Recent experimental and theoretical work [1] has demonstrated the formation of electrostatic shocks in laser heated near overdense plasma profiles with strong gradients. It was found that these shocks are launched due to strong electron heating in a density gradient, and that these structures can accelerate monoenergetic beams of ions. The physical mechanism for the electrostatic shock formation is associated with the interaction of two plasma slabs with different densities and temperatures. Sorasio et al. [2] developed a non-relativistic model which predicts the range of possible shock Mach numbers depending on the initial density and temperature ratios, showing that much higher Mach numbers can be generated than in the case of the classical limit $M \approx 3.1$ [3] for equal density and temperature ratios. A condition for reflection of ions off the shock front was developed, basing on the assumption that the electrostatic shock potential energy has to exceed the ion kinetic energy, and ions are accelerated with approximately two times the shock speed. We have generalized the work of Sorasio et al. [2] to the regime relevant for the relativistic conditions for intense laser plasma interactions and we show that the Mach number, at which ions are reflected, is decreased. With the knowledge of the counterstreaming upstream and downstream flow speeds, and the distribution functions for the electrons along the full shock profile, the condition for appearance of the Weibel instability can be calculated, both in the electron and ion flows, making it possible to determine the transition from electrostatic to an electromagnetic shock character.

References

