PLASMA CAGE:
A TRAP FOR THE FOURTH STATE OF MATTER

"The Plasma Science & Engineering Laboratory brings together researchers and students across many disciplines at UAA."

Our universe is teeming with plasma. Known as the fourth state of matter, plasma occurs when atoms have their electrons stripped away (e.g. by extreme heat) and is akin to electrically charged gas. It makes up over 99.99% of the normal matter in the cosmos, including stars, nebulae, and the intergalactic medium. Closer to home, the solar wind plasma interacting with the Earth's magnetic field causes the aurora borealis that we are so fortunate to enjoy here in Alaska. Lightning bolts, welding torches, and fluorescent lighting are other common plasma phenomena.

Dr. Nathaniel Hicks, Assistant Professor of Physics at UAA, has dedicated his career to understanding the plasma state of matter and applying this knowledge to tackle scientific questions facing society. Much of Dr. Hicks' work to date has focused on the plasma physics of fusion energy: when hydrogen plasma is heated to high temperatures and confined at high density, hydrogen nuclei can fuse together at a sufficient rate to produce abundant, clean electricity that could go a long way toward solving some of the world's energy and environmental challenges. In his doctoral work at UCLA, Dr. Hicks produced the first symmetric neutralized ion beam, designed for applications that heat and diagnose fusion reactor plasma. As a post-doc at the Max-Planck-Institut, Dr. Hicks worked to implement some of the first real-time measurements and stabilization of magnetic islands that can cause fusion reactor plasma to disrupt. While in a U.S. Department of Energy research fellowship at the University of Washington, Dr. Hicks designed a new kind of plasma polarimeter to measure the magnetic field inside a spheromak device.

Dr. Hicks' collective research accomplishments allowed him to set his sights on creating a new experimental research program at UAA in Plasma Science & Engineering. He sought to synthesize his expertise in ion sources, beams, and accelerators, magnetically confined fusion plasma physics, radio-frequency and microwave plasma interactions, and computational plasma modeling techniques to conceive of and explore a completely new approach to trapping and studying plasma: Plasma Confinement by Alternating Gradient Electrodes, or "PCAGE" for short. In PCAGE, electrodes surrounding a plasma have radio-frequency (RF) alternating voltage applied to them, such that plasma particles oscillate in space, but experience a net focusing force toward the center of the device. The amplitude and frequency of the applied voltage can be chosen such that the negatively charged electrons are strongly trapped, but the heavier, positively charged ions are not affected by the RF. The positive ions are, however, attracted to the cloud of trapped electrons, and in this manner, the plasma as a whole is collectively confined. A patent application for this technology is in process.

The PCAGE research was initially funded by $10k from UAA's Innovate Awards, which helped Dr. Hicks receive a $100k NSF-DOE grant for studies of fundamental plasma physics in the PCAGE device. The focus of this grant is to perform detailed computer simulations of the plasma trapping and dependences on various trap parameters. This will lead to a follow-on phase that focuses on experimental demonstration and investigation of the effect, using the ultrahigh vacuum chamber and diagnostic equipment in Dr. Hicks' laboratory — a unique facility in Alaska. Looking ahead to that phase of the research, Dr. Hicks is currently the lead investigator on a $25k UAA Innovate Award Multidisciplinary project to develop a new plasma source that will feed the PCAGE device as well as other experiments. This "helicon" plasma source is a state-of-the-art means of coupling RF power into a column of gas, such that high density, highly ionized plasma is produced. It can also be used to perform experiments on spacecraft propulsion, a topic for which Dr. Hicks' students have won NASA/Alaska Space Grant research fellowships and will pursue.

Dr. Hicks is currently receiving funding from NASA/Alaska Space Grant to develop a Plasma Science and Engineering teaching laboratory at UAA, in particular because of many exciting new plasma applications that span other disciplines. For example, in his present Innovate Award research, Dr. Hicks is working with colleagues and students in Biological Sciences and the College of Engineering to explore how Atmospheric Pressure Plasma may be used in a variety of ways from sterilizing bacteria to treating cancer in human subjects.

Dr. Hicks also hopes to inspire the next generation of Alaskan scientists, engineers, and future UAA students, and with his students he has constructed a portable Planeterrella auroral simulator experiment (funded by a UAA Faculty Development Grant, with additional funding to begin this summer from NSF/American Physical Society). This device is designed to travel to schools and events, and showcase the wonders of plasma and the spirit of curiosity at UAA. Dr. Hicks is very pleased to be a part of the UAA community, where the culture of innovation and cross-disciplinary collaboration is a perfect fit for advancing his work in plasma science and engineering.

ABOUT DR. NATHANIEL HICKS

Dr. Nathaniel Hicks is an Assistant Professor in the Department of Physics & Astronomy at UAA. He received his PhD and MS. in physics from UCLA, and his BS in physics from Washington State University. Before coming to UAA, he held research positions at the University of Washington and the Max-Planck-Institut für Plasmaphysik in Germany. Dr. Hicks' research focuses on innovations in fusion energy science, basic plasma physics and diagnostics, and interdisciplinary plasma science and engineering. His work is presently receiving funding from NSF, the U.S. Dept. of Energy, NASA and UAA Innovate.