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Grounded, in High Orbit: Undergraduate Space Research at the University of New Hampshire

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commentary

Grounded, in High Orbit: Undergraduate Space Research at the University of New Hampshire

—George Clark and Morgan O'Neill (Edited by Jennifer Lee)

George Clark and Morgan O'Neill graduated in 2009 from the University of New Hampshire with Bachelor of Science degrees in physics. George is currently a PhD candidate in space physics at the University of Texas at San Antonio; Morgan is a PhD candidate in atmospheric physics at the Massachusetts Institute of Technology.

George: My journey into space, the final frontier, began at UNH. I was admitted into the physics department in 2005, where I immediately started to work under Dr. Eberhard Möbius on the Interstellar Boundary Explorer (IBEX), a NASA satellite. I joined forces with Morgan O'Neill, who was also a first-year student; our job was to test a star sensor for the IBEX satellite. This was a tall order for a couple of first year undergraduates. What did we know about photomultiplier tubes, optical designs, digital oscilloscopes or light sources? Dr. Möbius' guidance, patience and confidence in students allowed us to succeed in developing an instrument for the NASA IBEX satellite.

The authors calibrating the star sensor in UNH's Facility for Optical Calibration at Low Light Levels in 2007 (David Sims, UNH-EOS.)

Morgan: Physics was a lifelong fixation for me, and when time came to apply for college, I already knew that I wanted actual research to be a hallmark of my four years. I was accepted to UNH as the 2005 TYCO Scholar, and two days after my high school graduation I moved onto UNH's campus to begin work on the IBEX star sensor. Dr. Möbius' invitation and encouragement allowed me to wade knee-deep into research before I even started college classes.

George and I started working together with the UNH-IBEX team. One of the best parts about this job was the constant interaction with the other IBEX scientists and engineers. They are brilliant and resourceful, funny, patient and kind. George and I attended weekly team meetings and got to interact as peers. I would sometimes have to pinch myself: is this really happening? Is this thing I work on each day really going into space? Is work allowed to be this fun? But it didn't stop there: we both got involved in helping run the UNH observatory, where we got to play with the large telescope and teach basic astronomy to the public. IBEX, however, was the highlight of being an undergraduate at UNH. I honestly can't imagine where else I would have had the chance to do such work with such great people. The little star sensor was an education in and of itself.

George: The star sensor is a small device, no larger than a modern cell phone. It uses the stars to provide accurate pointing for determining the interstellar flow direction. To understand how the star sensor will function in space, we first needed to measure its behavior here in our labs. Morgan and I spent our early days trying to make our lab dark, like space. It was no small feat. We covered doors, laptops and electronic lights. We spent countless hours in the lab, between homework and exams, testing the star sensor. After the first year, a dark clean room was built in the magnetospheric-ionospheric lab in Morse Hall. Our new test setup included a motorized stage, which allowed the star sensor to "spin" as if it were on the spacecraft and provided a uniform light source, which we modified with apertures to appear like a star, a

cluster of stars, and even the moon. This testing facility allowed us to calibrate the star sensor under a slew of conditions which we anticipated it would undergo in space. The testing and analysis of the star sensor was the main body of our research at UNH.

Morgan: The summer after my sophomore year, I was awarded a Summer Undergraduate Research Fellowship Abroad by UNH. Dr. Möbius has colleagues at the Space Research Centre in Warsaw, Poland. He encouraged me to apply for the grant and helped me prepare my proposal. Maciej Bzowski and Marek Hłond are on the IBEX team, and I spent a summer in Warsaw working with them to improve the pointing of the star sensor. Specifically, I sought to incorporate the moon in the database of objects that the star sensor could use for orientation. Unlike seemingly fixed stars in the sky, the moon is very large, very bright, and very fast. However, it also has a very well-defined orbit. Under the mentoring of Dr. Bzowski, I learned how to use NASA's SPICE astrometry database and developed a program that allowed the star sensor to use the moon. From any point in IBEX's orbit, the SPICE–based functions could determine where the moon was, whether it was visible, and if so, what its size and phase were. It worked, and I felt triumphant, but that was not the only result of my summer abroad. I also picked up (very bad) conversational Polish and learned an enormous amount of Polish culture and history from Dr. Bzowski and others at the Institute. Each weekend I traveled to a different city in Poland or the surrounding countries. I took over 3000 photos, stumbled upon cultural parades and outdoor concerts and hiked a mountain range. That summer was amazing. I don't know if I'll be able to top it, even though I will certainly try! I returned to UNH and continued to characterize the star sensor's behavior with respect to the moon. Launch was slated for my senior year, and there was much preparation still to do.

George: On October 19, 2008, IBEX was launched into Earth orbit on a Pegasus XL rocket. To celebrate the launch of IBEX, there was a party in Morse Hall. IBEX team members, students, friends and family all gathered around the projection screens to watch this triumphant moment. As I watched, I remember feeling excited and anxious at the same time. Mistakes happen, and science is no stranger to Murphy's Law. During the launch there was a dead zone, where we did not have contact with IBEX for a while. This was nerve-racking, but in the end the satellite persevered and now orbits the Earth once every eight days. The star sensor is healthy and continues to gather light from the stars, planets and moon. The instrument in space, gathering data, is the very same one Morgan and I handled in the lab just months earlier. Not everyone is lucky enough to have such an experience; and, although I remain humble, I cannot also help thinking, "Wow, I did that!"

Morgan O'Neill in front of MIT's Great Dome in Cambridge, Massachusetts.

Morgan: One of the great things about doing undergraduate research at UNH is the opportunity at every turn to explain yourself. Scientists are only as good as their ability to communicate their work to others; otherwise any discoveries they make can't be replicated and verified. George and I frequently presented our progress and solicited advice at the weekly IBEX team meetings. UNH's Undergraduate Research Conference (URC) was a great way to learn how to put together a good research poster. I earned four awards of excellence at the URC and traveled with George to present our work at the American Geophysical Union Joint Assembly in Toronto. UNH supported us every step of way and gave us resources to be good students and good researchers simultaneously.

I cannot stress enough how important undergraduate research is for science students who want to pursue advanced degrees. I am positive that my strong research background was the single most important factor in my graduate school application. I am now a PhD student at the Massachusetts Institute of Technology, studying atmospheric science and climate physics (hurricanes!). UNH opened doors for me that I could not have dreamed of as a high school student. I am so grateful for the support I received as a student and the confidence placed in me as a researcher. Though my experience was unique, it wasn't the only one to raise eyebrows. Classmates of mine traveled to France, Spain and to the European Organization for Nuclear Research (CERN) in Switzerland to conduct research with some of the brightest minds in the world. I was constantly amazed by the depth and breadth of independent inquiry going on in my small physics class of fourteen people. UNH's main campus is in Durham, but the adjunct campus is global in scale, encompassing any region or idea that a student cares to pursue.

George: My work on the star sensor and the support of the UNH physics department, the Space Science Center and IBEX team gave me the opportunity to travel to Toronto, San Francisco and San Antonio to present my research in conference or working-team meetings. I was also a recipient of two awards of excellence at the URC, which helped fund my travels. These meetings exposed me to the space physics community and allowed me to gain recognition for my work. Ultimately it was my undergraduate research that brought me to Texas, where I now live, to pursue a PhD in space physics in the joint program between University of Texas at San Antonio and Southwest Research Institute (SwRI). Pursuing a PhD in a different part of the country—some say a country within itself— was a bold step for me and my wife. The day after our wedding we packed the UHaul and started our trek to San Antonio, a city rich in Mexican and, surprisingly, German culture. We have experienced Wurst Fest, country western dance halls, Mexican markets, hiking in the Southwest and the famous 6th Street in Austin, just fifty miles north. I have also been expanding my scientific knowledge by meeting new graduate students, scientists and engineers. The space science and engineering group at SwRI is composed of brilliant people whom I learn from every day. Recently, with the support of my mentor, I was awarded a National Science Foundation travel grant to present a research poster in Aspen, Colorado. At that conference I met colleagues from Brazil, California and Colorado. The scientific web is exciting and growing for me at a huge pace, and it all started from the opportunities UNH presented to me as an undergraduate.

George and Chelsea Clark at the Texas Welcome Center in Orange, Texas.

George and Morgan: Our advice to current undergraduates at UNH is to work hard and get involved in research early. UNH is on the front line of academic research and will offer numerous opportunities that will enrich your life and career. We each arrived with a vague notion of what we wanted to do and a lot of energy to do it. UNH enabled us to learn through research and helped us discover what we're really passionate about.

To read more in this issue about Professor Möbius and this project, go to Joshua French's research article and to Mentor Highlights.

Author Bios

Although he now lives in Texas, ***George Clark*** *is a New Englander and calls Wakefield, New Hampshire, his hometown. During a two-year interval between finishing high school and entering the University of New Hampshire, George took an introductory astronomy class at Granite State College taught by John Gianforte. "His class was amazing," George says. "He took us to the UNH observatory multiple times (where he volunteered) and showed us distant galaxies, nebulae, star clusters and the planets. John played a crucial role in my decision to apply to UNH for physics."*

George has many professional and personal plans for his future. They include becoming a professor at a research university where he could "play" in the lab and design particle instruments for space-based missions to study planetary magnetospheres. He would also like to give back to the community by teaching physics. As for a personal life, he says, "Have a family with my wife Chelsea. Get my pilot's license. Start a bakery shop someday. Travel the world with my backpack and a good pair of shoes. Learn to play the piano. Sleep is definitely overrated."

Morgan O'Neill *grew up outside Seattle, Washington, but attended high school in Monson, Massachusetts. Her long-range plans after graduate school are to become a professor at a research university, but she is also really interested in public science education of science. "In the short term," she said, "I would like to reach out to*

different groups in Boston and clear up misconceptions of climate change, with a more long-term goal of helping shape a national dialogue on climate change that is based on science and not myth or politics."
Morgan credits her parents with playing "a huge role" in her decision to become a scientist. "I watched Star Trek regularly before I could even read," she says, "and during the summer in elementary school, my dad would host 'super summer science sisters' for me and my sisters. We would make up small, fun experiments and build things like solar ovens.