Filming a Relativistic Plasma Wave

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Laser-plasma-based wakefield accelerators are changing the scientific landscape bringing on new hopes for high energy physics, compact light sources, and societal applications. Many of these applications critically require the precise characterization of the plasma wakefield that largely affects the bunch's quality they provide. Advanced diagnostics of such highly transient, microscopic bunch and field structures, however, remains very challenging. After introducing the context and the status of this research, I will shortly explain the physical processes that are involved in plasma accelerators, I then will report on recent major results that demonstrate for the first time the real-time visualization using FREM (Femtosecond Relativistic Electron Microscopy) of laser-driven nonlinear relativistic plasma wave [1], its transition to electron-driven wakefield [2] and the visualization of the relativistic electron bunch [3].

[1] Y. Wan, O. Seeman, S. Tata, S. Smarstev, I. Andriyash, E. Kroupp, and V. Malka, *Nature Physics* (2022), https://doi.org/10.1038/s41567-022-01717-6
[2] Y. Wan, S. Tata, O. Seemann, EY Levine, S Smartsev, E Kroupp, V Malka, *Science Advanced* eadj3595 (2024)
[3] Y. Wan, S. Tata, O. Seemann, EY Levine, S Smartsev, E Kroupp, V Malka, *Light: Science & Applications* 12 (1), 116 (2023)