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Weightless Wonders

A joke in the lab turns into a zero-gravity experiment for four students.

By Beth Kelley

Have you ever wanted to turn off gravity?

Four ambitious undergraduates got that opportunity when they participated in the Microgravity University program put on by NASA last June. Microgravity University is a summer program that allows undergraduate students to propose, design, fabricate, fly in, and evaluate a reduced gravity experiment.

Zero gravity affected Mike Hvasta and Rachel Sherman as well as their experiment.

Mike Hvasta, Brandon Bentzley, Justin Nieusma and Rachel Sherman, all from The College of New Jersey (TCNJ), conducted an experiment on dusty plasma using zero gravity—and gained an experience of a lifetime.

Turning off gravity

The process started in the summer of 2007. Hvasta, who was then a senior at TCNJ, held a research position under Andrew Zwicker, head of the Science Education Program at the Princeton Plasma Physics Lab (PPPL), imaging dusty plasma structures, and investigating an illumination method that allows for three-dimensional imaging using fluorescent dust.

"Most of the visible universe, i.e. nebulae, comet tails, planetary rings, young solar objects etc., are all made of dusty plasma," explains Hvasta. "On the ground, dusty plasmas play a big role in fusion and plasma processing, but all the ground-based studies are always limited to 1G where their dust essentially stands still."

Hvasta and Zwicker joked about needing to turn off gravity to see how the plasma would act. Zwicker had previously heard of the Microgravity University Program and suggested it to Hvasta.

"He handed me an application for Microgravity University and told me that there actually was a possibility for us to do this research with NASA," Hvasta says. "I spent the better half of the summer working on the proposal and then,

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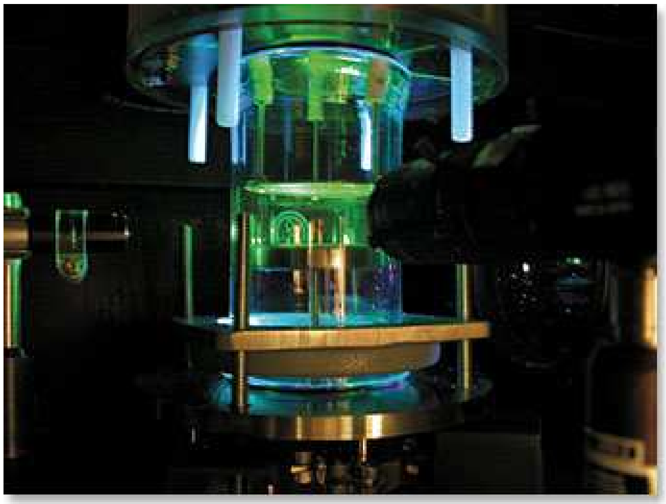
when classes started in the fall, I asked for volunteers from the physics department [at TCNJ] to help out." That's when Sherman, Bentzley and Nieusma joined the team. "By Halloween, we had submitted our proposal, and on December 6th we were notified that we were selected." Together the four students formed Team Dusty Plasma Experiment, or Team DPX.



The students tested their equipment, a laser and a reaction chamber shown here, before taking it to Microgravity University.

The students spent the rest of the school year working with Zwicker and their adviser, TCNJ physics professor Romulo Ochoa, to design and build their experiment and raise funds. They received financial support and supplies from PPPL, TCNJ, Edmund Optics, Pfieffer, and the U.S. Department of Energy Office of Science.

Ochoa says his job as an adviser was fairly hands-off, working mostly to help them raise funds from various groups and dealing with administrative concerns. "For the most part, the team members did an extraordinary job of solving their problems on their own."

The Big Drop

In June 2008, Team DPX traveled to Houston to prepare for their flight and set up their experiment. The flights occur on a NASA DC-9, also called the "Weightless Wonder" or "Vomit Comet." The NASA DC-9 flies in a parabolic flight pattern, creating either a zero-gravity or double-gravity effect. During the flight, the plane makes approximately 20 rotations.

"In the 'Weightless Wonder,' we were able to study dust in a variety of positions ranging from 0G to 1.8G, which, to the best of our knowledge, hasn't been done intentionally before," Hvasta says.

The team also had to adapt to the changes between 0G and 1.8G on themselves. Hvasta described the experience as taking the feeling one gets when driving quickly over the top of a hill in a car or going over the top of a roller coaster "to the absolute extreme."

Zwicker recalls that Sherman called him within minutes of getting off the plane. "All she could say was, 'It was amazing,'" he says.

The team got good results from their experiment, and Bentzley gave a presentation of the group's work at the American Physical Society (APS) division of Plasma Physics meeting in November 2008. However, there is still more to the experiment that was not covered in the first two flights, and they are still processing most of the data.

“They were very ambitious going into it, so they got good data,” Zwicker says. Of all their research goals, “they got through maybe 25% of them.”

Now seniors at TCNJ, Sherman and Nieusma submitted a new proposal and were accepted to participate in the Microgravity University program in summer 2009. They have also formed Team DPX II with new, younger students.

Mentoring

Zwicker says despite being bitterly jealous of the students’ experience, he is also proud to have served as a mentor to the students. “From the mentor side, it’s great because it was a total experience of a lifetime for them,” he says. Hvasta, for instance, plans to get a PhD in plasma physics and started his first year at University of Wisconsin Madison this past September. “So clearly it’s a life-changing experience for him.” Bentzley plans to begin an MD PhD program in September 2009.

“Experiences like these show undergraduates how much they have learned and how much they can accomplish when they set their minds on a given goal,” Ochoa says.

Team DPX has also had the opportunity to mentor and inspire younger students. The team did outreach events and talks at several middle schools around TCNJ, both before and after their trip, explaining their research and their experience on the Weightless Wonder. “It made me feel great when I saw the younger kids getting involved and asking really good questions about the project,” Hvasta says.

Help From EO

When Mike Hvasta contacted Edmund Optics (EO) for advice on the Team DPX experiment, he was paired with product line engineer Bruce Butkus. Butkus gave a full professional consultation, discussing the project and different options for the team. He also recommended possible lenses and video systems the team could use to record the dusty plasma in zero-gravity.

EO donated a digital color CCD camera, a Double Gauss 75mm lens for the camera, and an optics track.

Butkus says he and EO rank these types of projects and partnerships with students very highly. The outreach, he explains, “doesn’t have a big impact on us. It’s just a few pieces of equipment.” But it is immensely helpful and important for the students.

“These are the people who will be leading the country in the next 10 years. And it’s really great for their career,” he says.

Edmund Optics provided optical equipment, T-shirts for the whole team, a hat, and mouse pads. Team DPX included, left to right, Brandon Bentzley, Justin Nieusma, Mike Hvasta, and Rachel Sherman.

Hitting the Dusty Trail in Zero Gravity

There is solid, liquid, gas, and then plasma, a three-dimensional structure that is in everything from lightning to fluorescent light bulbs. Dusty plasma has applications ranging from planetary rings to fusion reactors.

A video camera screen displays dusty plasma.

In Team DPX's experiment, "Using Fluorescent Dust to Obtain a Three-Dimensional Analysis of a Dusty Plasma," the foursome wanted to see how this dust would act in zero gravity using a three-dimensional illumination method with fluorescent dust that glows under ultraviolet light. This method was used by DPX team member Mike Hvasta and Andrew Zwicker, head of science education at the Princeton Plasma Physics Lab. They found it to be more effective than traditional two-dimensional laser-sheet techniques or Stereoscopic Particle Image Velocimetry.

Hvasta described this technique in his proposal to NASA: "By using fluorescent dust, the three-dimensional structure was brightly and uniformly illuminated through exposure to UV radiation provided by a standard mercury lamp. This enabled all macro-particle dynamics within the vacuum chamber to be easily filmed because the depth of field was the only restriction on the number of particles in the frame."

Dusty plasma usually has negative charges, which repel each other and push the plasma cloud upward and out. However, in gravity, the dust is pushed flat. In order to study how the dust would move in outer space and explain some motional effects that Hvasta and Zwicker saw in 2007, the team needed zero gravity so the dust could float away from the dust tray.

Looking at preliminary data from the 2008 experiment, Team DPX members believe their technique will give comparable results to older techniques, and that it will allow researchers in the future to obtain a much clearer look at plasmas.

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