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# Energetic Particle Acceleration and Transport: Interplanetary Coronal Mass Ejections and Shocks

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Solar Energetic Particles (SEPs) from suprathermal (few keV) up to relativistic ( $\sim$ few GeV) energies are accelerated at the Sun in association with solar flares and coronal mass ejection (CME)-driven shocks. In this review, we present important recent results of the study of Interplanetary CMEs and shocks in relation to energetic particle acceleration and transport, taking advantage of multi-point, multi-instrument observations available by a fleet of spacecraft in the heliosphere. The Solar Orbiter (SolO) and Parker Solar Probe (PSP) pioneering missions have been providing unprecedented measurements of energetic particles in the near-Sun environment. In particular, we present the properties of an Interplanetary CME-driven shock and its evolution with heliocentric distance, observed on September 5, 2022 by PSP at an unprecedentedly low heliocentric distance of 0.07 au, then reaching SolO which was radially well-aligned at 0.7 au. An overview of the characteristics of the energetic particle population at each spacecraft is also discussed in relation to magnetic and plasma structures and expectations from acceleration processes. Furthermore, we present the detailed analysis of the widespread SEP event on January 20, 2022, during which the measurements of the EPD experiment onboard SolO made the unusual observation that particles first arrived from the anti-Sun direction. i.e. streaming towards the Sun. The STEREO-A and MAVEN spacecraft also observed the event suggesting that particles spread over at least  $160^\circ$  in the heliosphere. The aim of the study is to show how SEPs are accelerated and transported to SolO and near-Earth spacecraft as well as the examination of the influence of a magnetic cloud present in the heliosphere at the time of the event onset on the propagation of the energetic particles. An overview of interesting observations made by multiple spacecraft in the heliosphere (e.g. PSP, BepiColombo, SolO, STEREO-A) during the widespread SEP event on February 15-16, 2022, one of the most intense SEP events observed so far in solar cycle 25 is also presented. Results from analyses of the corresponding Energetic Storm Particle (ESP) event ( $\sim 0.05 - 2$  MeV ions) as observed by the PSP ISOIS/EPI-Lo instrument on February 16, 2022 at 0.35 au from the Sun is also summarized and other unique observations of multi-spacecraft events.

## Contribution Type

### Theme

Energetic Phenomena

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