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Wave propagation and power deposition in blue-core helicon plasma

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The wave propagation and power deposition inside and outside the blue-core helicon plasma are computed, together with their transitional behaviours prior to and after the blue-core formation. Computations refer to the experiments on the CSDX (controlled shear decorrelation experiment) (Thakur et al., Plasma Sources Science and Technology 23: 044006, 2014 and Thakur et al., IEEE Transactions on Plasma Science 43: 2754–2759, 2015). It is found that the radial profile of wave electric field peaks off-axis during the blue-core formation, and the location of this peak is very close to that of particle transport barrier observed in experiment; the radial profile of wave magnetic field shows multiple radial modes inside the blue-core column, which is consistent with the experimental observation of coherent high m modes through Bessel function. The axial profiles of wave field indicate that, once the blue-core mode has been achieved, waves can only propagate inside the formed column with distinct phase compared to that outside. The wave energy distribution shows a clear and sharp boundary at the edge of blue-core column, besides which periodic structures are observed and the axial periodicity inside is nearly twice that outside. The dispersion relation inside the blue-core column exhibits multiple modes, a feature of resonant cavity that selects different modes during frequency variation, while the dispersion relation outside gives constant wave number with changed frequency. The power deposition appears to be off-axis in the radial direction and periodic in the axial direction, and mostly inside the blue-core column. Analyses based on the step-like function theory and introduced blue-core constant provide consistent results. These details of wave propagation and power deposition during the blue-core formation are presented for the first time, and important for understanding the mechanism of blue-core phenomenon. The equivalence of blue-core plasma column to optical fiber for electromagnetic communication is also explored, and preliminary calculation shows that the total reflection can indeed occur if the incident angle is larger than a threshold value. This may inspire a novel application of helicon plasma, and is one of the most interesting findings of present work.

References

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