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Nernst Thermomagnetic Waves in Magnetized High Energy Density Plasmas

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The Nernst effect plays the dominant role in the subsonic transport of magnetic flux in high-energy-density (HED) plasmas, where the plasma beta is high, and the temperature diffusivity is much greater than the magnetic diffusivity [1]. This is the parameter range characteristic of MagLIF and other magneto-inertial fusion approaches near stagnation. We demonstrate the transport of magnetic flux in HED plasmas proceeds via the Nernst thermomagnetic waves propagating at the Nernst velocity with respect to the plasma particles down the temperature gradient. The plasma resistivity strongly damps their propagation in the opposite direction. The Nernst wave propagation is a manifestation of an anomalous skin effect transporting magnetic flux into a conducting fluid where it cannot penetrate by diffusion. The Nernst waves, physically similar to those theoretically predicted in the 1960's [2] and observed in metals at cryogenic temperatures [3], have never been discussed for strongly driven, highly inhomogeneous, magnetized HED plasmas at keV temperatures. We report semi-analytic self-similar and numerical solutions of the plasma transport equations involving the Nernst waves, describe the numerical challenges of their modeling and the use of such solutions for extended-MHD and kinetic code verification. We also discuss the effect of the Nernst waves on the losses of heat and magnetic flux from magnetically insulated hot plasmas.

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