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Theory for Self-organized Patterns on Liquid Anodes

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A variety of self-organized structures have been observed in different plasma systems. Among these, radially symmetric patterns of rings and spots often emerge when an aqueous solution is used as an anode in an atmospheric DC discharge. These patterns are confined to the surface of the water, and their size and structure depend on the total plasma current and the salt concentration of the solution.

We propose a theoretical explanation for these patterns based on the interfacial electrostatics and reaction-diffusion equations for electrons and ions in the anode sheath. Using Turing linear stability analysis, we derive an analytical model for the patterns with cylindrical harmonic functions representing the various modes of rings or spots. The model predicts a phase diagram that shows which critical values of plasma current and aqueous salt concentration cause the discharge to transition from a uniform spot to a self-organized ring structure (the lowest order mode). The theoretical phase diagram is then compared to experimental results.

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