

# Spatiotemporal beam-plasma instabilities in the ultrarelativistic regime

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The propagation of particle beams through plasma can give rise to instabilities, relevant for astrophysical and laboratory systems. For ultrarelativistic beams, the oblique two-stream instability (OTSI) generally prevails the early beam-plasma interaction. For conditions relevant to the E305 experiment, which is devoted to study such beam-plasma instabilities with the FACET-II facility at SLAC, we have shown that the instability is spatiotemporal due to the finite length of the beam. This spatiotemporal character is not only prominent during the linear growth, as demonstrated with our recently developed theory, but also during the nonlinear phase of the instability. Next, we will discuss two innovative methods of the instability probing: ultrafast dark-field shadowgraphy and single-shot energy-resolved transverse-momentum-spread measurements. The latter method relies on the use of chirped beams and allows to access the front-to-rear spatial coordinate from energy-resolved measurements in a single shot. Our modeling demonstrates their potential to benchmark OTSI theory and codes against experimental data. Finally, while the instability generally starts from noise, we have also shown that it can be seeded and controlled using the beam interaction with a nano-structured solid target. Our work thus opens the way to a powerful experimental platform for the study of ultrarelativistic beam-plasma instabilities.

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