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Measurement of Microwave Propagation in Periodically Structured Dusty Plasma

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Recent experimental investigations have demonstrated that the incorporation of nano- or micron-scale dust particulates into plasma systems can substantially modify fundamental plasma parameters and physical characteristics.[1] These alterations encompass critical factors such as electron/ion density profiles, electron temperature distributions, spatial electric field configurations, and electron energy distribution functions. [2]

The unique electron dynamics observed in dusty plasma environments differ markedly from those in conventional plasma systems, leading to distinctive physical phenomena, including abnormal electromagnetic properties that deviate from typical plasma behavior. As a result, electromagnetic waves entering dusty plasma environments exhibit varying degrees of scattering and transmission characteristics.[3, 4]

In this experimental investigation, we employed a custom-designed low-voltage plasma generation system to establish stable alternating current glow discharge plasma. A specially engineered high-permeability PVC substrate coated with F_3O_4 nanoparticles was systematically introduced into the plasma confinement region, creating a periodic dust-plasma microstructure. Subsequent analysis focused on characterizing microwave propagation characteristics within this structured medium. Through precision measurements conducted using a vector network analyzer (VNA), we quantitatively assessed microwave transmission parameters while experimentally confirming the significant influence of periodic dust particle distribution on electromagnetic wave propagation.

References
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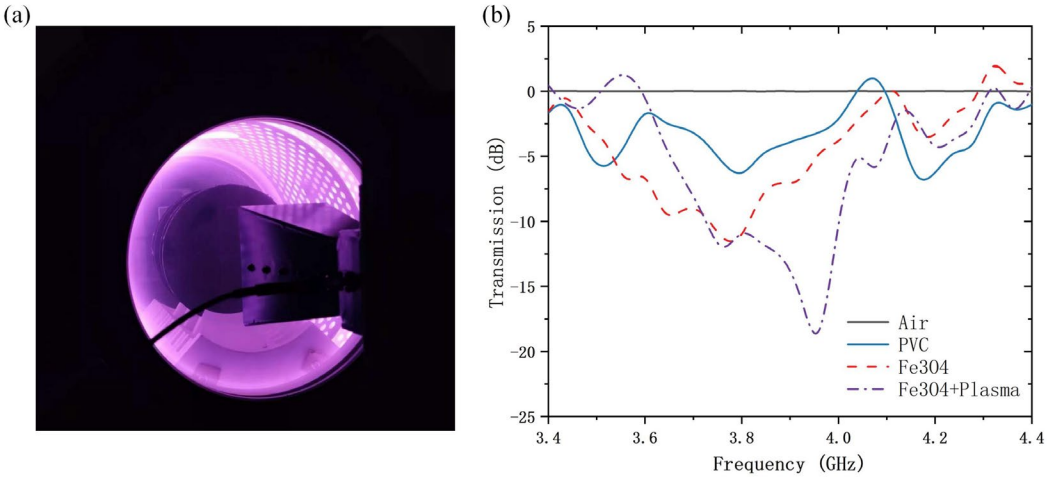

Figure 1. (a) Plasma discharge device and microwave testing system. (b) The microwave transmission characteristics were measured using a vector network analyzer after introducing a one-dimensional array of PVC plates coated with Fe_3O_4 nanoparticles into the plasma environment.