National Aeronautics and Space Administration

CSSP March 2023 Agency Update

Peg Luce

Acting Heliophysics Division Director, NASA

Congratulations to Dr. Nicola Fox on her appointment to Associate Administrator for the Science Mission Directorate!

Thank you for your service to the Heliophysics Community!

NASA Heliophysics Division Leadership

Peg Luce, Acting Division Director

Nicole (Nicki) Rayl, Associate Director for Flight

Heliophysics Missions

Heliophysics Mission Fleet

Heliophysics missions are strategically placed throughout our solar system, working together to provide a holistic view of our Sun and space weather, along with their impacts on Earth, the other planets, and space in general. NASA's heliophysics mission fleet includes 19 operating missions using 26 spacecraft, 13 missions in development, 1 mission under study, a robust sounding rocket program and a variety of CubeSat missions.

- ESA = European Space Agency
- JAXA = Japan Aerospace Exploration Agency

*Numbers in parentheses indicate how many spacecraft each mission includes.

*Objects Not to Scale

UNDER DEVELOPMENT

- AWE (ISS)
- Carruthers Geocorona Observatory
- ESCAPADE (2)
- EUVST (JAXA)
- EZIE (3)
- GDC (6)
- HelioSwarm (9)
- HERMES (Gateway)
- IMAP
- MUSE
- PUNCH (4)
- SunRISE (6)
- TRACERS (2)

PRIMARY OPERATION

- Parker Solar Probe
- Solar Orbiter (ESA)

EXTENDED OPERATION

- ACE
- AIM
- GOLD (SES-14)
- Hinode (JAXA)
- IBEX
- ICON
- IRIS
- MMS (4)
- RAD (Curiosity)
- SDO
- SOHO (ESA)
- STEREO
- THEMIS-ARTEMIS (2)
- THEMIS (3)
- TIMED
- Wind
- Voyager (2)

science.nasa.gov/heliophysics

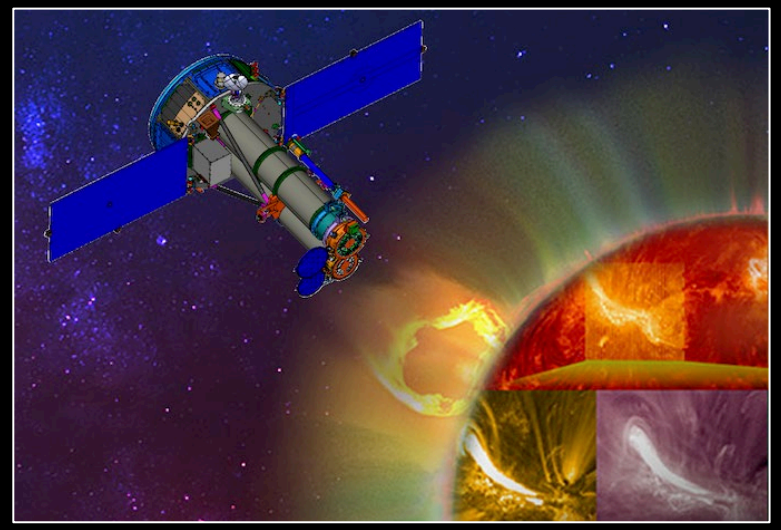
Heliophysics Budget Features

What's Changed

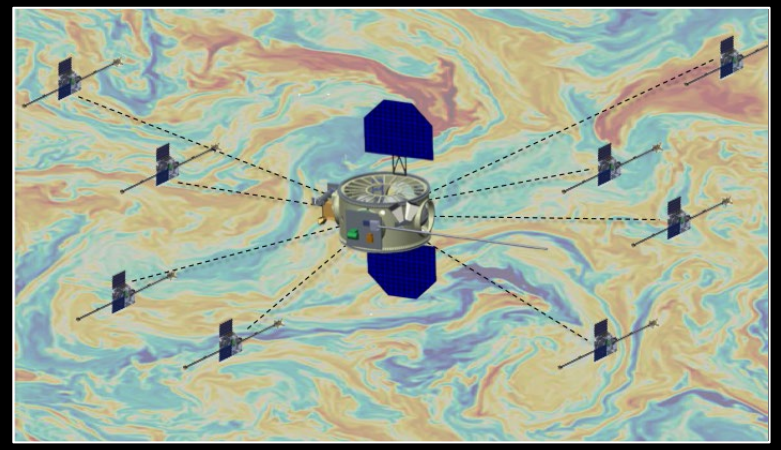
- New Explorers MIDEX selections: MUSE and HelioSwarm
- Active funds management enabled selection of 3rd DRIVE Science center
- Investments to support Heliophysics Digital Resource Library and AI/ML efforts
- Non-confirmation of Solar Cruiser due to schedule and budget concerns
- Because of other budget pressures in the Science portfolio, the budget proposes a pause in GDC development until Decadal Survey recommendations are received

What's the Same

- Explorers solicitations in 2022 (SMEX) and 2025 (MIDEX)
- Orbital Debris and Space Situational Awareness investments to address gaps in orbital object detection and gaps in our scientific understanding of their interactions with the environment
- Space Weather program includes HERMES instruments for Gateway, space weather research and applications, partnership on ESA Vigil mission
- Robust research program
- Continued support of 12 missions in development and 18 operating missions
- DYNAMIC AO release scheduled in FY23. Given other priorities within the Science portfolio, there is no funding for DYNAMIC in the FY24 President's budget



The Multi-slit Solar Explorer (MUSE) mission science will reveal the physical processes of the solar corona and the eruptions at the foundation of space weather



HelioSwarm features a hub spacecraft and eight smaller ones that will work together to measure solar wind turbulence

Geospace Dynamics Constellation (GDC)

Mission Science Team

Project Scientist
Doug Rowland

Deputy Project Scientist
Larry Kepko

Deputy Project Scientist
Katherine Garcia-Sage

Interdisciplinary Scientist
Rebecca Bishop

Interdisciplinary Scientist
Yue Deng

Interdisciplinary Scientist
Jeff Thayer

MoSAIC PI
Mehdi Benna

CAPE PI
Dan Gershman

AETHER PI
Laila Andersson

TPS PI
Phillip Anderson

NEMESIS PI
Mark Moldwin

Geospace Dynamics Constellation (GDC) and Dynamical Neutral Atmosphere-Ionosphere Coupling (DYNAMIC)

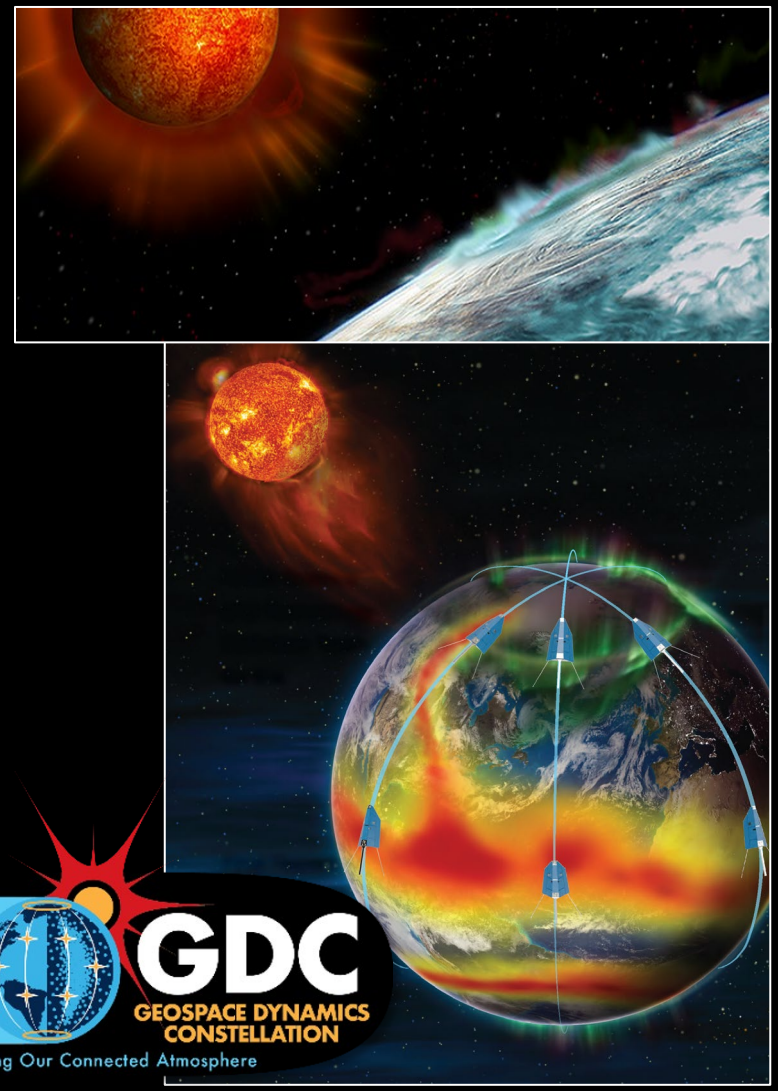
GDC and DYNAMIC provide a whole-system study of upper atmospheric dynamics by combining their scientific and technical capabilities

- In science…
  - GDC: Understand the upper atmosphere's internal processes and dynamics, and response to energy inputs from Earth's space environment (*energy from above*)
  - DYNAMIC: Understand the effect of lower atmosphere variability on the processes and dynamics of the upper atmosphere (*energy from below*)
- In architecture…
  - GDC: Provides in situ measurements of the upper atmosphere (above 300 km)
  - DYNAMIC: Provides altitude profiles of the upper atmosphere (below 300 km altitude), leverages GDC measurements

Tentative DYNAMIC AO timeline

- Dec 9, 2022 Community Announcement released
- Mar 24, 2023 Draft AO released
- May 2023 Final AO release (target)

Flying DYNAMIC and GDC together achieves two Decadal Survey-prioritized science investigations in a cost-effective manner



DRIVE Science Centers

DRIVE Science Centers, implemented as a NASA-NSF partnership, are part of an integrated multi-agency initiative, DRIVE (Diversity, Realize, Integrate, Venture, Educate), put forward as a high priority recommendation of the 2013 Solar and Space Physics Decadal Survey. DRIVE Science Centers are focused on grand challenge goals that are both ambitious and focused enough to be achievable within the lifetime of the center.

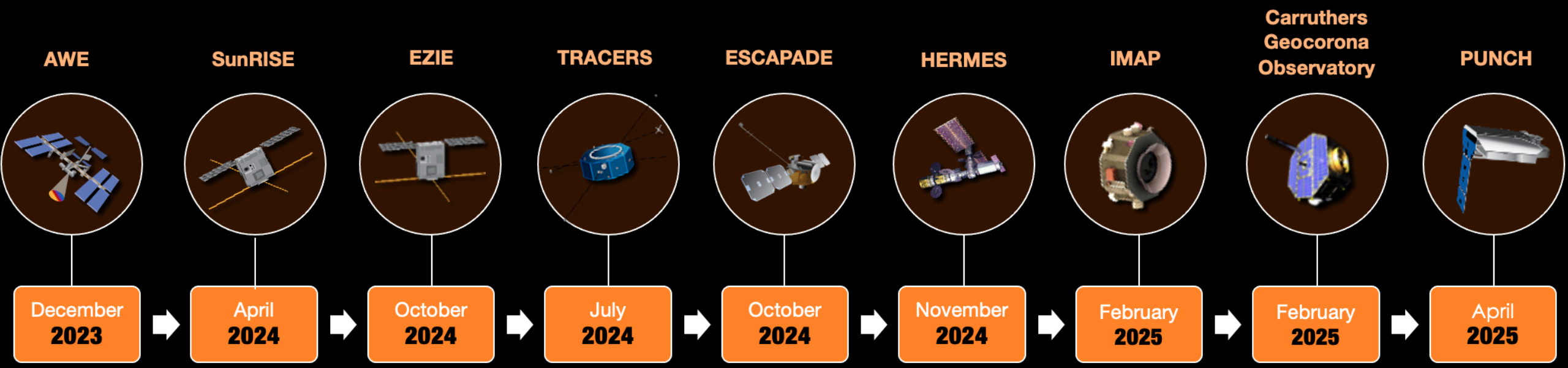
On March 17th, 2022, NASA selected three DRIVE Centers:

Title, PIs, and Institutions

- Consequences of Flows and Fields in the Interior and Exterior of the Sun (COFFIES)
    - Hoeksema / Stanford
- Center for Geospace Storms (CGS)
    - Merkin / JHU/APL
- Our Heliospheric Shield
    - Opher / Boston University

HELIOPHYSICS
BIG YEAR

HELIO MISSION FLEET TIMELINE

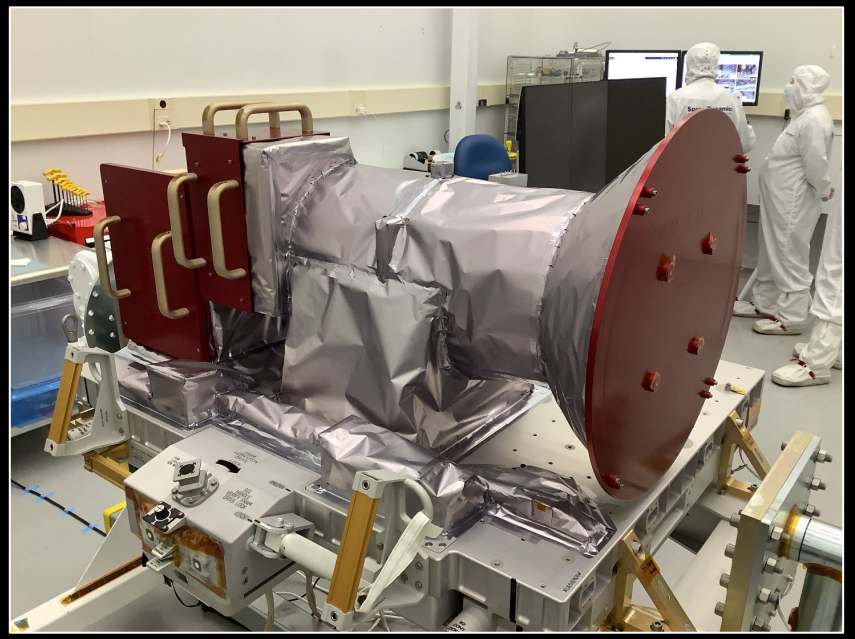


Atmospheric Waves Experiment (AWE)

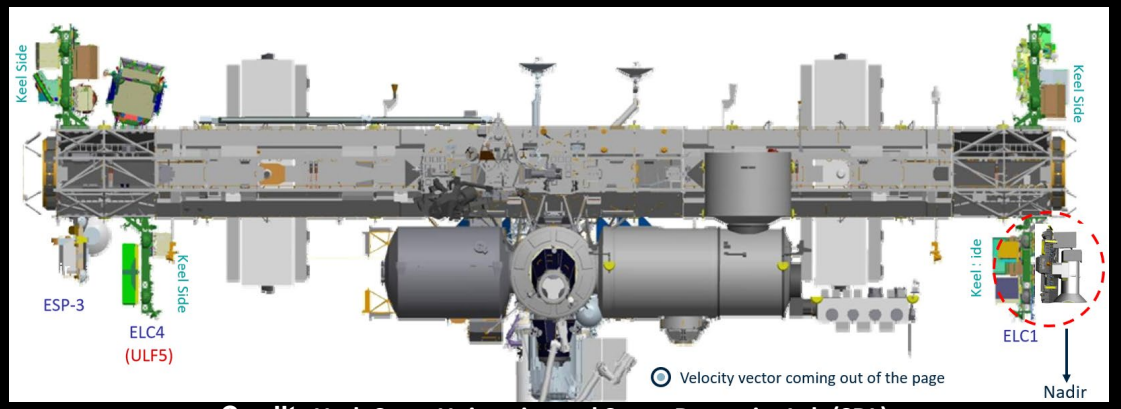
- The Atmospheric Waves Experiment (AWE) is planned to launch in December 2023, and will deploy the nadir-viewing Advanced Mesospheric Temperature Mapper (AMTM) on the exterior of the International Space Station in low Earth orbit.
- From its space station perch, AWE will measure atmospheric emissions, called airglow, in the infrared to determine how wave energy from terrestrial weather is transported into the upper atmosphere.
- The new experiment will, for the first time, obtain global observations of an important driver of space weather in a dynamic region of Earth's upper atmosphere that can cause interference with radio and GPS communications.

Recent Updates

- Successfully completed its critical space environment tests. AWE Launch to ISS in Dec. 2023.
  - https://blogs.nasa.gov/awe/
  - https://science.nasa.gov/missions/awe



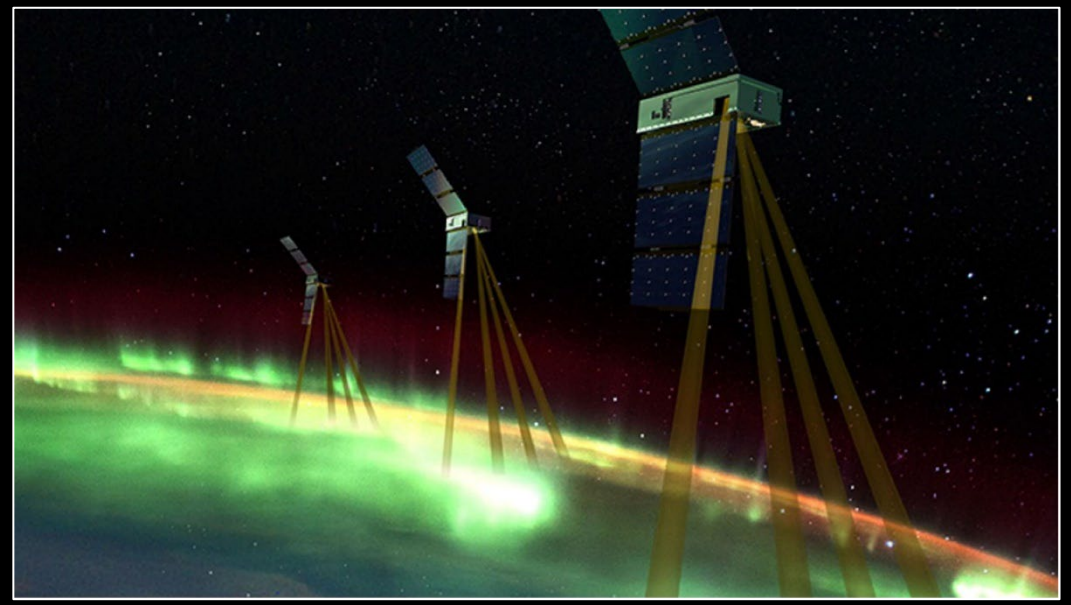
AWE AMTM instrument is built and ready for storage until delivery to KSC for launch. **Credit: Utah State University and Space Dynamics Lab (SDL)**



Credit: Utah State University and Space Dynamics Lab (SDL)

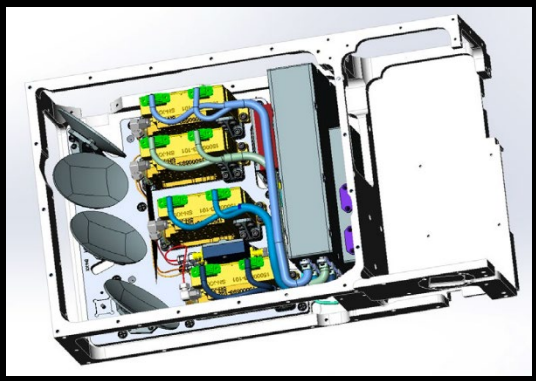
Electrojet Zeeman Imaging Explorer (EZIE)

- EZIE will explore the connections between the Sun, the magnetosphere, and the atmosphere that drives space weather near Earth.
- EZIE is a set of three 6U CubeSats that will study the auroral electrojet, which are electrical currents flowing about 60 to 90 miles above the poles that link the beautiful aurora to the Earth's magnetosphere, and which responds to solar activity and other drivers.
- EZIE will employ a novel measurement technique (Zeeman splitting of 118 GHz molecular oxygen emissions) to answer decades-long debate on how the auroral electrojet behaves during geomagnetic storms.
- Results from the mission will help scientists understand and ultimately predict how the Sun and Earth act together as an interconnected system, helping to protect space-based assets and mitigate space weather effects on satellite navigation and radio communications.



Credit: APL/NASA

Credit: Blue Canyon Technologies



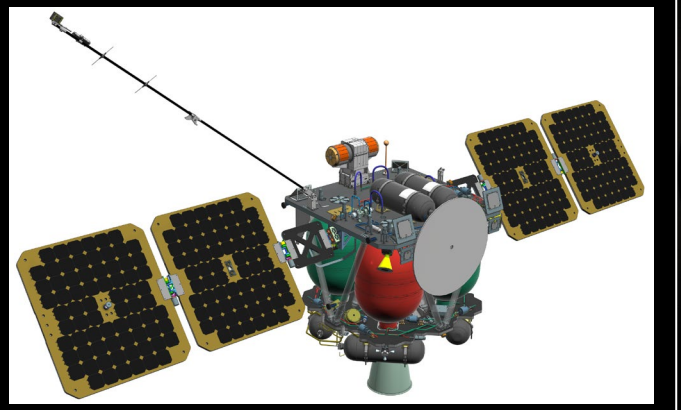
Mockup of Microwave Electrojet Magnetogram Instrument (MEM)
Credit: Jet Propulsion Laboratory

Recent Updates

- EZIE recently completed its Critical Design Review.
- EZIE-Mag Education and Outreach Program is developing hands-on magnetometer kits for distribution to middle and high school students
- More EZIE info at https://science.nasa.gov/missions/ezie

Escape and Plasma Acceleration and Dynamics Explorers (ESCAPADE)

- ESCAPADE is comprised of two small ESPA Grande-class spacecraft
  - To be launched as secondary payloads on in 2024
  - Arrives at Mars science orbit April 2026 for 11-month science mission
- Using instruments to measure magnetic fields, ions, and electrons, the ESCAPADE spacecraft will
  - Analyze how Mars' magnetic field guides particle flows around the planet;
  - Observe how energy and momentum are transported from the solar wind through Mars' magnetosphere;
  - Study what processes control the flow of energy and matter into and out of the atmosphere.



Credit: University of California, Berkeley

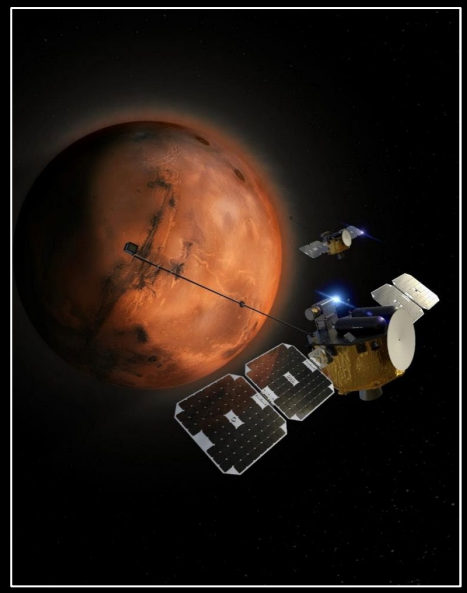


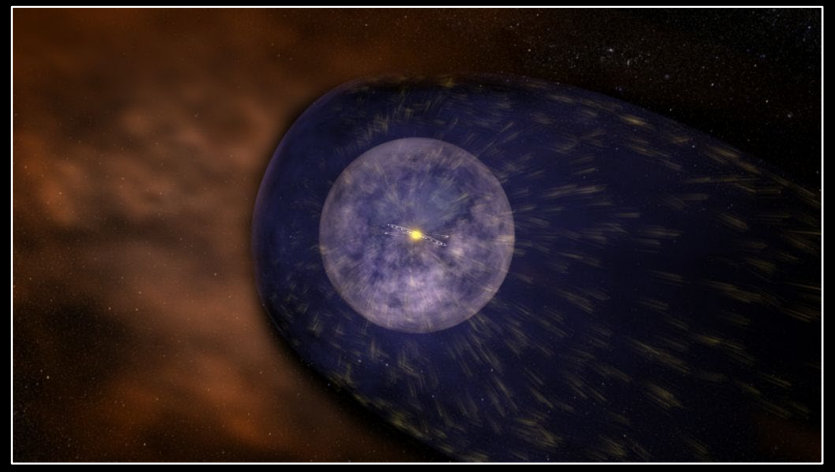
Illustration of the ESCAPADE spacecraft in orbit around Mars. ***Credits: Rocket Lab USA/UC Berkeley***

Recent Updates

- Planetary launch window is August 6-15, 2024
- To be launched as primary payloads on Blue Origin New Glenn

Interstellar Mapping and Acceleration Probe (IMAP)

- IMAP will explore the heliosphere and decode the messages in particles from the Sun and beyond.
- Three of the instrument suites will work together to build detailed maps of the boundaries of the solar system using energetic neutral atoms, which travel from the edge to Lagrange point 1 (L1), the point between the Sun and Earth where gravitational forces balance.
- IMAP's other instruments collect information from the Sun's solar wind and provide timely updates about space weather conditions.



NASA's IMAP, will help us better understand the nature of interplanetary space, which is dominated by a constant flow of particles from the Sun called the solar wind. ***Credit: NASA***

Recent Updates

- The IMAP spacecraft primary structure is assembled and beginning integration of its propulsion system.
- IMAP successfully completed its critical design review in Jan. 2023.
  - https://blogs.nasa.gov/imap/2023/01/31/nasas-imap-mission-successfully-completes-critical-design-review/

Credit: Johns Hopkins Applied Physics Laboratory

Carruthers Geocorona Observatory

- Carruthers Geocorona Observatory will survey the exosphere, the outermost layer of Earth's atmosphere. Carruthers is the first mission dedicated to charting changes there.
- It seeks to answer basic questions about the nature of Earth's exosphere, like its shape, size, and density, and what causes them change over time.
- Carruthers will ride to space along with IMAP, the Interstellar Mapping and Acceleration Probe, which will explore the boundaries of the heliosphere, the bubble that is inflated by the solar wind and surrounds the Sun and planets.

The Carruthers Geocorona Observatory mission will provide insights into how Earth's exosphere is influenced by changes in space, including the solar wind, shown here flowing from the Sun in this illustration. ***Credits: NASA***

Dr. George Carruthers, right, and William Conway, a project manager at the Naval Research Institute, examine the gold-plated ultraviolet camera/spectrograph, the first moon-based observatory that Carruthers developed for the Apollo 16 mission.
Credits: U.S. Naval Research Laboratory

Recent Updates

- In December 2022, NASA renamed its Global Lyman-alpha Imager of the Dynamic Exosphere, or GLIDE, mission in honor of Dr. George R. Carruthers.

Space Weather Program

Space Weather Research to Operations / Operations to Research (R2O2R)

- ROSES-23 focused topics:
  - Data Assimilation for Neutral Density Forecasting
  - Open Call

Space Weather Grand Challenge

- Identify the next low-latency data stream to enable a significant advancement in space weather forecasting

HERMES & Gateway

- HERMES: space weather instrument suite led by HPD will observe solar particles and the solar wind.
- HERMES Payload I&T is expected to begin in April/May 2023
  - LRD for the first Gateway launch (which will include HERMES) is Oct 2025.
  - HPD working with the Gateway Program on future opportunities for competitive science payloads.

Space Weather Pipeline

- Constructing four instruments, SPAN-E, SST, ECP-Lite, Faraday Cup for future flight opportunities
- RFI for commercials platforms that can host instruments is about to be released

Vigil

- Vigil AO will be released soon with updates based on feedback from Draft AO

This photo was taken from the ISS on Feb. 28th and shows the sweeping scale of the aurora during a geomagnetic storm **Credits: NASA/Josh Cassada**

Research and Analysis Update

- Heliophysics R&A Programs have grown significantly since DRIVE Initiative was recommended by 2013 Decadal Survey

- ROSES-2022 selection rates are healthy
  - Space Weather Centers of Excellence selections are imminent
  - Eclipse 2024 element in ROSES 2022
  - Three DRIVE Science Centers selected in 2022 have kicked off Phase 2 activities

- ROSES-2023 solicitation provides the greatest scope ever offered for NASA Heliophysics
  - New Technology Program and Space Weather Program
  - Growing number of Cross-Divisional programs
  - New opportunities with AI/ML aspects (MDRAIT and H-ARD)

ROSES 2022 Selections to date

ROSES 2022 Selections					
ROSES Element	# Proposals Received	# Proposals Selected	% Selected	# New PI	% New PI
SWR202R	17	4	23%	2	50%
HGIO	87	25	28%	15	60%
HTIDS	24	11	45%	5	45%
HFOS	7	4	57%	2	50%
H-TM	10	6	60%	3	50%

2023 Research and Analysis Program Elements

- HSR: Supporting Research (Dual Anonymous Format)
- HGIO: Guest Investigator (Dual Anonymous Format)
- Living With a Star (LWS) Science
- Space Weather R2O2R (+Transition)
- HTIDS: Technology and Instrument Development for Science
- HLCAS: Low Cost Access to Space
- HFOS: Flight Opportunity Studies
- HFORT: Flight Opportunities for Research and Technology
- HITS: Heliophysics Innovation in Technology and Science
- H-ARD: Heliophysics AI/ML-Ready Data
- H-TM: Heliophysics Tools and Methods
- H-CSI: Heliophysics Citizen Science
- SOGI: Solar Orbiter Guest Investigator
- Multi-Disciplinary:
  - Habitable Worlds
  - FINESST
  - MDRAIT: Multidomain Reusable Artificial Intelligence Tools
  - XRP: Exoplanets
- In-Development: Two new Space Weather Offerings!

https://science.nasa.gov/researchers/solicitations/roses-2023/research-opportunities-space-and-earth-science-roses-2023-released

Inclusion, Diversity, Equity, and Accessibility (IDEA) in Heliophysics

IDEA initiatives in Heliophysics are a long-term and far-reaching effort, but immediate and mid-term action and problem solving will advance initiatives in parallel with systemic, enduring activity.

2024 Decadal Survey is Underway

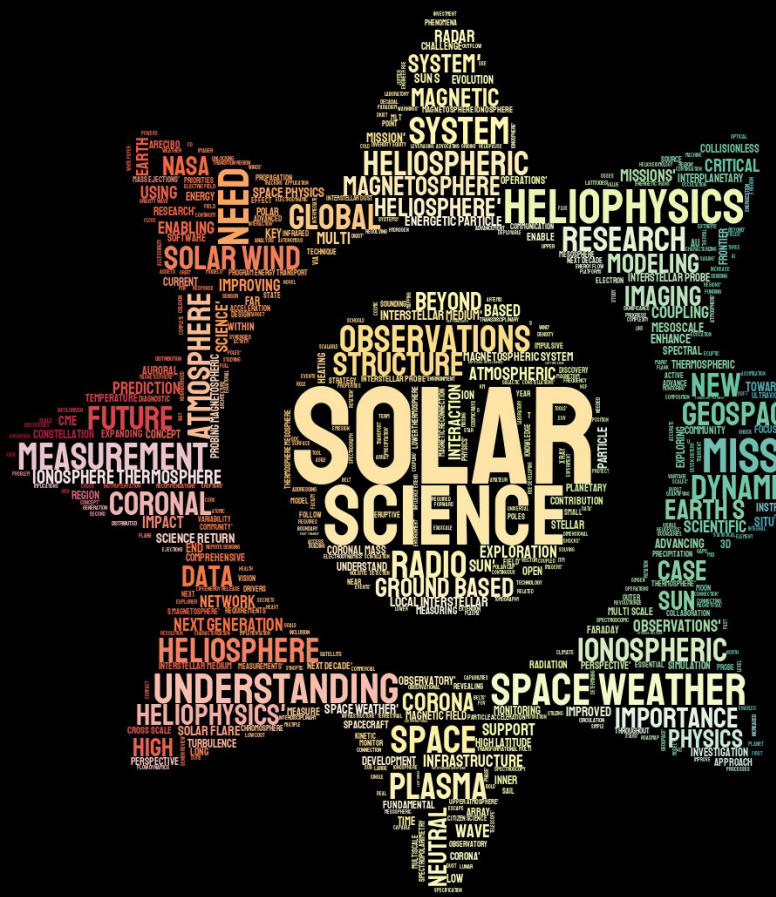
*Importance of the Decadal Survey cannot be overstated. This is **the** opportunity to set a vision for the next decade and beyond!*

- Decadal Survey is charged to "generate consensus recommendations to **advance and expand the frontiers of solar and space physics** in the current decade and **lay the groundwork for continued advances in future decades**." [Decadal Survey, Statement of Task]

- For more information, including on upcoming panel meetings, see the NASEM website:
  - https://www.nationalacademies.org/our-work/decadal-survey-for-solar-and-space-physics-heliophysics-2024-2033

Image credit: National Academies of Science website

492 white papers submitted



Word cloud of the Heliophysics Decadal White Paper titles, Credit: James Paul Mason

SMD: Transform to Open Science (TOPS)

From 2022 to 2027, TOPS will accelerate the engagement of the scientific community in open science practices through events and activities aimed at:

- Lowering barriers to entry for historically excluded communities
- Better understanding how people use NASA data and code to take advantage of our big data collections
- Increasing opportunities for collaboration while promoting scientific innovation, transparency, and reproducibility.

NASA is designating 2023 as the Year of Open Science, a global community initiative to spark change and inspire open science engagement through events and activities that will shift the current paradigm.

- TOPS has three overarching goals:
  - Increase understanding and adoption of open science principles and techniques in our Mission and Research Communities
  - Accelerate major scientific discoveries through supporting the adoption of open science
  - Broaden participation by historically excluded communities

Join the TOPS email list: https://science.nasa.gov/open-science/transform-to-open-science


eclipse
THROUGH THE EYES OF NASA
NASA
The 2023 & 2024
Solar Eclipses
through the eyes of NASA
Lunar topography data from NASA's Lunar Reconnaissance Orbiter and the Japan Aerospace Exploration Agency's SELENE lunar orbiter were used to precisely calculate the location of the Moon's shadow for the 2023 and 2024 solar eclipses. The planetary positions are from NASA's Jet Propulsion Laboratory Development Ephemeris 421. Earth imagery from NASA's Blue Marble: Next Generation series were used to create the terrain and Earth at night imagery from NASA's Black Marble were used under the eclipse paths.
2023 Annular Solar Eclipse
Saturday October 14, 2023
2024 Total Solar Eclipse
Monday April 8, 2024
Credit: Michala Garrison and the Scientific Visualization Studio (SVS), in collaboration with the NASA Heliophysics Activation Team (NASA HEAT), part of NASA's Science Activation portfolio
Eclipse calculations by Ernie Wright, NASA Goddard Space Flight Center
2023 Annular Solar Eclipse
2024 Total Solar Eclipse
9:15 AM PDT
9:20 PDT
9:25 PDT
10:30 MDT
10:35 MDT
10:40 MDT
11:45 CDT
11:50 CDT
12:00 CDT
12:05 PM CDT
2:20 PM CST
2:25 CST
2:30 CST
1:30 CDT
1:35 CDT
1:40 CDT
1:45 CDT
1:50 CDT
1:55 CDT
2:00 CDT
2:05 CDT
3:05 EDT
3:10 EDT
3:15 EDT
3:20 EDT
3:25 EDT
3:30 EDT
4:35 PM ADT
2023 Maximum Partial Obscuration (%)
2024 Maximum Partial Obscuration (%)
2023 Path of Annularity Sat. October 14, 2023
Along a path about 125 miles wide, the Sun will appear as a "ring of fire" in the sky. Annularity lasts up to 5 minutes depending on the viewer's location within this path.
2024 Path of Totality Mon. April 8, 2024
Along a path about 115 miles wide, the Moon will completely block the Sun in the sky. Totality lasts up to about 4 minutes and 28 seconds depending on the viewer's location within this path.
Outside of these paths, viewers within the 48 contiguous U.S. states and many other areas will see a partial solar eclipse (in the shaded areas below).
Find More: http://solarsystem.nasa.gov/eclipses
NP-2022-11-909-GSFC

2023

2024

SOLAR ECLIPSES

https://solarsystem.nasa.gov/eclipses/

© Colleen Pinski

HELIOPHYSICS BIG YEAR

Get Involved and Stay Informed!

Stay in touch and help us find new ways to highlight your work and keep you in the loop!

Sign up for the NASA Eclipse Newsletter to receive updates on eclipse activities!

- https://tinyurl.com/ym9epkjy

Stay up to date with what's happening at Headquarters:

- https://science.nasa.gov/researchers/virtual-townhall

Let us know what you've been working on:

- https://bit.ly/SubmitHelioScience

Learn more about the next solar eclipse:

- https://solarsystem.nasa.gov/eclipses/home/

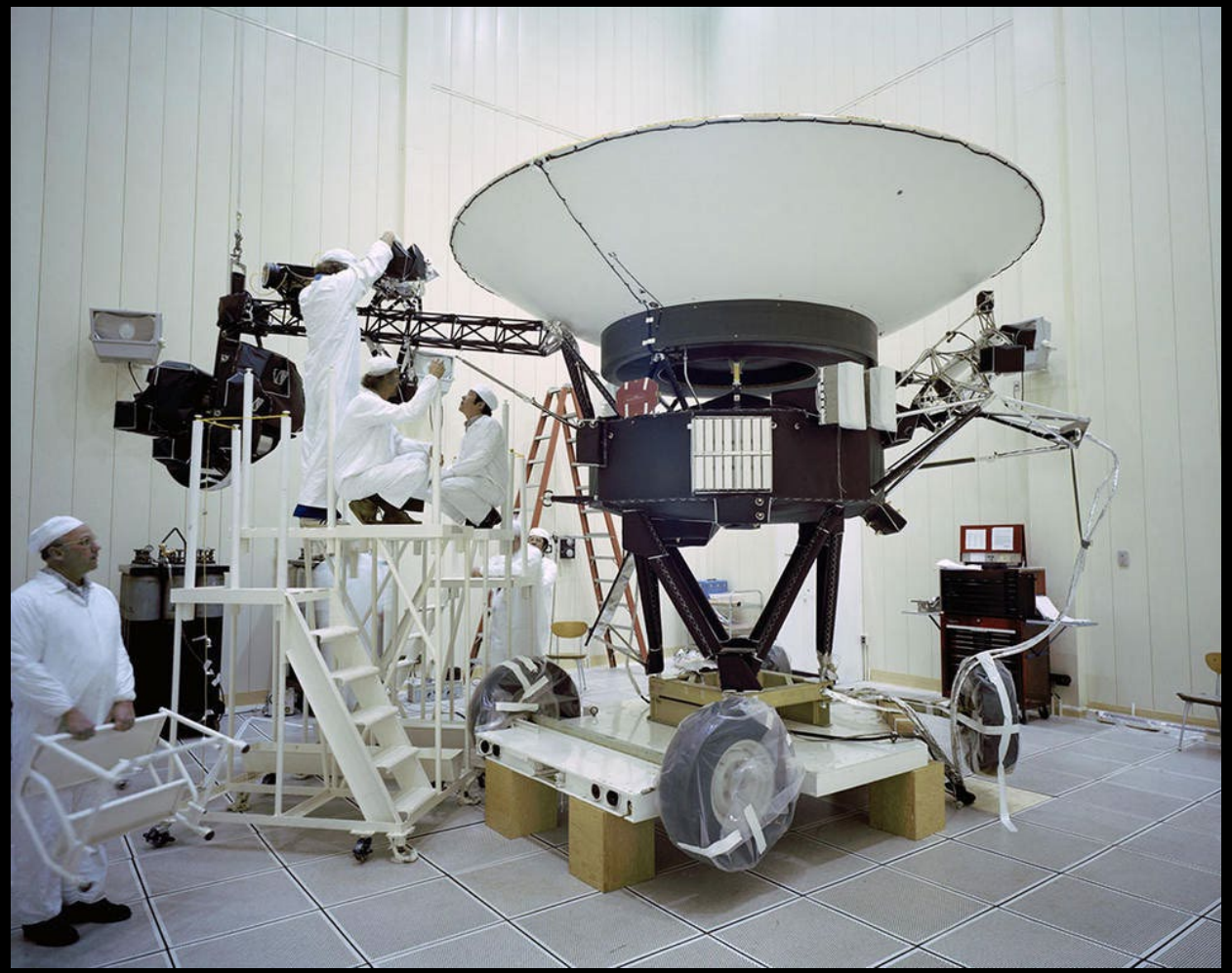
Join us for our next Community Town Hall:

- https://science.nasa.gov/researchers/virtual-townhall

NASA.gov/sunearth **blogs.nasa.gov/sunspot** **@NASASun** **facebook.com/NASASunScience**

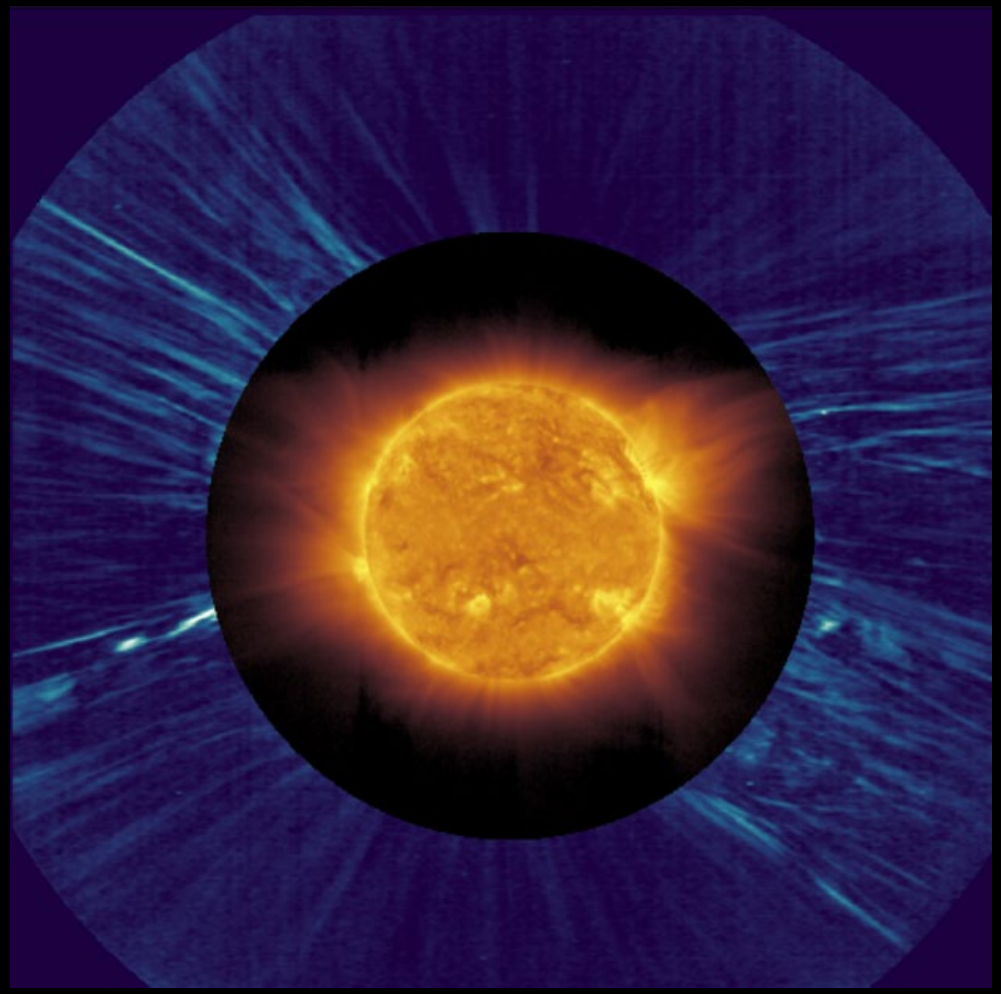
IT'S A GREAT TIME TO BE A HELIOPHYSICIST

Voyager, NASA's longest-lived mission, turns 45



July 2022 Cover of Scientific American

Solar Orbiter observes magnetic switchback



First ever remote sensing observation of an S-shaped ‘switchback’ magnetic feature in the solar wind by combining data from the EUI Telescope

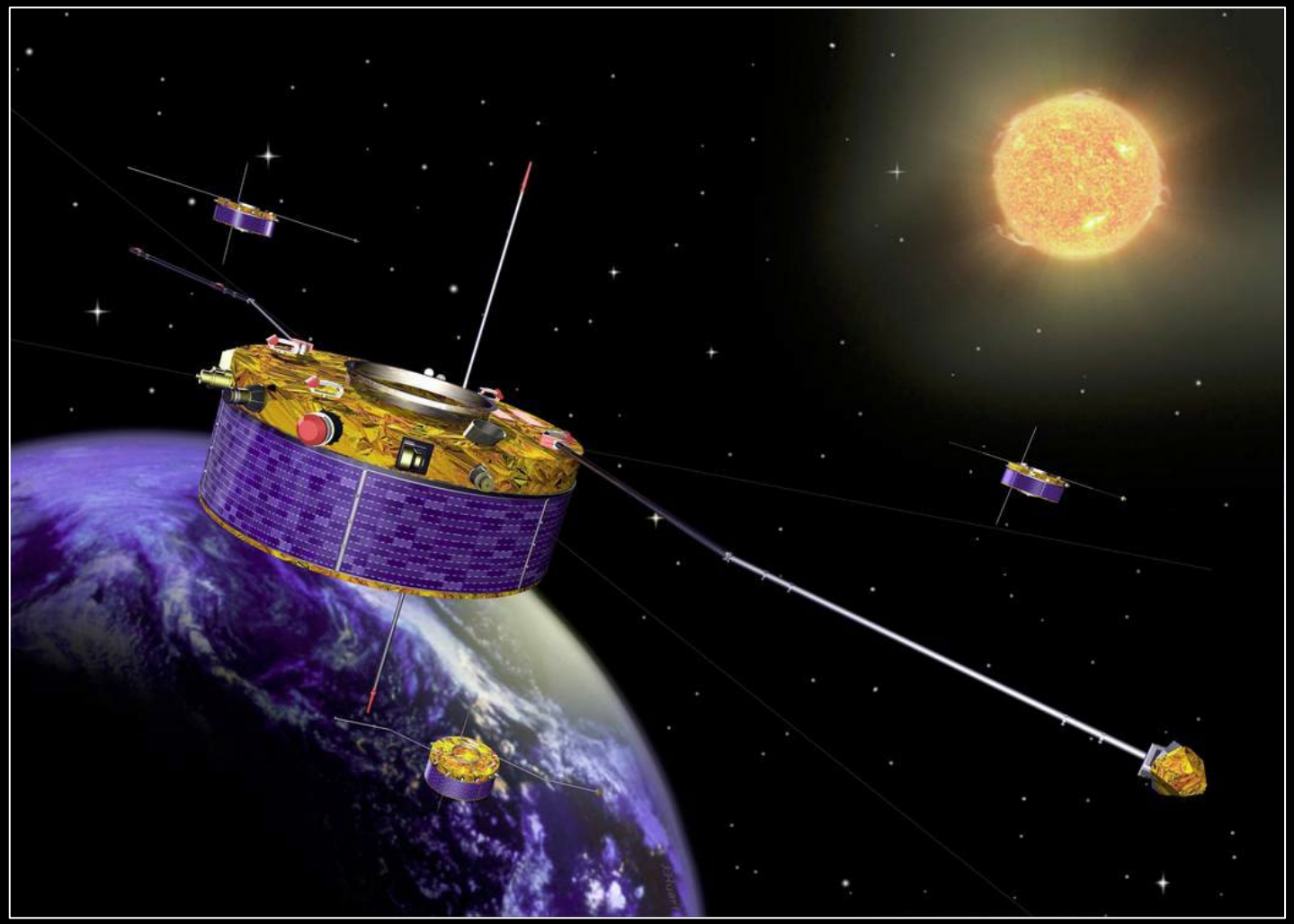
PARKER SOLAR PROBE ENCOUNTER #13

On Sept 6, Parker Solar Probe reached perihelion #13

Geospace Dynamics Constellation (GDC)

- GDC will provide key advances in our understanding of Earth's ionosphere-thermosphere system, including providing the scientific foundation for our ability to quantify and forecast space weather effects both on Earth and in space.
- NASA is happy to announce the start of the GDC mission science team!
  - Project Scientist – Dr. Doug Rowland
  - Deputy Project Scientists – Dr. Larry Kepko & Dr. Katherine Garcia-Sage
  - Interdisciplinary Scientists - selected Nov 2021
  - Dr. Rebecca Bishop (The Aerospace Corp.), Prof. Yue Deng (Univ. Texas, Arlington), Prof. Jeffrey Thayer (CU Boulder)
  - Investigations, delivering science instruments—selected Apr 2022
    - Modular Spectrometer for Atmosphere and Ionosphere Characterization (MoSAIC): Dr. Mehdi Benna, UMBC
    - The Comprehensive Auroral Precipitation Experiment (CAPE): Dr. Daniel Gershman, NASA GSFC
    - Atmospheric Electrodynamics probe for THERmal plasma (AETHER): Dr. Laila Andersson, CU Boulder
    - Thermal Plasma Sensor (TPS): Dr. Phillip Anderson, University of Texas, Dallas
    - Near Earth Magnetometer Instrument in a Small Integrated System (NEMISIS): Dr. Mark Moldwin, University of Michigan
- Spacecraft procurement via GSFC-managed RFP, proposals received Feb. 10, 2023

Cluster, joint ESA/NASA mission, turns 22 as it continues to explore the magnetosphere



Artist's depiction of the four Cluster spacecraft in Earth's magnetic field. Credit: ESA

NASA Cluster spacecraft on July 16, 2000. ***Credits: ESA/Starsem-S.Corvaja***