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Investigation of Global MHD Instabilities in Multispecies Z-pinch Plasma

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Work in progress

Investigation of multispecies plasma is important for many applications [1,2], including tokamak, laser ablated , Z-pinch, space and astrophysical plasmas. 3D hybrid simulations of multispecies plasma can provide valuable insight into the processes related to the magnetic field and current distribution, energy partition between the different ion species, growth rates of MHD instabilities.

In the process of plasma ablation from wires in a wire array, consisting of deuterium and palladium, plasma in the precursor consists of heavy and light ions. To study the physics of the multispecies plasma in the precursor region (the region where most of the heating takes place), we use the multifluid description. This approach allows to study development of global MHD instabilities inside the precursor and identify what ion component can be responsible for support of the current in this region and as a result is associated with the magnetic field distribution inside the precursor plasma. Dependence of the growth rates of MHD instabilities from the density ratio of heavy and light ions as well as kinetic energy partition between the two plasma components will be investigated as well.

We will also present results of 3D hybrid simulations of sausage and kink instabilities in the multi-component plasma of the precursor.

In order to determine dependence of magnetic field distribution inside the current-carrying plasma of the precursor from the densities of the light (proton) and heavy (palladium) ion components, we carried out 3D hybrid simulations of two component plasma with the following setup.

Inside the conducting cylinder we placed two ion components with density and magnetic field profiles, corresponding to the Bennett profile.

Simulation results for two runs

Run 1. 10% of proton density and 90% of palladium density
Run 2. 90% of proton density and 10% of palladium density
are presented below.

In Figures 1-3 distribution of magnetic field and densities of protons and heavy ions in Run 1 are presented.

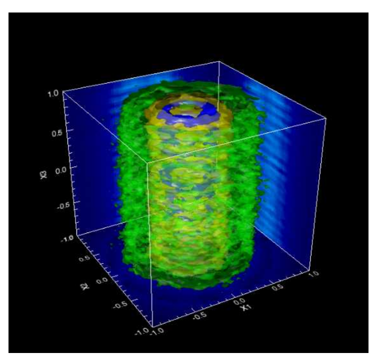

Figure 1. Distribution of magnetic field inside the simulation box at the moment t = 120 (time is in dimensionless units).

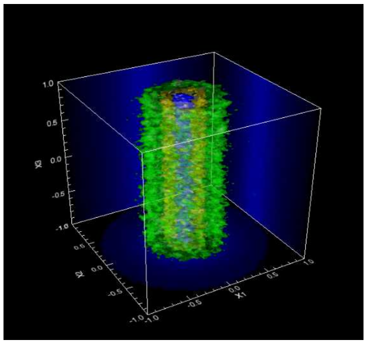

Figure 2. Run 1. Proton density distribution at the moment t= 120.

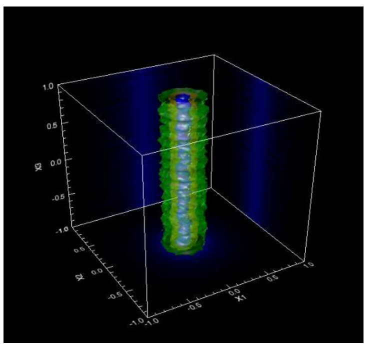

Figure 3. Run 1. Heavy ions density distribution at the moment t= 120.

It is clearly seen from Figures 2 and 3 that protons and heavy ions have different special distribution. Proton distribution has much larger radius in comparison with heavy ions. Important result, seen in Figure 1 is that distribution of the magnetic field tends to follow the proton distribution, i.e. it is much wider then the distribution of heavy ions. It means that protons (light ions) are the component, which is responsible for carrying current in the system.

Similar result was observed in Run 2 and presented in Figures 4 (magnetic field), 5 (proton density) and 6 (heavy ion density).

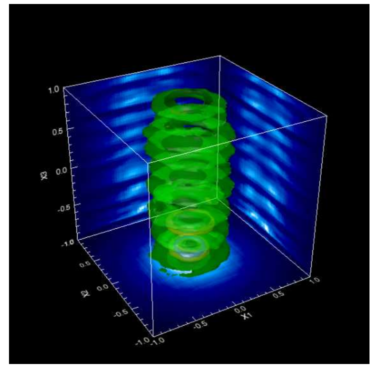

Figure 4. Run 2. Distribution of magnetic field inside the simulation box at the moment t = 110.

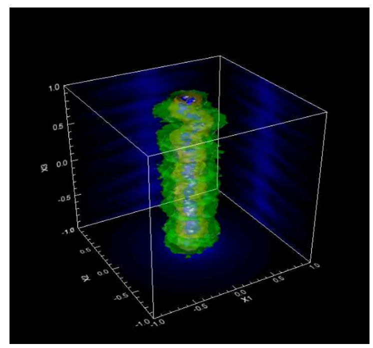

Figure 5. Run 2. Proton density distribution at the moment t= 110.

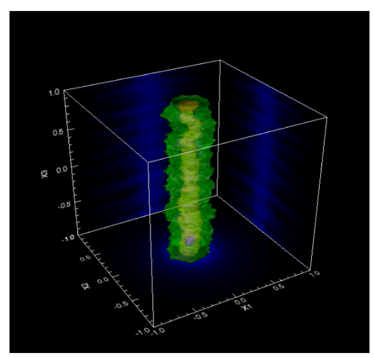

Figure 6. Run 1. Heavy ions density distribution at the moment t= 110.

[1] R.M. Winglee, JGR 109 (2004) A09206.

[2] L. Ofman, J.M. Davila, Astrophys. Journal, 553 (2001) 935.

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