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Underlying mechanisms in the dynamic profile formation of high-density helicon plasma

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Helicon plasma source, employing the helicon wave [1], is of current interest because of their promise in stably providing high-density (~ 1019 m-3) and low electron temperature (~ a few eV) plasma under a wide range of parameters, e.g. device scale, magnetic field, neutral pressure etc. [2-4]. Due to these distinctive advantages, the helicon source is used for various applications, including plasma processing, nuclear fusion, electric thrusters, and space laboratory experiments [5].

Helicon plasma is generated by using the helicon wave, i.e., electromagnetic whistler wave in a bounded plasma. Over the past decades, researches on the helicon plasma have revealed some important mechanisms of efficient plasma production. The efficient power absorption can be partly explained by the strong collisional damping of the quasi-electrostatic wave called 'Trivelpiece-Gould' (TG) wave [6].

The formation of the density profile is determined by the balance between the source and the loss fluxes, which is a key element in understanding the flux transport and the source flux generation mechanisms. In our study, we have constructed the self-consistent fluid model that includes the wave excitation, momentum equation, electron energy equation, and neutral dynamics, noting the balance between the source and loss fluxes. Using this model, we have succeeded to reproduce the experimental results [7]. The formation mechanism of the density profile of helicon discharge, which has been a dispute for a long time, is investigated in detail including the effect of the neutral dynamics.

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