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Investigation of two-fluid plasma state by extending ion skin depth

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Validity of one-fluid MHD is one of recent theme in our laboratory. Experimental data [1] obtained during a relaxation process of a spherical reversed field pinch [2] was compared with a theoretical model [3]. However, some difficulties emerged in the comparison, possibly due to the approximation as the one-fluid MHD.

A two-fluid plasma is a challenging subject in experimental plasma physics. Unlike the one-fluid MHD, the two-fluid plasma allows both ion and electron fluids to move independently. This model was proposed in theoretical and computational plasma physics to explain observations such as high-β equilibria of field-reversed configurations and the anomalous resistivity required for fast magnetic reconnections. However, no direct experiments focusing on the two-fluid plasma state have been conducted, although some researchers have discussed it.

This lack of study is mainly due to the experimental difficulty of probing the short-scale length of the ion skin depth λ_i where the two-fluid plasma state or the two-fluid effect is expected to emerge. However, λ_i can be far longer in non-neutral plasmas, because of the relatively low ion density. Because of this and other benefits of using non-neutral plasmas, we proposed a new experiment and developed a linear machine called the BX-U linear trap [4].

The BX-U is a modified version of the Penning-Malmberg trap wherein both positive and negative harmonic potential wells are created by using a set of multi ring electrodes. Pure lithium (Li^+) ion and electron (e^-) plasmas are not only produced independently but also trapped simultaneously. Confinement properties of those non-neutral plasmas were investigated [5-8]. In particular, weakly magnetized Li^+ plasmas were extensively studied also numerically [9].

Regarding diagnostic tools, we employed a micro-channel plate (MCP) followed by a phosphor screen [10]. To capture of images of Li^+ ion and e^- plasmas in one attempt, we developed a new innovative method of changing the axial potential applied to the MCP using a high-voltage vacuum relay [11]. This method allows consecutive images of Li^+ and e^- plasmas to be successfully captured.

By using the method, we have succeeded to capture the two images of Li^+ ion and e^- fluids before and after the superimposition [12]. The scale length of the Li^+ ion plasma is set to be the ion skin depth. In this conference, we present our recent results for experimentally exploring differential rotation equilibria of Li^+ ion and e^- plasmas [13, 14].

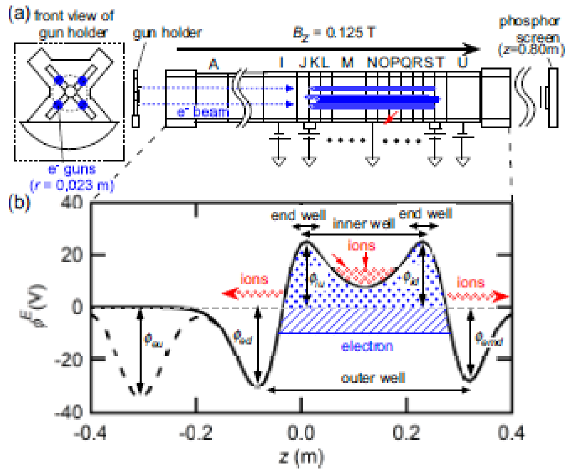

Figure 1 Schematic of the BX-U linear trap in which a nested trap can be formed. We have exactly adjusted the axial profile of potential and avoided psedo ions generated in the side trap of the nested one [T. Okada *et al*, to be submitted.]

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