Acceleration Efficency of High Energy Electrons in Oblique Shock Waves

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Collisionless Shock Waves are thought to be the origin of high energy particles in space and have been studied for many decades. However, our understanding of particle acceleration in shock waves is limited.

Fermi acceleration, which is well-known as a standard theory of shock particle acceleration process, assumes mildly relativistic particles for high acceleration efficiency. Therefore, a pre-acceleration mechanism is required in order to trigger the Fermi process. Furthermore, electrons are less likely to be accelerated by this process unless their Larmor radii are comparable to those of protons because of their small mass. This, so-called 'injection problem', is one of the most important problem of space and astropysics.

Recently, electron surfing acceleration process in high Mach number shocks has attracted attention as a possible solution to this problem. Two-stream instability (Buneman Instability; BI), which is caused by relative drift velocity between upstream electrons and reflected ions, has shown to produce large amplitude solitary wave structures at its nonlinear stage. Some electrons trapped in the potential structures, then feel the mortional electric field, and are accelerated along the shock surface. Time scale of this process is fast (the order of inverse electron gyrofrequency) compared to the Fermi acceleration process, therefore, this process is believed to play an important role in a high Mach number shock waves.

However, the electron acceleration efficiency, maximum energy and the physical process in oblique shock waves are not well understood. Therefore, in this report, we will discuss the structure of oblique, high Mach number shock waves and the acceleration efficiency. Recent particle simulation studies of relatively low Mach number shocks with a realistic mass ratio showed that modified two-stream instability (MTSI) is excited in the shock transition region, however, the relation between MTSI and BI in the high Mach number shock waves is still unclear. We will also discuss the difference between these two cases.