Retrieving ultrastrong plasma magnetic fields via ejected electron polarization

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Ultrastrong magnetic fields evolving in plasma dynamics are accompanied by electrons' radiative spin flips. The electron spin could provide a new degree of freedom to extract information on the structure and magnitude of the transient plasma fields. Here we present the radiative spin polarization of ejected electrons from the interaction of an ultrastrong short laser pulse with near critical density plasma in an ultrarelativistic regime [1]. Our PIC simulations show explicit correlations between the angle resolved electron polarization and the structure and properties of the transient plasma magnetic field. While the magnitude of the spin signal is the indicator of the magnetic field strength created by the longitudinal electron current, the asymmetry of electron polarization is found to gauge the island-like magnetic attributed to the transverse current induced by the laser wave front. Our studies demonstrate that the spin degree of freedom of ejected electrons could potentially serve as an efficient diagnostic tool to identify strong plasma fields.

References
[1] Z. Gong, K. Z. Hatsagortsyan, and C. H. Keitel, arXiv:2103.12164 (2021).

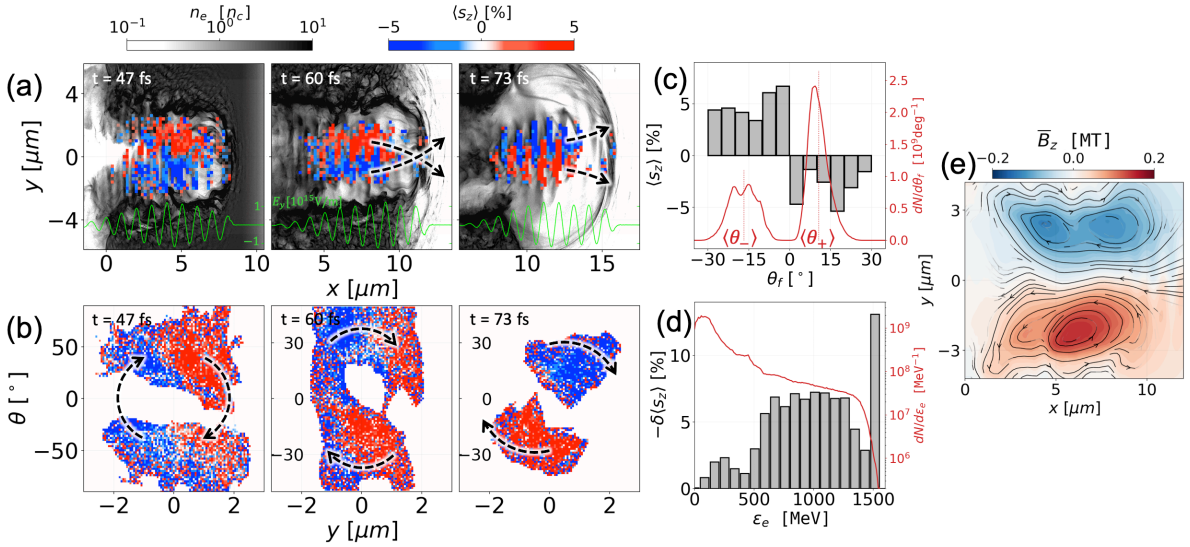

Figure 1. 2D PIC simulation results. (a) and (b) show the snapshots of electron spin polarization distribution in spatial coordinate and transverse phase space, respectively. The green solid lines in (a) profile the laser transverse electric field at the slice y=0. (c) Angular distribution of electron number and spin polarization. (d) Electron spin polarization ratio and energy spectrum (e) The quasistatic plasma magnetic field obtained from PIC simulations, where the black arrows denote the direction of electric current.