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Shock acceleration around Mercury orbit: from interplanetary shocks toward supernova shocks

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The origin of high energy particles seen radiating in astrophysical synchrotron sources is still a major unresolved problem of high-energy and plasma astrophysics. These sources include supernova remnants (SNRs) and extragalactic radio sources by jets etc. The shock acceleration has been discussed as one of important processes producing the high-energy particles, and there are many theoretical and observational efforts on the high-energy particle acceleration/heating so far.

From in situ measurements at the planetary shocks and at the interplanetary shocks, the energetic ions with a power-law spectrum has been observed, and they are believed to be produced by the diffusive shock acceleration. For the energetic electrons in the astrophysics context, the radio spectra of SNRs and the emission from active galactic outflow, for example, are believed to be produced by the shock acceleration, and much work has been concerned with the diffusive shock acceleration of electrons. However, the energetic electrons with a power-law spectrum at the interplanetary shocks and at the planetary bow shocks are rarely ever observed, and the diffusive-type acceleration seems to be malfunctioning in the Heliosphere. The electron nonthermal acceleration still remains an unresolved issue of considerable interest.

We would like to discuss that to get a better understanding of shock acceleration it is very important to explore the interplanetary shocks initiated by solar flare/CME around the Mercury orbit, because the interplanetary shocks may develop into a high Mach number shock with the Alfven Mach number Ma = 40 around 0.4 AU. The astrophysical shocks may have the lager Mach number of 100 or so, while the bow shocks/interplanetary shock around the Earth is limited to about Ma = 10. The interplanetary shock observations around the Mercury orbit may bridge the gap of our understanding between the very high Mach number astrophysical shocks and the low Mach number shocks around 1 AU.

In the presentation, we also discuss our recent theoretical results on the suprathermal electron acceleration mechanism in a high Mach number regime by using a particle-in-cell simulation. We find that shock surfing acceleration producing the suprathermal electrons occurs in the shock transition region where a series of large amplitude electrostatic solitary waves (ESWs) are excited by Buneman instability. Furthermore, some of these suprathermal electrons may be effectively accelerated up to the shock potential energy determined by the global shock size. Finally, we should like to make a point that it may be possible to explore many aspects of the high energy particle acceleration from in situ observations at the interplanetary shocks together with recent progress of the computer simulation study.