Smoothed Particle Hydrodynamics and its application to the solution of fusion-relevant MHD problems

L.Vela Vela[1], R. Sanchez[1], J.M.Reynolds-Barredo[1], J.Geiger[2]

[1] *Universidad Carlos III, Leganes, Spain*

[2] *Max-Planck Institute for Plasma Physics, Greifswald, Germany*

The present contribution aims at demonstrating the potential advantages of simulating MHD scenarios typically considered among the magnetically-confined-plasma community using SPH. The SPH method, or Smoothed Particle Hydrodynamics, is a Lagrangian numerical method originally designed to solve the equations of Hydrodynamics and later extended to Magnetohydrodynamics [1].

In SPH every particle corresponds not only to a small portion of the fluid but also serves as an interpolation node for its neighbours. Using this interpolation procedure one can discretise the spatial derivatives of ideal/resistive MHD on a co-moving frame and obtain evolution equations for the particle's position, velocity, mass density and internal energy. In contrast to PIC codes, the magnetic field in SPH is not solved with an underlying regular grid but is evolved with all the other plasma properties. This makes SPH completely mesh-free and opens up the possibility of an efficient parallel implementation.

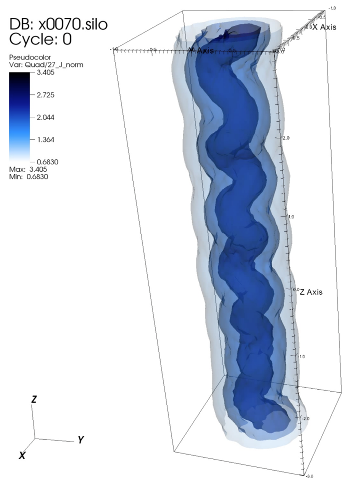

Figure 1: *Simulation of an unstable Z-pinch. The m=0 (kink) mode, shown here, is the most unstable mode of the system.*

The contribution presents first a series of numerical tests where the properties of the SPH method are explored (Energy Conservation, Dissipation, Symplectic Integrators, Interpolation Kernels, etc) and second, a battery of realistic 3D cylindrical plasma columns (Theta pinch, Zeta pinch and Screw pinches) where the accuracy of the method is quantitatively tested, its solutions benchmarked against known MHD stability solutions and its suitability for future toroidal applications demonstrated.

References

[1] J.D.Price, "Smoothed particle hydrodynamics and magnetohydrodynamics", Journal of Computational Physics, **231**, 759-794, (2012)