Studies on neutral gas flow and heat effects in argon inductively coupled plasma

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Neutral gas flow and heat is one important component of low pressure radio frequency plasma physics, which is dynamically coupled to species source kinetics, neutrals transport, electron properties and ions energy, etc. Ref. [1] explained the experimentally observed non-monotonic variation of electron temperature versus the applied power via a fluid model in argon inductively coupled plasma. It is found that **the power value of temperature transition region the model predicted is rather lower than the experiment**, and this implies the importance of gas heat effect in this issue. In Ref. [2], the gas flow characteristics and its influence on the plasma were systematically investigated at relatively low powers; nevertheless, the gas heat that is important at high powers was not reported yet. **Ref. [3] measured spatially resolved, line integrated, excited state densities, and neutral and ion temperatures in argon inductively coupled plasma.** To the authors, up to date, these interesting experimental results of Ref. [3] have not been captured perfectly via numerical simulations, even though the models, such as fluid and hybrid model, prevail and are used in low temperature plasma source for unveiling various underlined mechanisms. As a result, the mechanisms that were proposed for attempting to interpret these phenomena cannot be authenticated. In this work, first, we will utilize the Pegasus software that couples complete neutral species transport equations to investigate the influence of gas heat on the non-monotonic trend of electron temperature versus power. In addition, considering the fact that the ions transport equations exclude the ion energy kinetics in the Pegasus while the ion energies are probably tightly coupled to neutral energies via elastic and charge exchange collisions occurring between them[3], our second job is to develop the old version of our self-owned fluid code that based on either stagnant background gas or deals with simple diffusion and source kinetics for neutrals, by including full dynamics of neutral gas flow and heat behavior, as well as ion energy transport process. Concretely, the flux-corrected-transport (FCT) algorithm[4] or the implicit continuous-fluid eulerian (ICE) technique[5] might be selected for numerically solving the above extra species equations. In a word, all these efforts are aimed at revealing the behind mechanisms of gas dynamics and their correlations with other aspects of low temperature plasma physics.

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