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High-Cadence EUV Imaging, Radio, and In-Situ Observations of Coronal and Interplanetary Shocks: Implications for Energetic Particle Acceleration

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We present a multi-spacecraft study of two recent solar eruption events in June 2010. Shock waves in the lower corona were directly detected in extreme ultraviolet imaging with the Atmospheric Imaging Assembly (AIA) instrument on board the Solar Dynamics Observatory (SDO) mission. The events occurred over two 20-minute intervals on two consecutive days - June 12 and 13, 2010. For the first time, coronal shock waves were imaged off-limb with an unprecedented 12-second cadence, making possible the analysis of those features' kinematics and morphology in the corona between 1.2 and 2 solar radii. We obtain initial velocities and accelerations for the two waves, and find excellent agreement with shock velocities estimated from concurrent metric type II burst observations. The evolution of the events in interplanetary space is followed using radio, in-situ plasma and particle observations from the STEREO, SOHO, and ACE spacecraft. Using multiple spacecraft allows us to obtain a more complete picture of the events' evolution and to reduce ambiguity in interpreting the observations. We compare the properties of the events from the remote and in-situ observations. Our analysis suggests that shock acceleration low in the corona may be responsible for the elevated energetic particle fluxes observed in both events. However, one event exhibits a blast wave-like form with no discernible driver in EUV images, while the other shows a clear CME-like driver. We attempt to reconcile the two types with the in-situ signatures we observe.