Scientists developing pulsed nuclear fusion system for distant missions

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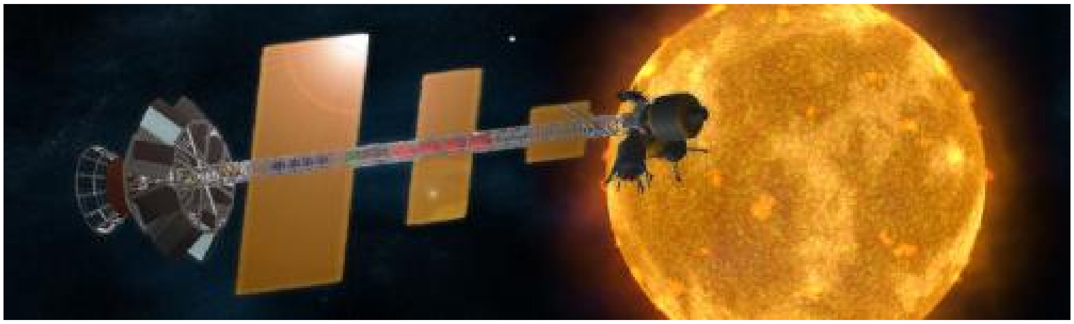

(Phys.org) -- The ticket to Mars and beyond may be a series of nuclear slapshots that use magnetic pulses to slam nuclei into each other inside hockey pucks made of a special, lightweight salt.

A physics team from The University of Alabama in Huntsville's Department of Mechanical and Aerospace Engineering soon will take delivery of a specialized system to see if they can "Z-pinch" a tiny bit of that salt into the heart of a star.

“We are trying to develop a small, lightweight pulsed nuclear fusion system for deep space missions,” explained Dr. Jason Cassibry, an associate professor of engineering at UAHuntsville. “If this works we could reach Mars in six to eight weeks instead of six to eight months.”

In hockey, a slapshot digs the head of the hockey stick into the ice to bend the shaft, like an archer’s bow, storing energy for a sharper snap against the puck and drive it down the ice rink. Cassibry and his team will attempt to drive a hollowed-out puck in on itself, fusing lithium and hydrogen atoms and turning a little of their mass into pure energy.

The “pucks” are approximately two inches wide and an inch thick, smaller than a regulation three-inch puck. They are made of lithium deuteride (LH 2), the lightest metal combined with the middle-weight form of the lightest element.

Nuclear fusion is the process at the heart of the Sun, where four hydrogen atoms combine to make one helium atom, with a small amount of matter converting into pure energy. The UAHuntsville experiments will start at the midpoint of that cycle, where heavy hydrogen (one proton plus one neutron) fuse with each other or with lithium (not a normal part of solar fusion). But getting nuclei together is like firing two positively charged BBs up the slopes of Mount Everest to meet head-on at the peak.

To arrange that meeting, the team (including UAHuntsville, The Boeing Co., NASA’s Marshall Space Flight Center, and a growing list of other participants) will experiment with the Decade Module Two, or DM2, an L3 Communications pulsed power design used by the Department of Defense for weapons effects testing in the 1990s in Tullahoma, TN. DM2 will be relocated to the Aerophysics Lab on Redstone Arsenal this summer.

Like a photographer's flash, DM2 comprises banks of capacitors that store an electrical charge for release on command. This strips the target into an electrified gas or plasma. Electricity flowing through it generates a magnetic field that compresses the plasma. That's the Z-pinch effect.

“It's equivalent to 20 percent of the world's power output in a tiny bolt of lightning no bigger than your finger," Cassibry said. "It's a tremendous amount of energy in a tiny period of time, just a hundred billionths of a second."

But in total, it is about the same energy as a liter of gasoline.

The reactions of the plasma and the by-products will tell whether the theory behind the pulse fusion propulsion model is valid. One uncertainty, for example, is whether the electrons stripped off the atoms will carry away a lot of heat.

"First we have to test the concept, run our models against actual measurements," he said. "Once we have a good understanding, we can extrapolate this to see what we have to do to exceed break-even for propulsion applications."

Break-even means producing more energy than you consume. It is the magic term in nuclear fusion power research where physicists hope to harness the Sun in a magnetic bottle. UAHuntsville endeavors to work with the mainstream controlled fusion projects supported by the Department of Energy (DOE), but the application to fusion propulsion is very different and does not compete directly with the DOE efforts.

"They are as different from us as a coal plant is from a chemical rocket," Cassibry said. "What we are trying to do requires very lightweight power systems in different packaging constraints."

If the studies work out, they could lead to a system that fuses lithium-deuterium pellets and uses an electromagnetic field as the nozzle for that the exhaust pushes against and also captures part of the energy to recharge the system. That is the next area to tackle if the Z-pinch approach proves out.

This is in no way a warp drive. At its heart, the pulsed fusion engine — like any other rocket engine — is a flying tea kettle. Cold material goes, gets energized and hot gas pushes out.

In a working nuclear pulse engine, pellets would be fired up to 10 times a second and produce up to 10,000 Newtons of thrust. That's a modest 2 percent of what a Space Shuttle Main Engine could do. With a spaceship weighing hundreds of tons, the crew likely would feel nothing more than a light tapping.

"So you're not flying pinned to the back of the cabin," Cassibry added.

Also unlike the Shuttle, the pulsed fusion engine is not designed for launch from the Earth nor will it run out of fuel in 8-1/2 minutes. Instead, it will run continuously for weeks at a time to quickly spiral out of Earth orbit and then set course for another planet. After a high-speed coast lasting a few weeks, the engine would fire for another week or two to decelerate into orbit around the destination planet. Alternatively, it could be attached to an asteroid and run for months to gently nudge its trajectory away from Earth.

And that would be an excellent goalie save.

Provided by University of Alabama in Huntsville

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