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Development of lithium ion plasmas for two-fluid plasma experiments

二流体プラズマ状態検証のためのリチウムイオンプラズマ源の開発と閉じ込め実験

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We prepare a new experimental test on whether or not the extend MHD states can exist in laboratory plasmas. The most remarkable feature of the experiment is to use two linear non-neutral plasmas: pure lithium ion (Li^+) and electron plasmas. Up to now, we have finished constructing multi-ring trap that produce both positive and negative electrostatic potential wells in order to confine those non-neutral plasmas independently. Many electronic circuits for accurately operating the experiment are installed to the machine. A Li^+ source successfully emits Li^+ ions with low energy (~ 1 eV) which would probably enough to exclude all effects due to the thermal motion from the Li^+ fluid motion. Four small electron cathodes working around 1,300 K are now assembled, and will be ready to produce four electron wires in the machine.

1. Introduction

Recently, `*extended MHD models*' that include an MHD plasma with flow, a Hall MHD plasma, and a two-fluid plasma are proposed in both theoretical and computational fields of plasma physics. Those models have been applied to explain recent experimental observations in fusion plasmas. In fact, those phenomena can be never understood by the conventional MHD model. However, no experimental tests for the extended MHD models have ever been conducted yet.

There exist two reasons why extended MHD models are unexplored. Firstly, those models hold in a short scale length, while the conventional MHD is available in any scale lengths. Actually, the ion skin depth λ_i is considered to be the typical scale length where the effect due to the extended MHD state could significantly emerge, which is too short to be accessed in fusion plasmas. Secondly, it should be a right method for testing the extended MHD in experiments that we investigate if the extended MHD state will maintain after an extended MHD plasma is formed.

For this purpose, we need to produce a notable plasma in which both ion and electron fluids move independently; this is actually called a two-fluid plasma. However, it is hard to produce such plasmas by discharging neutral gas. This is because through the ionization process of neutral gas, both ion and electron fluids usually move together.

2. Advantage of using non-neutral plasmas

The above difficulties may be avoided using non-neutral plasmas (NNP). NNP can be formed with relatively low densities, thus providing much longer λ_i. Also, those plasmas are extremely stable. The confinement time of NNP lasts even more than several days, alleviating experimental difficulties in diagnosing properties of the extended MHD plasmas.

Figure 1 shows the dependence of the size parameter S_*, which is equivalently the parameter of L/λ_i, on the ion density n_i. Here, L is a typical scale length of a plasma and λ_i is the ion skin depth [1].

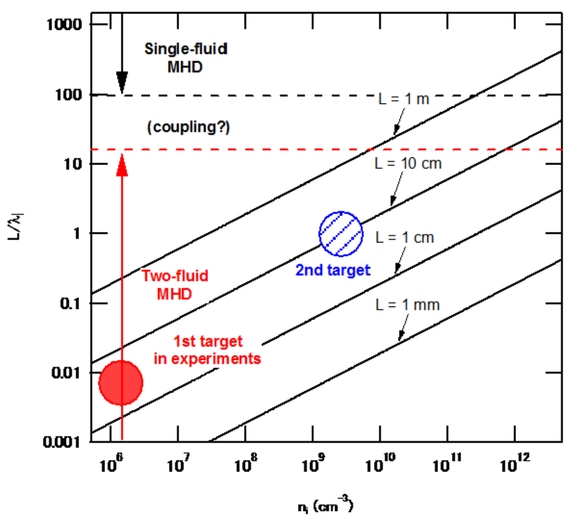

Fig.1. Dependence of the size parameter S_* on the ion density n_i. The ion species used in this experiments is lithium ions.

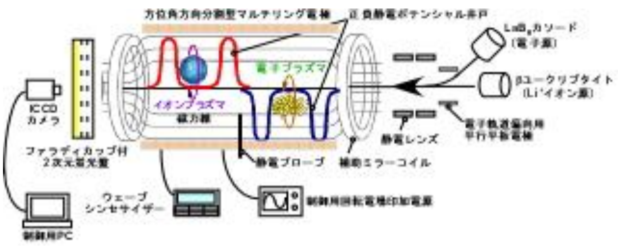

Fig. 2. Scheme of the proposed experiments.

Values of λ_i less than 30 are theoretically required to produce a two-fluid plasma, one of extended MHD plasmas. As recognized, plasmas with $n_i < \sim 10^{12}$ cm^{-3} is required for laboratory experiments having L = 10 cm to which NNP produced in linear machines can easily access.

3. The proposed experiment

Figure 2 shows a schematic diagram of the proposed experiment. In the linear machine, a pair of positive and negative electrostatic potential wells is externally produced. In the positive potential well, an Li^+ plasma is confined, while a pure electron plasma in the negative potential one.

Then, those non-neutral plasmas are merged together. By precisely controlling densities of both Li^+ and electron plasmas independently, we can explore an unrevealed research field of extended MHD plasmas.

Up to now, we have finished constructing multi-ring trap that produce both positive and negative electrostatic potential wells in order to confine those non-neutral plasmas independently. Many electronic circuits for accurately operating the experiment are installed to the machine. A Li^+ source successfully emits Li^+ ions with low energy (~ 2 eV) [2] which would probably enough to exclude almost all crucial effects due to the thermal motion from the Li^+ fluid motion. Four small electron cathodes working around 1,300 K are now assembled, and will be ready to produce four electron wires in the machine.

Acknowledgments

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References

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[2] Y. Hana *et al.*, 22C02 in this conference.