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MICROGRAVITY NEWS

MICROGRAVITY RESEARCH PROGRAM

NASA Helps Students Get Their Experiments Off the Ground

NASA's Reduced Gravity Student Flight Opportunities Program provides a chance for undergraduate students like David Halaas (left) and Justin Reed (right), of the University of Washington, to fly their physics or other science research in short spans of microgravity on a KC-135 jet.

NASA is launching nearly 400 students closer to their career goals and dreams this year during the 2001 Reduced Gravity Student Flight Opportunities Program run by Johnson Space Center (JSC) in Houston, Texas. The program provides an opportunity for undergraduate students nationwide to fly their experiments in microgravity conditions for short time periods on a KC-135 jet. In addition, high school and graduate students can participate in the ground crews for the experiments. The experience lets young researchers team up with NASA scientists to solve real scientific problems. It also gives them a taste of the procedures investigators must put their research through before they fly their investigations on a space shuttle or on the International Space Station (ISS).

The NASA program, which began in 1995, is administered by the Texas Space Grant Consortium (TSGC), a group of 34 academic and industrial organizations that develops projects in higher education, research infrastructure, and public service. It has grown from a pilot project of four student teams from Texas universities to a nationwide program involving 96 teams (48 in the spring and another 48 this summer).

In the Shoes of a Scientist

"This is a great way for students to have firsthand experience with how science actually works," explains Wesley Tarkington, of JSC's University Affairs Office.

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Inside...

Profile:

National Aeronautics and Space Administration
Physical Sciences Division

From the Director...

Recent microgravity research in condensed matter and atomic physics has allowed us a macroscopic glimpse of the workings of the atomic world. Imaging and manipulation of the submicroscopic building blocks of all matter are improving our understanding of fundamental processes involved in the assembly and evolution of complex physical and biological systems and are drawing us closer to the interface between these systems. At this interface, a transition takes place from purely thermodynamically driven physical processes to biologically programmed mechanisms, and we converge upon a finite combination of circumstances from which life emerges.

The low-gravity environment offers the potential for significant advances in understanding these circumstances because the environment can be used as a theoretical AND experimental tool to alter the evolutionary paths along which complex systems develop. When we remove the gravitational bias, we can observe how physical and biological systems evolve, altering their detailed processes to arrive at a different final equilibrium configuration. These observations will not only allow scientists to develop new insight into the inner workings of nature, but perhaps to also witness the emergence of new natural constructs conforming to the gravity-free environment.

Results of past microgravity-based research provide vivid examples of new observations that have been enabled by this unique environment. For example, evidence has been gathered to show that self-assembling mechanisms in model colloidal suspensions are altered. The theoretical understanding of these self-assembling models is prerequisite to the successful study of more complex self-assembling systems such as lipid bilayer membranes, nano-structures, and surface proteins. Removing the gravitational bias also has been convincingly shown to alter the fluid shear flow environment, directly affecting crystallization, cell assembling, and gene expression processes. The ultimate application of these discoveries will depend greatly on our securing a detailed theoretical understanding of the various causes and effects associated with these empirical observations.

Past ground-based and flight research has also allowed us to make much more accurate measurements related to specific scientific problems. For example, we can determine more precisely the temperature dependence of the specific heat of Superfluid Helium closer to the Lambda Point transition.Our investigators also have conducted benchmark experiments on dendritic solidification.

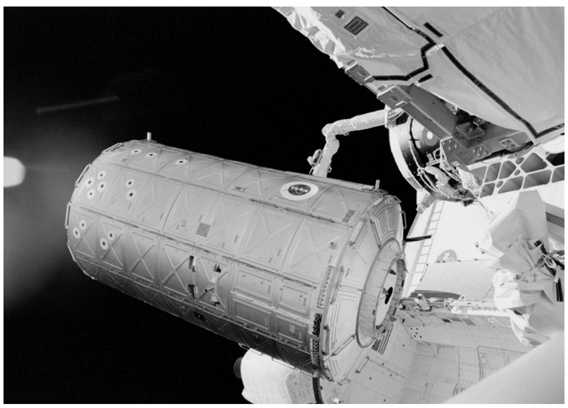
The challenge of developing a rigorous and world-class research program that helps eliminate barriers to the understanding of significant scientific issues is OBPR's major responsibility. No less of a challenge, however, is focusing on the efficient implementation of effective but reductionist theoretical and experimental tools of physical sciences, to resolve fundamental biological issues that are largely based on a holistic approach. Overall, OBPR's primary goal should be to develop and apply powerful theoretical and experimental tools to identify and tackle the primary questions raised by the removal of gravity. These primary questions have already been raised in disciplines as diverse as Condensed Matter Physics, Fundamental Biology, Materials Science, Biotechnology, and Human Physiology. However, important scientific issues of the new century will require effective inter-disciplinary approaches and will benefit from a new viewpoint. OBPR can provide a solid interdisciplinary research community and will employ gravity as a controlled, adjustable variable.

Eugene Trinh

Flight Update: Destiny

Science in Space May Shape Our Destiny on Earth

Mission Specialist Marsha Ivins had just 5 cm (2 inches) of clearance in which to use a robotic arm to maneuver the $1.4 billion, school bus–sized Destiny laboratory module out of the cargo bay of the space shuttle *Atlantis*. Does that sound tricky? Add the fact that NASA did not have a backup in case of damage, and that the module was the most expensive ever built for space, and you can imagine the pressure on the *Atlantis* crew to make sure things went right when they attached Destiny to the International Space Station (ISS).



The Destiny laboratory module, the centerpiece of the International Space Station, is lifted from the *Atlantis* payload bay by the shuttle's robotic arm so the crew can attach the module to the station.

Destiny, which Roger Crouch, senior space station scientist for NASA, has called NASA's "jewel in the sky," is the centerpiece of the ISS, and its installation marks the beginning of a new era of scientific research in space. The laboratory module will enable scientists to conduct virtually continuous state-of-the-art research in a microgravity environment and will provide both more space for crewmembers and a command station capability from which the entire space station can be controlled.

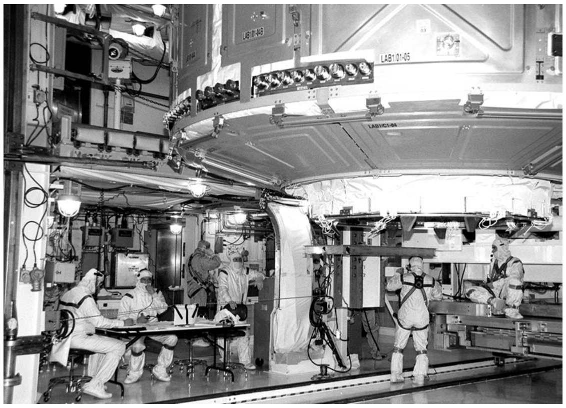
Although scientists have had access to up to two weeks of microgravity at a time through space shuttle flights, many experiments require longer spans of time in a microgravity environment to maximize their results. Destiny and the ISS will provide much more time in orbit, allowing for studies of longer durations than were possible on previous orbiters, including *Skylab*, the first United States space station, placed in orbit in 1973 and designed to be a temporary lab for studying the effects of long-term spaceflight on humans; Spacelab, a research module that was flown in the cargo bay of the space shuttle for on-orbit experimentation; or even the Russian space station, *Mir*. With a permanent, state-of-the-art laboratory on the ISS, many more experiments can be run — and repeated — in microgravity.

The space station module has also been designed to allow experimentation to keep pace with technological advances. The unit features modular racks, so that improved technologies can easily be added to the science module as they become available. Although the technology available for research on Destiny is similar to that available on Spacelab, the means for replacing outmoded technology was limited in the older lab. *Mir*, which re-entered Earth's atmosphere and splashed down on March 23, had already been in orbit for a decade (from 1986 to 1996) before the United States became involved in conducting research onboard, and the space available for hardware was limited on the Russian space station.

Lastly, NASA now has the infrastructure in place to get more experiments into space. According to Crouch, these three things — longer times in a microgravity environment, the ability to keep pace with technological advances, and an existing infrastructure for getting experiments into orbit — create a new standard for research in space. Says Crouch, "It puts us in the situation of having all the right stuff to get significant things done over time."

Many people have great expectations about a science laboratory in space and the advances that might come from research performed there. However, as Crouch noted, it's important to remember that just as a lot of basic research, usually over many years, goes into scientific developments here on Earth, the same process will occur in space. Space-based research shows much promise, especially in that it provides a unique microgravity environment not easily obtainable here on Earth, but as with any scientific endeavor, the cries of "Eureka!" won't be heard until the basic work has been completed. Destiny puts researchers on Earth in a good position to get that basic research done and then build on it.

Scientists can hope for a better understanding of how life functions on Earth and perhaps develop new drugs or other therapies for disease. They may also discover a means to create better materials for use on Earth and in space and perhaps engineer faster computer chips. Environmentalists and geologists may be able to better understand the differences between natural and human-caused changes to our own planet and determine ways to mitigate those changes. And



NASA workers at Kennedy Space Center in Cape Canaveral, Florida, move Destiny into the *Atlantis* payload bay.

scientists may discover better ways to keep people healthy and safe in Earth's orbit during short-term missions for now, and later for long-duration missions to other planets. Humans should see the benefits of space-based research in many ways.

Since Destiny was delivered to the space station on February 9, subsequent shuttle flights have carried additional hardware and equipment to make the research module and the station more useful to its inhabitants and to researchers. During the STS-102 flight, which took place March 8–21, the space shuttle *Discovery* carried the Expedition 2 crew to the ISS (to replace the Expedition 1 crew), along with one of the

The newly installed Destiny laboratory module is shown on the left side of this photo, which was taken from the space shuttle *Atlantis* as it departed the ISS.

Italian-made Multi-Purpose Logistics Modules (MPLMs), "moving vans" that are designed to function as both cargo carriers and space station modules. On this mission, the MPLM transported equipment racks and the first research rack, the Human Research Facility, which contains apparatus for monitoring crew health. On later missions, the modules also will carry refrigerator-freezers for transporting experiment samples and food to and from the station. When the MPLM is attached to the station so that cargo can be unloaded, it provides some life support, fire detection and suppression, electrical distribution, and computer functions.

On April 19, the space shuttle *Endeavour* transported to the ISS the Rafaello MPLM containing six systems racks and two EXpedite the PRocessing of Experiments to Space Station (EXPRESS) racks for the Destiny lab as part of the STS-100 mission. EXPRESS racks, which were designed to maximize the space station's research capabilities, are standardized payload rack systems that transport, store, and support experiments aboard the ISS. The EXPRESS rack system supports science payloads in several disciplines and features standardized hardware interfaces to enable integration of multiple payloads, as well as removable experiment subracks that can be exchanged in and out of the EXPRESS racks as needed. *Endeavour* also transported the Canadian-made robotic arm, the first part of the Space Station Remote Manipulation System, which will be attached to the ISS to facilitate future construction and movement of hardware on the external structure of the ISS without requiring astronauts to work outside the station.

In addition to all this hardware, several microgravity experiments flew to the space station aboard STS-100. One was the Physics of Colloids in Space (PCS) experiment, which is housed in an EXPRESS rack and led by Principal Investigator David Weitz, of Harvard University. The experiment involves the growth and behavior of three different types of colloid samples: binary colloid alloys, colloid-polymer samples, and fractal aggregate samples. Colloids are systems of fine particles suspended in fluid. Binary colloid alloys consist of two different sizes of polymethyl methacrylate beads in solution. The particle-size ratio and particle-volume fraction are varied to produce different crystal structures. By studying the formation of crystal structures at different particle ratios and volume fractions, researchers can determine the necessary ratios and fractions for creating new materials with specific physical or optical properties.

In the colloid-polymer samples, a nonadsorbing polymer is added to a colloid sample containing uniformly sized plastic spheres to change the attractive forces between plastic particles in the colloid. Researchers will study this system to obtain data on the liquid, transitional, and solid characteristics of the colloids.

The fractal aggregate samples consist of mixtures of nanometer-sized silica or polystyrene particles. These solutions will form weak gels that have fractal structures, where the structure is repeated over and over on an ever-decreasing scale. A natural example of fractal structure can be seen in a tree, where the branches are smaller versions of the tree's structure. Polystyrene gels have been observed to continue to evolve even after the initial gel formation is complete. This experiment will investigate whether a lower volume fraction will affect the aging process and whether the evolutionary behavior that occurs after gel formation is unique to polystyrene gels.

On Earth, the movement of particles in colloids can be largely directed by the effects of sedimentation and buoyancy flows, which result from gravity. These gravitational effects significantly modify the self-assembly of the colloidal particles. Placing the colloid samples in a microgravity environment on the ISS will allow the particles to assemble themselves into structures that show crystalline order. Using the facilities aboard the ISS will allow the researchers to run their experiments for a longer duration than they've had access to in prior experiment runs, and that should allow for the growth of larger crystals and enable the researchers to make more detailed studies of the crystal growth.

STS-100 also carried some protein crystal growth experiments to the ISS in two Single-Locker Thermal Enclosure System (STES) units. The STES is a refrigerator-incubator module that can house various devices such as the Protein Crystallization Apparatus for Microgravity (PCAM) for growing biological crystals

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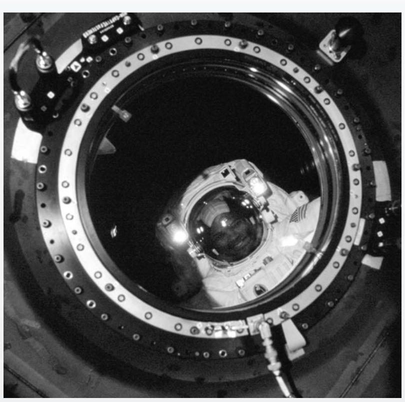
Shaping Destiny

Its name suggests its importance to the future of the space program, and many scientists and civilians alike are devoting their careers to research that will be performed in its laboratory racks. Even so, Destiny itself looks like not much more than a very large aluminum can. Weighing in at 14,400 kg (16 tons), the Destiny module is 8.4 m (28 ft) long and 4.3 m (14 ft) in diameter. Its size is usually compared to that of a school bus, an apt description given that school buses transport students for learning, and Destiny will transport scientific experiments in space to help us learn more about life on Earth.

The waffle structure of the module's exterior aluminum skin provides strength to the shell.

The module is made of aluminum and consists of three cylindrical sections, welded end to end, and two end cones. It features an optical-grade round window, 50 cm (20 inches) in diameter, located in the center section of the module. The window will be used for Earth-observation experiments.



Mission specialist Robert L. Curbeam, on the second spacewalk of STS-98, was photographed by an Expedition One crewmember through Destiny's optical-grade window.

The exterior of the module was designed with a "waffle" pattern to strengthen the structure. This outer aluminum layer also protects the module from debris and reflects the intense heat of the sun to ease the strain on the module's air conditioning system. An intermediate shield made of material similar to that used in bulletproof vests will also serve to protect the module from space debris. Finally, an inner insulating blanket will protect the module from the extreme temperatures of space.

When fully outfitted, Destiny will contain 23 racks (structures that contain the equipment required to perform various functions aboard the ISS). The racks, which each weigh up to 540 kg (1,200 pounds) when full, are 1.85 m (73 inches) tall and 1.1 m (42 inches) wide. Their modular design will allow hardware to be easily interchanged. "Standoffs" at the base of each rack hold the racks in place and provide space for the ductwork, pipes, and wiring that run to the rack and throughout the lab.

Ground-Based Research Update

Combustion Under Pressure: A New Understanding Revealed

Automobiles, jet aircrafts, and even rockets all have one thing in common: they are powered by internal combustion engines operated under high pressures, in the range of 5–100 atmospheres (atm). (By comparison, normal atmospheric pressure that we experience at sea level is only 1 atm.) Combustion under high pressures is thermodynamically more efficient; that is, more of the heat energy produced by the combustion reaction is converted to desired mechanical energy. Furthermore, because of the intensified burning, it also enables the reaction to take place under more fuel-lean conditions, in which there is more oxygen than chemically required to consume the fuel. These unique attributes lead to improved fuel efficiency, reduced emissions of combustion-generated pollutants, and reduced production of carbon dioxide, which is a major contributor to global warming.

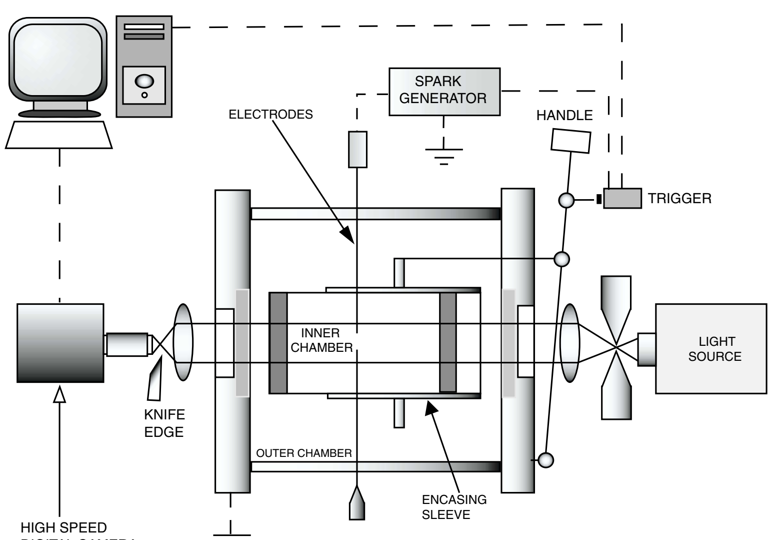
However, most of what is known about the combustion processes within internal combustion engines comes from experiments conducted at 1 atm, where flames are relatively easy to control and observe. When pressure increases, as microgravity Principal Investigator Chung Law, of Princeton University, explains, so does the degree of difficulty in conducting well-controlled experiments and consequently obtaining useful scientific data.

An Impossible Mission

Can researchers tell what will happen to a flame at high pressure from experiments conducted under normal atmospheric pressure conditions? According to Law, such extrapolations are highly unlikely to lead in the right direction. “The basis for extrapolation, namely data obtained around 1 atm, is just too limited for any reliable prediction of what could be happening with a flame at 50 or even 100 times the normal pressure.” There’s just no substitute for conducting experiments under high-pressure conditions.

But in order to conduct well-controlled, high-temperature, high-pressure combustion experiments in the past, researchers often had to sacrifice the ability to observe the combustion processes. “High-pressure experiments have been frequently done in what we call ‘bombs’ — totally enclosed, windowless systems,” says Law. After igniting a fuel mixture inside such a combustion chamber, researchers would take measurements of the pressure increase caused by the burning of the fuel. “From that,” Law explains, “you would speculate what has happened inside the bomb based on some assumed combustion processes.” While some valuable data, such as the fuel consumption rate, have been obtained from conducting these kinds of experiments, the lack of visual observation could render the studies mostly qualitative and quite unsatisfactory.

Of critical importance, then, is actually observing the flame during the combustion process. But combustion



An ingenious design makes what used to be a mystery quite clear for combustion researchers. This apparatus, designed by Law, allows high-pressure combustion reactions to be observed for the first time. Inert gas in the outer chamber keeps the fire in check, never allowing it to get out of control or reach the optical glass, through which a high-speed digital camera records the reaction.

chambers that allow the flame to be visually observable through special optical windows are vulnerable to the buildup of temperature and pressure inside the chamber. After ignition, a flame will continue to grow until it engulfs the combustion chamber. At the end of combustion, the combustion products not only have a very high temperature, frequently in excess of 2,000 kelvin, but the chamber pressure is also several times that of the starting pressure, which is already quite high. Optical glass thin enough to allow the flame to be observed without distortion cannot withstand this enormous pressure and temperature buildup. However, making the glass thicker would compromise its optical quality.

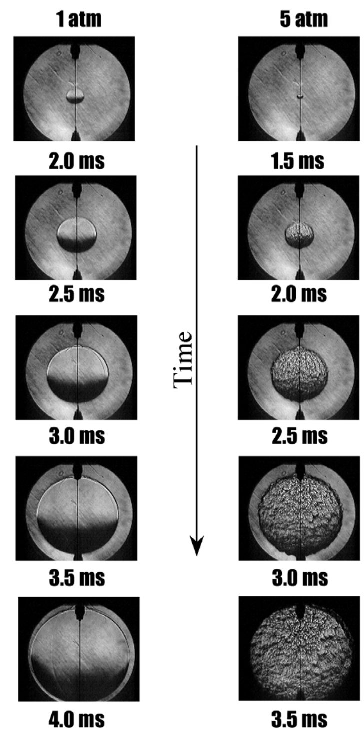
A Picture Is Worth a Thousand Words

Challenged by the need to unambiguously study the effects of pressure on flame propagation, Law and his research associates, Stephen Tse and Delin Zhu, devised an apparatus that would allow them to obtain images of the flame as it propagates, while maintaining the chamber pressure constant at its initial value, which can be as high as 60 atm. The apparatus comprises two chambers, one inside the other, with aligned optical windows. A sleeve connecting the two chambers can be opened and closed. After evacuating both chambers, and with the sleeve closed, researchers pump the combustible gas under study into the inside chamber and an inert gas into the outer chamber. After the pressures inside the two chambers are equalized, the sleeve is opened. The inert gas and the combustible gas come into contact, but with very little mixing.

The combustible gas is then immediately ignited by a centrally located spark. The resulting spherical flame propagates outward until it meets the boundary of the inert gas and is extinguished. Since the volume of the inner chamber is much smaller than that of the outer chamber, there is negligible pressure buildup within both chambers during combustion. The entire process, from flame ignition to propagation and extinction, can be recorded on high-speed video. “The ability to do this kind of experiment puts us one step forward in understanding high-pressure combustion,” says Law.

Observing the images of the flame as it propagates turned out to be highly rewarding. Law was surprised to see that the flame has a strong propensity to develop wrinkles over its surface for high chamber pressures. This is shown in figure 1 for the flame propagation sequences in mixtures of hydrogen and air at two different pressures. At 1 atm, the flame surface remains smooth as it propagates outward upon ignition.

Figure 1



Combustion theory gets an update when flames in high-pressure combustion reactions reveal their “wrinkles.” At 1 ATM, the flame surface remains smooth as it propogates outward, but at even slightly increased pressures (5 atm), the flame develops a bumpy appearance. Modeling of flames in internal combustion engines will benefit from this new revelation.

However, at even a moderately high pressure of 5 atm, wrinkles develop over the flame surface.

The fact that the flame surface *can* become unstable and develop wrinkles is not surprising. Indeed, as early as the 1940s, Russian physicist Lev Landau predicted that the flame surface is always unstable. However, smooth flames such as those on a gas stove are the kind that is routinely observed, and the possible occurrence of wrinkled flames has been treated as more of an exception than the rule. What *is* surprising from Law’s experimental observation is the strong propensity and prevalence of wrinkled flames at higher pressures. In hindsight, Law explains, this is reasonable because chemical reactions progress faster at higher pressures, yielding faster-burning flames that are more unstable.

The recognition that flames prefer to propagate in the wrinkled mode at high pressures fundamentally alters the understanding of the burning processes within internal combustion engines. This is because the rate of fuel consumption increases with the flame’s increasing area. Since the presence of wrinkles dramatically increases the flame's surface area, the flame actually burns much faster than previously realized.

Without seeing the flame, an investigator conducting high-pressure combustion experiments in closed vessels could easily be misled about the meaning of the fast rate of fuel consumption. If a smooth flame is assumed, then measuring the pressure increase inside the closed chamber could lead one to believe that a particular fuel has a very fast burning rate and to conclude that the chemistry of the combustion process must also be very fast. "It's not the chemistry so much as it's the morphology of the flame surface — the 'wrinkledness' of the flame — that causes the faster burning rate," says Law. "Without seeing the flame, you would be attributing the increased pressures to the wrong cause. If you wanted to improve the efficiency of the combustion process [by altering only the chemistry], you would be going in the wrong direction."

The discovery of the omnipresence of wrinkles at high pressures also promises to modify the understanding of the progress of chemical reactions in high-pressure combustion. In these instances, some of the reaction rates could have been assigned too high a value based on the higher burning rates measured. "This is a classic example of how errors in the interpretation of experimental results could propagate and consequently falsify fundamental physico-chemical data," Law cautions.

You Start With the Simplest

Law and his team at Princeton have begun their work on high-pressure combustion with hydrogen, the simplest of fuels. "All the other fuels — for example, methane, propane, benzene, and the alcohols — have hydrogen as a component," explains Law. "It's a building block. If you cannot describe what's happening in the case of hydrogen, you cannot proceed with studying these hydrocarbon fuels."

Law has conducted a large portion of his research at Earth's gravity, where the presence of buoyancy can have a significant influence on the propagation of weak flames, such as those associated with fuel-lean burning. Because of the slow flame propagation rate, buoyancy causes the hot combustion products to rise relative to the environment during flame propagation. This distorts the flame from the spherical shape it would have were gravity minimized. Such a distortion makes it much more difficult to analyze the experimental data and extract the fundamental information. Moreover, the effects of gravity are aggravated under high pressures. At higher pressures, the gas is even more buoyant because density is proportional to pressure. The higher the pressure, the greater the density differences between the hot gases and the cooler gases surrounding the flame. "The whole thing, then, calls for doing experiments in microgravity," Law concludes.

In NASA's 2.2-Second Drop Tower at Glenn Research Center in Cleveland, Ohio, Law is able to conduct his experiments on high-pressure burning without the disturbing influence of gravity. As the combustion chamber is released inside the drop tower and begins to fall, a spark plug inside the inner chamber is discharged, igniting the flame. The flame is spherical, and its propagation rate is well-defined and accurately measured from the imaged flame radii on the video. In the future, Law plans to introduce lasers to nonintrusively measure the temperature of the combustion reaction and to determine the composition of gases participating in the burning process. These measurements would allow even more insight into the chemistry of the combustion reactions.

While the drop tower provides an excellent microgravity platform, it is limited when it comes to really slow-burning, weakly combustible mixtures, which are of relevance to the study of flame extinction phenomena. Experiments on such slow-burning fuel mixtures require much longer microgravity times in order to observe the burning process in its entirety. Eventually, these experiments may need to be conducted on the International Space Station, which provides continuous access to microgravity.

Law is excited about the experiments his chamber design is already making possible. "Combustion has reached a very exciting stage," he claims. "It has evolved from an empirical science to an exact science. Now we can make a prediction, do a careful experiment, and test whether our theory is right." Without the ability to conduct experiments under difficult but realistic conditions, such as those of high pressure, he explains, "your information base is incomplete. No matter how beautiful your theory is, you need to have an experiment. That makes the data we are obtaining very valuable." Law is encouraged by the support he receives from NASA. "The NASA program is funding fundamental research with useful outputs," he says. "That's the best kind of research." μg

Science Program Report

NRAs

Biotechnology

In response to the most recent NASA Research Announcement (NRA) in microgravity biotechnology, 43 researchers were selected to receive grants totaling approximately $27 million over four years to conduct microgravity biotechnology research. The research selected from among 225 proposals included experiments involving cellular, macromolecular, and microbiotechnology. A complete list of funded projects may be found on the Internet at *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2001/01-126a.txt*. ☐

Fluid Physics

Proposals in response to the NRA in microgravity fluid physics (available on the World Wide Web (WWW) at *http://peer1.idi.usra.edu/peer_review/nra/01_OBPR_02.html*) were due May 11. For more information, contact Gerald Pitalo, enterprise scientist for fluid physics at NASA headquarters; e-mail: *gpitalo@hq.nasa.gov*; phone: (202) 358-0827. ☐

Materials Science

An NRA soliciting research in microgravity materials science will be released in mid-2001. Details about the NRA will be available on the WWW at *http://microgravity.hq.nasa.gov/business.htm#current*. ☐

International and Interdisciplinary

Proposals in response to the **Broad Agency Announcement (BAA)** recruiting investigators to conduct research in the area of **fundamental technologies for the development of biomolecular sensors** were due April 30. More information about this BAA can be found on the web at *http://rcb.nci.nih.gov/appl/rfp/17016/Table%20of%20Contents.htm*. ☐

Proposals received in response to an **International Announcement of Opportunity** soliciting research to be conducted on the International Space Station (ISS) were reviewed by the International Microgravity Strategic Planning Group in May. Final selections for funding will be made in September. ☐

Meetings and Events

Biotechnology

Principal Investigator (PI) Rafat Ansari, of the National Center for Microgravity Research on Fluids and Combustion (NCMRFC), presented a seminar titled **"Detection of Ocular Radiation Damage Using Dynamic Light Scattering"** to employees at SynZyme Technologies, a biotechnology company in Irvine, California, on January 24. The company has developed a drug that may protect astronauts from harmful radiation in space, but the drug still needs to be tested. SynZyme is interested in embarking on a collaborative project with NASA to use Ansari's light-scattering techniques to test the efficacy of the drug. ☐

Combustion Science

Glenn Research Center (GRC) hosted **crew training for the Combustion Module-2 (CM-2) facility** January 30–31. CM-2 is scheduled for launch on STS-107 next spring. The training introduced the seven STS-107 crewmembers to the scientific aspects of the three major combustion experiments that will be conducted in the facility: Laminar Soot Processes, Structure of Flame Balls at Low Lewis-Number, and the Water Mist Fire Suppression Experiment. The training involved both classroom sessions and hands-on sessions, in which the crewmembers practiced making adjustments to critical science parameters. ☐

The **Sixth International Microgravity Combustion Workshop** was held May 22–24 in Cleveland, Ohio. Hosted jointly by GRC and NCMRFC and sponsored by the Physical Sciences Division and the Microgravity Combustion Science Discipline Working Group, the biennial workshop is a forum for the exchange of results from NASA-sponsored microgravity combustion science research and technology development efforts. In addition to presentations regarding ongoing investigations, there were poster sessions dedicated to new investigations and hardware exhibits. Attendees also learned about the anticipated NRA calling for proposals to conduct microgravity combustion science research studies and found out how the participants might become involved in NASA's microgravity combustion science program. For more information, visit the workshop web site at *http://www.ncmr.org/events/combustion2001/index.html*. ☐

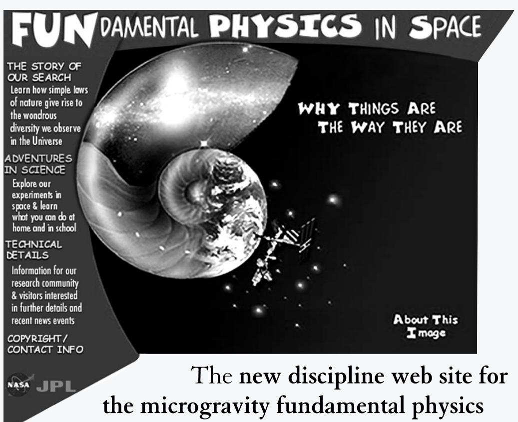
Fundamental Physics

On February 5, Melora Larson, of the Jet Propulsion Laboratory, gave the opening lecture for the **61st lecture series on "What Physicists Do"** at Sonoma State University in California. Larson is the project scientist for the Low-Temperature Microgravity Physics Facility (LTMPF), a facility that will house low-temperature experiments on the ISS. Her talk, titled "Low-Temperature Research on the International Space Station," described the history of fundamental physics research in space and the development of the LTMPF, introducing the audience of students and members of the community to the types of science that are enabled by the space station. Larson was brought to the attention of the organizers of the lecture series through the Profiles of Women in Microgravity web site, located at *http://microgravity.nasa.gov/WOMEN/*. □

This year's **Fundamental Physics in Microgravity Workshop** was integrated with the 2nd Pan-Pacific Basin Workshop on Microgravity Science, which was held May 1–4 in Pasadena, California (see International Meetings section). Fundamental physics PIs presented their papers over the course of seven breakout sessions, and Nobel Laureate David Lee, of Cornell University, presented the opening plenary talk for the meeting. □

Materials Science

The **2001 National Space & Missile Materials Symposium** was held in Monterey, California, June 25–28. This year's theme for the symposium was "2001: A Materials Odyssey From Laboratory to Space." The program began with a plenary session that consisted of talks given by leaders from the Air Force, Navy, Army, and NASA; Dennis Smith, deputy director of space transportation at Marshall Space Flight Center, was featured in this session. The program also included a full day of tutorials, with topics such as "Fundamentals of Carbon Nanotube Materials," "Biomimetics and Biomaterials and Their Connection to Aerospace Technology," and "Nanoscale Materials and the National Nanotechnology Initiative," all subject areas of recent emphasis in the microgravity research program. In addition, there were four major technical sessions in the areas of missiles, access to space, operating in space, and survivability (a classified session); a poster paper session; exhibits; and several social activities to facilitate networking and interaction among conference attendees. More information about this symposium can be obtained from its web site at *http://www.usasymposium.com/space2/index.htm*. □



The **new discipline web site for the microgravity fundamental physics program** is now available at *http://funphysics.jpl.nasa.gov*. The site contains background material about research in fundamental physics, describes many of the experiments that are supported by the program, and presents the results of several fundamental physics flight experiments. The Library section of the web site (*http://funphysics.jpl.nasa.gov/technical/library/library.html*) contains an archive of significant events for the fundamental physics program, a list of investigators who are currently performing research, and links to their web sites, when available. The Fundamental Physics in Space Roadmap, a document describing the directions that the fundamental physics research program is expected to follow over the next 15 years, is also available in the Library section.

Interdisciplinary Meetings

The **Space Station Utilization Advisory Subcommittee** (SSUAS) held its winter meeting January 22–24 at the Lunar and Planetary Institute in Houston, Texas. The SSUAS is a board of scientists and researchers who promote ISS users' access and accommodations. Topics of discussion at the meeting included the research vision for the station and plans for the assembly period, crew training, and payload integration and testing. The space station's unstable budget and its impact on research, especially delays and cuts to previously approved research, were frequent topics of discussion for SSUAS members. In addition, attendees voiced concern regarding the potential deletion of the station's habitation module and the subsequent impact to microgravity research in the U.S. laboratory. □

The fourth annual **Microgravity Environment Interpretation Tutorial** was held March 6–8 in Cleveland, Ohio. Organized by the Principal Investigator Microgravity Services (PIMS) project, the tutorial was designed to assist microgravity project scientists and researchers in understanding the microgravity environment their experiments are exposed to and learning how to quantify and analyze the effects of that environment on their experiments.

The primary focus of the meeting was on the environment of the ISS, but other microgravity platforms were also addressed. In addition, tutorial attendees were introduced to the many services that PIMS offers to researchers. These include acceleration data analysis and interpretation; identification of acceleration sources related to vehicle systems, experiment hardware, and vibration isolation systems; and development of data analysis techniques and displays based on user requirements. PIMS also offers characterization of the microgravity environment of the ISS in support of PIs as well as preparation of mission summary reports aimed at furthering PIs' understanding of the microgravity environment. For more information about the tutorial or about the PIMS project, contact Kenol Jules, PIMS project scientist; phone: (216) 977-7016; e-mail: *jules@schnellest.lerc.nasa.gov*. □

The **Microgravity Transport Processes in Fluid, Thermal, Materials, and Biological Sciences II Conference** will be held September 30–October 5 in Banff, Alberta, Canada. Principal Investigator Satwindar Sadhal, of the University of Southern California, will serve as the conference chair and scientific secretary. The purpose of the conference is to provide a forum for the exchange of technical information and ideas among the various scientists and engineers working in microgravity fluid, thermal, biological, and materials sciences. For more information about the conference, visit the conference's web site at *http://www.engfnd.org/engfnd/1ay.html*. □

The **Conference and Exhibit on International Space Station (ISS) Utilization** will take place October 15–18 at Kennedy Space Center in Florida. The conference, which is sponsored by NASA and the Boeing Company and organized by the American Institute of Aeronautics and Astronautics (AIAA) and the Florida Space Research Institute, will include many sessions chaired by NASA personnel supporting the Physical Sciences Division. Further information about the conference may be obtained on the WWW at *http://www.aiaa.org/calendar/index5.cfm?id=136*. □

International Meetings

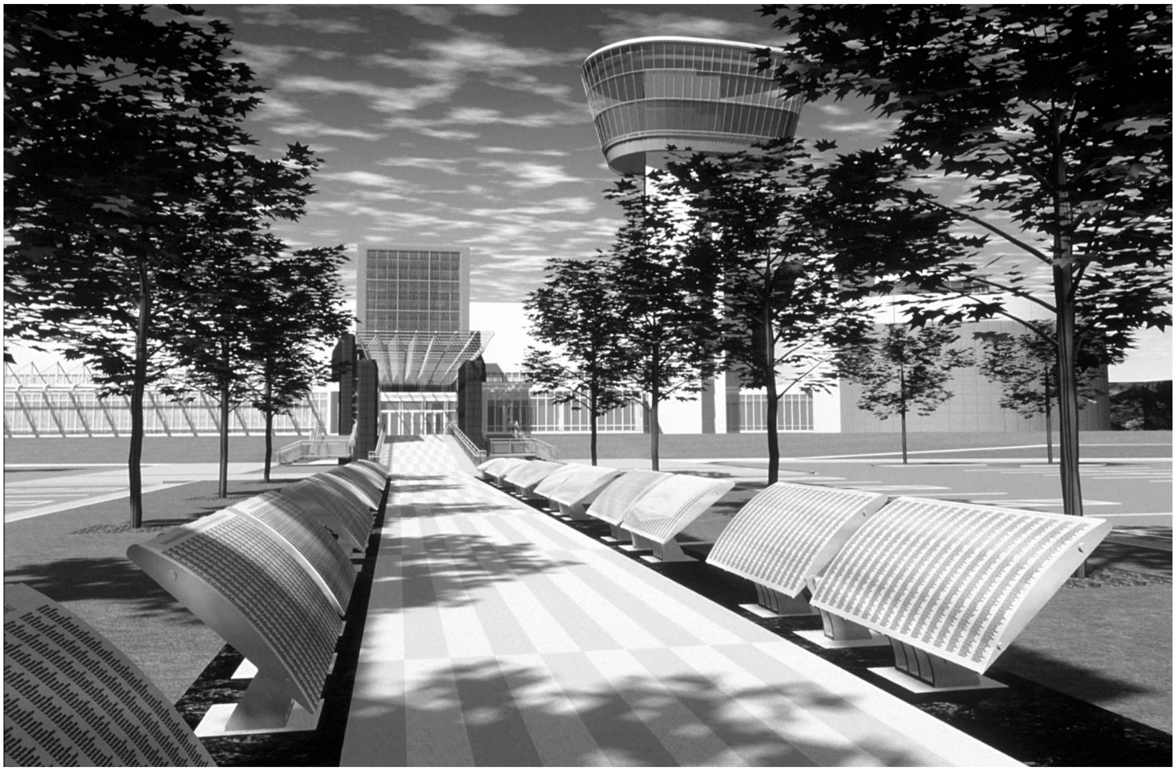
Abstracts of papers that were presented at the **Second Pan-Pacific Basin Workshop on Microgravity Sciences** are available in PDF format on the WWW at *http://space.usra.edu/ppbws_2001/programs.html*. The workshop, held May 1–4 in Pasadena, California, was sponsored by the Association of Pacific Rim Universities, the National Society of Microgravity Science and Application of China, and the Japan Society of Microgravity Application. Other participating organizations included NASA, the National Space Development Agency of Japan (NASDA), the Chinese Academy of Sciences, the Canadian Space Agency (CSA), and the Russian Space Agency (RSA). Topics covered by microgravity researchers from the Pacific-basin countries, as well as researchers from Europe and other countries, included astrobiology and life sciences, biotechnology, colloids and pattern formation, combustion and chemical reaction, and crystal growth and solidification processes. The workshop also addressed experimental techniques, fundamental physics, instability of thermocapillary flow, life sciences, multiphase flow and transport processes, nanostructure formation, and thermophysical properties. Information on the conference and other news on microgravity science is available on the workshop's web site at *http://space.hsv.usra.edu/ppbws_2001*. □

The **38th Space Congress** was held May 1–4 in Port Canaveral, Florida. This year's theme for the conference was "A Space Odyssey — The Next 50 Years." The Space Congress was created by the Canaveral Council of Technical Societies to stimulate interest and promote professionalism in the space program. The international conference was targeted not only toward professionals in the space industry, but also toward those from the peripheral industries and disciplines that make space transportation and exploration possible.

Over the course of the conference there were three panel sessions, "U.S. Government and Commercial Issues," "International Perspectives," and "Science," and paper sessions that included topics such as global space initiatives, education about space-based research and development, the space station, and scientific knowledge gained from space. More information about the conference can be obtained from the congress's web site at *http://SpaceCongress.org/2001/*. □

An **International Workshop on Miscible Interfaces** was held July 2–5 in Paris, France. The workshop was intended to offer a venue for disseminating and discussing a host of new findings in the area of flows in miscible fluids (fluids that are mutually soluble) with steep concentration gradients. Topics covered in the workshop included hydrodynamic instabilities involving miscible fluids, Korteweg stresses and effective surface tension, fluids near critical points, thermodynamics and theoretical aspects, numerical simulations, reactive systems, and miscible flows under microgravity. The meeting also encouraged communities that work on different aspects of miscible fluid flows to share information and present the most up-to-date overviews of what is happening in the field. □

The **10th International Conference on II-VI Compounds** will be held September 9–14 in Bremen, Germany. The conference will cover all aspects of basic and applied research on narrow- and wide-gap II-VI semiconductors. Information on registration and other conference details is available on the WWW at *http://www.II-VI2001.uni-bremen.de*. μg



Visitor's approach to the new Udvar-Hazy Center will be lined with plaques inscribed with the names of donors. The Donald Engen Observation tower will give visitors a view of flight activities at Dulles International Airport.

Smithsonian Seeks Microgravity Artifacts

Scientists wondering what to do with leftover flight hardware that isn't quite right for an upgrade to the next generation of science might consider donating it to the National Air and Space Museum for display at its new facility at Dulles International Airport, near Washington, D.C.

The Air and Space Museum is the aviation and space wing of the Smithsonian Institution, America's beloved "national attic." Investigators who have visited the museum know that the museum shows only a small portion of its collection. Many artifacts are stored in Suitland, Maryland. To display the overflow, the museum is building a new annex at Dulles International Airport. The Stephen F. Udvar-Hazy Center (named for its principal donor) should open in 2003, the centennial anniversary of Orville and Wilbur Wright's first powered flight at Kitty Hawk, North Carolina. While most of the new center will be devoted to aircraft, one hangar will be devoted to space.

"The space shuttle *Enterprise* will be the dominant object in the new space hangar," says Valerie Neal, the Air and Space Museum space history curator responsible for *Enterprise*, which NASA donated in 1985. "It will be at center stage." On stage with *Enterprise* will be an artifact familiar to many microgravity scientists: the Spacelab module used on 10 missions, from Spacelab 1 in 1983 to the first Microgravity Science Laboratory mission (MSL–1) in 1997.

Neal is well-known to many microgravity scientists. Working in Huntsville, Alabama, in the 1980s, she led a unique writing group that produced booklets describing Spacelab missions. Although the current medium is different, the work she's been doing at the National Air and Space Museum since 1989 is similar — she explains to the public what is done in space and why.

"When we put the Spacelab module on display," Neal explains, "we want to show the variety of valuable, sometimes groundbreaking, research that was conducted in Spacelab and on the shuttle. For scientific research, Spacelab and the shuttle are the bridge from *Skylab* [NASA's early space station, which orbited from 1973 to 1979] to the International Space Station."

Neal is seeking donations of experiment hardware that flew on the shuttle. (See sidebar for details.) Her first such acquisition is a Space Acceleration

Space shuttle *Enterprise*, the dominant object to be displayed at the new center, is carefully nestled amidst vintage warbirds. The Spacelab module, in protective white plastic, is at bottom right.

Measurement System (SAMS) instrument flown on shuttles and on the Russian space station, *Mir*.

Shuttle-era science holdings are sparse because apparatus are often reflown or recycled. "We would like to have different kinds of experiments to show the public," she continues. "We will also need help from principal investigators in developing the explanatory material so we present an accurate as well as understandable story."

Not every donated artifact will go on immediate display. "We are still developing our exhibit plans and will consult with senior NASA scientists to help us choose," Neal explains. "We might rotate some artifacts so repeat visitors can see something new or lend some artifacts to other science museums around the country."

Microgravity investigators who have artifacts available should contact Neal at the following address:

Valerie Neal, Curator
Space History Division, MRC 311
National Air and Space Museum
Washington, DC 20560-0311
Phone: (202) 357-2099
Fax: (202) 786-2947
E-mail: *Valerie.Neal@nasm.si.edu*

For additional information about the Udvar-Hazy Center, visit the center's web site at *http://www.nasm.edu/nasm/ext/*.

Editor's note: This is the first of a new series of columns describing the Microgravity Research Program's outreach and education activities. Potential contributors should contact Dave Dooling, Outreach & Education Project Manager, by e-mail at *dave.dooling@msfc.nasa.gov*. μg

Deciding What to Donate

Not everything old makes a good museum artifact. "Donation is preceded by a fair amount of dialogue — conversations or correspondence — between donor and curator to decide what is an appropriate acquisition," Air and Space Museum Curator Valerie Neal cautions. "We evaluate donations on a case-by-case basis. In general, we place highest priority on objects that have flown on missions, then backups or flight-certified spares, then training units. The more intact and less cannibalized [i.e., stripped for parts] they are, the better. We also are interested in selected companion documents, such as operational data books, crew procedures, and end item specifications for the technical archives."

Donors should check with the property managers and historians at their home institutions and with program management at NASA to ensure that ownership of artifacts is clearly defined and the property transfer is legal.

Cover story continued

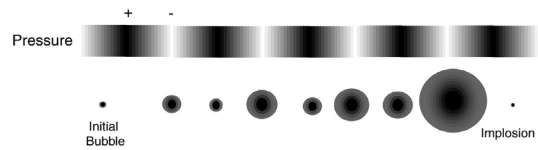
"The process that the students follow is very similar to what NASA scientists follow as they prepare their experiments that were first conducted in normal gravity to be flown on an upcoming mission."

Just as NASA researchers begin by asking a question, so do the student scientists. Would a cardiopulmonary resuscitation device used on Earth work on the ISS? Would a nonflickering flame behave differently without the effects of gravity? Or, as Justin Reed, a sophomore in physics at the University of Washington (UW) asked, would minimizing the effects of gravity allow researchers to control the size and quantity of nanoparticles formed from collapsing bubbles in a metallic solution?

Reed and fellow UW team members David Halaas (sophomore), Andrew Cook (senior), and Paul Parazzoli (senior) posed this question last fall in their proposal to NASA and TSGC to participate as a Spring 2001 team. The students had been assisting with the research of their professor Thomas Matula, also a microgravity fluid physics principal investigator, who was using sound waves to create bubbles in a metallic solution (metallic salt dissolved in solution). Matula was investigating the effect of gravity on the intensity of light emitted by the bubbles as they collapsed, and working on this project led the students to form a new hypothesis.

The students had observed that when they directed a sound wave through a metallic solution, hundreds of bubbles would form in the cavitation field, the region where the lower part of the wave created negative pressure. In the span of picoseconds (trillionths of a second), the bubbles would expand with gas absorbed from the surrounding liquid until they were large enough to resonate from the sound wave. Once the bubbles began resonating, they would absorb acoustic energy. They quickly grew over the course of one acoustic cycle until inertia would dominate the expanse. The bubbles couldn't sustain themselves, and they would implode suddenly. Reed explains, "Imagine blowing up a balloon very quickly in a swimming pool. If you blow really hard to increase the inflation of the balloon, the water will push back on the walls of the balloon, causing you to get a mouth full of air!"

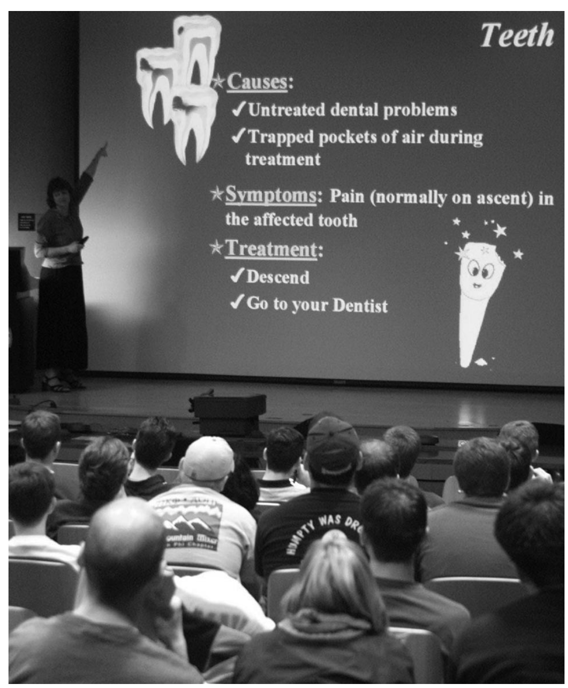
When the bubbles collapse, they cause rapid heating and then cooling rates, creating a unique chemical environment. "The liquid as a whole does not heat that rapidly," says Reed. "It will increase about [36°F] from room temperature [73°F] in 10 minutes. But the interior of some of the individual bubbles can increase up to



Bubbles in the path of the negative pressure portion of a sound wave expand with gas absorbed from the surrounding liquid until they are large enough to resonate. Once this resonance is achieved, inertia dominates the expanse, and the bubbles implode suddenly.

10,000 kelvins," (about 18,000°F, or three times the surface temperature of the Sun). This rapid change of temperature releases hydrogen and oxygen-hydrogen free radicals that may then react with the metal particles in the solution to form metal particles on the order of nanometers (billionths of meters) in size. The result is a colloid, which is a system of fine particles suspended in a fluid. The metal particles in the colloid are very much in demand. Reed illustrates, "They have many different applications ranging from medical research to electronic circuits. They can be used in such studies as DNA identification, drug delivery, and surface treatments."

The team believes that in normal gravity, buoyant convection (the tendency of less dense particles to rise) may limit the rate of formation of these nanoparticles.



KC-135 training includes teaching participants how to avoid the possible physiological effects of parabolic flight, such as toothache and queasiness.

Student flight crews learn to recognize the effects of hypoxia, or deprivation of oxygen, through simulations of cabin pressure drops during altitude chamber training.

Reed explains, “As bubbles move upward through the liquid, drag force distorts their spherical shape. As a consequence, the bubbles may not be spherical when they collapse. In this case, the amount of energy focused at the center of the bubble, and therefore its temperature, will be decreased.” He and his fellow students hypothesized that in microgravity, the absence of buoyancy would allow the bubbles to be spherical when they collapse, allowing more of the collapsing bubbles to attain the extremely high temperatures needed to trigger the formation of nanoparticles. The near-absence of convection in microgravity would also lead to a change in the size of the formed nanoparticles.

The students determined on their own what hardware and procedures they would need to test their sonochemical idea and submitted their plans to NASA and TSGC last fall. Once their project was approved for participation during the spring flights, the students fine-tuned their experiment with the guidance of their faculty adviser, Matula, and their volunteer NASA adviser, David Smith, an aerospace technologist in structural materials at Marshall Space Flight Center in Huntsville, Alabama. The advisers offered insight to the team on technical aspects that would help them reach their objectives.

On a Roller Coaster With Wings

This spring they were ready to fly their experiment. They arrived in Houston on a Thursday in March for ground training. The first day involved setting up all their equipment and receiving official welcomes from program sponsors. Tarkington explains the rest of the schedule: “Friday morning they arrive here at Johnson Space Center at 7 o’clock, and we bus them over to mission control. One of our medical staff briefs them on the physiology they’ll experience during flight so they’ll know how to avoid getting flight sickness.” The KC-135 flies in a roller coaster–like parabolic pattern, creating a microgravity environment during its almost 30-second freefall followed by a minute and 15 seconds of 1.8 g during its climb. The repeated changes in gravity force can cause queasiness, especially for first-time riders. Flight crews also learn to recognize the effects of hypoxia, or deprivation of oxygen, through simulations of cabin pressure drops during altitude chamber training. The training teaches crewmembers the conditions during which they would don oxygen masks on the KC-135.

Tarkington continues, “Then we start Monday with the test readiness review. All the students demonstrate their hardware while operations staff assess the safety of the experiment itself and the hardware. Although the experiments have been deemed safe during the proposal process, our staff ask questions like 'How will this be bolted down?' and 'How is this going to move?' because things do tend to shift a little during the 1.8-g climbs, and we want everyone aboard the plane to be safe."

The next day, teams send two of their crew up to conduct the experiment. The pilot makes numerous parabolic dips and climbs, giving young researchers several opportunities to run their experiments. After about two hours of flying, the teams return to the ground to meet with their ground crews and go through debriefing. The next day, two other flight crew members from each of the teams fly the same experiments.

Back in the Lab

Once the flights are over and the students have gone home, the next stage of research begins: analyzing the data. Reed and his team are reviewing the data taken during both days of flight. Images of the nanoparticles taken with a transmission electron microscope will show in depth the effects that microgravity had on the formation of the particles. What they learn from the images will be compiled into a final technical report that they will send to NASA and TSGC. The report will also be posted on their web site, *http://depts.washington.edu/sonochem/*. Their information may be made available to NASA scientists and engineers and other members of the professional community.

Tarkington explains that some of the results may be useful to NASA: "We typically are researching some of the same types of things the students are. Universities tend to be on the forefront of scientific research, as is NASA, so the program makes a perfect match for us."

Reed's team also will share their findings through presentations at local high schools to encourage youth to get involved in the growing fields within science and technology. And as Tarkington sees it, inspiring more young people to become scientists is precisely the aim of the program: "We really do change a lot of lives. A lot of the students that come here, especially from the community college and high school programs, leave here saying, 'I wanted to be an auto mechanic, but forget that. I want to be an engineer.' Or 'I want to be a life scientist.' The Reduced Gravity Student Flight Opportunities Program is a great way to experience what science is all about." μg

Once the flight is over, students go back to their home universities to analyze the data, compile reports, and share their experiences and findings with other students in the hopes of inspiring more young people to become scientists.

How to Participate

Students interested in participating in the Reduced Gravity Student Flight Opportunities Program must go through a rigorous application process. First, the idea for a project is developed by a team of undergraduate students, either as part of a class project or as independent research. The team submits a letter of intent to the Texas Space Grant Consortium. Soon thereafter they submit a detailed proposal that includes technical information about the experiment, an explanation of why it should fly in microgravity, and a safety assessment of its operation. The proposal also must include the names of the team's flight crew members (at least four undergraduates) and optional ground crew members, who may be graduate, undergraduate, or high school students, and the team's plan for educational outreach after the flight.

Scientists and engineers from NASA and TSGC review the applications for their technical merit, their experiment safety evaluation, their outreach plan, and their administrative detail. Teams whose proposals are selected receive comments and suggestions from reviewers. The teams may be asked to supply additional information, and all flight crew members must complete a medical exam performed by an aviation medical examiner who is certified by the Federal Aviation Administration. Teams whose proposals are not selected also receive reviewer comments and suggestions for improving the experiment so the project has a better chance of being selected in future competitions.

For more information on the program, including deadlines for submitting proposals and more detail about selection criteria, visit the program's World Wide Web site at *http://www.tsgc.utexas.edu/floatn/*.

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Flight Update: Destiny *continued from page 5*

in microgravity. At this time, both STES units are in EXPRESS Rack 1 aboard the ISS and are housing PCAM cylinders. In mid-May, the PCAM cylinders, with protein samples in solution, were activated. In these experiments, a precipitant attracts the water away from the protein solution. As water is removed from the solution, the proteins can begin to crystallize. At the end of the experiment, the system will be deactivated to isolate the crystals for transport back to Earth for subsequent study.

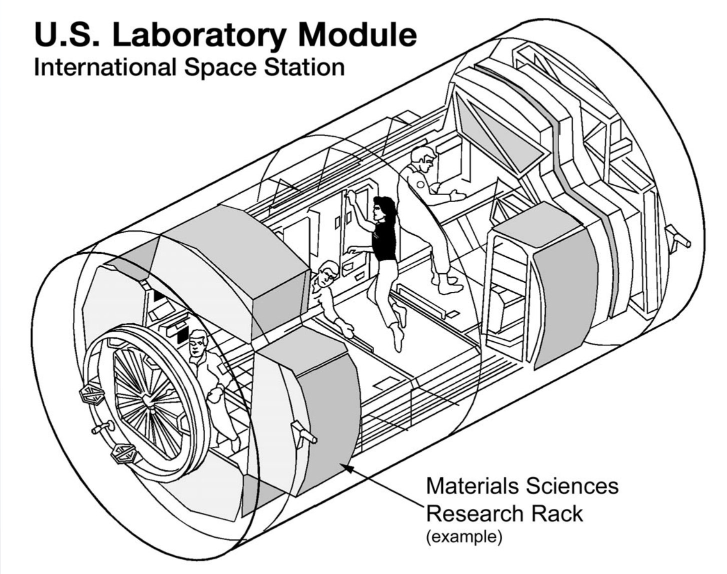
Also flown to the ISS aboard STS-100 were the Space Acceleration Measurement System (SAMS) and the Microgravity Acceleration Measurement System (MAMS). SAMS collects, processes, records, and delivers acceleration data aboard the ISS so that researchers can assess the effects of acceleration on their microgravity experiments. MAMS measures frequencies and provides the data to researchers so they can assess the effects of frequency changes as a result of acceleration on their experiments.

Later this summer, STS-105 will transport to the ISS two more EXPRESS racks for research use, U.S. stowage racks, and International Standard Payload Racks, carried in an MPLM.

To learn about future shuttle missions, visit NASA's Human Spaceflight web site at *http://spaceflight.nasa.gov/shuttle/future/index.html*. For information on progress of the assembly of the ISS, visit *http://spaceflight.nasa.gov/station/assembly/index.html*. To track where the ISS will be visible in the night sky, visit one of the following web sites: *http://liftoff.msfc.nasa.gov/temp/StationLoc.html* (from Marshall Space Flight Center [MSFC]) or *http://spaceflight.nasa.gov/realdata/sightings/* (from Johnson Space Center [JSC]). The MSFC site gives the station's location in relation to the globe, provides latitude and longitude information, and has an automated mailing list option. The JSC site has a listing of sighting opportunities. μg

On the Racks

Much of the research conducted on Destiny will be housed in racks, which are refrigerator-sized structures that hold experiment hardware or computers designed to control experiments or perform other functions. Destiny will eventually house a total of 23 racks, 12 of which will be designated for scientific research. They are modular in design so that the racks themselves or the hardware within them can easily be removed and exchanged as research needs or technology changes. The size and weight of the racks precluded them from all being transported onboard Destiny for its flight aboard *Atlantis*, although a few of the control systems racks were included. Racks will be added during subsequent shuttle flights, and research capabilities aboard Destiny will continue to expand.



This cutaway line drawing depicts the size of the Destiny laboratory module relative to the ISS crewmembers. The shaded sections represent some of the refrigerator-sized research racks. Eventually Destiny will house a total of 23 racks.

Jennifer Lewis

What can turn a high school student with a proclivity toward science into a passionate researcher honored with numerous awards and hailed as an extremely promising contributor to her chosen field? A hands-on experience in a research laboratory, of course. Almost any scientist will tell you that working in the lab is an inspiring experience, and that's just what it turned out to be for Jennifer Lewis, colloid scientist and professor at the University of Illinois, Urbana-Champaign (UIUC).

Lewis's mild interest in science became a passion when she began work in a research lab, processing electrical-based ceramics as an undergraduate at the University of Illinois. "Getting an opportunity to see science at work and to contribute to it was something that really became motivating for me," says Lewis, even when her first contributions were, as she describes it, "at the 'gofer' level."

Her undergraduate experiences led her to pursue her doctorate at the Massachusetts Institute of Technology, where she narrowed her field of study to colloidal processing of advanced materials. These materials, formed from colloids, mixtures consisting of solid particles dispersed in a gas or a liquid, are quite complex and, at the same time, ubiquitous. "Colloids are the building blocks for a large variety of materials," explains Lewis, "including advanced ceramics, coatings, inks, drug delivery systems, and more." Lessons learned from delving into the mysteries presented by colloidal phenomena therefore have far-reaching applications in a broad range of technologies.

In 1990, Lewis joined the faculty of UIUC, where her work has been recognized with many honors, including a National Science Foundation Presidential Faculty Fellow Award in 1994 and a prestigious invitation to contribute a Centennial Feature article on "Colloidal Processing of Ceramics" to the *Journal of the American Ceramics Society*. (This cover article appeared in the October 2000 issue.)

Lewis crossed paths with NASA in 1994, when Michael Wargo, enterprise scientist for microgravity materials science at NASA headquarters, invited her to participate in a review of the ongoing efforts in ceramics for what was then the Microgravity Research Division (now the Physical Sciences Division). "That provided exposure to the kind of programs NASA supports and motivated me to apply for research funding," recalls Lewis. Her path merged with NASA's when her research was selected for financial support in 1998.

"My work that NASA is funding involves colloidal stability in complex fluids. In these materials we study the influence of highly charged nanoparticles on the phase behavior (how the crystals form) of otherwise attractive colloidal microspheres (colloidal particles that attract one another). Such fluids serve as precursors for the self-assembly of colloidal crystals," explains Lewis.

"As optical communications and computing technologies continue to gain in importance, there is an increasing need for devices that can control the flow of photons at wavelengths of 1.5 microns, the most important wavelength for optical communication," she continues. The controlled engineering of colloidal crystals that would allow light to pass through the material only at specific defect locations (e.g., waveguides) is critical to future photonic applications.

Work with these materials is still at a fundamental stage, which means that Lewis and her research group are discovering new knowledge about the materials' phase behavior. "The thing I find most exciting about this research is making new observations and then sitting down and trying to put the puzzle together to understand the origin of those observations."

But the thrill she gets at that moment of discovery is augmented by the fact that she's not experiencing it alone. Supervising the 10 graduate students in her research group at UIUC — "watching them come along, watching them develop as scientists themselves," she says — is perhaps the most rewarding aspect of her work, and it's clear that, to Lewis, the two types of development are intertwined. Not only is she sowing the seeds for the next generation of colloid-based materials, but she's also preparing the next generation of researchers to continue the work.

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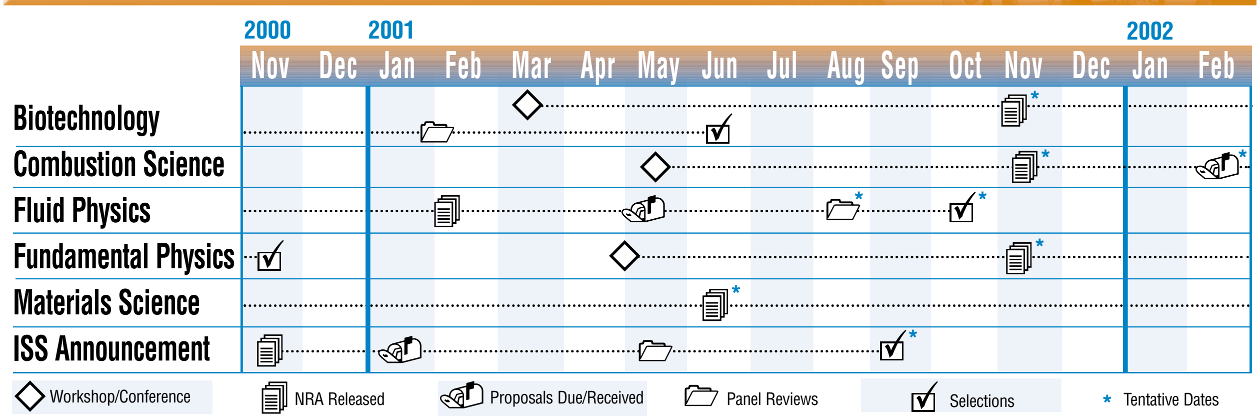
Symposium Calendar

September 9–14
10th International Conference on II-VI Compounds
Bremen, Germany

September 30–October 5
Microgravity Transport Processes in Fluid, Thermal, Materials, and Biological Sciences II Conference
Banff, Alberta, Canada

October 15–18
Conference and Exhibit on International Space Station Utilization
Kennedy Space Center, Florida

NASA Research Announcement Schedule



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