Experimental observations of the non-resonant streaming instability during the early stages of quasi-parallel collisionless-shock formation

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Collisionless shocks arise in many astrophysical systems and are the likely source of the highest energy cosmic rays found in the universe. In particular, when collisionless shocks form in the presence of a background magnetic field that is aligned with the plasma flow, the so-called quasi-parallel configuration, efficient particle acceleration has been measured in astronomical observations [Johlander ApJ 914 (2021)] and in numerical studies [Caprioli ApJ 783 (2014)]. Because of the collisionless behavior within these systems, shock mediation and subsequent particle acceleration must occur through the generation of, and interaction with, turbulent electromagnetic fields. Laser-based experiments provide a unique means to create relevant plasma conditions in the lab to study the microphysics associated with electromagnetic field generation relevant to quasi-parallel collisonless-shock formation. To this end, a new experimental platform has been developed and fielded at the Omega Laser Facility that utilizes asymmetric plasma flows, aligned with a background magnetic field. Ion streaming instabilities are allowed to grow and the resultant field structures are characterized with proton imaging. Analysis of this data has identified the non-resonant streaming instability as the dominant field-generation mechanism during the early stages of quasi-parallel-shock formation at high Alfvénic Mach numbers [Bolaños PRL (in review)]. Experimental and computational results will be shown and discussed.