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Study on the evolution of the plasma state of electric explosive wires

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Warm dense matter (WDM) is one of the core research topics in astrophysics, inertial confinement fusion, and high-energy density physics. Generally, WDM has a density ranging from 0.001 to 10 times the normal density and a temperature ranging from 0.1 to 100 eV. There are many ways to generate warm dense matter in the laboratory. The plasma generated by the exploding wire technique is initially in the WDM range after the wire explosion. The plasma has the advantages of axial symmetry and uniformity along the wire direction, which gives it certain advantages in plasma state diagnosis and characteristic studies. Moreover, the plasma state in the later stage has a relatively long lifetime (several µs) and is relatively stable, making it suitable for related research as a relatively low-density plasma target[1-2].
We have designed and constructed an exploding wire plasma discharge device and performed corresponding discharge experiments and diagnostic tests in air : Capacitor 4 µF ; High voltage 10 kV; The wire 0.2 mm copper. The plasma was photographed using an ICCD camera, and the multiple repeated photographs showed excellent repeatability and stability of the discharge. Therefore, the discharge process can be described by photographing at different time points in multiple experiments, as shown in the figure 1. At the same time, we used multiple photodetectors of different wavelengths to diagnose its spontaneous emission and used the gray body radiation approximation to calculate the plasma temperature, obtaining a temperature variation of 0.5 to 1 eV in the first 200 ns after ignition. Due to time constraints, density measurement using laser interferometry has not been performed. However, based on volume expansion estimation, the average density is above 0.005 times the normal density, which can be considered close to the WDM state.

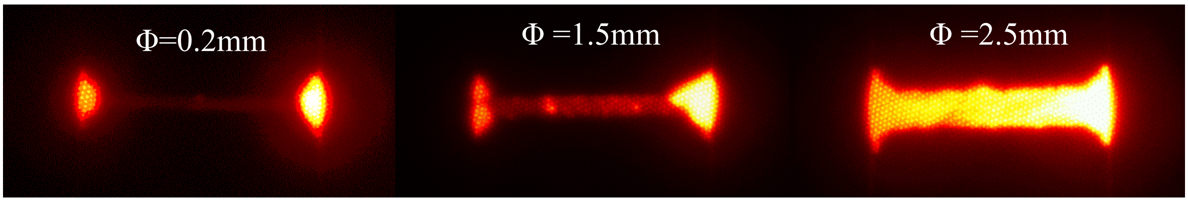

Figure 1. ICCD image: a) t=0, Φ=0.2mm; b) t=100ns, Φ=1.5mm; c) t=200ns, Φ=2.5mm

The laser interferometry can provide density evolution for plasmas with densities below 10^{20} cm^{-3}. Spectrometers and other devices can capture the evolution of spontaneous emission spectra. However, information such as ion charge state and opacity in the plasma cannot be directly obtained. Therefore, it is necessary to use other methods, such as simulation programs combined with temperature and density data, to calculate and obtain new plasma evolution information and verify the accuracy of the simulation program using spectroscopic data. Currently, we are studying the use of FAC and FLYCHK simulation programs, and the simulation results can also verify the applicability of the relevant programs in exploding wire plasma.

[1] Braams C M . Gastroenterology, 2002, 44(8):1767.
[2] Sarkisov G S, et al.. Physical Review E, 2005, 71(4): 046404.