Controlling perpendicular electric fields with biased electrodes

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The ability to impose and control an electric field perpendicularly to magnetic surfaces in magnetized plasmas is of great importance to a broad range of applications [1]. It has notably been shown in recent years that plasma rotation in E×B configurations could offer opportunities to develop new plasma separation techniques [2], as proposed for instance for nuclear spent fuel and rare earth elements recycling [3,4].

A key step to advance these technologies is to understand how the electric potential distributes itself in a magnetized plasma column, and in particular how the perpendicular electric field can possibly be controlled via the electric bias applied on polarized electrodes terminating a magnetized plasma column (see Figure 1). Progress towards this goal requires addressing a pair of basic underlying questions, namely how the electric potential applied on a biased electrode is transferred to the plasma through the sheath [5], and how this potential then varies along a given magnetic field line in a quasi-neutral plasma [6].

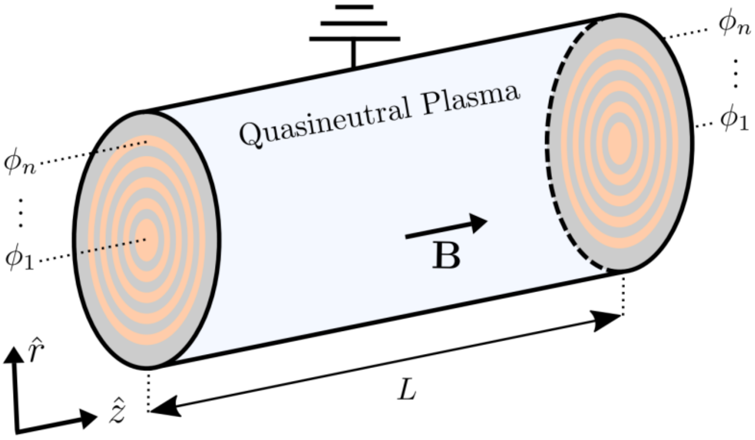

Figure 1 : *Magnetized plasma column terminates on two symmetrical sets of independently biased ring electrodes (in orange) at potential* $(\phi_1, \cdots, \phi_n)$ *with respect to the grounded vacuum vessel. The entire domain is permeated by a uniform axial magnetic field* $\boldsymbol{B} = B_0\,\hat{\boldsymbol{z}}$.

So far, these two problems have mostly been treated separately. In this work we consider the particular case of negatively biased electrodes and examine in a unified model the combined effects of biasing and emission on the voltage drop across the sheath and along magnetic field lines.

References

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