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# Spatiotemporal dynamics of beam-plasma instabilities in the ultra-relativistic regime

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Relativistic beam-plasma instabilities play a crucial role in high-energy astrophysical sources, such as gamma-ray bursts or blazars, in particular to create the electromagnetic turbulence responsible for the synchrotron emission of accelerated particles in these sources. These instabilities are also important in certain experimental concepts of particle accelerators or ultra-intense photonic sources based on beam-plasma or laser-plasma interaction [A. Benedetti et al., Nat. Photon. 12, 319 (2018)].

In order to characterize, for the first time in the laboratory, their dynamics in the ultra-relativistic regime and their potential as sources of gamma radiation, a series of experiments (named E-305) is planned on the new accelerator FACET-II of the SLAC National Accelerator Laboratory. As part of this project, we will present a theoretical study of the evolution of the instabilities in the presence of a finite size beam as produced by an accelerator. A novel theory describing the spatiotemporal dynamics of electrostatic oblique modes will be presented [P. San Miguel Claveria et al., Phys. Rev. Research 4, 023085 (2022)]. For an ultra-relativistic beam, this model reveals, in good agreement with particle-in-cell simulations, the intrinsic spatiotemporal character of the instability, thus disproving the usual theories which suppose a purely temporal growth. Finally, we will determine the conditions for the instabilities to dominate over the beam self-focusing dynamics due to plasma wakefield excitation.

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