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Influence of m_p/m_e on particle acceleration

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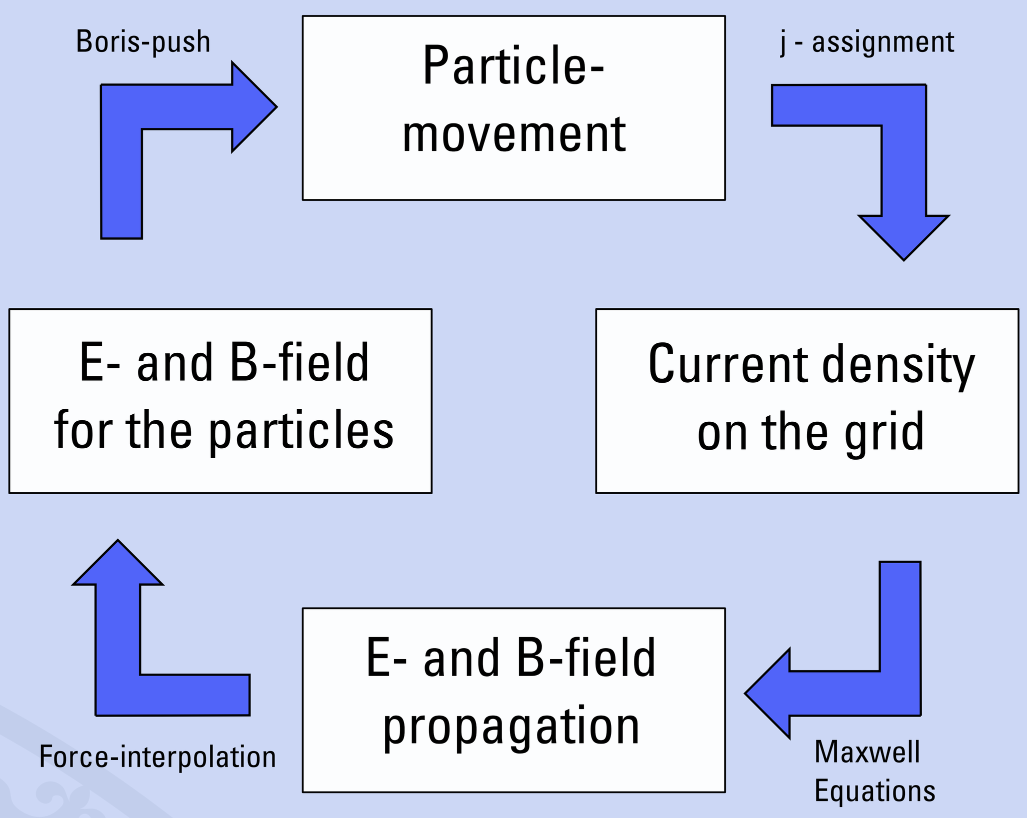
The Particle-in-Cell code ACRONYM

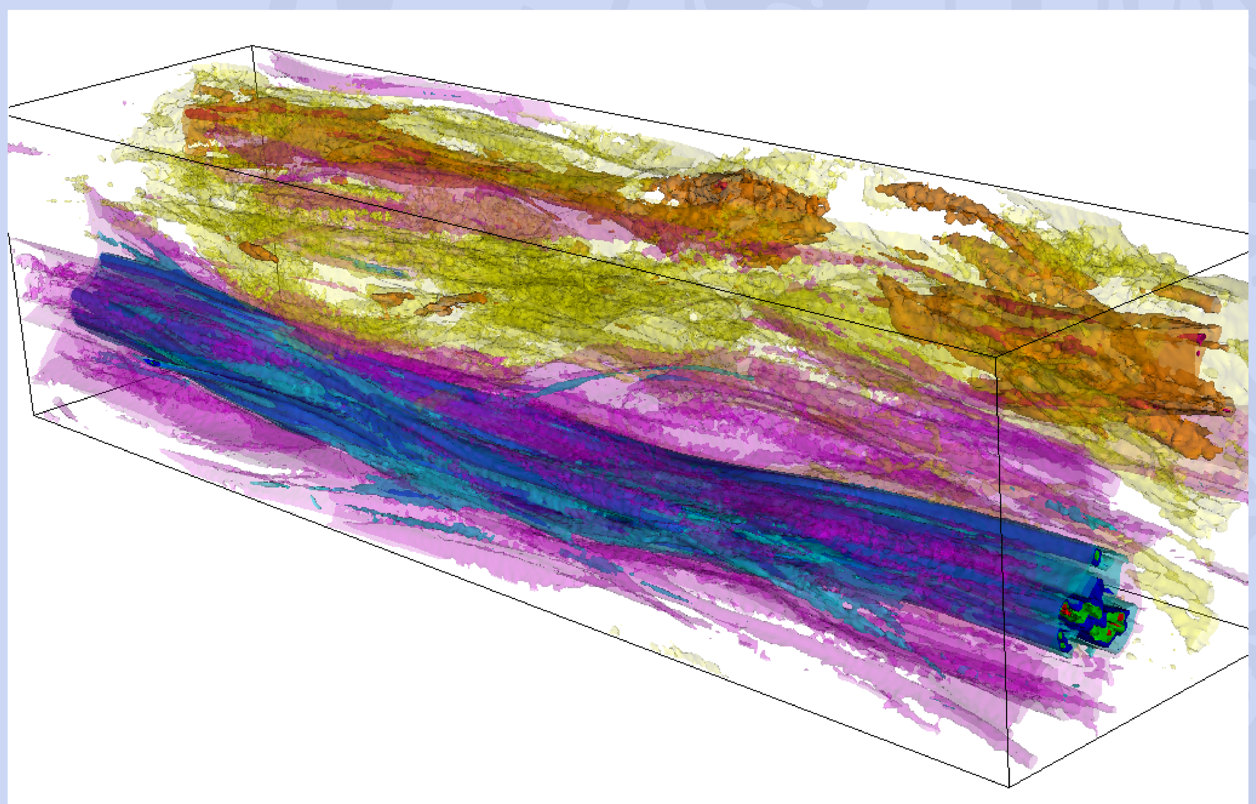
The PiC code ACRONYM (**A**nother **C**ode for **R**elativistic **O**bjects, **N**ow with **Y**ee-Lattice and **M**acroparticles) is a three-dimensional, MPI-parallelized fully relativistic kinetic plasma simulation code developed by Thomas Burkart, Oliver Elbracht and Urs Ganse. It has been extensively tested with analytical testcases and numerical simulations of independent groups.

The applicability of this code ranges over a vast numer of length scales and it can be used to study phenomena in the laboratory, heliospheric, and astrophysical plasma. Studies of plasma phenomena where in situ measurements of the particles and fields can be done are the key to verifying the validity of the numerical code.

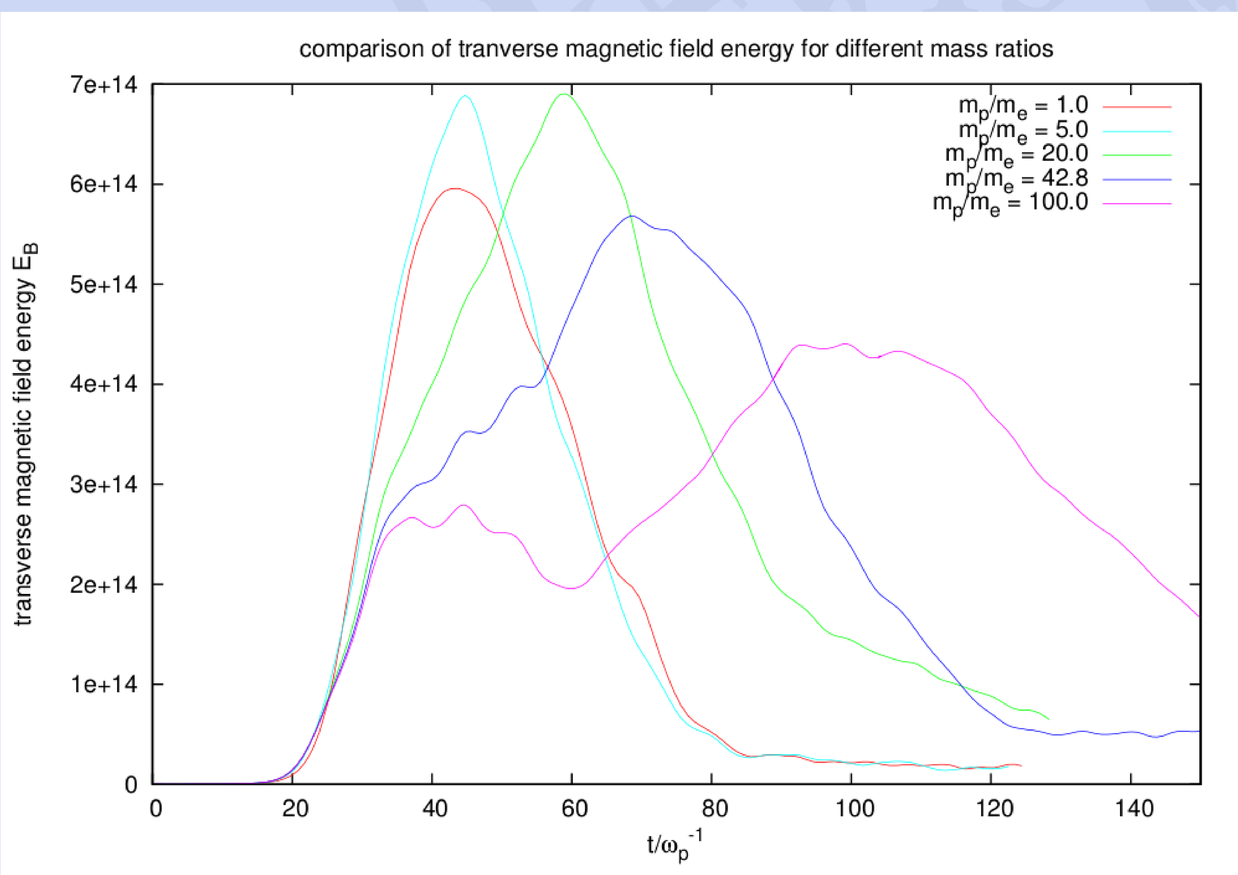


Simulation setup

- $128 \times 128 \times 512$ cells corresponding to $10 \times 10 \times 40\ c/\omega_p$
- counterstreaming plasma ($\gamma = 10$) with 12 ppc in the background and 8 ppc in the jet medium $\Rightarrow 1.68 \cdot 10^8$ particles
- thermal velocity $v_{th,e} = 0.1c,\ \ v_{th,p} = 0.1c \cdot (m_p/m_e)^{-1}$
- mass ratio $1.0 \leqslant m_p/m_e \leqslant 100$
- periodic boundary conditions in all dimensions



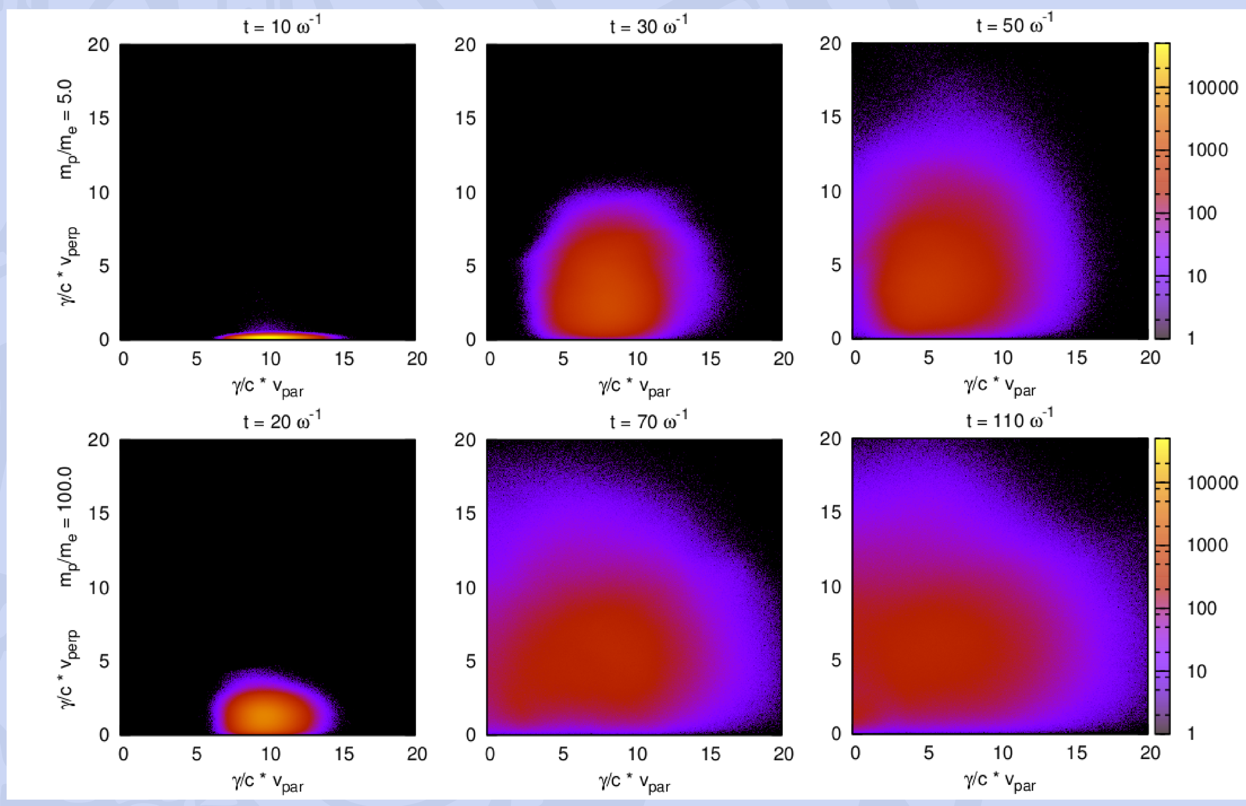
Development of the magnetic fields



The magnetic fields generated are a valuable indicator for the appearance of the instability. For high mass-ratios the instability seems to develop in two phases, for e^-/e^+ and p^+, respectively.

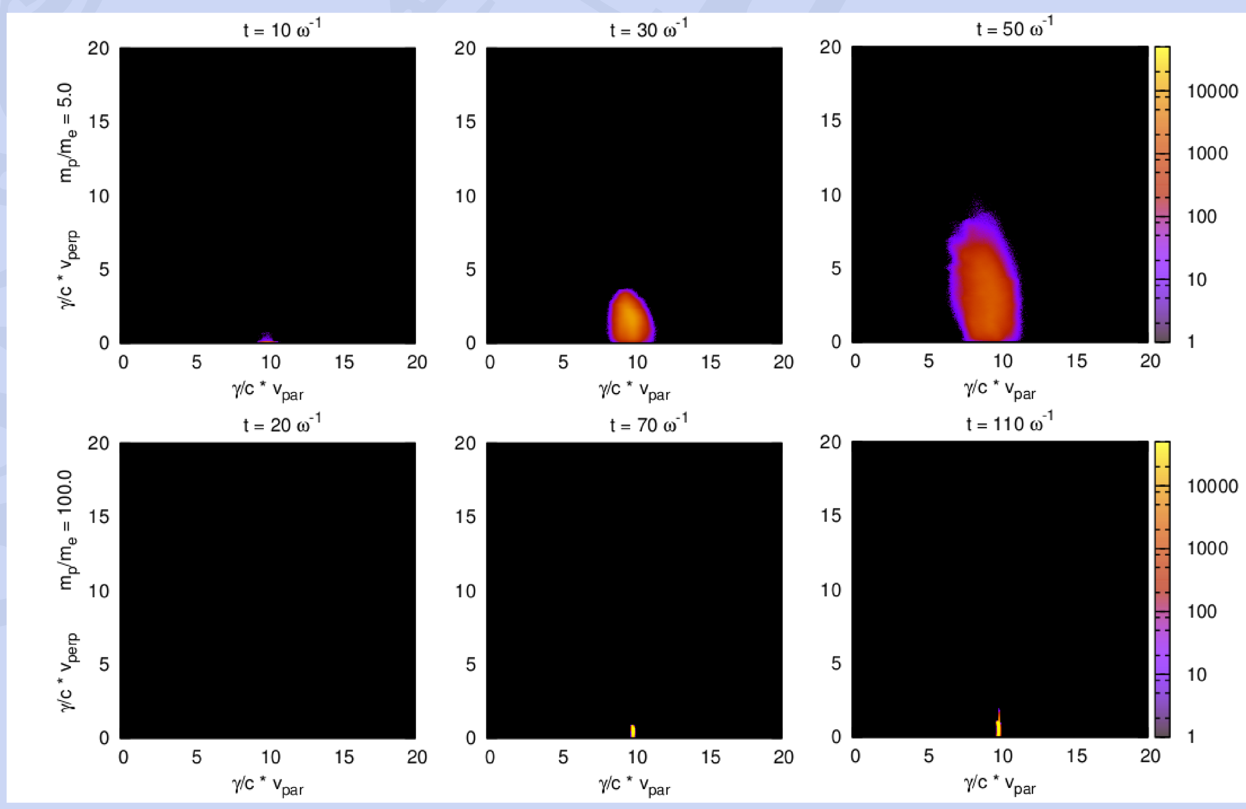
Particle acceleration for different mass-ratios

Two-dimensional histograms of $\gamma v_\perp/c$ over $\gamma v_\parallel/c$ in the lab rest frame. In the upper picture, electrons and positrons are shown, in the lower picture only the protons are plotted. One can state that most of the particle acceleration is happening in the tranverse direction.



2D histograms of the electrons and positrons:

- Low mass-ratio: e^-/e^+ are accelerated until the end
- High mass-ratio: e^-/e^+ gain energy until about $t = 70\omega_p^{-1}$



2D histograms of the protons:

- Low mass-ratio: p^+ are accelerated over the whole simulation time
- High mass-ratio: p^+ acceleration starts around $40\omega_p^{-1}$

Result

For the low mass-ratios of $m_p/m_e < 40$ electrons/positrons and protons are getting accelerated along, at high mass-ratios of $m_p/m_e > 40$ one can see that the instability develops in two phases.