Discharge modes and transitions of argon helicon plasmas in low and high magnetic fields

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Abstract: Helicon plasma is characterized by high density and high ionization due to helicon waves excited in magnetized plasmas at low pressures. Waves excited in helicon plasma source consist of two components, i.e., the weakly damped, bounded fast “helicon” (or H-) wave, and the strongly damped, slow “Trivelpiece-Gould” (or TG-) wave. In regime of low or high magnetic fields, the wave modes and their transitions of argon helicon plasmas are much different at increasing RF power and hence the plasma density. When the external magnetic field is strong above a critical strength, multiple distinct wave modes were observed experimentally at increasing RF powers and/or external magnetic fields, with the wave mode jumps from lower order eigenmode to a higher one. Blue Core appears in the center of plasma column above a critical RF power and magnetic field. When the magnetic field is weak (below 200 G), multiple density peaks at low field (or low field peaks, LFPs) were observed at increasing magnetic fields, with the wave mode jumps from higher order eigenmode to a lower one. LFP is benefited from H-TG resonance or TG anti-resonance. Both multiple wave modes and LFPs are related to the change of axial and/or radial eigenmodes, and H-waves generally play an important role. The plasma density and the magnetic field are the crucial factors to determine the wave modes and the transition in argon helicon plasmas.