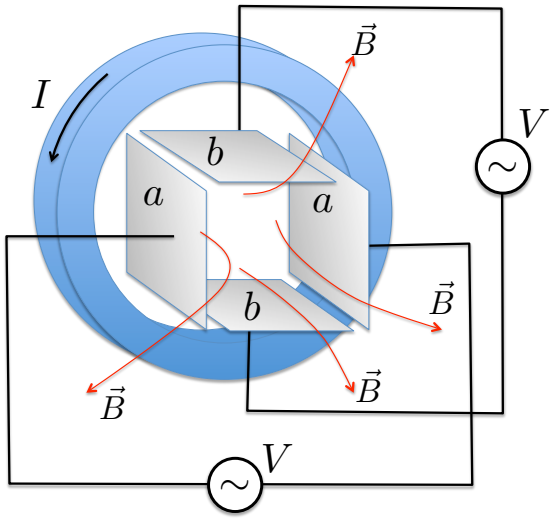
16.55 Ionized Gases
Problem Set #1

A certain research group has proposed a new type of plasma accelerator for space propulsion, as follows:



- A coil of current I produces a divergent $\vec{B}$ field in the region of interest.
- Two pairs of electrodes a-a and b-b are driven with equal alternating potentials $V\sin(\omega t)$ and $V\cos(\omega t)$ respectively, to produce a rotating $\vec{E}$ field in the region of interest.
- A plasma is generated in an upstream Helicon discharge and is made to flow between the electrodes.
- The rotating $\vec{E}$ field drives a rotating $\vec{j}$ current in this plasma. The product $j_\theta B_r$ is a force density f_z that accelerates the plasma and produces extra thrust.

A first set of experiments has failed to detect any difference between configurations with $+I$ and with $-I$ current. Approximate conditions were $d = 5cm$ (between electrodes), frequency $\omega/2\pi = 3kHz$, plasma density $n_e = 10^{18}m^{-3}$, plasma temperature $T_e = 10eV$.

Based on your understanding of plasma response to applied fields, propose an explanation for the negative results. What combination of d, n_e, T_e and frequency would lead to the behavior expected by the proposers? Comment on the practicality of the resulting device.

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