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AD ASTRA'S CHRISTOPHER OLSEN PRESENTS GROUNDBREAKING VASIMR® RESULT IN PhD THESIS MILESTONE.

[Houston, TX For immediate release] – Christopher Scott Olsen, a Research Scientist at Ad Astra's Houston Research Laboratory, formally presented the results of his 5-year company-sponsored PhD research on the physics of magnetic nozzles. The scientific seminar was conducted yesterday at Rice University's Department of Physics and Astronomy as part of Olsen's oral PhD defense before his thesis committee, which included professors Paul Cloutier (emeritus and committee chair), Franklin Chang Díaz (adjunct) and David Alexander, all from the Department of Physics and Astronomy and Prof. Frank Tittel from the Department of Electrical and Computer Engineering.

In his talk, entitled *"Experimental Characterization of Plasma Detachment from Magnetic Nozzles,"* Olsen described the potential mechanisms responsible for the observed separation of accelerated plasma in the VASIMR® magnetic nozzle, thus providing useful thrust. The investigation is also relevant in explaining the intricate behavior of high energy plasma jets observed in solar flares and mass ejections in distant galaxies and stars. The experimental data show that two interrelated mechanisms in particular: loss of "adiabaticity" and the onset of plasma turbulence appear to dominate the detachment process.

In an expanding magnetic nozzle, adiabaticity can be interpreted as loosely requiring that the expansion be relatively gentle, compared to the speed of the plasma particles themselves, or alternatively, as the particles fly at high speed out of the nozzle, they see a magnetic field that changes relatively slowly. In an efficient nozzle, adiabaticity is important early on in the expansion to efficiently convert the plasma heat into collective flow velocity; however, once the particles are accelerated, the loss of adiabaticity is also desirable to precipitate their separation from the magnetic field. Olsen's experimental findings show a region downstream of the magnetic nozzle throat where the adiabatic condition breaks down and sets the stage for the detachment to occur.

Christopher Olsen's oral PhD defense at Rice University before his thesis committee: (seated at the table, from L to R) Profs. Frank Tittel (Electrical & Computer Engineering), Paul Cloutier (Physics, emeritus), David Alexander (Physics) and Franklin Chang Díaz (Physics, adjunct)

The second part of the detachment mechanism comes about because plasmas are populations of charged particles, positive ions and negative electrons, that like to flow comfortably together. Any attempt to separate the two populations

leads to electric forces that try to restore the even mix. Olsen's experimental findings show that, because of their large difference in mass, the loss of adiabaticity occurs at a different point along the nozzle for ions than for electrons. This leads to charge separation, giving rise to restoring oscillatory forces, which in turn unleash natural plasma instabilities and turbulence inducing the particles to "shake loose" from the nozzle.

Observation of these phenomena required unique experimental conditions hitherto unavailable and painstaking measurements with carefully calibrated instrumentation over thousands of highly repeatable plasma firings. Ad Astra's 200kW VX-200 VASIMR® test bed, operating in the company's 150 m^3 vacuum chamber, provided the required experimental set up to obtain these measurements. An array of multiple plasma diagnostics collected data over thousands of high power shots in a three year period.

Christopher Olsen's work highlights the strong emphasis the company continues to have on education. Three other Ad Astra PhD candidates are in the pipeline: Mr. Jorge Oguilve and Mr. Juan Del Valle at the company's Costa Rica laboratory in Liberia and Mr. Matthew Giambusso, at Ad Astra's US facility near Houston. All of them are company employees and insure the strong creativity and constant flow of fresh ideas that bring innovation to the company. "Educating our young is good for business and Chris' research provides clear evidence. We are very proud of his work and congratulate him on this achievement" said Ad Astra CEO, Dr. Franklin Chang Díaz. "Ad Astra will continue to promote education in math and science as a way to insure our strong technological future" he added.

While theoretically predicted years ago, observation of plasma detachment from the VASIMR® magnetic nozzle has been difficult to measure in the laboratory due to physical constraints in the configuration and parameter range of previous experiments, as well as the vacuum chamber volume and vacuum level in which they were conducted. However, the unique conditions of the VX-200 device and Ad Astra's large vacuum facility and pumping capacity have made these investigations possible for the first time. These experiments are expected to continue. However the full relevance of research on plasma flow in magnetic nozzles will be enabled by Astra's planned VF-200 experiment on the International Space Station where the absence of chamber walls and virtually infinite vacuum will allow investigators to probe the full parameter space for these systems.

ABOUT THE TECHNOLOGY

Short for Variable Specific Impulse Magnetoplasma Rocket, VASIMR® works with plasma, an electrically charged gas that can be heated to extreme temperatures by radio waves and controlled and guided by strong magnetic fields. The magnetic field also insulates any nearby structure so temperatures well beyond the melting point of materials can be achieved. The plasma can be harnessed to produce propulsion. In rocket propulsion, the higher the temperature of the exhaust gases, the higher their velocity and hence the higher their fuel efficiency. Plasma rockets feature exhaust velocities far above those achievable by their chemical cousins, so their fuel consumption is extremely low.

ABOUT AD ASTRA

Ad Astra Rocket Company was established in early 2005 to commercialize the technology of the VASIMR® engine, an advanced plasma propulsion system with potential to support an emerging in-space transportation market. The company has its main laboratory and corporate headquarters at 141 W. Bay Area Boulevard in Webster, Texas, USA, about two miles from the NASA Johnson Space Center. Ad Astra also owns and operates Ad Astra Rocket Company, Costa Rica, a supporting research and development subsidiary in Guanacaste, Costa Rica.