

The supersonic motion of a fluid around a blunt object leads to the formation of a shock wave standing in front of the object. In space the best known and widely studied example of such a shock wave is the Earth's bow shock in front of the magnetosphere. However, in interplanetary space the simple description of a shock wave is no longer valid: the medium is an ionized gas with several constituents, ions and electrons, and electromagnetic fields. Secondly, the mean free path for collisions between ions and electrons is so large that the medium can be considered collisionless. Using hydromagnetic theory it has been recognized very early that above some critical Mach number (flow speed in units of magnetosonic speed) resistivity alone is not sufficient any more in order to produce the necessary dissipation in the bow shock. Part of the incoming ions are reflected; these reflected ions provide an important portion of the dissipation required to satisfy the Rankine-Hugoniot conservation laws at the shock. As these ions propagate upstream they can excite hydromagnetic waves by ion/ion beam instabilities which in turn scatter the ions back to the shock. This eventually leads to the phenomenon that part of the solar wind ions are accelerated to high energies. Collisionless shocks have been studied by numerical simulations for more than 3 decades. These simulations employ either the hybrid formalism, where the ions are treated as particles and the electrons are a massless fluid, or the particle-in-cell (PIC) method which includes both ion and electron kinetic effects. We will discuss the advantages and limitations of both of these approaches and will compare results from simulations with recent in situ bow shock measurements.