IV. Science

MHD To Protect High-Speed Vehicles in Earth's Atmosphere and Outer Space

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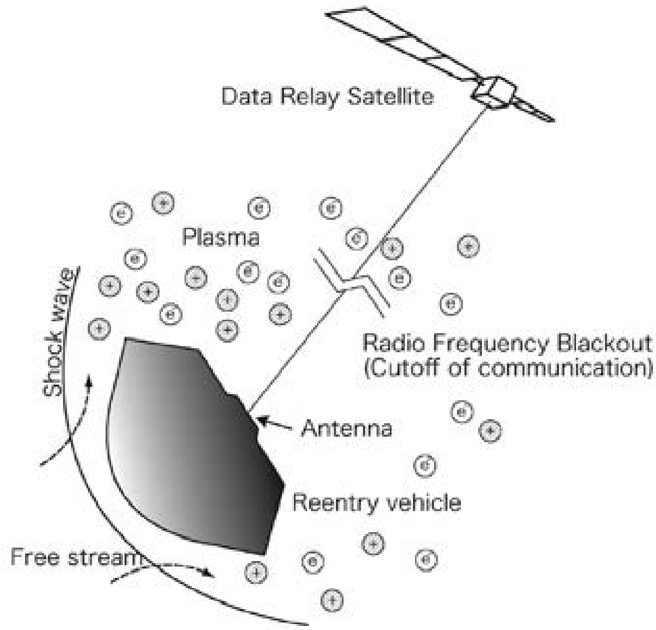
Jan. 8—Vehicles moving at high speed through the Earth's atmosphere, such as ICBMs or IRBMs, space rockets and capsules, experience shock waves that surround the front end of the vehicle. These shock waves are due to the extremely high pressure of air being pushed out of the way by the moving vehicle. The high pressure creates enormous heat, such that the air in the shock wave forms a plasma, consisting of rapidly moving electrons and positively charged particles.

The hot plasma can damage the surface of the vehicle, to the point of causing it to disintegrate. The dense shock wave can slow the vehicle down and make the direction of flight unstable and uncontrollable. The electric and magnetic fields produced by the plasma can interfere with radio communication used for flight control with the vehicle (**Figure 1**).

FIGURE 1
Illustration of Atmospheric Entry Conditions



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A rocket, moving right to left, compresses air in front of it into a shock wave; the compressed air forms a hot plasma with negatively charged electrons separated from positively charged ions. The heat of the plasma can damage or disintegrate the rocket, and the plasma particles also interfere with communication from a satellite shown on the upper right.

To reduce these harmful effects, the vehicle usually requires a heavy shield to protect it—called a thermal protection system (TPS)—and that the velocity of motion through the air be kept below the threshold for damage. Both of these conditions pose significant limits on vehicle design. Space vehicles have, up to now, been protected by composite or ceramic tiles, as used in the Space Shuttle Program, or by heat shields that are designed to burn off—called ablative shields—such as on the SpaceX Dragon capsule.

Magnetohydrodynamics and MEESST

Russia, however, has recently implemented a new application of a technology that protects very-high-speed missiles in the atmosphere from burning up, and allows radio transmission to steer the missiles. Russian President Vladimir Putin has stated that this technology has been used in Russia's *Oreshnik* missile, which has been used successfully in the war in Ukraine. The *Oreshnik* is said to travel to its target at 10 times the speed of sound, and is therefore not stoppable by current anti-missile technology developments available in the West.

No details have been released regarding this technology.

A relatively new technology is being developed by the European Space Agency, to significantly decrease the harmful effects of shock waves that form at the front end of supersonic missiles and rocket ships. This technology uses magnetohydrodynamics (MHD), which is a combination of electromagnetics—the effects of electric and magnetic fields on the motion of charged particles—and hydrodynamics—the physical movement of liquids and gases, such as the swirling of water, that does not depend on charge.

Both of these types of effects are utilized in this MHD system to protect the traveling vehicles. The system being developed is termed MHD Enhanced Entry System for Space Transportation (MEESST).[1]

In this MHD technology, high-intensity magnetic fields are created in the vehicle; high-temperature superconducting (HTS) materials are required to produce the magnetic fields. The magnetic fields disrupt the shock wave, and push plasma out of the way so it does not retard the motion of the vehicle. The uses of magnetic fields in this manner are termed "magnetohydrodynamic" effects.

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Russian President Putin has said that Russia experimentally used a missile against Ukraine based on new physical principles, impervious to air defenses due to its hypersonic speed. One possibility is that Russia is using MHD. Putin is shown here on Jan. 21, 2025.

The details of the European Space Agency's MEESST system are described below. There are indications that the Russian *Oreshnik* missile uses a system which is based on MHD, but is otherwise quite different from the MEESST program. There are also indications that China may be developing an MHD system to protect supersonic rockets in the atmosphere. Details of the Chinese system are likewise not publicly available.

The MEESST research is being conducted by a consortium in Europe. This consortium includes universities, research institutions, and industry. Funding for this project is from the European Space Program through its European Space Agency Science Program. The MEESST research group has started using computer simulations to plan experiments, which will be followed by ground testing in the future using simulated Earth and Mars atmospheres.

The lead agency in the MEESST consortium is the Von Karman Institute of Fluid Dynamics (VKI), particularly for the problem of radio communication with the high-speed vehicle which is disrupted by the surrounding plasma. The lead agency for control of heat effects is the Institute of Space Systems (IRS) at the University of Stuttgart, which has a long experience with hypersonic entry systems and the use of MHD for plasmas for rocket thrust that use technology similar to MEESST. Both VKI and IRS can use wind tunnels to mimic the Earth and Mars atmospheres and generate plasmas that are useful for testing MEESST designs. These facilities can use either air for Earth atmosphere designs, or carbon dioxide for Mars atmosphere designs.

The University of Luxemburg is creating models of radiation and radio communication blackouts. The high-temperature superconductors used to create the magnetic fields needed for protecting space vehicles are being made by the Karlsruhe Institute of Technology.

Principles of the MEESST

The U.S. National Aeronautics and Space Agency (NASA) has an interest in this, for use in the re-entry phase of space vehicles.

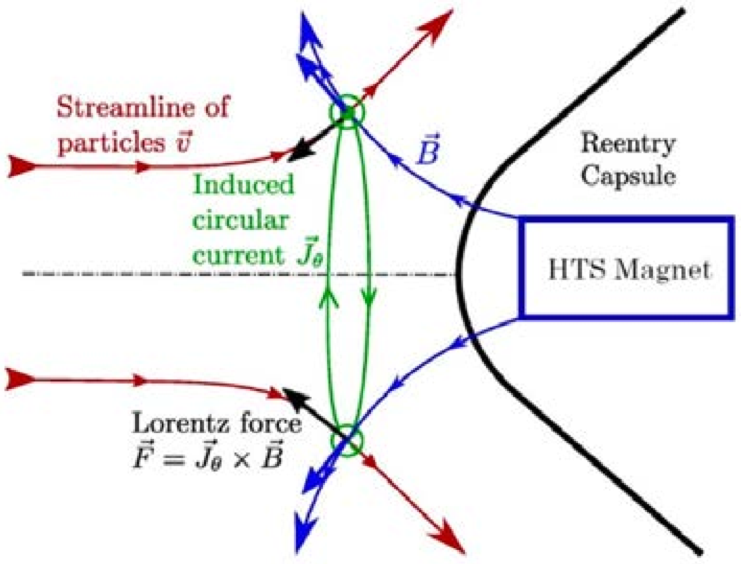
A rocket moving rapidly through the atmosphere at many times the speed of sound causes atmospheric compression at its front end, that heats the surface in the range of megawatts of energy per square meter. At these temperatures a plasma sheath forms that prevents radio transmissions from penetrating, causing a blackout. The MEESST system produces a magnetic field that interacts with the plasma and screens it away from the rocket (**Figures 2** and **3**).

The geometry of the magnetic field produced creates a *Lorentz force*. This is a magnetic force acting

1. Andrea Lani, *et al.*, "A Magnetohydrodynamic Enhanced Entry System for Space Transportation: MEESST," *Journal of Space Safety Engineering*, Vol. 10, pp. 27-34, 2023.

FIGURE 2

Magnetic Field Configuration Introduced by the MEESST Device



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A high-temperature superconductor (HTS) electromagnet in the front of a rocket moving from right to left at a high speed. The magnetic field created, labelled B, points forward and outward. The relative *left-to-right motion of the particles crosses the magnetic field, deflecting the plasma particles away from the rocket by the right-hand rule for charged particles crossing magnetic field lines.*

on charged particles, which pushes the charged particles in the shock wave into spirals directed away from the front of the rocket.

The process is similar to the action of "magnetic mirrors" at the ends of a plasma fusion experimental machine, which keeps the plasma from escaping out of the ends of the containing cylinder by pushing it back in.[2]

This allows the rocket to move through a space with relatively little contact with plasma, so the heating is significantly less, and the radio communication is affected much less, enabling the communications to steer the rocket. This greatly reduces the requirements for the thermal protection system (TPS), thus reducing the required weight of the rocket.

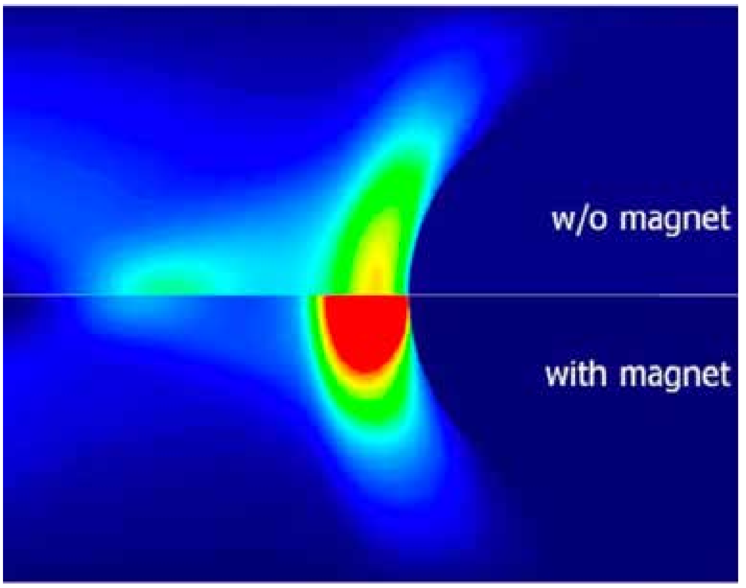
The strength of the magnetic field to achieve this effect needs to be in the range of 0.1 to 1 tesla. For comparison, the magnetic field of the Earth on the surface at the equator is 30 microtesla, so the magnetic field needed by the MHD Space Transportation System (MEESST) is in the range of 3,300 to 33,000 times the magnetic field at the Earth's surface. This extremely strong magnetic field indicates why a superconductor is needed for the electricity powering the magnet, so that the magnet does not heat up due to resistance to the required electric current.

The superconductor must be what is termed "high-temperature," meaning that the material has superconducting properties at temperatures significantly above zero degrees Kelvin (0K), compared to most superconductors that require temperatures near absolute zero. Maintaining the temperature near 0K requires much more refrigeration energy than at higher temperatures.

The definition of high temperature superconductors is that they function above 70K (degrees Kelvin). Zero degrees Kelvin is equal to –459.76°F (degrees Fahrenheit). In comparison, 70K is equal to –333.67°F. Currently the highest temper-

FIGURE 3

Illustration of Atmospheric Entry Conditions



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In the upper part of the diagram, the front tip of the rocket has the plasma sheath pressed against it and wrapping around it. In the lower half of the diagram, the MEESST system electromagnet pushes the plasma away from the front of the rocket, creating a space, shown in red, through which the rocket can travel with less heating and less interference in radio communications.

2. Ned Rosinsky, "'Minimum Energy' Configurations Can Make Superheated Plasmas," *Executive Intelligence Review*, Vol. 51, No. 41, pp. 33-40, Nov. 22, 2024.

ature superconductors, at one atmosphere of pressure, operate at 138K, which is –211.27°F.

However, there are materials that become superconductors at higher temperatures, if the pressure is high enough. Air pressure is measured in pascals, and the air pressure at sea level (“one atmosphere”) is approximately 100,000 pascals.

An extreme case is that a mixture of hydrogen sulfide, hydrogen and methane, under pressure of 267 gigapascals, which is 2.67 million atmospheres, becomes superconducting at 288K (57°F)—approximately room temperature.

Complicating Factors

Using a magnetic field to change the direction of motion of plasma particles in this manner, causes the positively charged particles to move one way, and the negative charges to move another way. This results in a separation of charges, which itself creates an electric field that tends to pull the positive and negative charges back together: This is termed a Hall effect. This may result in putting a limit on the strength of the magnetic field used, and it will require further experimentation to quantify and study this effect in various plasma geometries.

A second issue is that plasmas frequently do not follow simple, smooth geometries, as has been shown in experimental fusion power machines attempting to control high temperature plasmas.[3] As *EIR* has described, the pioneer fusion researcher Winston Bostick showed that plasmas are composed mainly of vortex filaments, which arise spontaneously. These filaments have a low resistance to the flow of electric currents. Bostick found that these vortex filaments are fragile, and can be disturbed if the plasma is given a jolt, creating a sudden increase in plasma resistance to electric currents (“anomalous resistance”). This is important for understanding radio interference from plasmas.

A third issue: It may be possible for most of the plasma to be held away from a rocket by using magnetic fields, but it would be difficult to eliminate it completely, so there will still be low levels of plasma near the rocket. Therefore, the use of computer-modeled ray-tracing is helpful for predicting the subtle effects of low-level plasma on radio waves; this work is ongoing.

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3. Ned Rosinsky, “The Principles of an Experimental Fusion Device: A Plasma Focus,” *Executive Intelligence Review*, Vol. 51, No. 37, pp. 35-42, Sept. 20, 2024.