National Aeronautics and Space Administration

2023

HELIOPHYSICS TECHNOLOGY ANNUAL REPORT

HESTO

HELIOPHYSICS STRATEGIC TECHNOLOGY OFFICE

HESTO LEADERSHIP

ROSHANAK HAKIMZADEH hakimzadeh@nasa.gov

Dr. Hakimzadeh is a Program Scientist and the Deputy Chief Technologist in the Heliophysics Division (HPD) at NASA Headquarters. In this role, she led the establishment of the Heliophysics Technology Program and the Heliophysics Strategic Technology Office (HESTO). Prior to joining HPD, she had a long and successful career at NASA's Glenn Research Center (GRC), where she led research and technology at the Branch, Division, and Directorate levels. Of note are her roles as GRC's Chief Technologist and Deputy Chief Technologist, where she provided technical leadership within GRC for the planning, management, and evaluation of a comprehensive, advanced, Center-wide technology development program to meet GRC's future mission responsibilities.

KYLE MCALLEN kyle.mcallen@nasa.gov

Mr. McAllen is the Program Manager for HESTO, a NASA Level II program based out of NASA's Wallops Flight Facility that supports the NASA Headquarters Heliophysics Technology Program. He previously was the Launch and Test Director at NASA's WFF, leading ISS Commercial Resupply, National Reconnaissance Office Orbital, DoD Testing and Evaluation, Navy Fleet Forces Training Exercises, and Sounding Rocket suborbital science missions out of Wallops Island, Virginia and Poker Flats, Alaska. He has also served on the Range Commanders Council Range Operations Group, National Rocket Propulsion Test Management Group, and NASA's Rocket Propulsion Test Management Board.

STEVEN CHRISTE steven.d.christe@nasa.gov

Dr. Christe is a Research Astrophysicist in the Heliophysics division at NASA's Goddard Space Flight Center. His background and interests have focused on the science of impulsive energy release on the Sun, such as solar flares. He has worked on multiple sounding rocket launches (FOXSI) and a balloon mission (HEROES), which have matured X-ray detectors and grazing-incidence focusing optics. Dr. Christe was the Principal Investigator for the FOXSI Small Explorer mission concept, which was selected for a Phase A study, and is currently leading the development of an X-ray detector for the PADRE H-FORT mission.

MELISSA COLD melissa.a.cold@nasa.gov

Ms. Cold serves as the Program Specialist for HESTO through NASA's Wallops Flight Facility Small Satellite and Special Projects Office (S3PO). She works closely with the NASA Science Mission Directorate (SMD) Program Officers in the oversight of grants, cooperative agreements, and technology awards. She also serves in a similar capacity for other programs across Heliophysics and Astrophysics, including the H-FORT, Pioneers, and APRA programs. Throughout her NASA career, Melissa has supported multiple organizations across WFF in a resource management capacity and NASA Kennedy Space Center as the Lead Resource Analyst for the Exploration Research and Technology Program.

WELCOME

In 2020, NASA established the HEliophysics Strategic Technology Office (HESTO) to support and manage its Heliophysics Technology Program (HTP). Hosted at NASA Goddard Space Flight Center's Wallops Flight Facility (WFF), HESTO is tasked with facilitating HTP investments, nurturing project maturation, and promoting technology infusion toward furthering the greatest benefit to the science community. HESTO informs and guides solicitations and nurtures advancement of technology investments to ensure the successful delivery of new Heliophysics technologies. HESTO also supports our diverse scientific and technology community through outreach efforts, including events like our first annual Heliophysics Technology Symposium this year.

I am pleased to present this first Heliophysics Technology Annual Report, which highlights HESTO's ongoing Heliophysics Technology investments, including those awarded under our Heliophysics Technology and Instrument Development for Science (H-TIDeS) and Heliophysics Flight Opportunities Studies (H-FOS) program elements. I am also pleased to announce the recipients of our 2023 proposal selections, who will begin their work of discovery in 2024.

HESTO's guiding vision is to inspire new realms of Heliophysics knowledge, implemented through our mission of enabling novel and transformative capabilities and mission concepts; advancing science by disrupting the limits of what is measurable, observable, and achievable in Heliophysics; and setting the tone for the future of the field by enabling the technology that makes science and missions not conceivable or achievable today a reality of the future.

Roshanak

Roshanak Hakimzadeh, PhD
HESTO Program Scientist

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PORTFOLIO OVERVIEW

HELIOSPHERE

Investigations into the origins and behavior of the solar wind, energetic particles, and magnetic fields in the heliosphere, including their interactions with Earth, other planets, and the interstellar medium

MAGNETOSPHERE

Investigations into the physics of the magnetosphere, including the fundamental interactions of plasmas and particles with fields and waves and their coupling to the solar wind and ionosphere

SOLAR SCIENCE

Investigations into the Sun, including the processes taking place throughout the solar interior and atmosphere, as well as the evolution and cyclic activity of the Sun

ITM

Investigations into the physics of Earth's ionosphere, thermosphere, and mesosphere, including their coupling to the Earth's lower atmosphere and to the magnetosphere

HESTO is pleased to announce its 2023 selections:

2023

- **Laboratory XUV Spectroscopy: Increasing the Scientific Return of Solar Missions**
  PI: Amy Gall, Smithsonian Astrophysical Observatory 23-HTIDS23-0008
  Project to measure and identify lines from Fe VIII to Fe XXII ions by surveying the 50-200 Å XUV wavelength regime. These lines are important for advancing our understanding of the Sun and the solar corona and providing updates to atomic databases, such as CHIANTI.

- **Hybrid AC/DC Magnetometer with Attitude Determination and Control System**
  PI: Mark Moldwin, University of Michigan 23-HTIDS23-0001
  Project to advance an attitude determination and control system that can make research-quality magnetic measurements from DC to 1 kHz by developing a new hybrid magnetometer and ACS. The system will enable boom-less magnetometry on science and commercial small satellites.
- **Scanning Coronal and Heliospheric Imager (SCHI)**
  PI: Juliana Vievering, Johns Hopkins University 23-HTIDS23-0016
  Project to develop a new visible light telescope that provides high-resolution, wide field-of-view maps of the white light solar corona using novel achromatic hybrid metasurface Risley prisms (MRPs) to significantly reduce instrument size and complexity.
- **Multi-Needle Langmuir Probe for Detection of Extremely Small Spatial Structures in LEO**
  PI: Aroh Barjatya, Embry-Riddle Aeronautical University 23-HTIDS23-0023
  Project to develop a Langmuir probe (≥80 KHz sample rate) to enable CubeSat constellations that can perform high spatial resolution and high-fidelity plasma-density measurements. These measurements can address space weather science objectives and characterize micro-meteoroid orbital debris signatures.
- **A New HOPE for Ionospheric Outflow and Cold Magnetospheric Plasma Measurements**
  PI: Carlos Maldonado, Triad National Security, LLC 23-HTIDS23-0024
  Project to develop a new modified Helium, Oxygen, Proton, and Electron (HOPE) ion mass spectrometer to obtain high energy resolution observations of low-energy (0.5 eV to 100 eV) ion populations in ionospheric outflows and cold magnetospheric space plasmas.
- **Multi-detector Experiment for next-Generation Applications in Heliophysics (MEGA-H)**
  PI: Joshua Eskin, Ball Aerospace 23-HTIDS23-0025
  Project to develop a 395-megapixel, multi-detector camera system that uses an optical imaging system with an exit beam that is split onto four individual detectors.

- **CubeSat: On the Radiation belt electron Acceleration (CORA)**
  PI: Hong Zhao, Auburn University 23-HFOS23-0003
  Project to develop the CORA mission, with the goal to understand relativistic and ultrarelativistic electron acceleration and quantify the effect of inward radial diffusion as an acceleration mechanism in the radiation belts to GEO using a novel method of probing electron flux oscillations.

2022

- **Production Pathways of the OH Meinel Band Emission Required for TIMED/SABER Observations**
  PI: Konstantinos Kalogerakis, SRI International 22-HTIDS22-0008
- **Scaling Studies of Seeded Alfven Wave Parametric Decay Instability in the Laboratory**
  PI: Feiyu Li, New Mexico Consortium 22-HTIDS22-0019

- **Goddard Miniature Coronagraph** PI: Jeffrey Newmark, NASA's GSFC 22-HTIDS22-0004
- **Solar Neutron TRACking Instrument (SONTRAC) Follow-on**
  PI: Georgia de Nolfo, NASA's GSFC 22-HTIDS22-0005
- **Lightsheet Anomaly Resolution And Debris Observation-Neuromorphic (LARSDO-N)**
  PI: Andrew Nicholas, NRL 22-HTIDS22-0006 INTERDISCIPLINARY
- **HIRSL: a HIgh-Resolution Spectrograph in Lyman alpha**
  PI: Majd Mayyasi, Boston University 22-HTIDS22-0007
- **Measuring Plasma Parameters and Waves in the Ionosphere of Earth**
  PI: Mihailo Martinovic, University of Arizona, Tucson 22-HTIDS22-0013
- **Debris and meteoroid ENvironment Sensor (DENTS): Instrument Technology Development**
  PI: David Malaspina, University of Colorado, Boulder 22-HTIDS22-0014 INTERDISCIPLINARY
- **Development and Testing of a Miniaturized Double Langmuir Probe for Small-satellite Platforms**
  PI: Robert Clayton, Embry-Riddle Aeronautical University 22-HTIDS22-0018
- **Space Debris Detection and Characterization Using an in-situ LIDAR Sensor Platform**
  PI: John McVey, Aerospace Corp 22-HTIDS22-0020 INTERDISCIPLINARY
- **Miniaturized Charging Mitigation Shell Instrument for Magnetospheric Cold Plasma Sensors**
  PI: Justin Lee, Aerospace Corp 22-HTIDS22-0023

- **Satellite Space Weather Investigation Frontier (SWIFT)**
  PI: Mojtaba Akhavan-Tafti, University of Michigan, Ann Arbor 22-HFOS22-0001
- **Space Weather Impact on Planetary Emissions (SWIPE)**
  PI: Mary Knapp, MIT 22-HFOS22-0002 INTERDISCIPLINARY
- **Satellite Auroral Plasma Sounders (SAPS)** PI: Alex Chartier, Johns Hopkins University 22-HFOS22-0003
- **Loss Through Auroral Microburst Pulsations Satellite (LAMPsat) Flight Opportunity Study**
  PI: Mykhaylo Shumko, JHU/APL 22-HFOS22-0007

O INTERDISCIPLINARY

H-TIDeS

LNAPP

ITD

H-FOS

The technology portfolio is ROSES elements B.8 **Heliophysics Instrument Development for Science** (H-TIDeS) and B.10 **Heliophysics Flight Opportunity Studies** (H-FOS).

H-TIDeS includes the **Laboratory Nuclear, Atomic, and Plasma Physics** (LNAPP) and **Instrument Technology Development** (ITD) focus areas.

LNAPP supports studies that probe fundamental nuclear, atomic, and plasma physical processes and produce chemical and spectroscopic measurements that support spacecraft observations and atmospheric models. ITD includes innovative instrument and technology development that may be proposed as candidate experiments for future space flight opportunities.

PORTFOLIO OVERVIEW

2021

- Exploring 3D Collisionless Magnetic Reconnection in the Laboratory
  PI: Jan Egedal, University of Wisconsin, Madison 21-HTIDS21-0003
- Development of Grotifer: a CubeSat for Three-dimensional Electric Field Measurements
  PI: Solène Lejosne, University of California, Berkeley 21-HTIDS21-0002 INTERDISCIPLINARY
- High-Frequency Magnetic Loop for Heliophysics Exploration
  PI: Xiaojia Zhang, University of California, Los Angeles 21-HTIDS21-0004
- An Imaging Polarimeter for Hydrogen Lyman-α PI: Sam Tun Beltran, NRL 21-HTIDS21-0010
- Low-resource Instrumentation for Scientific Measurements in Planetary Thermospheres
  PI: James Clemmons, University of New Hampshire 21-HTIDS21-0012
- Dual Cluster Mission Concept Study PI: Xinlin Li, University of Colorado, Boulder 21-HFOS21-0001
- LabOratory for the Behavior of the SIoT Region (LOBSTR) PI: Rachael Filwett, Univ of Iowa 21-HFOS21-0002

2020

- Study of Coronal X-ray Jet Formation Using Advanced Numerical Simulations and Laboratory Experiments PI: Masaaki Yamada, Princeton University 20-HTIDS20-0017
- Lower Hybrid Drift Waves and Associated Electron Heating During Guide Field Reconnection
  PI: Hantao Ji, Princeton University 20-HTIDS-0-0018
- Solar Imaging Metasurface Polarimeter (SIMPol) PI: Roberto Casini, UCAR 20-HTIDS20-0002
- Advancement of a Lyot Filter Demonstration Instrument (LFDI) for Space-borne Solar Physics Investigations PI: Scott Sewell, UCAR 20-HTIDS20-0004
- Plasma Radiation Combined IN-situ Instrument (PRCINI)
  PI: Ian Cohen, JHU/APL 20-HTIDS20-0009 INTERDISCIPLINARY
- LIEFSI – Laboratory Investigation of Electric Field Sensor Instabilities
  PI: John Bonnell, University of California, Berkeley 20-HTIDS20-0010 INTERDISCIPLINARY
- Compact Ion Mass Spectrometer (CIMS) for Ionospheric Outflow and Cold Magnetospheric Plasma Measurements PI: Carlos Maldonado, Triad National Security, LLC 20-HTIDS20-0012
- Solar Neutron TRACking Instrument (SONTRAC) PI: Georgia de Nolfo, NASA's GSFC 20-HTIDS20-0014
- Development of an EMCCD Space Camera for UV Spectroscopy: Probing Nitric Oxide in the Polar Night PI: Leon Harding, VA Polytec 20-HTIDS20-0015
- Development of a Novel Nano-Transmitter Plasma Wave Antenna PI: Bill Amatucci, NRL 20-HTIDS20-0020
- Multi Look-Direction Magnetic Electron Spectrometer for Auroral Studies
  PI: Robert Michell, NASA's GSFC 20-HTIDS20-0021
- Mass Spectrometry of the Turbopause Region (MSTR)
  PI: Chad Fish, Orion Space Solutions 20-HTIDS20-0027
- CLASS, a Compact Lyman-Alpha Spatial Heterodyne Spectrometer
  PI: Seyedeh Sona Hosseini, NASA's JPL 20-HTIDS20-0028
- Increasing the Dynamic Range of Spaceflight Charged Particle Instruments
  PI: Christopher Mouikis, University of New Hampshire, Durham 20-HTIDS20-0031
- Miniaturized High-Energy-Resolution relativistic electronic Telescope (HERT)-Auburn
  PI: Hong Zhao, Auburn University 20-HTIDS20-0034
- Uranus Orbiter Mission: Determining the Scope and Feasibility of a Dedicated Heliophysics Mission PI: Ian Cohen, JHU/APL 20-HFOS20-0001
- Solar Transition Region UltraViolet Explorer PI: Alfred de Wijn, UCAR 20-HFOS20-0002
- A Large Constellation of Spacecraft for Mapping the 3D Magnetic Structure of the Solar Wind
  PI: Bennett Maruca, University of Delaware 20-HFOS20-0008
- Nitric Oxide Infrared Emissions Cubesat PI: Martin Mlynczak, NASA's LaRC 20-HFOS20-0009
- Plasma Tomography (PlaTo) Mission Study PI: Wendy Frank, University of Colorado, Boulder 20-HFOS20-0011

2019

- Laboratory Studies of OH(v) + O Multi-quantum Vibrational Relaxation Required for TIMED/SABER Observations PI: Konstantinos Kalogerakis, SRI International 19-HTIDS19-0003
- Fe IX Line Survey and Density Sensitivity Studies in Support of the NASA Heliophysics Program
  PI: Daniel Savin, Columbia University 19-HTIDS19-0005
- Excitation of Whistler-Mode Chorus Waves in a Laboratory Plasma
  PI: Xin An, University of California, Los Angeles 19-HTIDS19-0006
- Investigating Magnetospheric Whistler-Mode Chorus Features Using SPSC Laboratory Experiments PI: Erik Tejero, NRL 19-HTIDS19-0026
- Medium Energy Electron Telescope (MEET) PI: Xinlin Li, University of Colorado 19-HTIDS19-0001
- MICRO – Magnetograph using Interfermetric and Computational imaging for Remote Observations PI: Neal Hurlburt, Lockheed Martin 19-HTIDS19-0002
- Fast, Multi-spectral, Polarization-Sensitive IR Detectors for Solar Astronomy from 5 to 100 Microns PI: Gary Bernstein, University of Notre Dame 19-HTIDS19-0008
- Technology Development of High Speed CMOS Detectors and Multilayer Mirrors for Dynamic Solar Soft X-Ray Spectral Imaging
  PI: Christopher Moore, Smithsonian Astrophysical Observatory 19-HTIDS19-0017
- ACSEPT: A Compact Solar Energetic Particle Telescope PI: Brian Walsh, Boston University 19-HTIDS19-0019
- Development and Demonstration of an All Solid-State 4.7 THz Spectrometer Enabling Measurements of Thermospheric Winds, Temperature, and O Density
  PI: Sam Yee, Princeton University 19-HTIDS19-0027
- Development of the Alaska Cubesat Auroral Plasma Spectrometer (ACAPS)
  PI: Donald Hampton, Geophysical Institute 19-HTIDS19-0030

2018

- Laboratory Investigation of Satellite Gas-Surface Interactions for Accurate Construction of Atmospheric Models PI: Marcin Pillinski, University of Colorado, Boulder 18-HTIDS18-0025
- CHIMERA: A Hybrid Search Coil and Fluxgate Magnetometer for Small Spacecraft Missions
  PI: David Miles, University of Iowa 18-HTIDS18-0010
- Small UV Imager for Heliophysics Science Investigations
  PI: Thomas Immel, Space Sciences Laboratory/University of California, Berkeley 18-HTIDS18-0060

2017

- Development and Testing an Energetic Charged Particle Prototype with a Novel Synthetic Diamond Cherenkov Radiator PI: James Connell, University of New Hampshire 17-HTIDS17-0070

SPECIAL PROJECTS

- Solar wind and Pickup Ion Composition Energy Spectrometer (SPICES)
  PI: Susan Lepri, University of Michigan, Ann Arbor SPECIAL PROJECT INTERDISCIPLINARY
- MAGnetometers for Innovation and Capability (MAGIC)
  PI: David Miles, University of Iowa SPECIAL PROJECT

HELIOSPHERE | MAGNETOSPHERE | SOLAR SCIENCE | ITM | INTERDISCIPLINARY COMBINES MULTIPLE STUDY REGIMES

H-TIDeS: LNAPP, ITD | H-FOS

HESTO BY THE NUMBERS 2023 STATS

59 Active Projects

11 Mission Studies (H-FOS)

3 Special Projects

45 Technology Development (H-TIDeS)

9 Laboratory Studies (LNAPP)

35 Instrument Tech Dev (ITD)

94 Students

41 Universities

4 Federal Agencies & FFRDCs

4 NASA Centers

33 PI Institutions

43 PIs

32 First-Time PIs

21 PI States

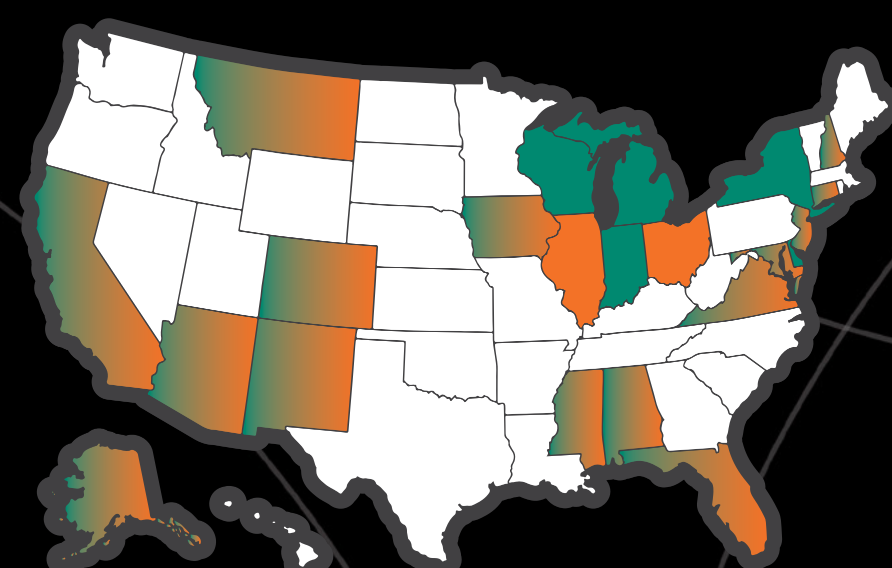
7 Non-Heliophysics PIs

54 Co-I Institutions

153 Co-Is

20 Co-I States

6 Co-I/Collaborator Countries



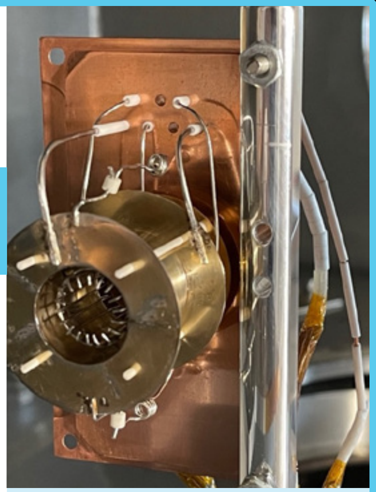
*Only includes projects active in 2023, not those awarded in January 2024.

TECH HIGHLIGHTS

RECONCILING THE LONGSTANDING MYSTERIES OF SATELLITE DRAG

Laboratory Investigation of Satellite Gas-Surface Interactions for Accurate Construction of Atmospheric Models

This research addresses important questions in satellite aerodynamics that will enable increased accuracy when using satellite drag for atmospheric model construction, validation, and assimilation. Specifically, our team is examining the physical underpinnings and assumptions underlying the satellite drag coefficient through a combination of laboratory data and orbital analysis. Inconsistencies in these two approaches have been noted since the beginning of the space age and are yet to be fully resolved. Furthermore, there has previously been very little information on how satellite-gas interactions change as we move upwards through the most congested orbital regions where the dominant oxygen atmosphere gives way to helium. The results of the study will be encapsulated in a software package called Vehicle Environment Coupling and Trajectory Response (VECTOR). VECTOR software calculates the coefficient of drag from a given set of input parameters. The software is publicly available at: swx-trec.com/vector/



Scattering experiment in the CU Boulder Aero department MBEAM lab

EARLY CAREER	POSTDOC	GRAD	UGRAD
	2	1	

Marcin Pilinski University of Colorado, Boulder
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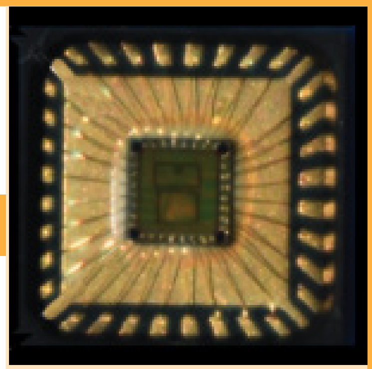
INNOVATIVE CHIP DEVELOPMENT TO ENABLE NEXT GENERATION ENERGETIC PARTICLE SENSORS

ACSEPT: A Compact Solar Energetic Particle Telescope

Solar energetic particles (SEP) originate at the Sun and are energized and transported by processes such as solar flares and coronal mass ejections. Understanding these processes requires an instrument that can measure multiple SEP species over a wide energy range. ACSEPT is an energetic particle telescope that can measure H to Fe ions with energies of 0.5 to 100 MeV/nuc. The Boston Extended Range Amplitude (BEAR) integrated circuit is a single channel readout integrated circuit designed to work with ACSEPT. It contains a modified charge-sensitive amplifier (CSA) that dynamically extends the range of the entire system by 2 orders of magnitude. The CSA uses switchable capacitors added in parallel to the detector to share the input charge, which reduces input signal and prevents the circuit from saturating. The BEAR integrated circuit was designed using Taiwan Semiconductor Manufacturing Company's 130 nm technology. Test results show the BEAR integrated circuit is capable of measuring charge between 61 fC and 49 pC.



Microscope image of the BEAR chip developed for ACSEPT

TRL 3 → 4 → 5

EARLY CAREER	POSTDOC	GRAD	UGRAD
1	3	1	

Brian Walsh Boston University
bwalsh@bu.edu 19-HTIDS19-0019

STUDIES OF OH(v) VIBRATIONAL RELAXATION BY OXYGEN ATOMS

Decoding the Energy Transfer Processes of Earth's Nightglow

Earth's upper atmosphere produces a faint chemiluminescence that illuminates the night sky, known as nightglow. The hydroxyl radical, OH, is an important species in the chemistry and energy balance of the upper atmosphere and its Meinel band emission is a dominant feature in the near-infrared region of the nightglow. Although a common target for remote sensing observations, there are multiple gaps in our understanding of the processes responsible for the production and loss of vibrationally excited OH(v) in the mesosphere, including relevant rate constants and reaction pathways. This research uses laser-based laboratory studies to better understand energy transfer between highly vibrationally excited OH and oxygen atoms and determine its kinetics for accurate analysis and interpretation of the Meinel band emission. Knowledge of the production and loss processes relevant to vibrational relaxation of OH is a critical input for analyzing observations of the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) radiometer on NASA's TIMED mission.

SRI's atmospheric chemistry and physics laboratory

Konstantinos S. Kalogerakis SRI International
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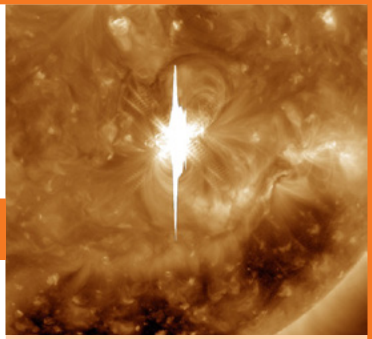
DYNAMIC SOFT X-RAY AND UV DETECTORS CATCH 'FLASHY' SOLAR FLARES

Fast Readout Detectors for Bright Solar Flares

Current detectors can be overwhelmed during large solar flares, as in this image of the Solar Dynamics Observatory (SDO) Atmospheric Imaging Assembly (AIA) instrument's charge coupled device (CCD) based imager that shows the detector saturating and blooming during an intense solar flare. The Harvard-Smithsonian team is developing next generation soft X-ray and ultra-violet (UV) high-speed readout detector and camera systems for future satellite missions to observe the Sun and astrophysical objects. Complementary Metal Oxide Semiconductor (CMOS) detectors are capable of uncovering solar flare plasma features that remain obscured using current detector technology and the new sensor technology mitigates both saturation and blooming. Compared to CCDs, these CMOS sensors use less power, are smaller, cost less, provide higher speed imaging and faster processing, and avoid CCD visual artifacts like saturating and blooming. The new CMOS-based sensors will be tested on an upcoming High-resolution Coronal Imager (Hi-C) NASA sounding rocket mission.



The SDO/AIA instrument's CCD detector saturating and blooming during a large solar flare

TRL 2 → 4 → 6

EARLY CAREER	POSTDOC	GRAD	UGRAD
8	1	2	4

Christopher S. Moore
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H-TIDeS LNAPP H-TIDeS ITD H-FOS HELIOSPHERE ITM MAGNETOSPHERE SOLAR SCIENCE

TECH HIGHLIGHTS

STUDYING A KEY DRIVER IN THE GENERATION OF EARTH'S RADIATION BELTS

Investigating Magnetospheric Whistler-Mode Chorus Features

Because the underlying nonlinear wave-particle resonant interactions of whistler chorus phenomena play a key role in Earth's radiation belt dynamics, developing and maturing electron distribution function measurement laboratory techniques is critical to understanding the effects and efficiency of these interactions. Investigations into chorus features, performed at the Naval Research Laboratory's Space Physics Simulation Chamber (SPSC), used nonlinear wave-particle interactions in experiment and simulation as they relate to whistler chorus waves, the dominant driver in the creation and clearing of Earth's natural radiation belts. These studies included investigations into the physical processes leading to the generation of whistler chorus modes, while developing and maturing the electron distribution function laboratory measurement techniques needed to understand the underlying physical mechanisms. Progress includes the first laboratory observation of sub-cyclotron resonant wave-particle interactions, the most likely underlying physical mechanism for the gaps in whistler chorus wave power observed in space.

EARLY CAREER	POSTDOC	GRAD	UGRAD
3		2	1

Erik Tejero US Naval Research Laboratory
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NRL's SPSC enables well-diagnosed, repeatable, controlled experiments in scaled ionospheric and magnetospheric plasmas

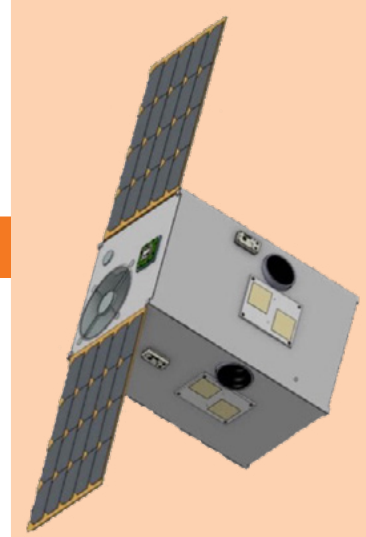
REVEALING THE MAGNETIC CONFIGURATIONS IN ACTIVE SOLAR REGIONS THAT LEAD TO INSTABILITIES

STRUVE: Solar Transition Region UltraViolet Explorer

Magnetism in the solar atmosphere is responsible for space weather through explosive processes, such as flares and coronal mass ejections (CMEs), but our ability to understand these processes is limited by a lack of observations. STRUVE's objective is to advance our understanding of energy build-up and storage in the solar atmosphere and its eventual release through flares and CMEs. STRUVE, a slit-scanning, full-Stokes spectropolarimeter CubeSat mission, is designed to observe the Sun in the near-ultraviolet in a promising wavelength band for chromospheric magnetic field diagnostics. This wavelength region contains the well-known Mg II h and k lines, as well as many Fe I and Fe II lines that together enable diagnostics of the magnetized plasma in the solar atmosphere from the photosphere through the chromosphere and up to the transition region at the base of the corona. This unprecedented capability is relevant to developing an improved description of the magnetically connected solar atmosphere.

EARLY CAREER	POSTDOC	GRAD	UGRAD
		2	

Alfred de Wijn High Altitude Observatory, National Center for Atmospheric Research dwijn@ucar.edu 20-HFOS20-0002



STRUVE CubeSats will enable space weather observations

QUANTUM DOTS ENABLE POWERFUL DETECTORS IN SMALL AND FLEXIBLE PACKAGES

QDS: Quantum Dot Spectrometer

QDS is an innovative quantum dot-based ultra-compact multispectral imager concept that eliminates typically necessary long pathlength optical components (e.g., prisms, gratings). Taking advantage of quantum dots' special optical properties due to quantum confinement effects turns a set of quantum dot (QD) pixels, each with a distinct absorption profile, into a compact spectral imager able to fit in a CubeSat. This novel standalone instrument concept is highly tunable to specific wavelengths, from ultraviolet to visible to infrared, and can enable a variety of applications across disciplines in Earth Science, Heliophysics, and Planetary Science, including oceanography, meteorology, atmospheric chemistry, volcanic ash characterization, and studies of clouds, aerosols, vegetation, and auroral emissions. The unique advantages of QDs can also enable novel mission architectures, such as the proposed ScienceCraft for Outer Planet Exploration (SCOPE) mission, which would incorporate QD sensors printed directly onto a solar sail to create an ultralightweight craft that is also the main science instrument.

EARLY CAREER	POSTDOC	GRAD	UGRAD
3	1	3	

Mahmooda Sultana NASA's Goddard Space Flight Center
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A 10 mm x 10 mm x 1 mm Quantum Dot array

TRL 1 → 4 → 4

CATCHING THE ULTRA-FAST AURORA WITH A MULTI LOOK DIRECTION MAGNETIC ELECTRON SPECTROMETER

APES-360: Acute Precipitating Electron Spectrometer-360

APES-360 builds on the successful development of APES, a single look-direction magnetic electron spectrometer that can achieve 1-millisecond (ms) time resolution for the entire energy spectrum from 500 eV to 30 keV. APES magnet geometries were modified to extend the field of view (FOV) to 16 look-directions, covering a 360-degree FOV over an anticipated energy range of 1 to 20 keV, which is currently optimized for precipitating electrons within Earth's aurora. Incorporating novel anode geometries and preamp designs enabled keeping the instrument's 1-ms time resolution, as well as its capability of operating over a large dynamic range of electron fluxes. By utilizing magnets of different strengths, APES-360 has the versatility to be optimized for different energy ranges to support a variety of science goals. The current prototype is slated for a winter 2025 rocket launch into the aurora to fully characterize its performance in a real space plasma environment.

EARLY CAREER	POSTDOC	GRAD	UGRAD
1	2	2	2

Robert Michell NASA's Goddard Space Flight Center
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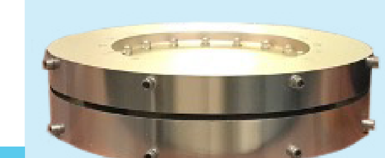


APES-360 optical system mechanical model showing the enabling magnet geometries

TRL 3 → 4 → 6

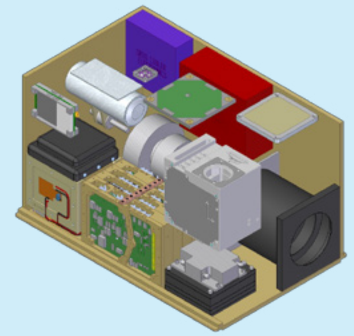
H-TIDeS LNAPP H-TIDeS ITD H-FOS HELIOSPHERE ITM MAGNETOSPHERE SOLAR SCIENCE

TECH HIGHLIGHTS

NEAR-REAL TIME OBSERVATIONS TO IMPROVE SPACE WEATHER FORECASTING

NICEcube: Nitric oxide Infrared Cooling Emissions Cubesat

Infrared radiation emitted by nitric oxide (NO) at 5.3 mm is a fundamental component of the energy budget of Earth's thermosphere between 115 and 300 km. For 22 years, vertical profiles of infrared cooling rates (W m-3) due to thermospheric NO have been derived from measurements made by the Sounding of the Atmosphere using Broad-band Emission Radiometry (SABER) radiometer on NASA's Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics (TIMED) satellite. SABER data show NO infrared cooling rates are critical to understanding and predicting the density response of the thermosphere. However, reliable density forecasts prior to, during, and after geomagnetic storm events remain elusive, as thermospheric density can increase or decrease rapidly during storm events. NICEcube, a 12U CubeSat, is designed to provide near-real time observations that will be assimilated into space weather models to create 'nowcasts' of thermospheric density. It is envisioned a future constellation of 4 to 6 NICEcubes will provide this critical new data for improving space weather forecasts.



A NICEcube equipped with a cryogenically cooled, one channel radiometer

Martin Mlynczak NASA's Langley Research Center
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NANOTECH-ENABLED "SNAPSHOT POLARIMETRY" PROMISES UNPRECEDENTED ACCURACY FOR SOLAR MAGNETISM DIAGNOSTICS

SIMPol: Solar Imaging Metasurface Polarimeter

Polarization modulation by ordered nano-structures (metasurface gratings) can be used to perform full-Stokes polarimetry without use of temporally- or spatially-variable optics. SIMPol is an imaging spectro-polarimeter capable of capturing 2D images of the Sun with full polarization information over a narrow spectral band. The design exploits recent advances in nanophotonics, enabling fabrication of a new class of polarization-analyzing diffraction gratings made of optical "metasurfaces." This produces four simultaneous images of linearly independent polarization states on a detector, achieving "snapshot polarimetry" – acquisition of a target's full polarization information with each camera frame – without the need for mechanisms. The method is operationally superior to temporal polarization modulation, which suffers from intensity fluctuations of the target (such as pointing jitter) during the modulation cycle. SIMPol can be used as a stand-alone instrument or installed at the exit pupil of an observatory telescope or other imaging system.

SIMPol observed four principal polarized orders during a calibration sequence

TRL 3 ➔ 3 ➔ 5

EARLY CAREER	POSTDOC	GRAD	UGRAD
3	1		

Roberto Casini National Center for Atmospheric Research
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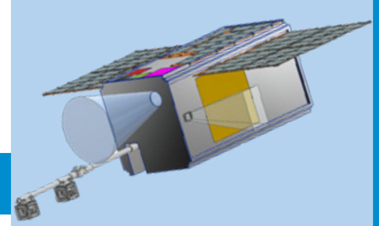
SMALLSATS BATTLE RADIATION ENVIRONMENT TO PROVIDE BIG INSIGHTS INTO THE RADIATION BELTS

LOBSTR: LabOratory for the Behavior of the SloT Region

The multi-SmallSat LOBSTR mission concept employs synchronized orbits to study the dynamics of energetic particles at the inner edge of Earth's outer radiation belt and at the outer edge of Earth's inner radiation belt. LOBSTR will characterize the dynamics at the inner edge of the outer belt and proton trapping at the outer edge of the inner belt with respect to magnetic local time (MLT). To observe multiple MLT, the LOBSTR SmallSats have near-equatorial orbits with a minimum of 60° longitudinal separation. LOBSTR answers remaining questions, including if injection events happen simultaneously globally or if loss and trapping mechanisms observed on either side of the radiation belt slot region have an MLT dependence. LOBSTR science is enabled by recent advancements in SmallSat technologies: the mission balances radiation exposure, satellite mass, and the fuel capacity needed to attain its science-enabling orbits.



LOBSTR will reveal injection and loss mechanisms of Earth's radiation belts

EARLY CAREER	POSTDOC	GRAD	UGRAD
3			

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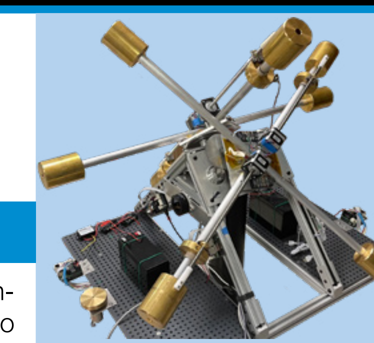
NEW INSTRUMENT DESIGN CLOSES A PERSISTENT ELECTRIC FIELD MEASUREMENT OBSERVATION GAP

Grotifer: 3D Electric Field Measurements CubeSat

Accurate knowledge of the full 3D electric field vector is fundamentally important to understanding the electrodynamics of space plasmas. Yet researchers still lack access to the reliable electric field measurements needed to close many significant science questions, which presents a significant barrier to progress. The only way to close this observational gap is a profound change in electric field instrument design. Grotifer leverages 50+ years of expertise in delivering highly accurate spin plane electric field measurements, while overcoming inaccuracies generated by spin axis electric field measurements. The key innovation for Grotifer ("giant rotifer," in reference to the wheel animalcule) consists of mounting double-probe sensors on two rotating plates, orthogonal to each other, on a non-rotating central body. This compact design answers the long-standing need for highly accurate measurements of the full electric field vector naturally present in space, while enabling lower cost deep space and constellation missions.



Grotifer attitude control system development and testing underway in the lab

TRL 3 ➔ 4 ➔ 5

EARLY CAREER	POSTDOC	GRAD	UGRAD
2			2

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H-TIDeS LNAPP H-TIDeS ITD H-FOS HELIOSPHERE ITM MAGNETOSPHERE SOLAR SCIENCE

INFUSION HIGHLIGHTS

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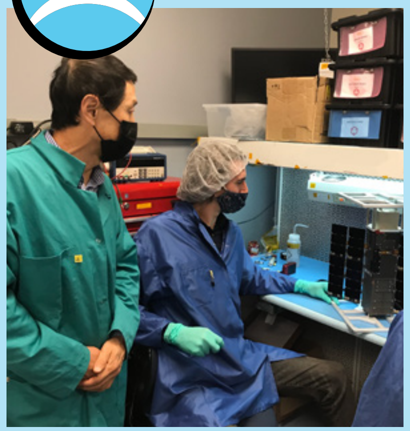
Laboratory for Atmospheric and Space Physics xinlin.li@lasp.colorado.edu



PI watching a student during project I&T

TRL 4 → 9 → 9

REPTile-2: Relativistic Electron and Proton Telescope integrated little experiment-2

UNDERSTANDING THE "KILLER ELECTRONS" IN EARTH'S MAGNETOSPHERE

The Educational Launch of Nanosatellites (ELaNa) initiative helps advance NASA exploration goals by supporting low-cost missions and expanding access to space. ELaNa #47, the Colorado Inner Radiation Belt Experiment (CIRBE) 3U CubeSat built by University of Colorado, Boulder, launched April 2023 into a highly inclined low Earth orbit with the goal of further understanding the formation of inner radiation belt electrons. CIRBE's single instrument, REPTile-2, an advanced version of REPTile incorporating full pulse height analysis and a new anti-coincidence technique, is a particle detector capable of measuring relativistic electrons in the energy range of 0.25 to 6 MeV. REPTile-2 measurements revealed, for the first time, detailed dynamic features of the radiation belt electrons, including long lasting drift-echoes (aka 'zebra stripes') across the entire inner belt and part of the outer belt. Ongoing REPTile-2 measurements will further enhance our understanding of the behavior of these potentially damaging electrons (aka 'killer electrons').

LASP

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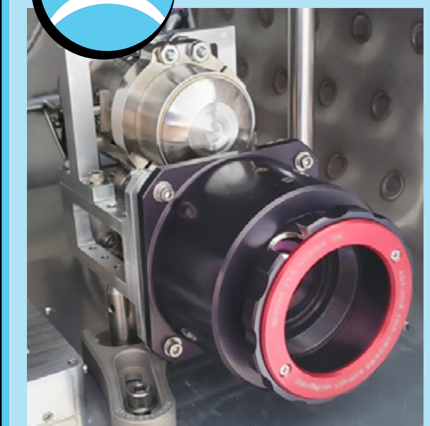


DWTS infrared radiometry camera

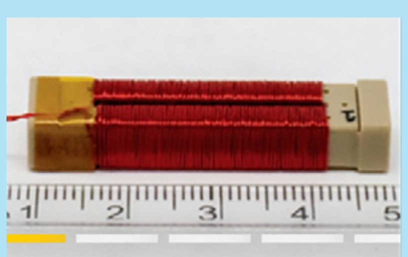
TRL 3 → 5 → 6

DWTS: Doppler Wind and Temperature Sounder

NEW TECHNOLOGY TO IMPROVE LONG-RANGE WEATHER FORECASTING

DWTS, a novel concept for measuring global wind and temperature from cloud-top to the thermosphere, can replace and augment failing systems, providing a path to low-cost data. DWTS is a cryogenically-cooled, infrared radiometry camera that uses gas filter radiometry to measure Doppler shifts and Doppler emission spectra broadening to infer wind and temperature. DWTS images the limb with high precision through low-pressure CO_2, NO, and N_2O gas cells, measuring temperature and wind continuously, day and night, from 15 to >250 km at intervals of 10 km along-track, with less than 2% uncertainty. A constellation of 6-12 DWTS SmallSats will provide unprecedented observation of global atmospheric dynamics from the lower stratosphere into the middle thermosphere, greatly improving weather forecasting. DWTS can support international demand for high-resolution forecasting, NOAA's need for precision weather prediction, and provide NASA satellite decay and re-entry monitoring, while contributing to NASA science observations and space weather forecasting.

GATS Global Atmospheric Technologies and Sciences · Ames Research Center · NOAA



New 'racetrack' format core

TRL 3 → 6 → 7

MAGIC: Magnetometers for Innovation and Capability

BUILDING A NEW GENERATION OF FLUXGATE MAGNETOMETER CORES

Fluxgate magnetometers have historically been dependent on a 25-year-old supply of 'ringcores' produced using a lost method. To enable a new generation of fluxgate magnetometers, the University of Iowa and a collaborator at the University of British Columbia are rebuilding and refining the technology needed to produce magnetometer cores. These new 'racetrack' cores start as base metal powders that are melted into custom alloys, cold-rolled into thin foils, formed into the core geometry, and then undergo multi-step treatments to optimize their magnetic properties. The MAGIC team has demonstrated that cores made using this new manufacturing process have comparable noise performance to legacy cores. Further optimizations could potentially miniaturize sensors, reduce noise, and enable efficient high-volume production for constellation missions. MAGIC will establish flight-heritage for this new design as a hosted technical demonstration payload on the Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites (TRACERS) SMEX mission in 2025.

IOWA · UBC

David Miles
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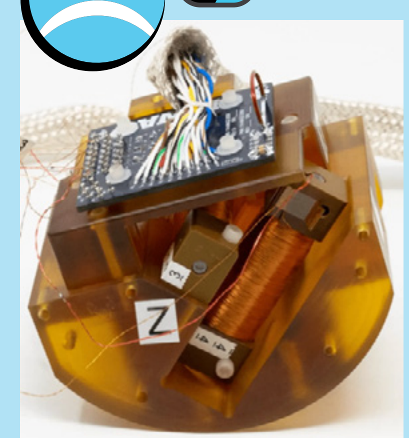
18-HTIDS18-0010



Hybrid CHIMERA sensor

TRL 3 → 6 → 6

CHIMERA: Hybrid Magnetometer for Smallsats

COMBINING SEARCH COIL AND FLUXGATE MAGNETOMETERS INTO ONE PACKAGE

CHIMERA is a hybrid magnetometer that operates simultaneously as a search coil magnetometer and as a fluxgate magnetometer, offering improved operational flexibility compared to conventional two-instrument approaches. Because independent search coil and fluxgate magnetometers interfere with one another – the search coil detecting the drive signal from the fluxgate and the fluxgate detecting a magnetic field bent by the search coil's ferromagnetic core – they are typically mounted on separate deployable booms. CHIMERA is able to measure the entire magnetic field range in a single compact sensor that requires only one deployable boom. This reduces requirements on the spacecraft, making CHIMERA well-suited to SmallSats. The team has shown the two techniques operate simultaneously without interfering and can be separated through signal processing. In 2022, CHIMERA flew as a rideshare payload on an ACES-II suborbital rocket mission. Lessons learned from this flight are being incorporated into the follow-on technology demonstration project, MAGIC.

IOWA · WFF

H-TIDeS LNAPP · H-TIDeS ITD · H-FOS · HELIOSPHERE · ITM · MAGNETOSPHERE · SOLAR SCIENCE

EARLY CAREER SPOTLIGHT

XIN AN

phyax1@gmail.com

Excitation of Whistler-mode Chorus Waves in a Laboratory Plasma | 19-HTIDS19-0006

Dr. Xin An is an Assistant Researcher in the Department of Earth, Planetary, and Space Sciences at University of California, Los Angeles (UCLA). He received his PhD in Space Physics from UCLA and BA in Space Physics from the University of Science and Technology of China. Dr. An's research interests include current sheet stability and wave-particle interactions in the Earth's magnetosphere and in the solar wind. Under the support of NASA's H-TIDeS program, he studies the excitation of whistler-mode chorus waves relevant to the Earth's magnetosphere using the LArge Plasma Device (LAPD) at UCLA.

LUCAS ANDERSON

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MSTR: Mass Spectrometry of the Turbopause Region | 20-HTIDS20-0027

Dr. Lucas Anderson is a research engineer with Orion Space Solutions and adjunct faculty at Utah State University's Center for Space Engineering. He is deputy PI of the NASA HTIDS Mass Spectrometry of the Turbopause Region; instrument PI/mission Co-I for the Active Thermal Architecture technology on the ESTO ACMES mission; and lead thermal engineer for Tetra-5. Lucas has worked in research, technology, and development with Space Dynamics Laboratory, Air Force Research Labs, ATK Test Division, and ASTRA Space. He has earned a BS/MS in mechanical and thermal engineering, a PhD in electrical engineering, and a post-doctoral position in space systems engineering.

BENNETT MARUCA

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Mapping the 3D Magnetic Structure of the Solar Wind | 20-HFOS20-0008

Dr. Bennett Maruca is an Associate Professor in the Department of Physics and Astronomy at the University of Delaware. He received his BS in Physics and in Mathematical Sciences from Carnegie Mellon University and AM in Astronomy and PhD in Astronomy and Astrophysics from Harvard University. Dr. Maruca's research focuses on kinetic processes in the solar wind and developing new instruments for observing space plasmas. He serves as an Associate Director of the Delaware Space Grant Consortium (DESGC), Director of the Delaware Space Observation Center (DSpOC), and Principal Investigator of the Solar Wind Experiment (SWE) on NASA's Wind mission.

CHRISTOPHER MOORE

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High Speed CMOS Detectors & Multilayer Mirrors | 19-HTIDS19-0017

Dr. Christopher Moore is a Research Associate and Lecturer at the Harvard and Smithsonian Center for Astrophysics. He has 10+ years of research experience in technology development, instrumentation, and solar physics, including microfabrication, vacuum systems, UV reflectance measurements, and working in clean rooms. Dr. Moore is PI for the Swift Solar Activity X-ray Imager rocket instrument and Instrument Scientist for the Miniature X-ray Solar Spectrometer CubeSat. He is also a member of the Hinode X-ray Telescope team. Dr. Moore's research includes solar UV and X-ray variations, solar magnetic field morphology, and solar flare dynamics.

IAN COHEN

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PRCINI: Plasma Radiation Combined IN-situ Instrument | 20-HTIDS20-0009

Dr. Ian Cohen is a Senior Professional Staff member and Deputy Chief Scientist of the Johns Hopkins Applied Physics Laboratory (APL) Space Exploration Sector. His research interests focus on experimental space physics, including magnetosphere-ionosphere coupling (e.g., ion outflow, auroral dynamics, and ionospheric feedback); energetic particle dynamics; and plasma and energetic particle instrumentation. He is interested in mission concept and instrument development and currently serves as Lead for the Energetic Particle Detector (EPD) Investigation aboard NASA's Magnetospheric Multiscale (MMS) mission and as Deputy Project Scientist for NASA's Interstellar Mapping and Acceleration Probe (IMAP).

SONA HOSSEINI

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CLASS: Compact Lyman-Alpha Spatial Heterodyne Spectrometer | 20-HTIDS20-0028

Dr. Sona Hosseini is a planetary scientist and a technologist who studies water's role in forming the solar system and universe. She conceptualizes innovative miniature optical spectroscopic techniques to enable novel fundamental measurements in future NASA space missions suitable for deep space and small satellites. Dr. Hosseini is recipient of the 2022 NASA Nancy Grace Roman Technology Fellowship award for her research on reforming Astrophysics Far-UV science investigation and developing new technologies to fill current measurement and science gaps and 2020 SPIE Early Career Achievement Award for her research on developing a miniature high sensitivity spectrometer for lunar missions.

MARCIN PILINSKI

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Satellite Gas-Surface Interactions for Construction of Atmospheric Models | 18-HTIDS18-0025

Dr. Marcin Pilinski is a Research Associate at the Laboratory for Atmospheric and Space Physics at the University of Colorado, Boulder. Previously, he worked at Orion Space Solutions as a research scientist, systems engineer, and deputy director of space systems. His research interests include aeronomy, satellite drag modeling, spacecraft gas-surface interactions, and data assimilation. His projects include assimilation schemes for specifying the space environment; Mars ionosphere-thermosphere research using MAVEN data; thermospheric neutral wind sensor development; teaching a graduate CubeSat design course; and exploring spacecraft gas-surface interaction near/above the oxygen helium transition.

ERIK TEJERO

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Investigating Magnetospheric Whistler-mode Chorus Features | 19-HTIDS19-0026

Dr. Erik Tejero received his BS in Physics and MS in Nuclear Engineering from the Massachusetts Institute of Technology and PhD in Plasma Physics from Auburn University. He was a Naval Research Laboratory (NRL) Karle's Fellow and is currently a Research Physicist in NRL's Plasma Physics Division, where he is the Head of the Space Experiments Section. Dr. Tejero's research interests include plasma waves and instabilities, nonlinear wave-particle interactions, and plasma diagnostics. He is PI of experiments making significant steps toward understanding the physics of Whistler-Chorus Waves.

SAMANTHA KENYON

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EMCCD Space Camera for UV Spectroscopy | 20-HTIDS20-0015

Dr. Samantha Kenyon is a Research Associate in the Virginia Tech (VT) Department of Aerospace and Ocean Engineering (AOE) and holds affiliate appointments in VT's National Security Institute (NSI) and Center for Space Science and Engineering Research. She is Deputy PI of the VT NSI HTIDS "Development of an EMCCD Space Camera for UV Spectroscopy: Probing Nitric Oxide in the Polar Night" project. In addition to her teaching responsibilities, she is PI of multiple other research programs. Dr. Kenyon earned her BS in Mechanical Engineering from Grove City College and MS/PhD in Aerospace Engineering from the University of Florida.

CARLOS MALDONADO

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CIMS: Compact Ion Mass Spectrometer | 20-HTIDS20-0012

Dr. Carlos Maldonado received his BS, MS, and PhD in Mechanical Engineering from University of Colorado, Colorado Springs. He is currently a staff scientist at LANL and PI of the Experiment for Space Radiation Analysis (ESRA) 12U cubesat mission to the radiation belts; a NASA HTIDS effort; the Autonomous Ion Mass Spectrometer Sentry (AIMSS); and a space plasma spectrometer for next generation DOE payloads. He is also an instrument scientist on the NASA IMAP-Hi and SWE instruments. Prior to LANL, he was a research scientist at the United States Air Force Academy, where he worked on nearly a dozen DoD payloads.

BRIAN WALSH

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ACSEPT: A Compact Solar Energetic Particle Telescope | 19-HTIDS19-0019

Dr. Brian Walsh is an Associate Professor at Boston University in the Center for Space Physics and Department of Mechanical Engineering. His research focuses on detector development for the study of planetary magnetospheres. He is particularly interested in the impact of the solar wind and solar energetic particles on Earth's magnetosphere. Dr. Walsh is involved in the development of novel integrated circuit designs to enable extended energy range detection for energetic particles, as well as X-ray imagers for planetary charge-exchange, and is PI of the ACSEPT instrument, which will enable particle detection over a large energy range and ion species.

HONG ZHAO

zzh0054@auburn.edu

HERT: High-Energy-Resolution Relativistic Electronic Telescope | 20-HTIDS20-0034

Dr. Hong Zhao is an Assistant Professor in the Department of Physics at Auburn University. She received her BA in Space Physics from Peking University and PhD in Aerospace Engineering Sciences from University of Colorado, Boulder. Before joining Auburn University, she worked as a Research Associate at the Laboratory for Atmospheric and Space Physics (LASP). Her research mainly focuses on understanding energetic charged particle dynamics in Earth's magnetosphere via data analysis, simulation, and space instrument and mission development. Dr. Zhao's projects include analysis of particle and field data from Van Allen Probes, MMS, GOES, THEMIS, SAMPEX, and other missions.

STUDENT TECHNOLOGISTS

ARIZONA STATE UNIVERSITY
- ✶ Angelica Berner EXPLORATION SYSTEMS DESIGN
- ✶ Johnathan Gamaunt EXPLORATION SYSTEMS DESIGN

AUBURN UNIVERSITY
- ✶ Skyler Krantz AEROSPACE ENGINEERING
- ✶ Will Teague PHYSICS

BAYLOR UNIVERSITY
- ♦ Rahul Banka PLASMA PHYSICS
- ✶ Ashley Antony Gomez ACSEPT

CORNELL UNIVERSITY
- ♦ Ritesh Pandohie APPLIED & ENGINEERING PHYSICS

GEORGE WASHINGTON UNIVERSITY
- ✣ John Grant Mitchell PHYSICS

HARVARD UNIVERSITY
- ✶ Sophia Sánchez-Maes ASTROPHYSICS

INTERAMERICAN UNIVERSITY OF PUERTO RICO
- ♦ Irving Dominguez Martinez MECHANICAL ENGINEERING

NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY
- ♦ Juliana Barstow MECHANICAL ENGINEERING & PHYSICS

NORTHEASTERN UNIVERSITY
- ♦ Brendan D'Aquino PHYSICS & COMPUTER SCIENCE

NORTHERN BURLINGTON COUNTY REGIONAL HIGH SCHOOL
- ○ Alex Alma PHYSICS

OCCIDENTAL COLLEGE
- ♦ Izzy Thomas PLASMA PHYSICS

PRINCETON UNIVERSITY
- ✶ Kendra Bergstedt HELIOPHYSICS, GEOSPACE
- ✶ Steve Majeski PLASMA PHYSICS
- ✶ Josh Pawlak PLASMA PHYSICS
- ✶ Adam Robbins PLASMA PHYSICS
- ✶ Rachel Wang HELIOPHYSICS, GEOSPACE

STANFORD UNIVERSITY
- ♦ Spencer Bell MECHANICAL ENGINEERING

UNIVERSITY OF ARIZONA
- ♦ Sarina Blanchard MECHANICAL ENGINEERING
- ♦ Ahmad Qureshi SOFTWARE/ELECTRICAL & COMPUTER ENGINEERING

UNIVERSITY OF CALIFORNIA, BERKELEY
- ♦ Tatsuyoshi Kurumiya MECHANICAL ENGINEERING
- ♦ Van Khoi Vu MECHANICAL ENGINEERING

HESTO is tasked with nurturing and supporting the maturation of Heliophysics Technology investments and facilitating their infusion into future missions. A HESTO goal is supporting the creation of a diverse and inclusive community of technologists striving to develop solutions to the biggest Heliophysics science questions. We engage and support student technologists in becoming future research, technology, and mission principal investigators. HESTO supports:

Discovery through transformative technological advancements fueled by a diverse community of student technologists.

Diversity and Inclusion that enables the widest potential participation in advancing technology by cultivating diverse technologists and scientific teams and inviting multidisciplinary technologists from outside the established Heliophysics community.

Community to foster collaboration and cooperation, catalyzing collaborative technological advancement among our diverse population of student scientists and technologists.

*Does not include all student participants from 2023

UNIVERSITY OF CALIFORNIA, DAVIS
- ✶ Humphry Chen PHOTONICS

UNIVERSITY OF CHICAGO
- ♦ Marwah Roussi PHYSICS

UNIVERSITY OF COLORADO, BOULDER
- ♦ Justin Astalos COMPUTER SCIENCE
- ✶ Tyler Bishop ASTROPHYSICAL & PLANETARY SCIENCES
- ♦ Jennifer Cuevas-Morales AEROSPACE ENGINEERING SCIENCES
- ✣ Ben Hogan AEROSPACE ENGINEERING
- ✶ Nicholas Jones AEROSPACE ENGINEERING
- ✣ Declan I'Brian AEROSPACE ENGINEERING
- ♦ Patricio Ramos MECHANICAL ENGINEERING

UNIVERSITY OF MARYLAND, COLLEGE PARK
- ♦ Danjing Chen MECHANICAL ENGINEERING
- ✶ Kyle Hrenyo PLASMA PHYSICS

UNIVERSITY OF MASSACHUSETTS, BOSTON
- ♦ Rachel Nere PHYSICS

UNIVERSITY OF NEW HAMPSHIRE
- ✶ Lance Davis PHYSICS
- ✣ George Suarez ELECTRICAL ENGINEERING

UNIVERSITY OF NOTRE DAME
- ♦ Collin Finnan ELECTRICAL ENGINEERING

UNIVERSITY OF THE VIRGIN ISLANDS
- ♦ Ryan Querrard COMPUTER ENGINEERING

UNIVERSITY OF WASHINGTON, SEATTLE
- ♦ Aryana Bhattacharyya PHYSICS

UNIVERSITY OF WISCONSIN-MILWAUKEE
- ♦ Emma Schultz-Stachnik UNDECIDED

VIRGINIA TECH
- ✶ Neha Chinthapatla AEROSPACE ENGINEERING
- ♦ Allison Hai AEROSPACE ENGINEERING
- ♦ Nathan Huh AEROSPACE ENGINEERING
- ✶ Michael Punaro ELECTRICAL ENGINEERING

WINDEMERE HIGH SCHOOL
- ○ Tristan Kidwell PHYSICS

KEY: ○ High School ♦ Undergraduate ✶ Graduate ✣ PhD

ACCOMPLISHMENTS & LOOKING AHEAD

GAP AND TREND ANALYSIS

To guide future investments in the Heliophysics Technology Program, HESTO is tasked with performing periodic technology gap and trend analyses using data collected from major sources of technology developments and the trends relevant to future Heliophysics missions. These sources include the Heliophysics Division's driving documents, including the Heliophysics Decadal Survey and Strategic Implementation Plans, as well as engagement with the science community. These gap and trend analyses will enable investment decisions and guide solicitations.

The goal for evaluating gaps and trends is to provide:

- Assessment of the current state of measurement capabilities to address the science goals of Heliophysics
- Identification of high-priority technologies and measurement techniques not currently available that are required to significantly advance Heliophysics science
- Determining high-priority technologies and measurement techniques at risk of becoming unavailable

The first HESTO gap and trend analysis was published in 2023. Highlights include:

High Priority

- Remote Sensing of coronal magnetic fields - Enables new understanding of solar-heliospheric-magnetospheric connections. Promises to enable more accurate space weather predictions and provide new understanding of solar wind acceleration and eruption initiation.
- Spinning Platforms - Many science objectives in Heliophysics require *in-situ* measurements over all angles with respect to the solar wind. The loss of this capability by industry partners would significantly impact the Heliophysics community.
- Technologies that enable deep space missions - Many new mission concepts require spacecraft in deep space (non-low-Earth orbits). Technology maturation is required in a variety of areas to enable these mission concepts.

Medium Priority

- Remote sensing of neutral winds in the upper atmosphere (e.g., Lidar, NO Sensors, THz imagers)
- High voltage power supply - Enables sensor miniaturization across many *in-situ* sensor types, including charged particle detectors and solar ENA detectors. Miniaturization of *in-situ* sensors is a major gap which, if closed would enable many missions.
- Spacecraft Autonomy - As missions concepts trend toward larger constellations combined with missions operating far away from Earth, spacecraft need to be able to operate without constant ground contacts, which may be expensive and too frequent.

H-TPAG: HELIOPHYSICS TECHNOLOGY PROGRAM ANALYSIS GROUP

To ensure community involvement in implementing the vision for NASA's Heliophysics Division (HPD) and Heliophysics Technology Program (HTP), HESTO has formed the Heliophysics Technology Program Analysis Group (H-TPAG). H-TPAG's purpose is to serve as a community-based interdisciplinary forum for soliciting and coordinating community analysis and input in support of HTP objectives and new technology development and investment in support of HPD. H-TPAG will enable direct and regular communication between NASA and the Heliophysics community and dialogue within the Heliophysics community that leads to science, technology, and programmatic input to NASA's HPD. The H-TPAG leadership, Professor Aroh Barjatya and Dr. Phyllis Whittlesey, will form its executive committee and will hold open meetings with members of the scientific and technology community. H-TPAG welcomes your involvement and questions. Contact H-TPAG leadership at: HelioTPAG@googlegroups.com

2023

- JUN — Gap and Trend Analysis
- OCT — HESTO Technology Symposium
- DEC — H-TPAG TOR and Chair and Vice-Chair Selected
- DEC — AGU
- DEC — HESTO Website Released

2024

- FEB — 2023 Annual Report Released
- FEB — ROSES-2024 H-TIDeS & H-FOS Solicitation Announcement
- WINTER — H-TPAG Charter Release
- SPRING — H-TPAG Committee Constituted
- JUL — H-TPAG Meetings
- SEP — HESTO Technology Symposium
- SUMMER — ROSES-2024 H-TIDeS & H-FOS Proposals Due
- DEC — AGU

2025

- JAN — 2024 Annual Report Release
- JAN — ROSES-2024 H-TIDeS & H-FOS Selections

As this inaugural issue of the annual Heliophysics Technology Report demonstrates, 2023 has been a busy year, and we're looking forward to another exciting year in 2024. We will continue to grow our support for our Principal Investigators (PIs) by welcoming a new Deputy Science Lead, who will enhance our science support, and by building a panel of Subject Matter Experts.

The next Heliophysics Technology Symposium will take place in September 2024 at NASA's WFF in Virginia. Although also a hybrid meeting, we hope to see many of you in person! This meeting will be open to relevant presentations from the entire community rather than only active HESTO PIs, will expand instructional talks, and offer tours of WFF facilities. We want this meeting to become one where technologists can network, learn, and collaborate. Watch for announcements of Symposium specifics by email and on our website.

NASA's Science Mission Directorate (SMD) is committed to ensuring proposals are reviewed equitably. To this end, SMD has begun to evaluate ROSES proposals using dual-anonymous peer review (DAPR) to minimize implicit and unconscious bias. We look forward to applying DAPR to Heliophysics Technology Program solicitations for ROSES 2025. To prepare prospective PIs, HESTO will provide guidance on our website and through a seminar at our 2024 Technology Symposium. To learn more, use the QR code to visit the SMD DAPR site below.

H-TPAG, under the leadership of Professor Barjatya of Embry-Riddle Aeronautical University and Dr. Whittlesey of the University of California, Berkeley, will form its Executive Committee and begin meeting in 2024. The purpose of this group is to provide feedback to HESTO about how it is serving the community and how it can improve.

Finally, we are looking forward to the summer release of the Decadal Survey for Solar and Space Physics report, which will guide technology investments to enable future Heliophysics science.

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About the Cover

HESTO is built upon fostering a powerful confluence of scientific exploration and technology innovation. The 2023 Annual Technology Report cover art is inspired by the power of science and technology meeting to reveal more about our Sun and Heliosphere. The artist's concept began with a photograph taken by astronaut Owen Garriott on August 9, 1973 (https://images.nasa.gov/details/9606705) as he observed a small flare near the limb of the Sun from Skylab 3. Using an image from the 1970s evokes how time and experience build our knowledge and progress over decades, the power of which is also embodied in the movement of the entwined solar-inspired graphical elements, representing creativity and energy, and the circuitry-inspired graphical elements, representing ingenuity and technological advancement.

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