AURORA-MHD

Magnetohydrodynamic Thermal Protection for Starship Reentry

PROBLEM

Starship's ~18,000 ceramic tiles require extensive inspection after every flight.
A reusable magnetic heat shield could eliminate tile maintenance entirely.

APPROACH

REBCO superconducting magnets generate a 2T field to deflect reentry plasma via MHD interaction.
Faraday power extraction from the plasma flow powers the system (self-sustaining operation).
Dual-model analysis: v1 (uncoupled Faraday) vs v11 (kinetic-ceiling-limited, physically corrected).

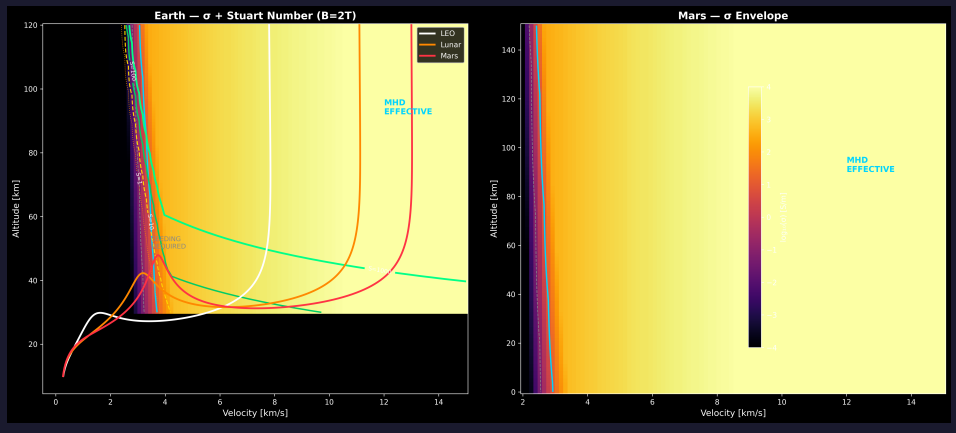
KEY RESULTS (v11 Physics-Corrected Model)

Metric	v1 (naive)	v11 (corrected)
Coil mass (2T, 20K)	264 kg	**~400 kg**
Flight system	264 kg (no aux)	**~500 kg (+105 kg aux)**
Extraction model	Uncoupled Faraday	**Kinetic ceiling-limited**
Peak extraction (LEO)	36 MW	**~200 kW**
Energy margin	24x (ad-hoc 1000x loss)	**~38x (physics-based)**
Self-sustaining?	Yes (all B >= 0.5T)	**Yes (B >= 1.5T, ride-through)**
Stuart number (LEO)	Not computed	**3,600 (S >> 1: robust deflection)**
Test suite	58 tests	**96 tests, 100% passing**

CENTRAL FINDING

Deflection is robust (S >> 1 at all conditions). Self-sustaining extraction is feasible but marginal.
The v1-to-v11 progression reveals a 200x reduction in extraction power -- all physically motivated:
Post-shock velocity (25x) + Effective area (25x) + Hall effect (1.7x) + Channel losses (3x)
Coupled MHD-CFD simulation is the critical next step to resolve the remaining uncertainty.

OPERATING ENVELOPE



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github.com/letsplay/aurora-mhd-feasibility

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