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Evaluation of Transport Properties in Warm Dense State by using Isochoric Pulsed-power Discharges

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Warm dense matter (WDM) is of key interest to understand the formation of plasma from a solid state, interior of giant planets, hydrodynamics of fuel pellet in inertial confinement fusion, and so on. WDM state is defined by density from 10-3 ρs (ρs is the solid density of matter) to 10ρs, and temperature from 0.1 to 10 eV. The characteristics of WDM are hard to study theoretically from first principle approach. On the other hand, to create and to characterize properly the WDM condition are difficult in a laboratory.

In this study, we evaluate the transport properties in WDM state by using pulsed-power discharge with isochoric heating [1-2]. The pulsed-power discharge is generated by a gap switch and low inductance capacitors (3×1.87 μF) charged up to about 15 kV. The stray inductance of the discharge device was estimated to be 165 nH from the preliminary experiment with the short-circuit. The features of the method are possible to produce an isochoric condition, use of a conventional tamper, avoiding skin effect, and direct spectroscopic measurement. To achieve isochoric heating, copper foam, which has pores from 50 μm to 600 μm of porous sizes and about 90 % porosity, was packed into a sapphire hollow capillary (φ5×10 mm). To avoid the creepage on surface sapphire, turbo-molecular and rotary pumps are set at bottom of the chamber. The interior pressure of the chamber is set to be less than 10-3 Pa. The density of WDM can be controlled by enclosed volume of copper foam.

The temperature of generated WDM was several thousand Kelvin estimated by the emission spectrum and the input energy history with SESAME equation of state [3]. Observed electrical conductivity and foam/plasma temperature is about 104 S/m and 4000 K in 0.1ρs. The observed electrical conductivity is in agreement with the other experimental results and predictions. The temperature dependence of electrical conductivity is neither metallic nor ideal plasma characteristics. We will also discuss the estimation of thermal transport in WDM state [4] in this conference.

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