INSTITUTE of PLASMA PHYSICS and LASER MICROFUSION
Association EURATOM

23 Hery Str., 01-497 Warsaw, Poland
tel. +48 22 6381460, fax +48 22 6668372
e-mail: sekretariat@ifpilm.pl • www.ifpilm.pl

Warszawa, 5 October 2011

Krypton Hall effect thruster for space propulsion

Electric propulsion (EP) is the future of astronautics. It can already compete successfully with chemical thrusters, especially for attitude control, orbit transfer and/or orbital station-keeping as well as for the main propulsion system for deep space missions. However, xenon, the propellant of choice in most EP devices, has a substantial drawback: its cost is very high. On the basis of the experience with plasma jet accelerators, a team of scientists and engineers from the Institute of Plasma Physics and Laser Microfusion in Warsaw has designed the Hall effect thruster optimised to work with krypton, a much more affordable noble gas.

Chemical propulsion is invaluable for the launch of payloads into space. The thrust, generated exclusively from the energy released by combustion of the propellants, is very large, but limited to durations of the order of seconds or minutes. In space, however, where atmospheric drag is negligible, technologies delivering much lower thrust over significantly longer durations (months or even years) have proven much more efficient. The leading low-thrust technology is plasma propulsion, where xenon is the preferred working gas. In the Institute of Plasma Physics and Laser Microfusion (IPPLM) in Warsaw, a Hall effect thruster has been designed to work with krypton, a noble gas ten times cheaper than xenon.

The Hall effect thruster is one of several existing electric propulsion technologies. In use since the 1970s in unmanned space flights, it has made it possible to manoeuvre precisely and correct satellite orbits. Lately, devices of this type have increasingly been used as the main propulsion system for deep space missions.

Hall effect thrusters convert the propellant into a plasma and produce thrust using an external electrical power source, most typically solar panels. Plasma particles (ions and electrons) are electrically charged and can thus be accelerated by an electric field to high velocities, of the order of 15-30 km/s as is the case with Hall thrusters (in contrast, expelled gases do not reach more than 4 km/s with chemical propulsion). Plasma propulsion produces a low thrust (from a few to 1000 mN depending on available power) but can operate over long durations and ultimately increase the velocity of the spacecraft by several kilometres per second.

“Plasma jet accelerators have been studied for many years in IPPLM. Building on this experience, our team has started, in May 2008, the development of a plasma Hall effect thruster using krypton as a propellant”, said Dr Jacek Kurzyna, the person responsible for the project.

The propellant used in the vast majority of Hall effect thrusters is xenon, a very rare and therefore expensive noble gas. Krypton, another noble gas, is up to ten times less expensive. Although a slightly higher energy is necessary to produce krypton ions, they are lighter than xenon ions and accordingly require lower acceleration voltages to achieve the same velocity. “From the very beginning, our thruster has been developed and optimised to operate with krypton. We had to design properly the magnetic field configuration and the appropriate magnetic circuit. Some elements had to be constructed in such a way that they can withstand increased heat loads”, explains Dariusz Daniłko, a PhD student from IPPLM.

The new thruster is medium-power, continuous-thrust propulsion device. Weighing less than 5 kg, it operates at a power of about half a kilowatt. “The SMART-1 lunar space probe sent by the European Space Agency (ESA) had a xenon thruster with power below 2 kW. It accelerated the vehicle by 3,6 km/s. Our thruster could therefore prove suitable as a main propulsion system in small spacecrafts”, says Dr Serge Barral from IPPLM.

The newly built Hall effect thruster is a prototype device ready to be tested in vacuum conditions. “If the outcome of the tests is positive, optimization of the device and a round of assessment tests will follow. The project, submitted to the second PECS call (Plan for European Cooperating State, an agreement concluded between Poland and ESA), has been recommended for funding. If funding is confirmed, this project will mark the beginning of the qualification process”, explains Dr Kurzyna.

The research on krypton Hall effect thrusters is expected to find applications beyond the field of astronautics. Plasma accelerators are routinely used in many technological processes, inter alia, for surface cleaning by plasma sputtering or etching, surface modification and thin film (e.g. diamond-like carbon) deposition. The team of scientists from IPPLM has suggested, in particular, a deposition process of thin oxide layers for photovoltaic solar panels based on the Hall thruster technology.

The design and construction of the Hall effect thruster have been entirely funded by IPPLM.

The Institute of Plasma Physics and Laser Microfusion (IPPLM) in Warsaw was established in 1976. The IPPLM carries out basic research and implementation in the area of magnetic confinement fusion and inertial fusion, plasma physics and pulsed high power technology. Most research and technology related projects are carried out within international cooperations in the framework of the fusion programme in the Euratom Community and HiPER consortium. The Euratom Association, with its headquarter in the IPPLM, coordinates magnetic fusion projects in thirteen Polish units. The programme of research in the institute is under the control and financial support of the Ministry of Science and Higher Education in Poland.

CONTACTS:

Dr **Jacek Kurzyna**
Institute of Plasma Physics and Laser Microfusion in Warsaw.
tel. +48 22 6381040
email: jacek.kurzyna@ifpilm.pl

LINKS:

http://www.ifpilm.pl/
Institute of Plasma Physics and Laser Microfusion in Warsaw.

http://press.ifpilm.pl/
Press releasses of the Institute of Plasma Physics and Laser Microfusion in Warsaw.

IMAGES:

IFPiLM111005b_fot01s.jpg **HR:** http://press.ifpilm.pl/images/2011/IFPiLM111005b_fot01.jpg
Krypton Hall effect thruster for space propulsion presented by Dr Jacek Kurzyna from the Institute of Plasma Physics and Laser Microfusion in Warsaw. (Source: IFPiLM/Grzegorz Krzyżewski)