Hypersonic Cruise and Re-entry Radio Frequency Blackout Mitigation: Alleviating the Communications Blackout Problem

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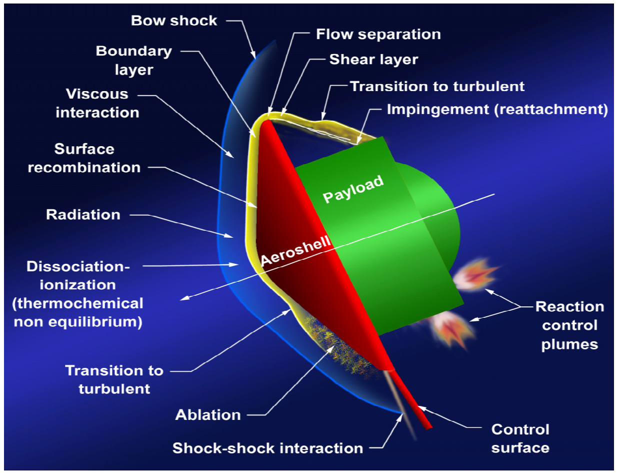
Hypersonic Cruise and Re-entry Radio Frequency (RF) Blackout Mitigation



A problem since the early days of space flight.
For an Earth re-entry scenario, blackouts can last between four to ten minutes.
For other planetary situations involving an atmosphere, such as for Jupiter, blackouts can last up to 30 minutes.
Space shuttle got around problem due to aerodynamic shaping and using TDRSS.
Not so for space capsule architecture (Ares, etc.) and future missions to other planets.
Future hypersonic cruise vehicles will also suffer plasma RF blackout.

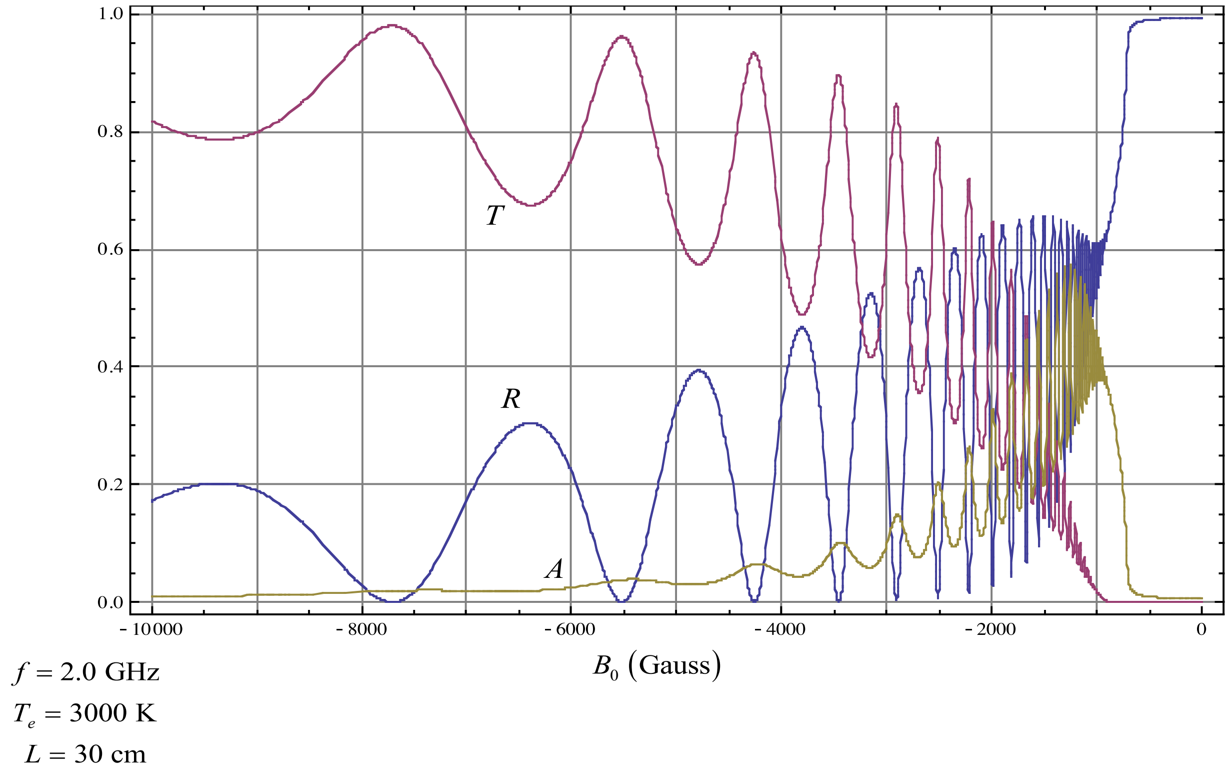
Technology Description and Key Challenges

RF Plasma blackout mitigation is clearly a key technological challenge that remains unsolved and is still an obstacle to re-entry and hypersonic flight.

The work proposed here will provide a method to transmit and receive RF communications and telemetry through a re-entry plasma thus alleviating the classical RF blackout phenomenon.

Based on recent theoretical work by the author, an applied magnetic field of nominal strength will create "magnetic windows" in the otherwise opaque plasma through which RF radiation can propagate.

Thus, an antenna and magnetic field control system must be developed to be placed behind the bow shock of the plasma to perturb the plasma parameters to create and maintain a magnetic window. For example, an antenna based on ferroelectric ceramics (to withstand plasma heating) placed within the applied magnetic field.



Reflection (R), Transmission (T), and Absorption (A) Coefficients vs. Applied Magnetic Field Strength for $n_e=10^{12}$ electrons/cm^3.

Reference: R. M. Manning, "Analysis of Electromagnetic Wave Propagation in a Magnetized Re-Entry Plasma Sheath Via the Kinetic Equation", NASA Technical Memorandum NASA/TM-2009-216096, December, 2009

Real-time *in situ* plasma diagnostic sensors were developed for this effort in a cooperative agreement with MIT in response to a NASA Research Announcement (NRA)

SiC-based MEMS Sensors for Real-Time Plasma Diagnosis During Spacecraft Re-entry

L. F. Velásquez-García and A. I. Akinwande

October 9th 2009

Massachusetts Institute of Technology

Summary

- MEMS-based plasma sensors (Langmuir probes, RPAs) were developed
- SiC coatings were explored to provide high-temperature resistance
- MEMS probes were successfully tested with a Hall effect plasma thruster
- Future work includes:
  - Debug noise issues of testing rig
  - Capture data from SiC coated probes
  - Include a second electrode on the RPA
  - Develop and test SiC probes
  - GPS antennas