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Comparison of Performance Efficiency of Different Types of RF Antennas for Permanent Magnet-based Helicon Plasma Source via Finite Element Simulations

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This work investigates the performance efficiency of three different RF antenna configurations: Half-Helix, Nagoya-III, and simple helical (coil type) in a permanent magnet-based Helicon Plasma Source (HPS) through finite element-based simulations. These simulation studies on argon and hydrogen plasmas focus on the wave coupling efficiency and power absorption to evaluate antenna effectiveness by analyzing key parameters such as plasma density and temperature. The simulations integrate electromagnetic wave propagation, plasma-fluid interactions, and the influence of the permanent ring magnet array on plasma production and its dynamics. Results reveal distinct differences in plasma generation and wave excitation characteristics, with the Nagoya-III antenna demonstrating superior power coupling in specific operational regimes compared to the other designs. These findings offer crucial insights for optimizing RF antenna structures in Helicon plasma sources, which are essential for the applications in ion beam generation, space propulsion, and plasma processing technologies. The study serves as a valuable reference for designing high-efficiency RF-driven ion sources.

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