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Multispacecraft study of shock-flux rope interaction

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Interplanetary (IP) shocks can be driven in the solar wind by fast coronal mass ejections. These shocks can accelerate particles near the Sun and through the heliosphere, being associated to solar energetic particle (SEP) and energetic storm particle (ESP) events. IP shocks can interact with structures in the solar wind, and with planetary magnetospheres. In this study we show how the properties of an IP shock change when it interacts with a medium scale flux rope (FR) like structure. We use data measurements from CLUSTER, WIND and ACE. These three spacecraft observed the shock-FR interaction at different stages of its evolution. We find that the shock-FR interaction locally changes the shock geometry, affecting ion injection processes, and the upstream and downstream regions. While WIND and ACE observed a quasi-perpendicular shock, CLUSTER crossed a quasi-parallel shock and a foreshock with a variety of ion distributions. The complexity of the ion foreshock can be explained by the dynamics of the shock transitioning from quasi-perpendicular to quasi-parallel, and the geometry of the magnetic field around the flux rope. Interactions such as the one we discuss can occur often along the extended IP shock fronts, and hence their importance towards a better understanding of shock acceleration.