To Mars in 70 days: Expert discusses NASA's study of paradoxical EM propulsion drive

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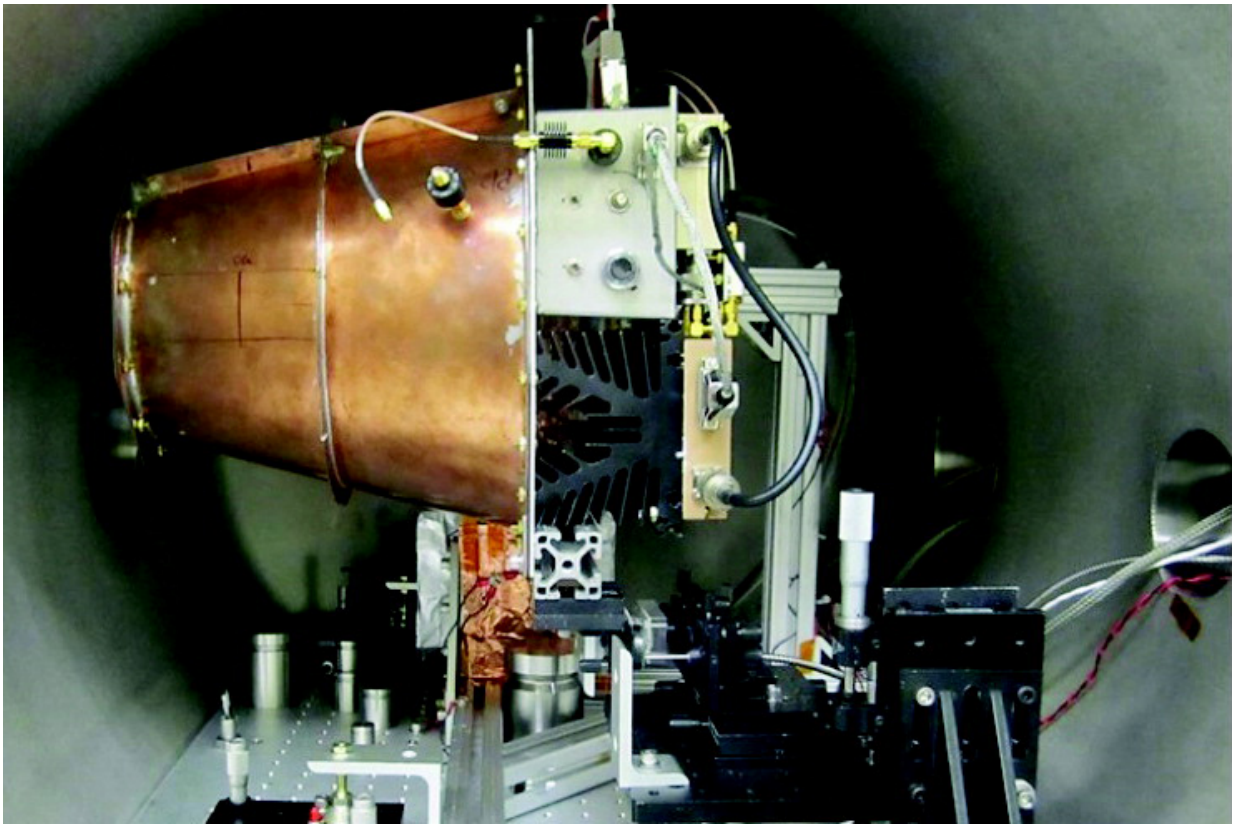

EM Drive in forward thrust configuration. Credit: NASA Photo

After months of speculation and rumor, NASA has finally released its long-awaited research paper on the controversial EM Drive propulsion system. The paper was recently published in the American Institute of

Aeronautics and Astronautics' peer-reviewed *Journal of Propulsion and Power*. If the electromagnetic technology proves sound, it could radically change the way humans travel in space, opening up the possibility of journeys to Mars in just 70 days. But there is no shortage of skeptics who are adamant that the drive is more science fiction than science fact. Critics are quick to point out that the drive violates one of the fundamental laws of physics, namely: for every action, there is an equal and opposite reaction. With the science world abuzz in light of the recent developments, UConn Today called on engineering professor Brice Cassenti, an expert in advanced propulsion systems, to help us understand what's happening.

Q. What is the EM Drive propulsion system and what makes it so unique?

A. An EM Drive uses electromagnetic waves (e.g., radar) to produce thrust, which is obviously something that is needed for a rocket engine. The drive consists of a truncated conical copper shell with a plastic (polyethylene) disc covering the narrow end of the truncated cone. An electromagnetic wave is induced inside the copper shell in the same manner as a microwave oven. The propulsion system is unique because the device uses no traditional fuels or propellants. Instead, in the simplest of terms, the electromagnetic waves bounce around inside the cone in a way that some say causes propulsion. In the NASA tests, a thrust of 1.2 millinewtons per kilowatt was reported for an EM Drive activated in a vacuum, which is a very, very small – but noticeable – movement. By not relying on traditional fuels, the EM Drive would make spacecrafts lighter, and eliminate the need for massive amounts of fuel currently required to launch a spacecraft to far-off destinations.

Q. What's behind all the skepticism about the EM Drive, and what's your take on all of this?

A. Although the EM Drive appeared to create thrust in these tests, there was no mass or particles of any kind expelled during the process. This is a violation of Newton's third law of motion, which says that for every action there is an equal and opposite reaction. Action and reaction is a direct result of the conservation of momentum. The violation of such a basic law as the conservation of momentum would invalidate much of the basis for all of physics as we know it. Hence, many scientists and engineers feel the thrust measurements reported for the EM Drive are due to experimental error. Adding to this is the fact that those who believe the results are valid do not yet have an experimentally or a theoretically plausible proven physical explanation. I personally believe that there is a mundane explanation for the results. For example, electric currents are heating components within the Drive that expand during the experiments, causing motion that would appear as a force. It is very difficult to remove such effects, although the authors of the journal article tried to remove not only these thermal effects but also many other possible sources for experimental errors. It is extremely difficult to know for sure that all of the possible sources for errors have been removed. The only sure method is to have a hypothesis (or theory) that can be tested independently.

Q. The fact that NASA's research has passed peer review is being heralded as a major step. What exactly does the peer approval mean in the context of ongoing research?

A. Peer review is important, since it means that other experts have reviewed the work, and the results are professional and important enough to distribute to others in the community. It does not mean, however, that the reviewers consider the results valid. A reviewer of the journal paper that I spoke with before the paper was submitted does not believe the results point to any new physics. But that person felt the

results are puzzling enough to publish.

Q. If the EM Drive really does work, does this mean Newton was wrong and there are mysterious other aspects of physics that we still don't understand?

A. If the results are valid, it definitely points to new physics. Newton's laws have already been shown not to apply at high relative speeds (where special relativity applies), in large gravitational fields, and with very small scale molecules. But Newton is still mostly right. There are certainly many aspects of physics that we do not understand. Some aspects are so mysterious that we don't even know where to begin!

Q. Everyone seems to be excited about the EM Drive being tested in space as the next step. What advantages are there to testing the device in space versus here on Earth?

A. If the EM drive is tested in space, then the acceleration could be directly measured, which would eliminate all of the confusion associated with force measurements. Space would provide an ideal vacuum, so the device would not have to be placed in a vacuum chamber, and it would provide a weightless environment, eliminating any need for a support (current tests rely on a balance arm so any resulting forces can be measured). But space missions are expensive – at a cost of $10,000 to launch one pound of material into orbit. It may be better to first try to experimentally find the cause for the thrust measurement, and only when the cost on the ground begins to approach the cost for an orbital mission should an experiment in space be performed.

Q. Is there anything else you would like to share about

the EM Drive to help us understand?

A. No, but over my professional life I have seen several of these exciting experimental or theoretical results reported in peer-reviewed literature. So far only the reality of black holes has come through. So, based on my experience, the probability of this holding up under further analysis and testing appears slim. But it's not zero.

More information: Harold White et al. Measurement of Impulsive Thrust from a Closed Radio-Frequency Cavity in Vacuum, *Journal of Propulsion and Power* (2016). DOI: 10.2514/1.B36120

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