

A mighty wind

Massachusetts Institute of Technology

When a current passes between two electrodes — one thinner than the other — it creates a wind in the air between. If enough voltage is applied, the resulting wind can produce a thrust without the help of motors or fuel.

This phenomenon, called electrohydrodynamic thrust — or, more colloquially, “ionic wind” — was first identified in the 1960s. Since then, ionic wind has largely been limited to science-fair projects and basement experiments; hobbyists have posted hundreds of how-to videos on building “ionocrafts” — lightweight vehicles made of balsa wood, aluminum foil and wire — that lift off and hover with increased voltage.

Despite this wealth of hobbyist information, there have been few rigorous studies of ionic wind as a viable propulsion system. Some researchers have theorized that ionic thrusters, if used as jet propulsion, would be extremely inefficient, requiring massive amounts of electricity to produce enough thrust to propel a vehicle.

Now researchers at MIT have run their own experiments and found that ionic thrusters may be a far more efficient source of propulsion than conventional jet engines. In their experiments, they found that ionic wind produces 110 newtons of thrust per kilowatt, compared with a jet engine’s 2 newtons per kilowatt. The team has published its results in the *Proceedings of the Royal Society*.

Steven Barrett, an assistant professor of aeronautics and astronautics at MIT, envisions that ionic wind may be used as a propulsion system for small, lightweight aircraft. In addition to their relatively high efficiency, ionic thrusters are silent, and invisible in infrared, as they give off no heat — ideal traits, he says, for a surveillance vehicle.

“You could imagine all sorts of military or security benefits to having a silent propulsion system with no infrared signature,” says Barrett, who co-authored the paper with graduate student Kento Masuyama.

Shooting the gap

A basic ionic thruster consists of three parts: a very thin copper electrode, called an emitter; a thicker tube of aluminum, known as a collector; and the air gap in between. A lightweight frame typically supports the wires, which connect to an electrical power source. As voltage is applied, the field gradient strips away electrons from nearby air molecules. These newly ionized molecules are strongly repelled by the corona wire, and strongly attracted to the collector. As this cloud of ions moves toward the collector, it collides with surrounding neutral air molecules, pushing them along and creating a wind, or thrust.

To measure an ion thruster’s efficiency, Barrett and Masuyama built a similarly simple setup, and hung the contraption under a suspended digital scale. They

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Published on Electronic Component News (<http://www.ecnmag.com>)

applied tens of thousands of volts, creating enough current draw to power an incandescent light bulb. They altered the distance between the electrodes, and recorded the thrust as the device lifted off the ground. Barrett says that the device was most efficient at producing lower thrust — a desirable, albeit counterintuitive, result.

“It’s kind of surprising, but if you have a high-velocity jet, you leave in your wake a load of wasted kinetic energy,” Barrett explains. “So you want as low-velocity a jet as you can, while still producing enough thrust.” He adds that an ionic wind is a good way to produce a low-velocity jet over a large area.

Getting to liftoff

Barrett acknowledges that there is one big obstacle to ionic wind propulsion: thrust density, or the amount of thrust produced per given area. Ionic thrusters depend on the wind produced between electrodes; the larger the space between electrodes, the stronger the thrust produced. That means lifting a small aircraft and its electrical power supply would require a very large air gap. Barrett envisions that electrodynamic thrusters for aircraft — if they worked — would encompass the entire vehicle.

Another drawback is the voltage needed to get a vehicle off the ground: Small, lightweight balsa models require several kilovolts. Barrett estimates a small craft, with onboard instrumentation and a power supply, would need hundreds or thousands of kilovolts.

“The voltages could get enormous,” Barrett says. “But I think that’s a challenge that’s probably solvable.” For example, he says power might be supplied by lightweight solar panels or fuel cells. Barrett says ionic thrusters might also prove useful in quieter cooling systems for laptops.

Ned Allen, chief scientist and senior fellow at Lockheed Martin Corp., says that while ionic thrusters face serious drawbacks — particularly for aerospace applications — the technology “offers nearly miraculous potential.”

“[Electrohydrodynamic thrust] is capable of a much higher efficiency than any combustion reaction device, such as a rocket or jet thrust-production device,” Allen says. Partly for this reason, Allen says Lockheed Martin is looking into the technology as a potential means of propulsion.

“Efficiency is probably the number one thing overall that drives aircraft design,” Barrett says. “[Ionic thrusters] are viable insofar as they are efficient. There are still unanswered questions, but because they seem so efficient, it’s definitely worth investigating further.”

Source URL (retrieved on 03/31/2015 - 7:55pm):

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