National Aeronautics and Space Administration

A Researcher's Guide to:

INTERNATIONAL SPACE STATION

Physical Sciences Informatics System

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Cover and back cover:

a. PSI: Providing Global Access to Microgravity Physical Sciences Data
b. This color image of an ethylene-air diffusion flame was recorded 1.3 seconds after ignition in the NASA Glenn Research Center 2.2~Second Drop Tower. The flame sheet and soot are clearly visible. Ignition was performed in microgravity, and most ignition nonuniformities have dissipated here. The camera used is a Nikon D100 digital still camera with a resolution of 6 megapixels. The scale is indicated by the 6-mm spherical burner (top). ISS final Configuration (bottom). (Image credit: NASA)

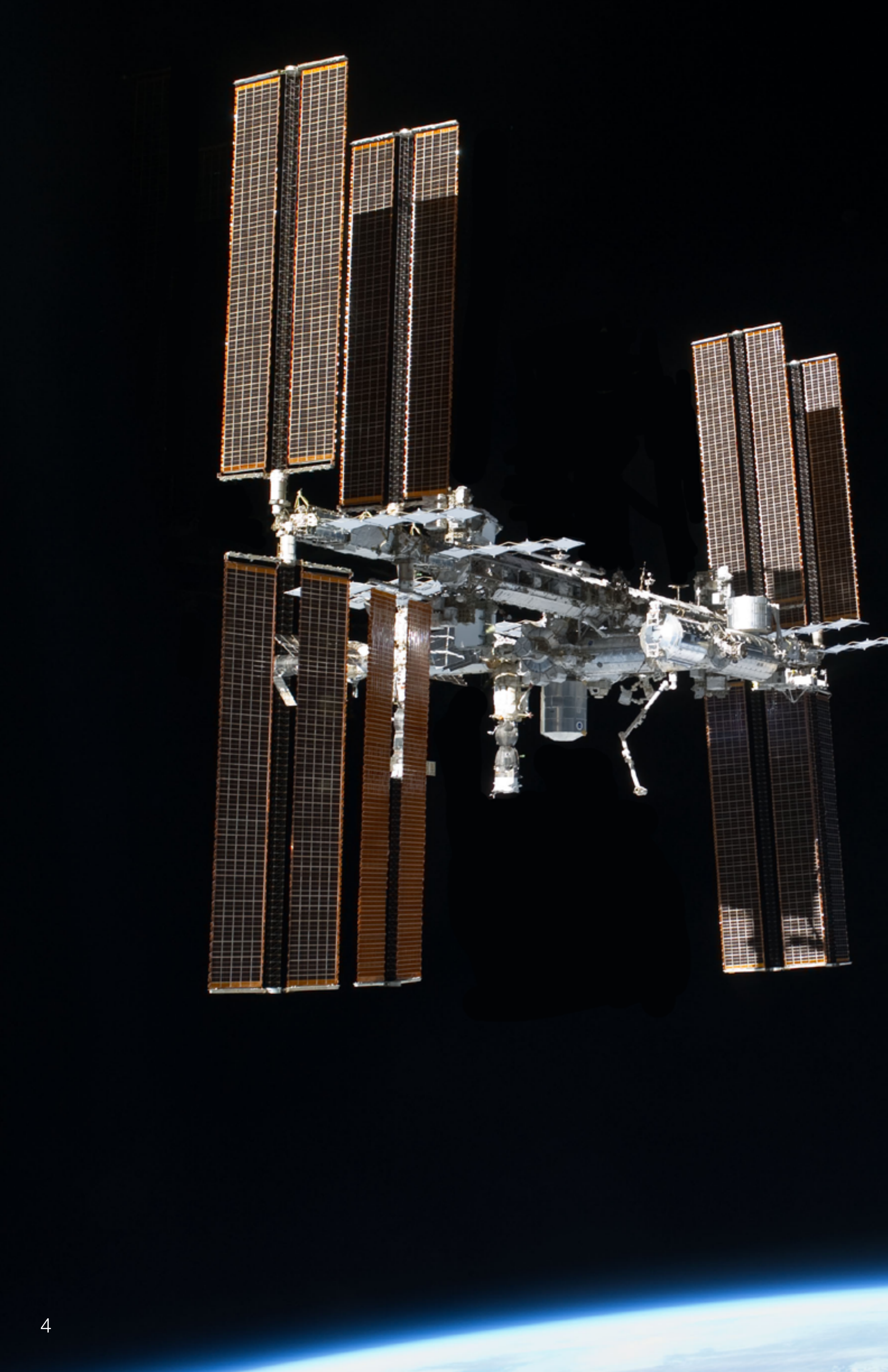
The Lab is Open

Orbiting the Earth at almost 5 miles per second, a structure exists that is nearly the size of a football field and weighs almost a million pounds. The International Space Station (ISS) is a testament to international cooperation and significant achievements in engineering. Beyond all of this, the ISS is a truly unique research platform. The possibilities of what can be discovered by using the results of research already conducted, as well as by conducting research on the ISS, are endless and have the potential to contribute to the greater good of life on Earth and inspire generations of researchers to come.

As we increase utilization of the ISS as a National Laboratory, now is the time for investigators to propose ways to use both existing and new research and to make discoveries unveiling new knowledge about nature that could not be defined using traditional approaches on Earth.

NASA s Physical Sciences Research Program conducts fundamental and applied physical sciences research, with the objective of enabling exploration and pioneering scientific discovery. NASA s experiments in the various disciplines of physical science reveal how physical systems respond to the near absence of gravity. They also reveal how other phenomena that have a small influence on physical systems in Earth's gravity can dominate system behavior in space.

Not only are we using the ISS to perform investigations, we are also taking the results from these investigations and making them available to researchers via open data. The PSI system (https://psi.nasa.gov) allows researchers to access the data from physical sciences investigations, most of which have been performed on the ISS.



Unique Features of the ISS Research Environment

1. **Microgravity**, or weightlessness, alters many observable phenomena within the physical and life sciences. Systems and processes affected by microgravity include surface wetting and interfacial tension, multiphase flow and heat transfer, multiphase system dynamics, solidification, and fire phenomena and combustion. Microgravity induces a vast array of changes in organisms ranging from bacteria to humans, including global alterations in gene expression and three-dimensional (3-D) aggregation of cells into tissue-like architecture.

2. **Extreme conditions** in the ISS environment include exposure to extreme heat and cold cycling, ultra-vacuum, atomic oxygen, and high-energy radiation. Testing and qualification of materials exposed to these extreme conditions have provided data to enable the manufacturing of long-life, reliable components used on Earth as well as in the world's most sophisticated satellite and spacecraft components.

3. **Low Earth Orbit** at 51 degrees inclination and at a 90-minute orbit affords ISS a unique vantage point with an altitude of approximately 240 miles (400 kilometers) and an orbital path over 90 percent of the Earth's population. This can provide improved spatial resolution and variable lighting conditions compared to the sun-synchronous orbits of typical Earth remote-sensing satellites.

Table of Contents

Introduction

The Physical Sciences Informatics (PSI) system (https://psi.nasa.gov) is a tool developed by NASA to serve as a data repository for the experiments performed on the ISS and other platforms. The goal of the PSI system is to enable global access to cutting-edge research data to fuel innovation and discovery. It enables more scientists to conduct research using data from the rich heritage of reduced-gravity flight investigations conducted through the NASA Physical Sciences Research Program.

Figure 1. NASA astronaut Catherine (Cady) Coleman conducts a session with the Capillary Flow Experiment 2 (CFE-2) Interior Corner Flow (ICF) Experiment. (Image Credit: NASA)

NASA's Physical Sciences Research Program and Physical Sciences Informatics System

NASA has conducted thousands of experiments in space to understand the effect of reduced gravity on physical, chemical, and biological systems. Reduced gravity manifests itself through effects such as reduced buoyancy-driven convection, sedimentation, and hydrostatic pressure. NASA's Physical Sciences Research Program conducts both fundamental and applied physical sciences research and supports the vision of the Space Life and Physical Sciences Research and Applications (SLPSRA) Division, which is to enable space exploration and pioneer scientific discovery. The Physical Sciences Research Program is organized into six disciplines: biophysics, combustion science, complex fluids, fluid physics, fundamental physics, and materials science (Figure 2). The goal of the research is to understand the physics and chemistry of systems in low gravity. Over the years, this research program has been guided by the National Research Council (NRC) reports, such as Microgravity Research in Support of Technologies for the Human Exploration and Development of Space and Planetary Bodies (2000), Directions in Microgravity and Physical Sciences Research at NASA (2003), and Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era (2011).

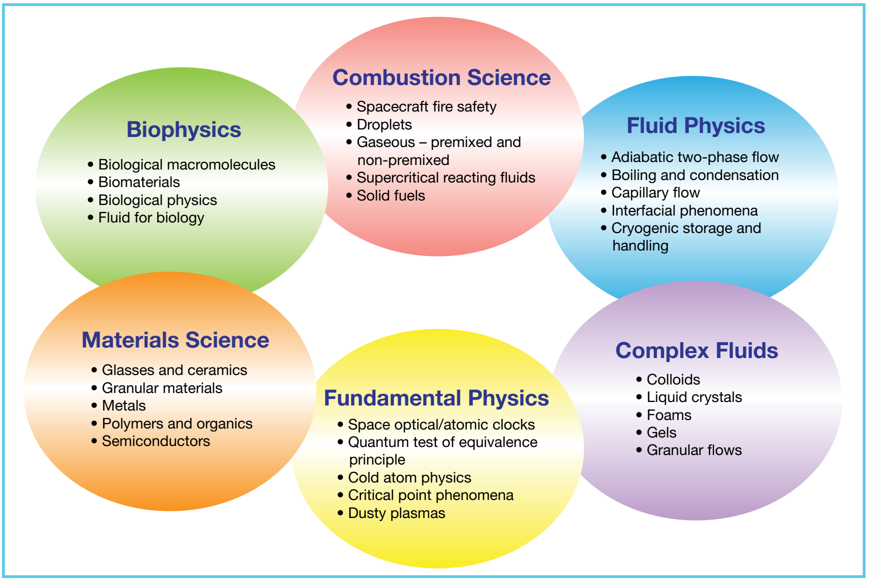


Figure 2. The six research areas for the Physical Sciences Research Program.

NASA's Physical Sciences Research Program benefits from collaborations with several international partners – Canadian Space Agency (CSA), European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), and the Roscosmos State Corporation for Space Activities (Roscosmos) – and foreign nations with space programs, such as France, Germany, and Italy. Additional partnerships have been formed within NASA, such as with the Space Technology Mission Directorate (STMD) and Advanced Exploration Systems (AES) division, as well as with other U.S. Government agencies, such as the National Institute of Standards and Technology (NIST) and the National Science Foundation (NSF), and with non-government organizations such as the Center for the Advancement of Science In Space (CASIS). The scale of this research enterprise promises new possibilities in the physical sciences. Some of these possibilities are already being realized in the form of innovations for space exploration and in advances in scientific knowledge that may lead to new ways of improving the quality of life on Earth.

NASA's experiments in the various disciplines of physical science reveal how physical systems respond to the near absence of gravity. They also show how other phenomena, which have limited influence in Earth's gravity, can dominate system behavior in space. Examples of observations in space include boiling in which bubbles do not rise, colloidal systems producing crystalline structures not achievable on Earth, circular flames burning around fuel droplets, and solidification of metal alloys producing a dendritic structure that is nearly uniform. Furthermore, reduced gravity enables the probing of ultra-cold atoms for longer duration and at lower energy compared to what is possible on Earth.

Physical science data and reports from completed ISS experiments are being loaded into the PSI system. This system is a web-based online informatics system containing science data from completed physical science reduced-gravity flight experiments conducted on the ISS, Space Shuttle flights, or Free Flyers, and from related ground-based studies. This informatics library is designed to be a research tool that allows investigators to expand upon the valuable research performed on reduced-gravity platforms to advance science in accordance with the open science research method. The PSI website is open to the general public to use in their research and further their knowledge. This database provides an opportunity to accelerate progress from ideas to research to products while also leading to advancements in fundamental research.

What is the Open Science Research Method?

Federal Government data are a valuable national resource. Managing Federal Government data to make the data open, available, discoverable, and usable to the general public, businesses, journalists, academics, and advocates promotes efficiency and effectiveness in Government, creates economic opportunities, and promotes scientific discovery. As a Federal Agency, NASA is required to publicly disclose the results of its sponsored research to generate knowledge that benefits the nation. Furthermore, promoting the full and open sharing of data with the research communities, private industry, academia, and the general public is a longstanding core value of NASA. Therefore, NASA has developed an Agency plan, "NASA Plan for Increasing Access to the Results of Scientific Research," which outlines a framework for activities to increase public access to scientific publications and digital scientific data resulting from NASA-funded research. The PSI system is designed as a tool for investigators to further science in accordance with the open science method, while also meeting the requirements of the nation's open data policy.

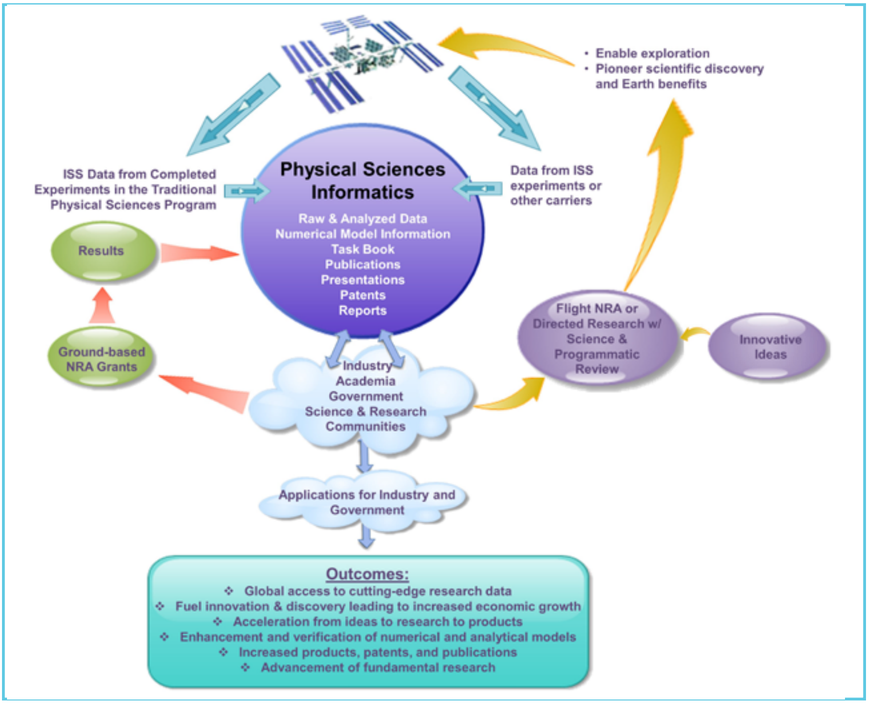


Figure 3. The Physical Sciences research program flow.

The open science method that has been adopted by NASA's Physical Sciences Research Program brings together the community of researchers to define an envelope of broadly scoped experiments that are conducted and analyzed, with the resulting data placed into the open-access PSI system. In this manner, the Physical Sciences open science vision (Figure 3) leverages raw and analyzed data from completed experiments to create experimental informatics libraries that support many more investigators who are conducting microgravity-derived research, converting what traditionally would be a single Principal Investigator (PI) research opportunity into multiple PI research opportunities. Data generated from the new research is loaded into the PSI, which provides mass dissemination of the new data to numerous investigators. In addition, open science can be viewed as the principle of providing access to the physical science data to other scientists in addition to the investigators who originally obtained the data.

Figure 4. ESA Astronaut Alexander Gerst works on the Microgravity Investigation of Cement Solidification (MICS) experiment aboard the International Space Station. (Image Credit: NASA)

PSI Research Areas

Biophysics

Biophysics is an interdisciplinary science that studies the application of physics to biological systems. Current investigations include protein crystallization, biofilms, and amyloid fibril formation.

- Protein crystals grown in space are often larger than those grown on Earth, as shown in Figure 5. It is theorized that the chemical conditions for optimal crystal growth are different in microgravity.
- Biofilms have been found to be growing on ISS surfaces and fluid systems, which cause biofouling, corrosion, and contamination. Studies on this subject will provide important data for the development of materials and methods for controlling biofilm formation to ensure environmental control systems, water supplies, and other necessary vehicle systems function properly during long-duration exploration missions.
- Amyloid fibril formation in proteins is widely studied because of its role in conditions such as Alzheimer's Disease and Parkinson's Disease, as well as its promise for advanced materials. The absence of gravity allows surface tension to provide fluid containment so that protein does not interact with solid walls. Flow effects on protein fibrillization can therefore be studied at fluid interfaces similar to physiological processes.

Microgravity fluid physics research will aid both respective fundamental science and translational research, leading to results applicable to numerous biophysical challenges encountered in space and on Earth.

The research area of biophysics includes the following themes:

- Biological macromolecules
- Biomaterials
- Biological physics
- Fluids for biology

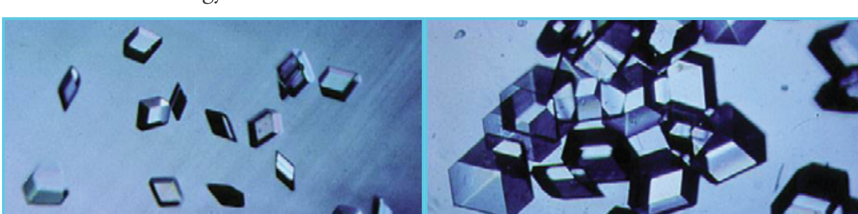


Figure 5. Images of human insulin crystals grown in 1-g (left) and microgravity (right). Crystals grown in microgravity are larger and of higher resolution. (Image Credit: NASA)

Combustion Science

Figure 6. Left: Flames on Earth in 1-g driven by convection currents. Right: Flames in microgravity exhibiting that convection does not occur in microgravity: the hot wax from the candle does not rise; instead, the hot gas diffuses and burns when reaching a supply of oxygen. (Image Credit: NASA)

One of the goals of the microgravity combustion science research program is to improve combustion processes, which are expected to lead to added benefits to human health, comfort, and safety. NASA's combustion science in microgravity research focuses on effects that can be studied in the absence of buoyancy-driven flows caused by Earth's gravity, as illustrated in Figure 6. This figure shows that the familiar teardrop shape of the flame on Earth, caused by upward airflow, becomes spherical in microgravity due to the absence of this flow. Research conducted without the interference of buoyant flows can lead to an improvement in combustion efficiency that has the potential for considerable economic and environmental impact.

Combustion science is relevant to a range of challenges for long-term human exploration of space that involve reacting systems in reduced and low gravity. These challenges include the following:

- spacecraft fire prevention, detection, and suppression
- thermal processing of regolith for oxygen and water production
- thermal processing of the Martian atmosphere for fuel and oxidizer production
- processing of waste and other organic matter for stabilization and recovery of water, oxygen, and carbon

Substantial progress in any of these areas will be accelerated significantly by an active reduced-gravity combustion research program using the open science method.

The research area of combustion science includes the following themes:

- Spacecraft fire safety
- Droplets
- Gaseous – premixed and non-premixed
- Supercritical reacting fluids
- Solid fuels

Complex Fluids

Complex fluids comprise a large class of soft materials including colloids, micro-emulsions, foams, liquid crystals, and granular material. It is possible to study these systems and gain insight into many diverse fields such as phase transitions, nucleation and crystal growth, coarsening, glass formation, chaos, field theory, and much more. Furthermore, research in complex fluids provides the underpinnings of translational research related to NASA's exploration of planetary surfaces as well as to terrestrial applications in industries such as pharmaceutical, chemical, plastics, soap and detergent, electronic display, and petroleum.

The need to conduct research in a microgravity environment is clear. Because of the relatively large size of the basic structures, gravitational forces dominate and cause sedimentation, convective flows, jamming, and other property gradients. Weaker forces such as surface tension and entropic forces are completely masked on Earth. In granular materials, stresses and yield properties are also sensitive to gravity. Figure 7 shows the effect of gravity on liquid crystal circular islands in a liquid crystal bubble film. The suspended liquid crystal islands in microgravity (right), allow the long-term, dynamic interaction of coarsening. On Earth (left image), due to sedimentation, the liquid crystal islands collapse into a continuous medium at the

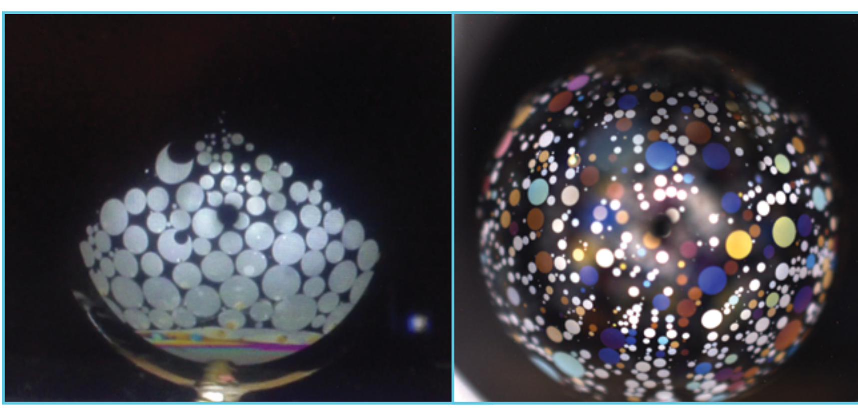


Figure 7. The dramatic effect of gravity on liquid crystal islands on a thin liquid crystal bubble film, on Earth (left) and in microgravity (right). On Earth, all the islands (circular domains of several layers of liquid crystal) were sedimented at the bottom of the extremely thin liquid crystal bubble film. The bubble film is about two to three layers of Smectic liquid crystal; each layer is 3 nanometers. In microgravity, the liquid crystal islands were dispersed over the very thin liquid crystal film. These islands coarsened into larger domains in about 20 minutes and remained dispersed throughout the bubble film. The liquid crystal microgravity tests were conducted on the ISS as part of the Observation and Analysis of Smectic Islands in Space experiment. (Image Credit: NASA)

bottom of the sphere. Using the open science method, including this informatics database, is anticipated to inspire new areas of research, enhance discovery, and increase innovation in soft materials.

The research area of complex fluids includes the following themes:

- Colloids
- Liquid crystals
- Foams
- Gels
- Granular flows

Fluid Physics

The goal of the microgravity fluid physics program is to understand fluid behavior of physical systems in space, thereby providing a foundation for predicting, controlling, and improving a vast range of technological processes. The absence of buoyancy and the stronger influence of capillary forces can have a dramatic effect on fluid behavior, specifically in reduced gravity. For example, capillary flows in space can pump fluids to higher levels than those achieved on Earth. In the case of systems where phase change heat transfer is required, it has been shown that bubbles will not rise under pool boiling conditions in microgravity, resulting in a change in the heat transfer rate at the surface. Consequently, these bubbles coalesce into a large bubble, as shown in Figure 8. The microgravity experimental data is archived in the PSI database where it can be used to verify computational fluid dynamics models. These improved models can then be used by future spacecraft

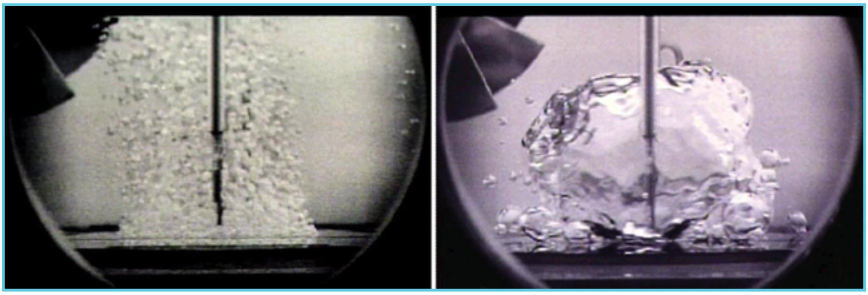


Figure 8. Left: Liquid heated to boiling point in 1-g, generating vapor bubbles that rise. Right: Liquid heated to boiling point in microgravity, which occurs in the absence of natural convection or buoyant flows. Under these conditions, bubbles generated at the heater coalesce into a single large bubble. (Image Credit: NASA)

designers to predict the performance of fluid conditions in space exploration systems such as air revitalization, solid waste management, water recovery, thermal control, cryogenic storage and transfer, energy conversion systems, and liquid propulsion systems.

The research area of fluid physics includes the following themes:

- Adiabatic two-phase flow
- Boiling and condensation
- Capillary flow
- Interfacial phenomena
- Cryogenics storage and handling

Fundamental Physics

The microgravity environment of space offers a unique experimental environment that enables high-precision measurements of fundamental physics in fields such as thermophysical measurements, atomic physics, and relativistic physics. This research is significant: it seeks to reveal the principles that govern the behavior of the physical world.

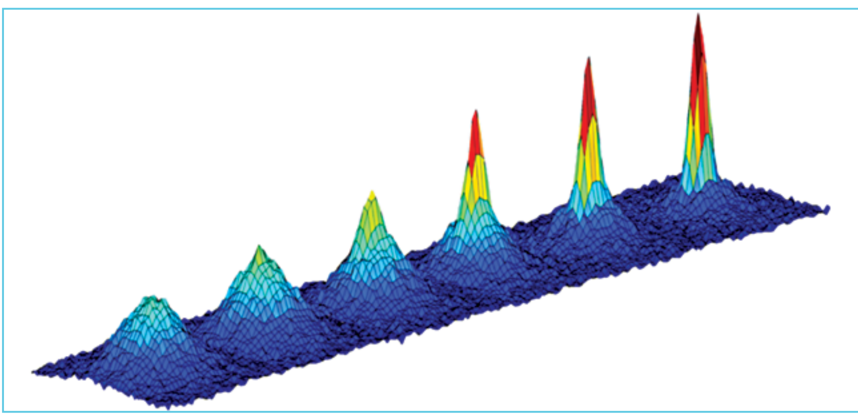


Figure 9. This series of graphs shows the changing density of a cloud of rubidium atoms as it is cooled to lower and lower temperatures (going from left to right) approaching absolute zero. The emergence of a sharp peak in the later graphs confirms the formation of a Bose-Einstein condensate – a fifth state of matter – occurring here at a temperature of 130 nanoKelvin (0.00000013 Kelvin) above absolute zero. The color shows density variations. Blue valleys represent the lowest density; red pointed peaks represent the highest density. Red signifies condensation of particles into the ground state; i.e., the lowest possible energy state. These tests were conducted on the ISS in the Cold Atom Lab. (Image Credit: NASA/Jet Propulsion Laboratory-Caltech)

The microgravity environment also leads to new measurement regimes that are not accessible on the ground. Examples include studies of ultra-cold atoms, dusty plasma, and critical phenomena. Furthermore, large gravitational potential variation, velocity, and spatial extent boost the science sensitivity enormously and provide access to particular physical effects. Figure 9 illustrates the formation of a Bose-Einstein condensate in space. On Earth, the condensate can only be observed for a very short time before it falls to the bottom of the experiment chamber. In space, these condensates can achieve lower temperatures and be observed much longer.

The research area of fundamental physics includes the following themes:

- Space optical/atomic clocks
- Quantum test of equivalence principle
- Cold atom physics
- Critical point phenomena
- Dusty plasmas

Materials Science

The goal of the microgravity materials science program is to improve the understanding of materials properties that will enable the development of higher-performing materials and processes for use both in space and on Earth. The program takes advantage of the unique features of the microgravity environment,

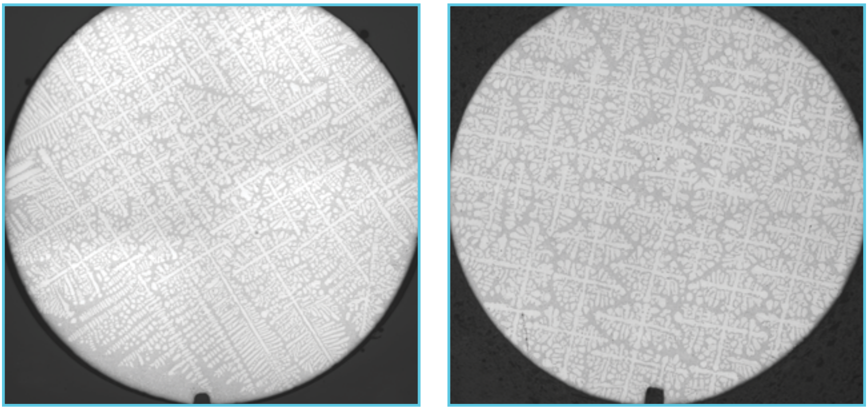


Figure 10. Left: Alloy solidified in 1-g reveals dendrite clustering from gravity-induced convection. Right: Alloy solidified in microgravity reveals a uniform dendrite network that is diffusion controlled, unlike the dendrites on the left where the effect of Earth's gravity induces convective and buoyancy effects. (Image Credit: NASA)

where gravity-driven phenomena such as sedimentation and thermosolutal convection are nearly negligible. Figure 10 shows the microstructure of an aluminum alloy grown on Earth and in microgravity. On Earth, natural convection leads to clustering of dendrites, whereas in microgravity, in the absence of buoyant flow, the dendritic structure is nearly uniform.

Major types of research that can be investigated include solidification effects and the resulting morphology, as well as accurate and precise measurement of thermophysical property data. These data can be used to develop computational models. The ability to predict microstructures accurately is a promising computational tool for advancing materials science and manufacturing. Using open science will create new opportunities to develop materials experiments and will make it easier for researchers in the government, industry, and academia to share information with the scientific community.

The research area of materials science includes the following themes:

- Glasses and ceramics
- Granular materials
- Metals
- Polymers and organics
- Semiconductors

How the PSI System Works

The PSI system contains publicly accessible science data from completed physical science reduced-gravity experiments from the six previously described disciplines: Biophysics, Combustion Science, Complex Fluids, Fluid Physics, Fundamental Physics, and Materials Science. These experiments were conducted on the ISS, Space Shuttle flights, and Free Flyers, or as part of related ground-based studies using drop towers or aircraft. Information from new investigations is added to the PSI system as it becomes available. This information consists of raw and analyzed data, science requirements, experiment design and engineering data (including applicable drawings), analytical or numerical models, publications, reports, patents, and commercial products developed because of the research. In addition to data in a textual or numerical format, for many of these experiments, large portions of both raw and analyzed data include digital images and videos.

The PSI system resides on the Athena software platform. This platform provides the capability for data visualization, advanced search, simultaneous views of multiple panels, interactive plots, ad hoc reporting capabilities, collaboration, and data sharing. The PSI system has multiple avenues for data entry and extraction. Data entry is available through a web interface that supports both single item and bulk data loading.

The PSI system contains a variety of information on the hardware, as well as both raw and analyzed data for each investigation. Links to papers and publications are also included in the database, which can be searched multiple ways. In addition to data search, the PSI system also allows the user to generate reports and send messages to the researcher who generated the data. The PSI system has a vast number of users across universities, industries, NASA and its support contractors, other government agencies and their support contractors, and international agencies as well as industries. To learn about PSI and the specific experiments that are available, navigate to the PSI website at https://psi.nasa.gov. The PSI screens and navigation described in this guide are subject to change as the system is refined over time. For the most current navigation guidance, please refer to the PSI system.

Using the PSI System

This section contains a step-by-step guide on accessing the PSI system and navigating experiment data. When first accessing the PSI website (http://psi.nasa.gov), general navigation is provided through a series of buttons along the top on a horizontal navigation bar, as shown in Figure 11.

Figure 11. PSI website navigation bar.

High-level information about experiments in PSI and information about any new or ongoing events related to NASA Research Announcement (NRA) activities relevant to using PSI are provided on the PSI landing page. The lists of Investigations available in PSI are also provided and organized by research area. To review the lists of experiments where all the available data have been loaded into the system, hover over the Investigations button and then click on the desired research area from the dropdown list. This button is highlighted inside the yellow rectangle in Figure 12.

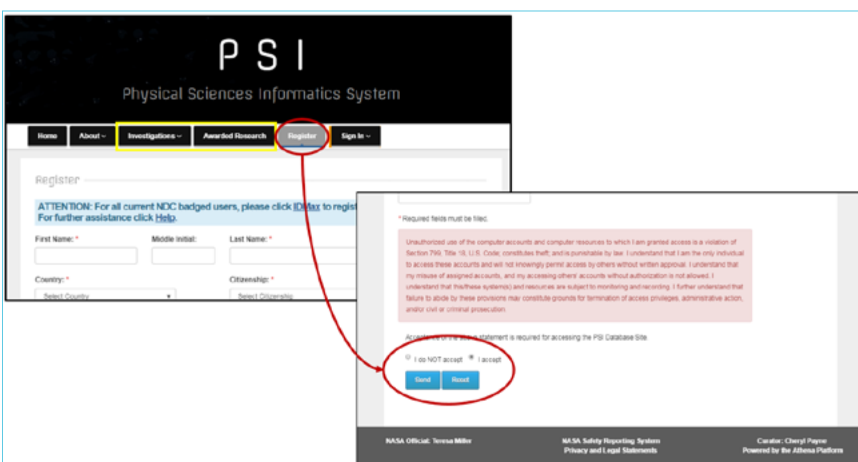


Figure 12. Highlighting Investigations, Awarded Research, and Register buttons on the navigation bar as well as the registration form submission button at the end of the form.

Through a series of NRAs, NASA has awarded research grants for the scientific community to use the data available in PSI and to propose new scientific research. The most current list of PSI-related research grants can be viewed by clicking the Awarded Research button. This button is also highlighted inside the yellow rectangle in Figure 12.

To request access to the PSI system from the PSI website, click on the Register button, fill out the application form, read and accept the usage agreement, and click the Send button to submit the request. The Register button and the Send button on the request form are both highlighted with red ovals in Figure 12. A notification email will be sent to the email address provided in the request form when the account has been provisioned, typically within 24 hours of submission. The email will contain user credentials for accessing the system.

Once the user account has been provided, sign in to PSI from https://psi.nasa.gov by hovering over the Sign In button, select Sign In from the dropdown list as highlighted with a red oval in Figure 13, and sign in to the system with the credentials provided in the account notification email.

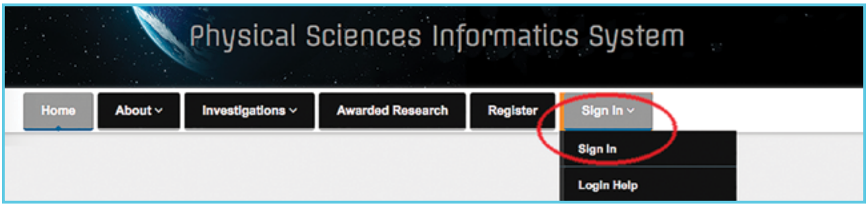


Figure 13. Sign In to PSI from the public website https://psi.nasa.gov.

Inside the PSI application, general navigation takes place through a series of buttons along the top on a horizontal navigation bar. The buttons are highlighted with a red rectangle in Figure 14.

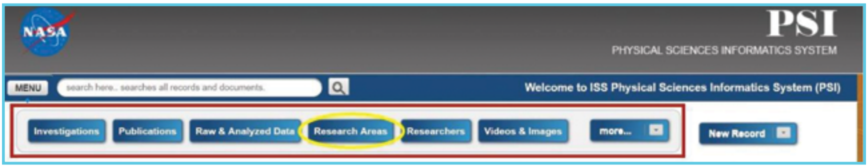


Figure 14. PSI system navigation bar.

The buttons on the top navigation provide lists of data in the appropriate category. The lists are sorted alphabetically. Filters can be applied to refine the list being returned. Clicking on the Research Areas button (highlighted with a yellow oval in Figure 14) returns an alphabetical list of the research areas in the RECORD NAME column as well as links to lists of the investigations in that particular research area in the ASSOCIATED CATEGORIES column, as highlighted with a red oval in Figure 15. Throughout the PSI system, items appearing in blue bolded text are clickable. Clicking on one of these items opens a new window, or panel, with the details about that particular item.

Note: Throughout this guide, the term “panel” is used to describe the PSI screens that are provided in Figures to explain navigating through the system.

Figure 15. Investigation lists organized by research area.

Clicking on one of the Investigations links in the ASSOCIATED CATEGORIES column, as shown in Figure 15, returns a list of alphabetically sorted Investigations in that particular research area. Links to associated categories of data are also available for that investigation. These data categories include experiment data, facilities, researchers, presentations, publications, and reports. This overview panel gives the user one-click access to each of these data categories. For the purpose of this guide, the investigations associated with the Combustion Science research area were selected, as highlighted with a green rectangle in this figure. Clicking on Investigations in the Associated Categories column for Combustion Science opens a new window with the Combustion Science investigations listed in alphabetical order, as shown in Figure 16.

Figure 16. Combustion Science investigations listed alphabetically with links to associated data available in the Associated Categories columns.

Note: For the purpose of this guide, from the list of Combustion Science investigations, the Flame Extinguishment Experiment (FLEX) investigation was selected from the RECORD NAME column, as highlighted with a green rectangle in Figure 16.

Note: For the remaining figures that feature panels, the header for the panel contains the panel name and the footer contains the data type or category for that particular panel.

In Figure 17, the panel name is Flame Extinguishment Experiment (FLEX) and a footer indicates that the data type is INVESTIGATIONS for this panel. The tabs along the top of the panel, as highlighted with a green rectangle, allow the user to click through the different data sets available in that panel.

- The General tab contains high-level, general information about the investigation, including researchers and points of contact.
- The Overview tab contains specific information about the research that is being conducted as part of the investigation as well as research applications for both Earth and space.
- The Data tab contains scientific data and other investigation information. A data organization document describes how the scientific data are organized in the PSI system, as highlighted with a purple oval. The experiment data are also located on this tab along with any science requirements documentation. The black down arrow, or download icon, on the far right side (highlighted with a red triangle) indicates that the data can be downloaded. Clicking on the arrow will download the data to the local computer.
- The Engineering tab, Pubs & Docs tab, and Comments tab on the Flame Extinguishment Experiment (FLEX) INVESTIGATIONS panel are discussed later in this guide, following in-depth guidance for navigating through an Experiment Data item.

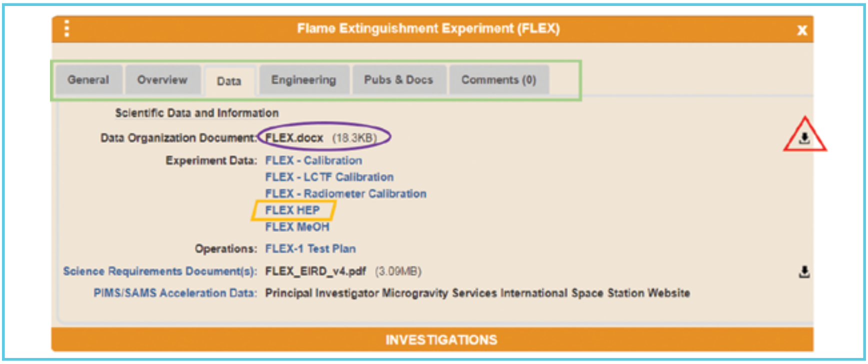


Figure 17. Investigation panel highlighting the different data tabs as well as the ability to download data.

The Experiment Data list contains all the experiment data associated with a particular investigation listed in alphabetical order. Open a new panel by clicking on one of the items in the Experiment Data list. The panel contains specific data and information about that experiment. In this case, FLEX HEP was selected from the Experiment Data listing, as highlighted with an orange parallelogram in Figure 17.

Note: The FLEX HEP EXPERIMENT DATA panel is used in Figures 18 through 26 to describe navigating through the raw, analyzed, video and image data related to the FLEX HEP experiment for the purpose of this guide.

Tabs across the top of the FLEX HEP EXPERIMENT DATA panel depict the different categories of data that are present on the panel, as shown in Figure 18. The Scientific Data and Information tab (highlighted with a red oval) contains any associated raw and analyzed data, as well as associated videos and images. Notice that the text on tabs may be truncated due to a character limit on the tab itself. The full tab text can be viewed just below the tab, as indicated in this figure. The General tab contains high-level, general information about the experiment. The Comments tab contains an area for users to post comments and/or questions about the experiment.

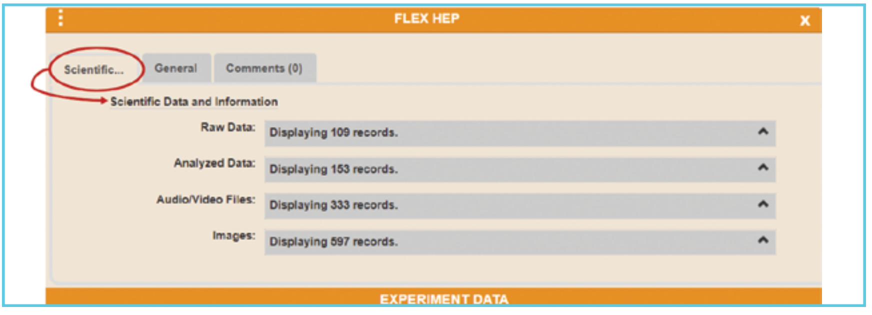


Figure 18. EXPERIMENT DATA panel highlighting the Scientific Data and Information tab.

Expanding the Raw Data list by clicking on the caret (^) on the right side of the list (highlighted with a red oval in Figure 19) and then clicking on any of the items in the list will open yet another panel with experiment specific raw data. In this example, FLEX 023_24_Oct_2009_Hep_196F002 was selected from the FLEX HEP Raw Data list and is highlighted with a green rectangle.

When the FLEX 023_24_Oct_2009_Hep_196F002 RAW & ANALYZED DATA panel opens, the familiar data tab configuration appears across the top of the panel.

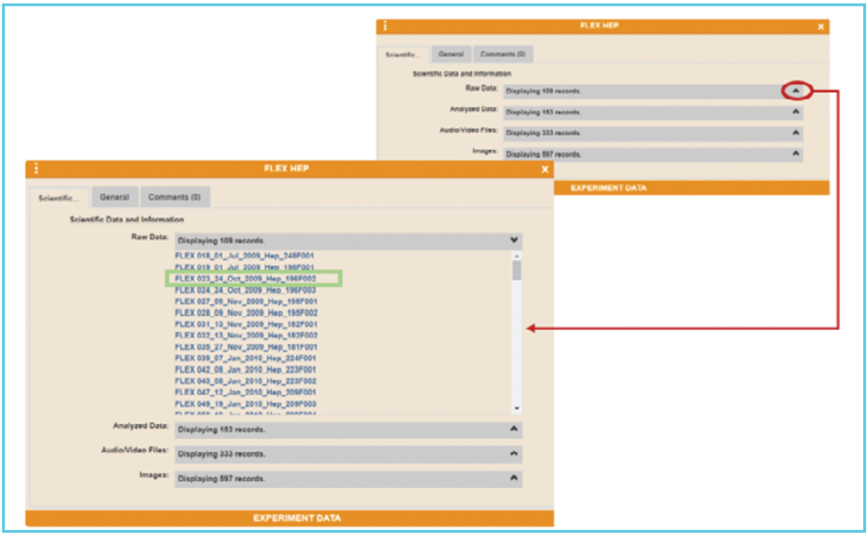


Figure 19. EXPERIMENT DATA panel highlighting the ability to expand the Raw Data list. By clicking on the caret (^), the Raw Data list is expanded to display the entire list with a right side scroll bar.

The General tab contains high-level, general information about the data. The Comments tab contains an area for users to post comments and/or questions about the data. On the Raw Data and Information tab, a list of raw data documents is displayed in the Raw Data list, as shown in Figure 20. When clicked, these items open via default programs available on the local machine. The entire list of raw data documents can also be downloaded to the local computer into a .zip file by clicking the download icon on the far right side of the panel.

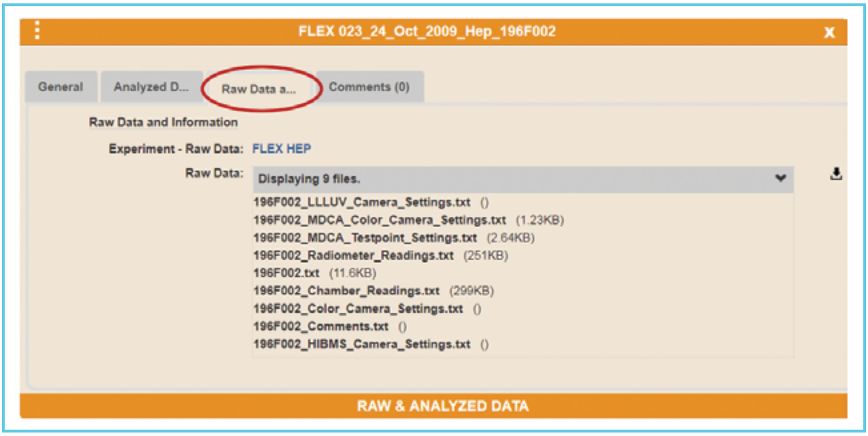


Figure 20. Highlighting the Raw Data and Information tab on a RAW & ANALYZED DATA panel.

Continuing with this example, in the FLEX-HEP EXPERIMENT DATA panel, clicking on the caret (^) on the right side of the Analyzed Data list (Figure 21) expands the list of available Analyzed Data.

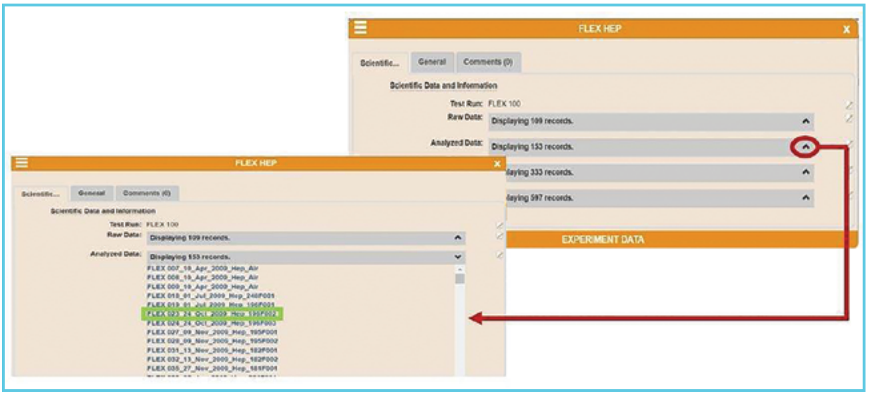


Figure 21. EXPERIMENT DATA panel highlighting the ability to expand the Analyzed Data list. By clicking on the caret (^), the Analyzed Data list is expanded to display the entire list with a right side scroll bar.

When the example FLEX 023_24_Oct_2009_Hep_196F002 RAW & ANALYZED DATA panel opens, the familiar data tab configuration is displayed across the top of the panel, as shown in Figure 22. The General tab contains high-level, general information about the data. The Comments tab contains an area for users to post comments and/or questions about the data. On the Analyzed Data

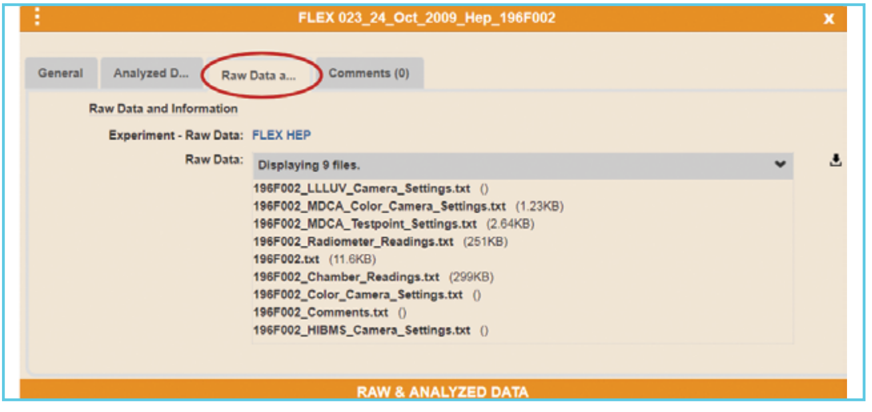


Figure 22. Highlighting the Analyzed Data and Information tab on a RAW & ANALYZED DATA panel.

and Information tab, a list of analyzed data documents is displayed in the Analyzed Data list. These items are clickable and open via default programs available on the local machine when clicked. The entire list of analyzed data documents can also be downloaded to the local computer into a .zip file by clicking the download icon on the far right side of the panel.

Continuing with this example, in the FLEX-HEP EXPERIMENT DATA panel, the list of available Audio/Video Files is expanded by clicking on the caret (^) on the right side of the Audio/Video Files list, as shown in Figure 23. Carbon Dioxide – C021H02A is highlighted with a green rectangle in this figure and is used for describing navigation of the videos and images within FLEX-HEP experiment.

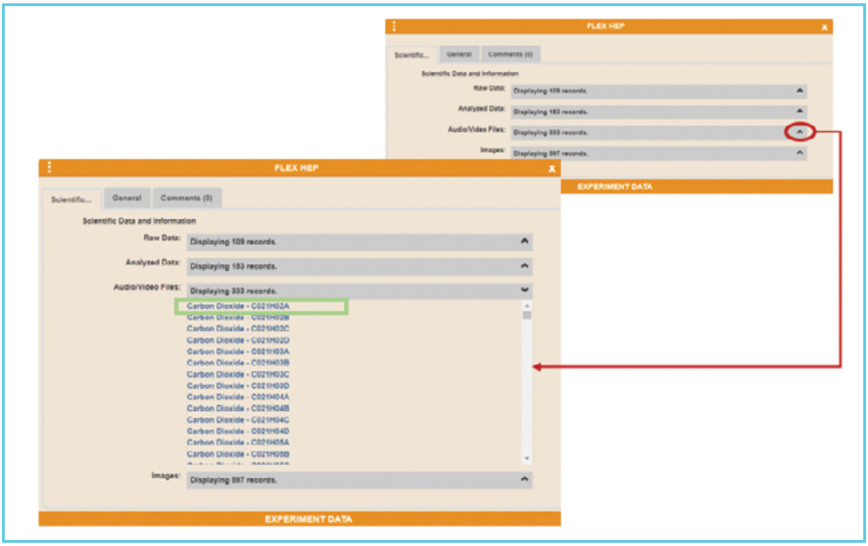


Figure 23. EXPERIMENT DATA panel highlighting the ability to expand Audio/Videos Files list. By clicking on the caret (^), the Audio/Video Files list expands to display the entire list with a right side scroll bar.

Video data is diplayed on the General tab along with high-level, general information about the Video and Images data. The Comments tab contains an area for users to post comments and/or questions about the data. See Figure 24.

Not all browsers support video streaming. Where browser video streaming is supported, the video is displayed on the General tab of the VIDEOS & IMAGES panel with a video control bar beneath the video. To view the video in the browser, click the play icon on the control bar, as highlighted with a yellow pentagon in Figure 24. Individual video files can be downloaded by clicking on the download button on the video control bar, as highlighted with a blue diamond, or via the download link underneath the video window, as highlighted with a green rectangle. If there are multiple videos, a dropdown selection box will appear for selecting which video to play. Multiple videos may be downloaded to a .zip file via the download icon on the far right side.

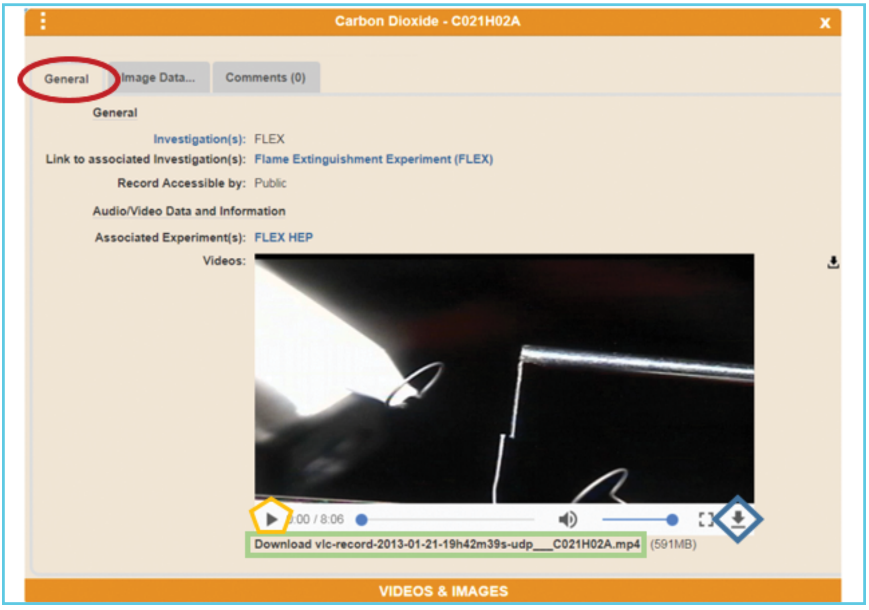


Figure 24. Video files on the General tab of the Carbon Dioxide – C021H02A VIDEOS & IMAGES panel, displaying video streaming in the browser window. The video control bar appears at the bottom of the video window.

Continuing with this example, in the FLEX-HEP EXPERIMENT DATA panel, the list of available Images is expanded by clicking on the caret (^) on the right side of the Images list, as shown in Figure 25.

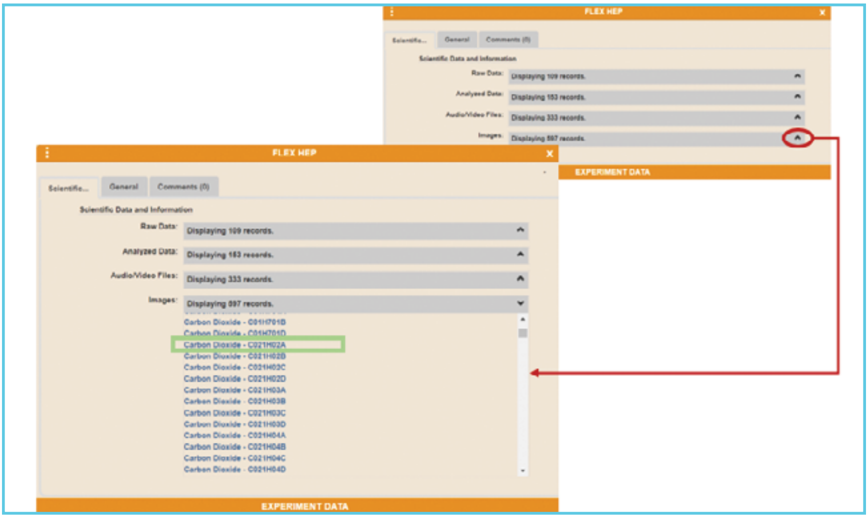


Figure 25. EXPERIMENT DATA panel highlighting the ability to expand the Images list. By clicking on the caret (^), the Images list is expanded to display the entire list with a right side scroll bar.

By clicking on the example Image Data and Information tab, the associated image gallery is displayed on the Carbon Dioxide – C021H02A VIDEOS & IMAGES panel, as shown in Figure 26. Clicking on an individual image opens it in a separate window that allows users to scroll through and zoom in on the image. If the original image files are available, they will appear in the Original Image Files field (highlighted with a green parallelogram), and a .zip file can be downloaded by clicking on the download icon at the far right side of the panel. The Comments tab contains an area for users to post comments and/or questions about the videos and images data.

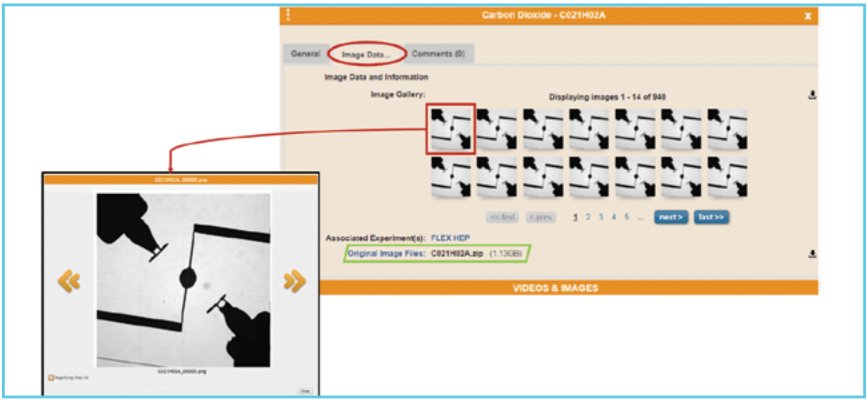


Figure 26. Image gallery on the Image Data and Information tab of the Carbon Dioxide – C021H02A VIDEOS & IMAGES panel, highlighting that images are clickable and can be expanded into an individual window for more detailed viewing. Original high-definition image files may be available for download.

Continuing with the Flame Extinguishment Experiment (FLEX) INVESTIGATIONS panel example, as originally seen in Figure 17, the remaining tabs contain Engineering data, publications and documents (Pubs & Docs), and Comments. The Engineering tab contains engineering documents and drawings. The Pubs & Docs tab contains associated publications, reports, presentations, and resulting products. As with previous navigation, the caret (^) on the right side of the list can be clicked to expand the list of publications associated with an investigation (Figure 27). The Comments tab contains an area for users to post comments and/or questions about the investigation.

Figure 27. Highlighting the publications listings associated with Flame Extinguishment Experiment (FLEX) INVESTIGATIONS panel. The lists of associated publications can be expanded to reveal a right side scroll bar.

Users requiring assistance may contact the PSI team by using the information provided at https://psi.nasa.gov by hovering over the Sign In button and then clicking on Login Help, as shown in Figure 28. Users may also contact the PSI team by using the information provided within the PSI system on the home page. See Figure 29.

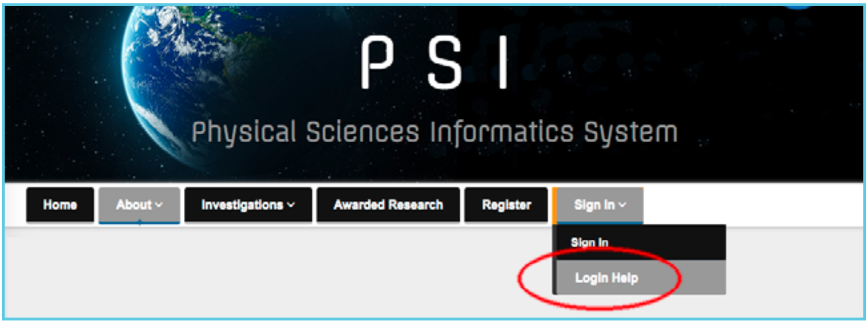


Figure 28. Requesting help from the PSI team. Contact information available at https://psi.nasa.gov.

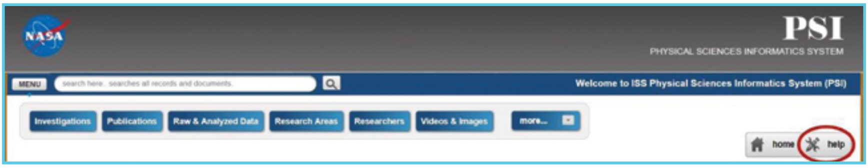


Figure 29. Requesting help from the PSI team. Contact information available within the PSI system on the landing page.

PSI Funding Opportunities

NASA provides funding for researchers to use PSI data through an NRA. The goals of the PSI NRA are to: a) promote rapid, multiple investigations resulting in more scientists participating in reduced-gravity research; b) allow new areas of research and discovery to occur more quickly through open access; and c) accelerate the "research to product or publication" timeline through the rapid sharing of data.

Annual calls for proposals via appendices are planned to be released every September through the NRA process. Each appendix will include details specific to that particular call for proposals, including a list of investigations that are eligible for use in developing a proposal.

The PSI NRA solicits ground-based research proposals that present a compelling case on how the experimental data from the PSI system will be used to promote the advancement of further research. Proposers must show a clear path from the scientific data obtained from the PSI system to the proposed investigation. In addition, the project must address an important problem in the proposed area of research and advance scientific knowledge or technology. Examples of possible investigations that utilize the PSI data include:

- enhancement and verification of numerical and analytical models
- development or enhancement of data analysis or other informatics tools to increase science readiness
- a new ground-based experiment or data analysis to verify phenomena observed in the original investigation
- a new ground-based experiment or data analysis that expands upon the results from the original investigation
- a new ground-based experiment or data analysis that is not directly linked with the science objectives from the original investigation

To view the list of prior selected proposals from the PSI NRA, visit the Awarded Research section of the PSI website at https://psi.nasa.gov/research.html. For information on the availability of funds and duration of awards for each appendix, check the detailed information provided for the PSI NRA on the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) website at https://nspires.nasaprs.com. To receive notification of future PSI solicitations, create an NSPIRES account and subscribe to the HEOMD solicitations mailing list as part of your account preferences. To find additional information on past and present research sponsored by the Physical Sciences Research Program, visit Space Life & Physical Sciences Research and Applications Division Task Book at: https://taskbook.nasaprs.com.

Acronyms

3-D	three-dimensional
AES	Advanced Exploration Systems
CASIS	Center for the Advancement of Science In Space
CFE-2	Capillary Flow Experiment - 2
FLEX	Flame Extinguishment Experiment
HEOMD	Human Exploration and Operations Mission Directorate
ICF	Interior Corner Flow
ISS	International Space Station
MICS	Microgravity Investigation of Cement Solidification
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
NRA	NASA Research Announcement
NRC	National Research Council
NSF	National Science Foundation
NSPIRES	NASA Solicitation and Proposal Integrated Review and Evaluation System
PI	Principal Investigator
PSI	Physical Sciences Informatics
SLPSRA	Space Life and Physical Sciences Research and Applications
STMD	Space Technology Mission Directorate
TRL	Technology Readiness Level

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10. Microbial Research
11. Microgravity Materials Research
12. Plant Science
13. Rodent Research
14. Space Environmental Effects
15. Technology Demonstration
16. GeneLab
17. Physical Sciences Informatics System

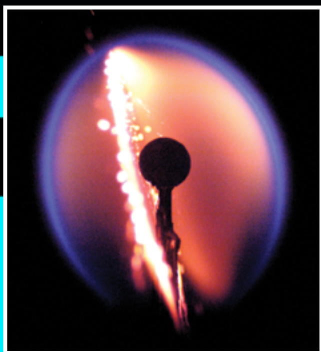
For more information...

Space Station Science
https://www.nasa.gov/iss-science

Station Facilities
https://www.nasa.gov/stationfacilities

Station Reference Guide: Utilization Edition
https://www.nasa.gov/sites/default/files/atoms/files/np-2015-05-022-jsc-iss-guide-2015-update-111015-508c.pdf

Station Opportunities for Researchers
https://www.nasa.gov/stationopportunities



National Aeronautics and Space Administration

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