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A Classification Scheme for the Strongest Solar Particle Events: Can We Learn about the Carrington Event with Modern Data?

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The Carrington Event of 1859 is the classic extreme solar outburst. It arrived at Earth in
18 hours and caused strong geomagnetic effects including strong prolonged induced currents. On July 23, 2012 a probably comparable event occurred on the Sun but aimed at STEREO A, 120° away from the Earth- Sun line. The sudden pressure enhancement in the plasma arrives after 18 hours, like the Carrington event, and had the potential to cause large geomagnetic disturbances if it had encountered the Earth's magnetosphere. We compare these two events with other extreme pre-space age and space-age events and use the STEREO data to diagnose the physical processes of this modern event. The large events do not have a wide range of arrival times. Most arrive within about 18 hours with small variance. The strong space-age events appear to reach a streaming limit in the energetic particle flux that may limit the maximum flux until the compression front arrives. The compression front, which travels ahead of the magnetic ICME, is not always a fast shock but can sometimes be a slow shock. We interpret this as due to the energetic particles forming a very hot plasma that allows the 2000 km/s speed of the outflow to be subsonic. Strong plasma waves accompany the energetic particles that are capable of scattering the particles. These waves can be both right handed and left handed at different times during the solar particle event. The STEREO A data provide an excellent means of studying how these very high fluxes are accelerated and transported through interplanetary space.