

On the Formation and Properties of Fluid Shocks and Collisionless Shock in Astrophysical Plasmas

A. Bret^{1,2}, A. Pe'er³

¹ *ETSI Industriales, Universidad de Castilla-La Mancha, 13071 Ciudad Real, Spain*

² *Instituto de Investigaciones Energéticas y Aplicaciones Industriales,
Campus Universitario de Ciudad Real, 13071 Ciudad Real, Spain*

³ *Department of Physics, University College Cork, Cork, Ireland*

When two cold plasmas collide, their interaction can be mediated by collisionless plasma instabilities or binary collisions between particles of each shell. By comparing the maximum growth rate of the collisionless instabilities with the collision frequency between particles of the shells, we determine the critical density separating the collisionless formation from the collisional formation of the resulting shock waves. This critical density is also the density beyond which the shock downstream is field free, as plasma instabilities do not have time to develop electromagnetic patterns.

We further determine the conditions on the shells initial density and velocity for the downstream to be collisional. If these quantities fulfill the determined conditions, the collisionality of the downstream also prevents the shock from accelerating particles or generating strong magnetic fields. We discuss the observational consequences in several astrophysical settings.