Numerical simulation of Weibel instability in laser interaction with plasma

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Weibel instability [1] is known to arise in systems with anisotropic particle velocity distribution. It leads to the growth of the magnetic field in form of thin (scale typically approximates to the skin length) filaments, which may further form stable large-scale magmetic fields in plasma. The condition for the instability arises in laser interaction with overdense plasma. Electrons accelerated by the pulse form a anisotropic system of a relativistic beam and plasma background, and the charge current filaments are formed. This mechanism lessens the efficiency of laser pulse energy transfer to electron acceleration due to energy loss for magnetic field formation.

The current study is dedicated to the investigation of energy transport to magnetic fields in such system with the use of numerical simulation. The simulation serving such purpose should take into account the three dimensional nature of the phenomena, have enough spacial and time resolution to show the fastest growing instability modes and be able to cover the size of a characteristic laser-plasma system in question.

We use the CFHall code [2]. It is based on the novel Locally-Recursive non-Locally Asynchronous algorithms. By taking account of the memory subsystem hierarchy it greatly decreases the time needed for simulation both on the massively parallel computer clusters and common desktop machines. The benefit for the current study is the ability to use enough cell resolution to provide several cells per smallest predicted filament structure in a 3D3V simulation.

While the three-dimensional small-scale scale filament structure can be neither observed by current experimental equipment, nor described comprehensively in the terms of known theoretical frameworks, the numerical experiment provides an insight to the mechanism of the instability process and provides estimates of the important output values (such as the ratio of energy converted to magnetic fields) depending on the control parameters.

References

[1] E. S. Weibel, *Phys. Rev. Lett.* 2, 83 (1959)

[2] A.Yu. Perepelkina, V.D. Levchenko, I.A.Goryachev, *Mathematical Models and Computer Simulations*, 3D3V kinetic code CFHall for magnetized plasma simulation (in press)