All-optical laser-based magnetic field generators: from nano- to picosecond laser regimes

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Our experiments, along with numerical and theoretical modelling, show and explain the generation of strong magnetic fields (B-fields), in the range of the kilotesla, using high-energy nanosecond or high-intensity sub-picosecond lasers interacting with solid targets of various curved geometries. Such capability paves the ground for novel magnetized high-energy density physics (HEDP) investigations, related to laser-generated sources of high-energy particles and their transport, to fusion energy production schemes and to laboratory astrophysics.

Magnetic fields of nanosecond duration are generated in a coil connected to a nanosecond laser-driven diode supplying a quasi-stationary electric current. This scheme was successfully applied for magnetizing solid-density targets and improving the relativistic electron beam transport in those targets. It is readily usable for other HEDP applications.

In the sub-picosecond regime, B-fields stem from supra-thermal electron ejection from the target or from laser-driven electron vortices. Data shows the presence of B-fields for more than 100 ps, a time scale much longer than the laser pulse duration. When confined within the target structure, these B-fields can be used for controlling electron and ion acceleration and guiding.

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