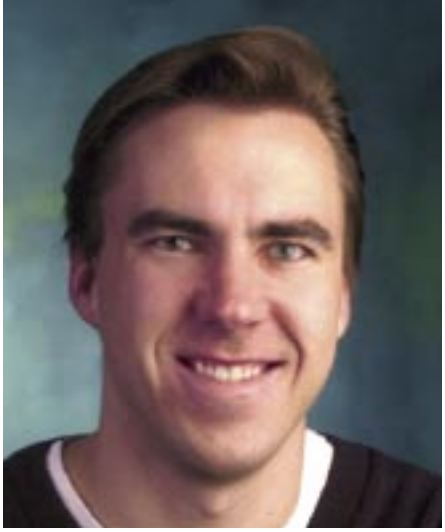
ION THRUSTERS AND AEROSPACE



L. BRAD KING
ASSISTANT PROFESSOR

Assistant Professor L. Brad King, 32, leads a new aerospace education and research program at Michigan Tech. King describes the program, established in 2000, as "a bold move" into an emerging technology with a vast potential for growth. King's leadership in the aerospace program is focused in two main areas; He works with graduate students to develop large-scale ion thrusters and supports undergraduate education as the MTU Aerospace Enterprise advisor.

As Director of Michigan Tech's Ion Space Propulsion (ISP) Laboratory, King provides opportunities for graduate students to develop innovations in space propulsion systems through projects funded by NASA, the Air Force Office of Scientific Research, and the Department of Defense. An experimentalist by nature, he takes a hands-on approach with research and pushes results beyond pen and paper to realize practical solutions. "Whether it's cutting steel, welding, or soldering wires, the graduate research assistants put in the sweat and hard work involved with experiments," said King. His drive to connect experimental results with real-world solutions is contagious and motivates his team of seven doctoral candidates to prove the performance of high-power ion propulsion innovations.

After reaching space atop a rocket, many spacecraft still have demanding propulsion requirements. There is substantial industry interest in the high-power ion thrusters under development at the ISP lab: it could be used to transport large payloads, move scientific satellites to outer planets, or drive communications satellites from low to high orbits. The benefits of existing small-scale ion thrusters are that solar panels serve as the root source of power, expelling ionized xenon propellant. This reduces the launch payload by eliminating the need to carry thruster fuel. "Our goal is to greatly increase the power of ion thrusters," says King.

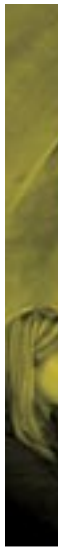
King's current work is part of NASA's Project Prometheus, an effort to develop an ion thruster with 100 times the power of existing ion thrusters. In addition, the comprehensive goal for the project involves increasing thruster longevity by 10 times and doubling its efficiency. To illustrate its complexity, King describes the task in terms of an automobile, "Imagine taking a 200 horsepower car engine and redeveloping it for 20,000 horsepower, doubling its efficiency and designing it to run for 100 years or 1,000,000 miles without maintenance." Despite these challenges, King's team is demonstrating success in their portion of the project. They expect to develop and run a 20 kilowatt ion engine in a vacuum chamber within the next two years and plan to be testing a 50 kilowatt or higher version within 5 years. The 20 kilowatt model is anticipated to have 50% efficiency—producing 10 kilowatts of thrust and 10 kilowatts of waste heat.

The electrical power source for a thruster of this size would require 3 football fields of solar panel surface area. Such enormous size is simply not feasible. And when satellites reach to the outer planets, solar panels are almost useless. High-power ion thrusters will likely have small nuclear reactions to power their electromagnets.

Spacecraft that use ion propulsion systems rely on the fact that like charges repel each other. Within an ion thruster, neutral particles of an element are ionized, or converted into positively charged particles. These ions are then repelled from the likewise positive charge of the ion thruster and are pushed out the back of the spacecraft. The force of the particles moving out of the thruster propels the craft in the opposite direction.

King compares the concept of ion propulsion to a person standing on a skateboard and holding a garden hose. If the person sprays water off the back of the skateboard, he causes it to move in the opposite direction. The force produced by ions exiting the spacecraft is tiny; it would only be enough to move a couple of paperclips in Earth's atmosphere. Due to the absence of gravity and friction, however, the low thrust of ion propulsion systems is very effective in space.

Xenon is the element commonly used as the propellant in ion thrusters. Spacecraft propelled by Xenon are limited by cost and efficiency. King's research promises to lower costs and improve efficiency of ion propulsion systems by using Bismuth instead of Xenon. In addition to being cheaper than Xenon, Bismuth is also physically superior for use in ion thrusters. King invented and patented a



"KING COMPARES THE CONCEPT OF ION PROPULSION TO A PERSON STANDING ON A SKATEBOARD AND HOLDING A GARDEN HOSE."

means of channeling a portion of waste energy to melt, vaporize, and ionize the Bismuth propellant.

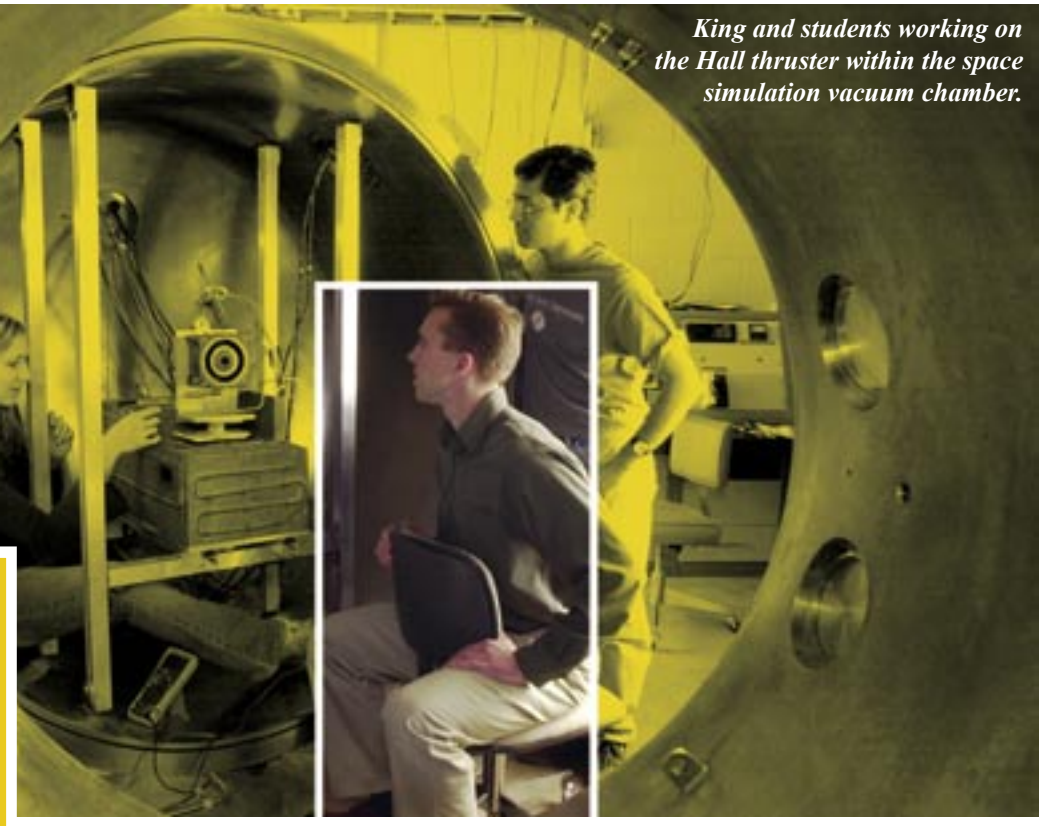
Ion thrusters must be thoroughly tested before they are launched—companies are unwilling to invest in novel aerospace technology without rigorous testing. Michigan Tech's ISP Lab has specially-designed vacuum chambers that permit the testing of full-scale ion thrusters—no other such facility exists in the world. King's work to develop Bismuth-powered ion propulsion systems will lead to substantial savings in high-power ion thruster development. When testing ion thrusters that use Xenon, the expelled Xenon must be constantly pumped out of the test chamber to maintain the vacuum. This costly pumping process is not as demanding when using Bismuth because this element—which is a solid metal that resembles lead—has a negligible affect on vacuum chambers.

King's research is shaping the future of ion propulsion systems and space travel. Replacing Xenon with Bismuth in ion thrusters will allow scientists to move bigger spacecraft farther into outer space. This technology could enable NASA to accelerate exploration of Mars, and any company using satellite technology would be able to keep their satellites in orbit longer. With far lower launch costs, the ion thrusters are much smaller and lighter than conventional thrusters.

Partially due to his work on ion propulsion systems, King was one of only sixty faculty members recently selected from U.S. colleges and universities to receive a Presidential Early Career Award, the highest honor bestowed by the U.S. government on outstanding scientists and engineers at the beginning of their careers. The award is valued at over $600,000. The National Research Council and NASA have also honored him, and he received three awards from the Johnson Space Center in Houston. He presented the Outstanding Paper in Electric Space Propulsion at the 1999 Joint Propulsion Conference in Los Angeles and he also received a National Science Foundation CAREER award, granting him at least $400,000 for his research and teaching programs.

King is a native of Michigan's Upper Peninsula, where coping with the challenges of the northern climate helped to shape his tenacity and respect for practical solutions. He studied aerospace engineering at the University of Michigan, where he earned BS, MS, and PhD degrees. Following a stint with the National Institute of Standards and Technology as a post-doctoral researcher, King joined Michigan Tech in 2000 to pioneer the institution's first-ever aerospace program. He feels fortunate to be living in Houghton and continuing his research in aerospace. "Professionally I am doing what I want to be doing and I am also living where I want to live," King says. "There are not many places you can do high-level scientific research and own a dog sled team."

He left Calumet, his hometown, after graduating from high school in 1989. "It's good to be back home," he says. "I spent ten years running around the country trying to find a place like the U.P., and it finally occurred to me, there is only one."



King and students working on the Hall thruster within the space simulation vacuum chamber.

MICHIGAN SPACE GRANT CONSORTIUM AWARDS

The vision of the Michigan Space Grant Consortium is to foster awareness of, education in, and research on space-related science and technology in Michigan. Its mission is to create, develop, and promote programs that support its vision and reflect NASA strategic interests. The consortium also encourages cooperation between academia, industry, state, and local government in space-related science and technology in Michigan.

Four students in Michigan Tech's ME-EM Department were recognized with this award in 2003-2004.

David Dame
Junior

Lindsay Godin
Graduate Student

Jason Makela
Graduate Student

Dean Massey
Graduate Student