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Using Forbush decreases to derive the transit time of ICMEs propagating from 1 AU to Mars

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The propagation of 15 interplanetary coronal mass ejections (ICMEs) from Earth's orbit (1 AU) to Mars (∼1.5 AU) has been studied with their propagation speed estimated from both measurements and simulations.

The enhancement of magnetic fields related to ICMEs and their shock fronts cause the so-called Forbush decrease, which can be detected as a reduction of galactic cosmic ray (GCR) intensity measured on-ground or on a spacecraft. This effect can be used to detect the passage of ICMEs at various locations in the heliosphere, for example at Earth (using neutron monitors), the STEREO A and B spacecraft (HET) as well the on the surface of Mars using the Radiation Assessment Detector (RAD) instrument on the Mars Science Laboratory (MSL) rover.

A set of ICME events has been selected during the periods when Earth (or STEREO A or B) and Mars locations were nearly aligned on the same side of the Sun in the ecliptic plane (so-called opposition phase). Such lineups allow us to estimate the ICMEs' transit times between 1 and 1.5 AU by determining the time delay between the corresponding Forbush decreases measured at each location. We investigate the evolution of the ICME propagation speeds before and after passing Earth's orbit and find that their deceleration due to interaction with the ambient solar wind may continue beyond 1 AU. We also find a substantial variance of the speed evolution among different events revealing the dynamic and diverse nature of eruptive solar events. Furthermore, the results are compared to simulation data obtained from two CME propagation models, namely the Drag-Based Model and ENLIL plus cone model.