called the Zeeman effect. The stronger the electrojets’ magnetic field, the farther the lines split apart.

Scientists have used this phenomenon to measure the magnetic fields of the Sun and other stars. In this case, it allows an indirect measurement of the current flowing in the electrojets.

Thanks to recent technological advancements, the EZIE team has developed a miniaturized instrument — the Microwave Electrojet Magnetogram (or MEM) — to measure the electrojets, and each EZIE satellite will carry one.

The MEM uses four reflective dishes, each pointed in a different direction, so the instrument can simultaneously collect microwaves from multiple angles before passing the light to a spectrometer.

EZIE-MAG AND MAKERPLACE

Outreach

The EZIE mission's EZIE-Mag program is a unique opportunity for students and teachers to directly contribute to a NASA mission. In reaching out to a range of communities across the nation, the program aims to break down barriers to access and allow young scientists to not only participate in the mission but also contemplate a future working in science.

EZIE-Mag is a magnetometer kit utilizing a small single-board computer and a sensor capable of measuring magnetic currents on the ground, obtaining science-quality data at a significantly lower cost than traditional magnetometers, which can cost between $25,000 and $500,000. Schools and educators can apply for a free kit on the eziemag.jhuapl.edu website.

As EZIE maps the electrojets above, the collection of EZIE-Mag units in use across the country will gather data from the ground to provide a comprehensive view of how Earth is connected to space. EZIE-Mag users can access the data collected from the kits by visiting the EZIE website.

MISSION

Management

NASA Leads

Dr. Joe Westlake
Director, NASA Heliophysics Division

Peg Luce
Deputy Director, NASA Heliophysics Division

Nicole Rayl
Associate Director for Flight Programs,
NASA Heliophysics Division

Dr. Jared Leisner
Program Executive, NASA Heliophysics Division

Dr. John McCormack
Program Scientist, NASA Heliophysics Division

Nick Chrissotimos
NASA Program Manager, Explorers

David Carter
NASA Deputy Program Manager, Explorers

Ryan Turner
NASA Mission Manager, Explorers

Dr. Larry Kepko
NASA Mission Scientist, Explorers

APL Mission Leads

Dr. Sam Yee
Principal Investigator

Dr. Nelli Mosavi-Hoyer
Project Manager

Kieran Hegarty
Deputy Project Manager

Dr. Jesper Gjerloev
Project Scientist

EZIE Instrument and Engineering Leads

Rebecca Kelly
Mission Systems Engineer, Johns Hopkins APL

Marc Hoffman
Deputy Systems Engineer, Johns Hopkins APL

Dr. Sharmila Padmanabhan
Instrument Manager, Jet Propulsion Laboratory

Dr. Pekka Kangaslahti
Instrument Systems Engineer,
Jet Propulsion Laboratory

Dr. Sidharth Misra
Instrument Scientist, Jet Propulsion Laboratory

Dave Baron
Spacecraft Manager, Blue Canyon Technologies

Jake Dembeck
Spacecraft Systems Engineer,
Blue Canyon Technologies

Edmond Mitchell
Safety and Mission Assurance Lead,
Johns Hopkins APL

About APL

The Johns Hopkins Applied Physics Laboratory solves complex research, engineering and analytical problems that present critical challenges to our nation. APL scientists, engineers and analysts serve as trusted advisors and technical experts to the government, ensuring the reliability of complex technologies that safeguard our nation's security and advance the frontiers of space.

From the Sun to Earth and beyond — with the Parker Solar Probe, Dragonfly and New Horizons missions — APL has designed and built more than 70 spacecraft and hundreds of specialized instruments and systems. Combined, these spacecraft and instruments have visited every planet in our solar system and collected information that has expanded humankind's understanding of the universe.

Slated to launch in spring 2025, NASA's Electrojet Zeeman Imaging Explorer (EZIE) will be the first mission to image the magnetic fingerprint of the auroral electrojets — intense electric currents flowing high above Earth's poles that are central to the electrical circuit coupling the planet's magnetosphere to its atmosphere.

Led by the Johns Hopkins Applied Physics Laboratory (APL), EZIE will use a trio of small satellites to characterize and record the electrojets' structure over space and time. It will fill gaps in our understanding of this space weather phenomenon and provide findings that scientists can apply to other magnetized planets, both within and outside our solar system.

https://ezie.jhuapl.edu/

EZIE

Electrojet Zeeman Imaging Explorer

24-02108