High precision probing of laser-solid interaction with laser-accelerated electron beams

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The collision of ultra-intense laser pulses with solids may initiate processes like current filamentation instability (CFI) and target normal sheath acceleration (TNSA). Studying the interplay of these processes is crucial, as they play an important role in e. g. novel particle accelerator concepts and are believed to be present in astrophysical events.

In the scope of this work, laser-solid interaction has been studied with unprecedentedly high temporal and spatial precision. For that, we use electron beams from a laser-plasma accelerator as probe beams. In contrast to previous studies (like in [1], [2]), we utilize the inherently small size and duration of these electron beams, which allows to locally probe the magnetic fields generated in the interaction. The TNSA and plasma instabilities have different effects on the probe beam, as their spatial scales of created magnetic fields are different. This may allow to distinguish these processes with high-precision data scans. In our study we were able to observe expanding surface charge clouds which are responsible for TNSA, as well as localized and long-lasting magnetic fields.

These experimental studies are accompanied by involved numerical simulations capturing the laser contrast induced plasma expansion, the main laser-plasma interaction, and the electron probing. We briefly discuss the numerical approaches and results.

This study establishes a very important application for laser-accelerated electron beams, particularly for the research on laser-solid interaction, and thus opens new possibilities for understanding important processes in plasma accelerators as well as astrophysical phenomena.

References

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