THE PHYSICS OF ACCELERATION AT SHOCKS AND OTHER COMPRESSIONS

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The acceleration of fast charged particles at shocks and more-gradual compressions has proved to be common and seems to be capable of accounting for the energetic particles and cosmic rays observed in a broad range of astrophysical sites, from the Sun and heliosphere to galaxies. The mechanism is most-commonly discussed in the context of ions at idealized, smooth, steady, parallel or quasi-parallel shocks. However, quasi-perpendicular shocks are more common than quasi-parallel, and the magnetic field and flow velocity in most, if not all, cases have significant random or fluctuating components. These all affect the acceleration significantly, sometimes in ways which are subtle and non-intuitive. In addition, electrons are observed and seem to be accelerated at the same time as the ions. The understanding of electron acceleration has remained less developed than that of ions.

The theory of particle acceleration at non-parallel shocks and compressions, including turbulent magnetic fields, will be discussed, and a new theory of the acceleration of electrons will be presented. Comparison with detailed *in situ* observations in the heliosphere, ranging from acceleration at co-rotating non-shock compressions and propagating shocks in the inner heliosphere to the recent observations of the two Voyager spacecraft at and beyond the solar-wind termination shock, will be discussed and compared with the theory.