3D NUMERICAL SIMULATION OF WIRE-ARRAY Z-PINCHES *

O.G. OLKHOVSKAYA[1]

[1]*Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences, Moscow, Russia*

Experiments at Angara 5-1 facility [1] on the current implosion of combined nested arrays [2] and single arrays of metalized dielectric fibers [3] have demonstrated stable and compact compression of the metal plasma. The presence of substances with a low rate of plasma ablation at the periphery of the arrays leads to suppression of the development of magnetic Rayleigh-Taylor instability in plasma at the axis of the array, as compared with the compression of the of single cylindrical wire arrays. As a result, stable and compact Z-pinches were formed, and SXR pulses with the amplitude of 5–7TW and the duration about 5ns were obtained.

The report is devoted to numerical simulation of implosion of combined arrays with various designs. The aim of the simulation is to explore the interaction of plasma flows and the magnetic field during the implosion of different types of wire arrays, determine the physical conditions for a shock wave region formation between the arrays, and help to control the time profile and amplitude of the resulting SXR pulse.

Three-dimensional numerical simulation is based on two-temperature radiative magnetic gasdynamic (RMHD) model with dissipation implemented in multiphysics program package MARPLE-3D [4]. The data on the equations of state and optical properties of matter were calculated using the THERMOS program [5]. For modeling combined arrays from various materials, the MARPLE-3D code has been upgraded to solve hydrodynamic problems for the flow of a multicomponent mixture. To describe the evaporation of wires under the action of a current, a semi-empirical model [6] is used, taking into account the experimental data on the plasma ablation rate [3]. Thus the process of non-stationary plasma generation of fibers and wires is reproduced adequately. Appropriate modeling of this complex multiphysics problem is based on high resolution numerical methods as well as on high performance computing. The implemented computer models are verified by experimental data.

The numerical simulation as a whole reproduces the main tendencies registered in experiments with combined arrays. The computations confirmed the experimentally found existence of an optimal configuration with an external array mass in the range 7–10µg/cm. Numerical simulation using 3D RMHD code made it possible to visualize the interaction of the plasma of the arrays, namely: the spreading of the plasma jets of the outer array as a result of their interaction with the magnetic field of the inner array and the formation of a quasi-homogeneous shell from the plasma of the outer cascade around the inner cascade. A comparison of the calculated values of the power and total energy of the SXR pulse with the experimental data was used to calibrate the RMHD code and the model of the matter properties.

The calculations were performed using supercomputers K-60 and K-100 in KIAM RAS.

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