Experimental study on longitudinal compression of electron plasma confined in Malmberg-Penning trap for compact simulator of energy driver in heavy ion fusion

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In a heavy ion inertial fusion device, heavy ion beams (HIB) with extremely high current should be prepared for the efficient implosion of a target. In order to realize a large amount of the current, an abrupt longitudinal compression of the HIB is required in the final stage of the device[1]. The sudden increase of the current density generates a high space charge effect which causes an increase of the beam emittance. In a result, the efficient fusion reaction would be prevented. A method for controlling the increase of beam emittance after the dramatic compression has to be studied. However, the study on the HIB in a large accelerator complex will cost a great expense.

Instead of HIB, an electron plasma in a Malmberg-Penning trap is a suitable material for the study on charged particle beam. The equivalence has been confirmed of the pure electron plasma and the charged particle beam in the center-of-mass frame under a proper scale transformation[2]. The compression in the longitudinal direction of HIB could be simulated by the compression in the longitudinal direction of the pure electron plasma as shown in Fig.1. The observed energy distribution in of the pure electron plasma could be related to the beam emittance of the HIB.

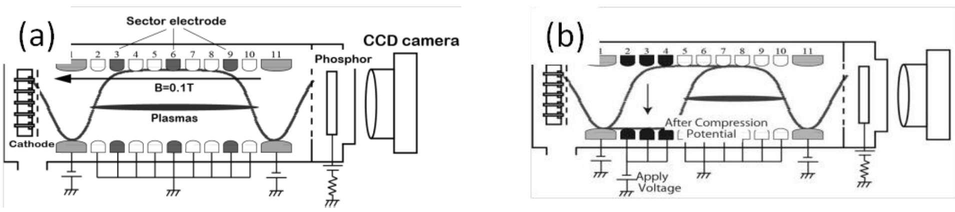

Figure 1: Schematic configuration of a Malmberg-Penning trap. Electrons are compressed longitudinally to the half of an initial length by manipulation of the confinement electric potential.

A longitudinal temperature and radial density distribution of a pure electron plasma with the initial central density of 6×10^{12} /m^3 have been measured before and after the compression in the longitudinal direction. The increase ratio of the longitudinal temperature during the compression with the magnetic field B = 0.02 T is almost 1.7 times larger than that with B = 0.1 T. This observation suggests that the strength of the magnetic field is a key to control of the beam emittance. On the other hand, the radial density distribution after the compression remains unchanged as the initial one in both cases. The results qualitatively agree with the numerical simulations[3].

References

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