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Development of a Superconducting Levitated Coil System in the RT-1 Magnetospheric Confinement Device

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To explore high-beta plasma confinement that may enable the advanced fuel fusion, we have constructed a new experiment, Ring Trap 1 (RT-1), which produces a magnetospheric configuration with levitating a superconducting magnet in a vacuum chamber. A supersonic flowing plasma is confined by the dipole magnetic field, which simulates Jupiter's magnetosphere. The theory of the "Double Beltrami Fields" predicts stable confinement of a high-beta (on the order of unity) plasma by the effect of dynamic pressure of the supersonic flow [1]. The first experiment using the RT-1 device was performed in January 2006. We have succeeded to levitate the coil and produce a plasma by injecting 8.2GHz microwave (1.5kW).

The magnet system of the RT-1 device is based on the technology developed in the previous Proto-RT and Mini-RT projects. The Proto-RT was the first magnetospheric device that proved the physical concept of the flowing-plasma confinement [2]. The Mini-RT was constructed to develop a superconducting levitated coil system using the Bi-2223 high-Tc conductor [3]. The RT-1 device employs the same concept, while some essential new technologies have been developed to improve the total performance of the system.

The major radius of the superconducting ring coil is 25cm. The field strength in the plasma confinement region varies from 0.3 T to 0.03 T. The conductor is first cooled to 20K, by helium gas provided by a GM refrigerator, in the maintenance chamber (located at the bottom of the plasma chamber), and, then, charged to 0.25MA (the coil consists of 12 pancakes and has a total of 2160 turns). After detaching the current leads and coolant (He gas) transfer tubes, the ring is moved up to the mid-plane of the plasma chamber and is then levitated by a feedback-controlled magnet installed on the top of the device. The weight of the ring is 110kg. Three-cord laser sensors measure the position of the levitated ring. We can continue the super-conducting operation for 7 hours before the coil temperature increases to 30 K. Current decay is less than 1% after 7 hours.

We produce plasma by injecting an X-mode microwave (8.2GHz). The maximum power of the Klystron is 100kW (1 sec. pulse operation).

The first plasma was obtained with 1.5 kW ECH [4]. The superconductor ring was levitated about 30mm over the lifter. After testing the catcher, which can catch the ring in case of an accidental drop, we will operate the device while moving the lifter away from the plasma region.

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