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Laser Wakefield Acceleration in Nanostructured Plasma

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Solid-state plasma wakefield acceleration has recently attracted attention as a novel method for achieving unprecedented ultra-high acceleration gradients on the order of 1 TV/m or beyond. In this context, recent advancements in nanofabrication techniques have opened up the possibility of creating structured plasmas with tailored properties. For instance, the utilization of carbon nanotube (CNT) bundles holds great potential for generating stable plasmas with electron densities reaching as high as 10^{24} cm^{-3} , i.e., orders of magnitude higher than conventional gaseous plasmas. As part of a new collaborative effort called NanoAc, we have conducted Particle-In-Cell (PIC) simulations to investigate laser wakefield acceleration in nanostructured solid-state plasmas based on CNT arrays. Our results confirm the attainment of wakefields at the TV/m scale. Additionally, we observed self-injection, sub-femtosecond bunch formation, and electron acceleration in micrometre-scale targets, yielding kinetic energies of $\sim 10 \text{ MeV}$. These findings open up promising possibilities to design novel ultra-compact accelerators and radiation sources. In this contribution, we present a summary of the work carried out by the NanoAc collaboration to date and discuss the preparation of future experimental tests in existing laser facilities.

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