MAR12-2011-000245

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

The Space Radiation Environment in Energetic Particles at the Earth

GARY ZANK, Center for Space Plasma and Aeronomic Research (CSPAR) and Physics Department, University of Alabama in Huntsville

Understanding the radiation environment in energetic particles at the Earth is critical to the stability, integrity, and longevity of satellite subsystems. The radiation environment comprises particles trapped in the Earth's radiation belts and magnetosphere, those generated by solar energetic particle events (SEPs), and galactic and anomalous cosmic rays. Of these different populations, the most highly variable, and consequently difficult to anticipate, is the SEP population. This is also the population that can often cause the most damaging effects. SEP events can be either impulsive or gradual (sometimes a mixture of the two) with the gradual events being larger, much longer lasting, and often with higher particle energies. Diffusive shock acceleration at a coronal mass ejection driven shock wave is generally invoked to explain gradual SEP events. The detailed [plasma] physics of the acceleration mechanism remains to be elucidated. We are fortunate in that very detailed observations of particle acceleration at shock waves, particularly in the guise of Space Weather, are providing considerable experimental insight into the basic physics of particle acceleration at a shock wave. Detailed interplanetary observations are not easily interpreted in terms of simple steady-state models of particle acceleration at shock waves. Three fundamental aspects make the interplanetary problem much more complicated than the typical astrophysical problem: the time dependence of the acceleration and the solar wind background; the geometry of the shock; and the long mean free path for particle transport away from the shock wave. An interplanetary shock is not steady, as it decelerates and expands into an expanding, temporal solar wind. Furthermore, the shock geometry varies from quasi-parallel to quasi-perpendicular along a shock front, and multiple shocks can be present simultaneously in the solar wind. Consequently, the shock itself introduces a multiplicity of time scales, ranging from shock propagation time scales to particle acceleration time scales at parallel and perpendicular shocks, and many of these time scales feed into other time scales (such as determining maximum particle energy scalings, escape time scales, etc.). We will discuss the basic physics of particle acceleration via scalings, their relationship to particle acceleration models, observations and geometry in both an astrophysical and space physics context. This will include discussing the physics of perpendicular and parallel shocks, upstream turbulence, particle spectra, and particle injection and the seed population. After acceleration of particles at an interplanetary shock, the transport of energetic particles is non-diffusive because of their large mean free path in the quiet solar wind. We will address the coupled acceleration and transport of heavy ions, Fe/O ratios, the variability among individual events, and seed particle populations. We will discuss theoretical models and address recent modeling efforts.