Interaction Between an Interplanetary Shock and a Magnetic Flux Rope

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Interplanetary (IP) shocks can accelerate particles and are associated with solar energetic particle and energetic storm particle events. As they propagate in the heliosphere, IP shocks can interact with structures in the solar wind and with magnetospheres. In this work we study an IP shock driven by a coronal mass ejection and show how the properties of the shock change when it interacts with a small-scale flux rope-like structure (FRLS). Data from Cluster, Wind, and ACE show that the spacecraft observed the shock-FRLS interaction at different stages of evolution. Wind and ACE observed the FRLS at shock crossing; Cluster observed the FRLS downstream, after it had crossed the shock. The shock-FRLS interaction changes shock geometry, affecting ion injection processes, energetic particles fluxes, and the upstream/downstream regions. While Wind and ACE observed a quasi-perpendicular shock, Cluster crossed a quasi-parallel shock and aforeshock with different ion distributions. The FRLS modified the shock on scales of at least ~ 10–20 RE. The complexity of the ion foreshock measured by Cluster is explained by the dynamics of the shock transitioning from quasi-perpendicular to quasi-parallel and the geometry of the magnetic field within the flux rope. Fluxes of particles with energy up to 125 keV are affected by the FRLS-shock interaction, modulating the associated energetic storm particle event. The interaction of a FRLS with an IP shock has not been discussed before using multispacecraft data. Interactions like this should occur often along shock fronts; hence, they are important for a better understanding of shock structure, evolution, and particle acceleration.