Laser-plasma interactions confined in the bulk of transparent dielectrics

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Focusing a pulse tightly inside a transparent dielectric at intensities 10^{14} W/cm^2 creates a plasma within the material in a few tens of femtoseconds. A single femtosecond pulse, shaped as a Bessel beam, can induce extremely high aspect ratio nano-void inside the bulk of sapphire or glass. This features an extremely high density of deposited energy, typically reaching the regime of Warm Dense Matter [1]. However, the configuration of the plasma formed inside the dielectrics was highly uncertain and the mechanisms of deposition of so high energy density were unknown. Here, using experiments and Particle-In-Cell (PIC) simulations, we report for the first time the formation of the high aspect ratio overcritical nanoplasmas inside dielectrics. Excellent agreement is found between several experimental diagnostic and our simulations, which additionally provide insights into the mechanisms of resonance, plasma heating and particle acceleration that are at play during the interaction.

We performed kinetic simulations using EPOCH PIC code [2] of the interaction between a Bessel pulse with a preformed nano-plasma rod. Figure 1 illustrates a comparison between the simulation results and measurements. Near and far-field fluence distributions are compared in top row and bottom row (middle and right) respectively. Resonance of the laser electric field is apparent (bottom left) and generates plasma waves near the critical surfaces (inset). We demonstrate the appearance of double layer and, for the first time to our knowledge, second harmonic generation by the laser-nanoplasma in the bulk of the dielectric.

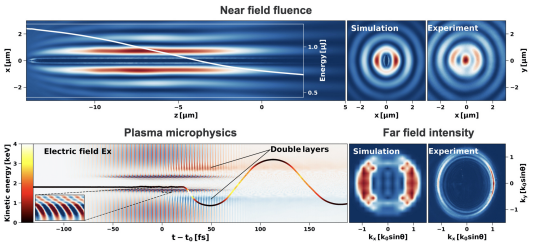

Figure 1: *The results of simulations in comparison with the experimental measurements.*

In conclusion, the performed kinetic simulations can shed light on the microphysics of ultrafast Bessel pulse interactions with nanoplasmas in an unprecedented regime inside the bulk of transparent materials.

This research has received funding from ERC (682032-PULSAR) and was granted access to HPC PRACE (PULSARPIC PRA19_4980), TGCC (A0070511001) .

References

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