Quasi-stationary magnetic fields generation with capacitor-coil targets

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Recent experiments [1,2,3,4] are showing possibilities to generate strong magnetic fields exceeding several megagauss with high energy laser pulses in a compact setup of a capacitor connected to a single turn coil. Hot electrons ejected from the capacitor plate (cathode) provide the source of a current in the coil. However, the physical processes leading to generation of currents exceeding hundreds of kiloamperes with a nanosecond laser pulse are not sufficiently understood.

Here we present a critical analysis of previous results and propose a self-consistent model for the high current generation in a laser-driven capacitor-coil target. It accounts for two major effects controlling the diode current: the space charge neutralization and the plasma magnetization. The model provides the conditions necessary for transporting strongly super-Alfvenic currents through the diode of the time of a few nanoseconds. The maximum current delivered by the diode is proportional to the hot electron temperature. The major control parameter is the laser irradiance $I\lambda^2$. The use of high laser intensities (tight focusing) and long wavelengths may improve the diode performance providing more energetic electrons capable to maintain a high current at a large tension. The model validity is confirmed by a comparison with the available experimental data.

The diode operation can be optimized by adjusting three characteristic times: the laser pulse duration, the response time of the external circuit (corrected by the effect of Ohmic heating) and the time of plasma propagation through the diode.

References

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