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Control of diameters of Li^+ and e^- plasmas for testing two-fluid plasma state

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A two-fluid plasma model is one of extended magnetohydrodynamics (MHD) models and widely used for explaining macroscopic plasma phenomena that cannot be explained by the conventional one-fluid MHD. In the two-fluid plasma model, velocity fields (V_i and V_e) of ion and electron (e^-) fluids are determined by corresponding each fluid equation of motion. However, such a two-fluid plasma state has not ever been verified in laboratory experiments. To investigate the two-fluid plasma state experimentally, we have experimented using lithium ion (Li^+) [1] and e^- fluids. These fluids can be confined not only independently but also simultaneously [2] in the BX-U linear trap [3].

Those plasmas are non-neutral plasmas because of their charge non-neutrality. Since they can be relaxed into rotating thermal equilibria, the confinement times of them can easily exceed the order of 1 sec. They azimuthally rigid-rotate in opposite direction each other, owing to their different charge polarity. These allow to conduct experiments without indistinct initial conditions of the Li^+ and e^- plasmas and exactly control the ratio of the ion density to the electron one.

In the BX-U, a uniform magnetic field in the axial (z) direction confines the Li^+ and e^- fluids radially. They are trapped in the corresponding positive and negative potential wells of the BX-U, respectively. Figure 1 explains how they are trapped and then superimposed each orther. Regarding diagnostics, a micro-channel plate (MCP) followed by phosphor screen [4] is installed in the most downstream region of the BX-U. When either Li^+ or e^- fluid enters the MCP, the phosphor screen emits light. This is taken as an image by a high-speed camera that is set outside the vacuum vessel. Using image processing, changes in two-dimensional shape of both Li^+ and e^- fluids are measured after the elapse of two-fluid plasma state as shown in Fig. 1(b).

Currently, we attempt to adjust the diameter of Li^+ plasmas and the diameter of e^- plasmas by changing each confinement time before the superimposition. In this conference, we will present the method in detail and compare the data obtained by use of it with the previous data.

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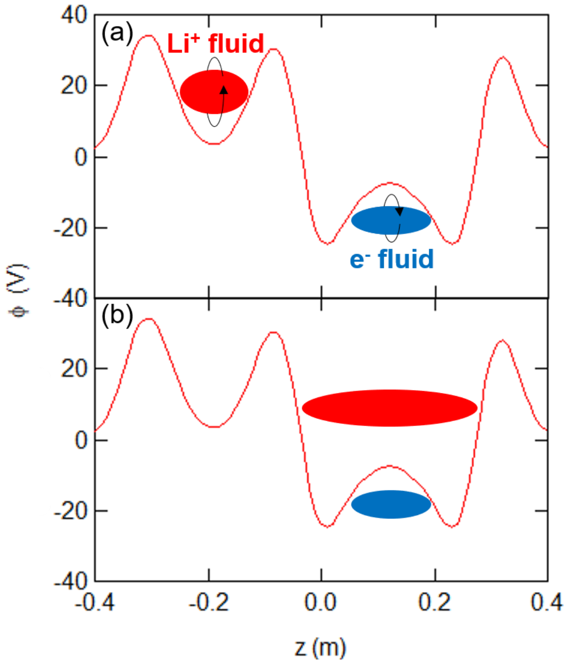

FIG. 1 Schematic of experimental procedure. (a) First, Li^+ and e^- fluids are confined and relaxed in corresponding thermal equilibrium in positive and negative potential wells. (b) Then, the Li^+ plasma is superimposed on the e^- plasma.

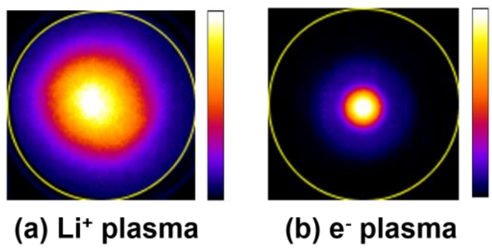

FIG. 2 A typical set of images of luminescence due to (a) Li^+ and (b) e^- plasmas before the superimposition.