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Driving mechanisms for Rotating Spoke and Electron Cyclotron Drift Instability in Magnetized Plasmas with E×B drift

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Despite the industrial successes of magnetron sputtering, space propulsion and Penning ion source, aspects of their performance, such as the specific impulse of Hall thruster and the deposition rate of high power impulse magnetron sputtering (HiPIMS), are still far from ideal. In order to optimize the performance of these discharges, among the most common laboratory magnetically confined plasmas, characterized by orthogonal electric and magnetic fields (i.e. E×B configuration), numerous studies has been devoted over the years.
In this type of plasmas, two important phenomena can be observed along the azimuthal direction (E×B direction) for a wide range of operations: the rotating spoke and the electron cyclotron drift (ECD) instability. The ECD instability is considered as a short wavelength (mm-scale) and high frequency (bout MHz) kinetic instability, while the rotating spoke is observed many times in the form of large scale (cm-scale) and high density coherent structures. They are considered as the main sources of anomalous transport (across the magnetic field) and electron heating, which greatly influence the performance of laboratory plasma devices. However, the physical nature and the driven mechanisms of ECD instability and spoke formation still remain unresolved today.
In our work, we have proposed and demonstrated the driving mechanisms of rotating spoke and ECD instability by deducing and analyzing the dispersion relation of azimuthal electrostatic waves. The spoke location is also defined by analyzing the azimuthal disturbance potential. By comparing with the several measurements in the literature, the proposed driven mechanisms in this work are able to predict correctly the experimental characteristics of the spoke and the ECD instability, such as their frequency, velocity and wavelength as well as the dynamic process of spoke.

Keywords
magnetized plasma
rotating spoke
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