§27. Study on Feasibility of Developing a Numerical Program for Two-fluid Plasmas Produced from Pure Ion and Electron (Nonneutral) Plasmas in a Linear Device

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Background Recently, extended MHD plasmas have been proposed, especially in both theoretical and computational fields of plasma physics. To test those experimentally, we have just started a new project[1] using two nonneutral plasmas: pure ion and electron plasmas. The most remarkable advantage to employing nonneutral plasmas is that the ion skin depth, that is a typical scale length of the extended MHD plasmas, can be extended to the plasma radius. This actually alleviates experimental difficulties in diagnosing properties of the extended MHD plasmas. With precisely controlling densities of both pure $^7Li^+$ ion and electron plasmas, the proposed method may explore an unrevealed research field of extended MHD plasmas.

A planned experiment The experiment is planned on a linear machine BX-U in which a pair of positive and negative electrostatic potential wells is externally produced. Figure 1 explains the planned experiment. In the positive potential well, a pure $^7Li^+$ plasma is confined independently, while an electron plasma in the negative potential one. Contrary to neutral plasmas, linear *nonneutral* plasmas with perfect axi-symmetry can relax to those thermal equilibrium states under a ultra high vacuum condition. For this reason, we have been carefully constructing the machine within 0.1 mm of the axi-symmetric error and preparing a pair of turbo molecular pumps to reach $P_0 < 10^{-9}$ Torr.

After being relaxed to thermal equilibrium, the pure electron plasma moves primary along magnetic field lines because of its fast motion along B. On the other hand, the pure Li^+ plasma mainly rotates around B field lines. Such independent motions of ion and electron fluids are those required by the two-fluid theory that is one of extended MHD plasmas. Then, both ion and electron plasmas are merged together into a two-component plasma. At the first series of the experiments, we will investigate changes in time evolutions of radial profiles of densities and perhaps velocities of the two-component plasma. With those data, we will experimentally examine whether or not the extended MHD plasmas emerge in laboratory plasmas.

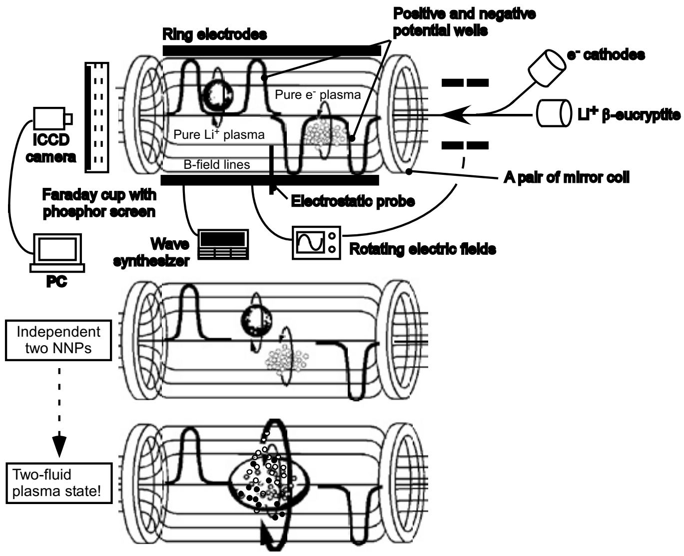

Fig. 1: The BX-U machine. In BX-U, a pair of positive and negative electrostatic potential wells is externally produced by a set of cylindrical ring electrodes. In the positive potential well, an $^7Li^+$ plasma is confined, while an electron plasma in the negative potential one. Then, those nonneutral plasmas are merged into an extended MHD plasma.

Discussions about simulation at NIFS If we can compare the experiments with simulation, it would be definitely better to understand what is going on in the two-component plasma. In order to discuss the possibility of developing a numerical code with researchers of NIFS, we held a scientific seminar at NIFS last December. Several problems were revealed. The biggest one is that the numerical code calculating full dynamics of the proposed experiment would require much larger than the amount of usable memory in current computation. To save the memories, the numerical program must concentrate some specific phenomenon that happens in the two-component plasma. Therefore, we conclude to put off the program development after seeing results outputted from the first series of experiments.

1) H. Himura, "A proposed test of extended MHD plasmas by merging of lithium ion plasmas with pure electron plasmas", *will be appeared in Denki Gakkai Ronbunshi A* (2010) (in Japanese).