§33. Study on Simulation Code for Two-fluid Plasma Experiment

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With progresses of theoretical and computational studies on plasmas, the "two-fluid plasma" has become one of hot topics in many plasma-related fields. In general, it is considered that the ordinary plasma consists of enormous ions and electrons. And, when it starts to move, both the ion fluid and the electron one move together while they keep electrical neutrality. In contrast, by the way of thinking called the two-fluid plasma, the ion fluid and the electron one can move independently each. As a result, there is more degree of flexibility of the two-fluid plasma than the one-fluid, that is, the MHD plasma on such properties as plasma motion, confinement, and stability. Using these unique features, many trials to explain phenomena that could never be understood by the knowledge of MHD have thus been performed flourishingly.

However, there is little number of experimental reports mentioning about two-fluid effects. Besides, those papers have simply pointed out the possibility that the two-fluid effects participate in the observed results, by indicating, for example, the difference between the ion velocity field and the electron velocity one. This is probably attributed to the fact that the space scale showing the two-fluid effects is considered to the order of the ion skin depth λ_i. In general, λ_i becomes thin, for example, λ_i is ~ 0.1 cm for the ion density n_i of ~ 10^{13} cm^{-3}. Thus, the direct measurement will be difficult. Another difficulty is that the position targeted for the active measurement does not completely stay at the same location all the time but moves in time, because the two-fluid plasma is intrinsically dynamic, having velocity and electric fields [1]. This fact strongly suggests that some passive instruments, which can clearly measure changes in time of spatial distributions, are suitable.

Thereby, the understanding of the two-fluid effects are still poor, let alone the two-fluid plasma. From these reasons, the two-fluid plasma is like a puzzle, an open question for laboratory plasmas. More sophisticated new method is thus needed to understand the two-fluid effects and the two-fluid plasma as well. To answer for these questions, we proposed a new basic experiment of generating a two-fluid plasma state by merging a lithium ion (Li^+) plasma and an electron (e^-) plasma in a linear device. Currently, we have successfully confined both Li^+ and e^- plasmas simultaneously. The confinement time of e^- plasmas is so far ~ 10 s longer than the binary Coulomb collision time. Thus, the e^- plasma is ready for the next merging experiment. On the other hand, the Li^+ plasma lasts ~ 3 s. Also, we have been developing several new diagnostics applied to the next merging experiment.

After the merging experiment is performed, the experimental observation should be compared with a simulation. For this purpose, we started to discuss the possibility of developing a numerical code for the merging experiment.

Two meetings were held during the 2014 academic year. At the first meeting, we reviewed what values of experimental parameters were expected to obtain in the forthcoming merging experiment. Moreover, we discussed what set of equations could be used to the numerical code, and concluded that the Braginskii's set [1] was probably adequate for our purpose. Because the merging experiment will be done in a linear machine called BX-U in KIT, we have thus written the set down in cylindrical coordinate perfectly. On the other hand, for a solver applied to Gauss's law, we are still trying to have it. At the second meeting, we checked details of all terms involved in the equation set in order to clarify if those can be ignored in simulation. Also, we discussed how we proceed this collaboration research. In the next academic year, we will experiment at first in order to consider the detail of the numerical code.

1) Braginskii, S. I.: 'Transport processes in a plasma', in *Review of Plasma Physics* ***1*** (1965) 205.