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Observational study of a geoeffective ‘stealth’ ICME from STEREO

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We propose a concept of ‘stealth’ Interplanetary Coronal Mass Ejection (ICME) in this paper, which type of ICME is only recognized by in-situ observation without corresponding clear halo or partial-halo coronal mass ejections (CMEs) from Large Angle and Spectrometric Coronagraph (LASCO) suite aboard the Solar and Heliospheric Observatory(SOHO). To understand the stealth ICMEs and their solar progenitor CMEs is crucial to improving current space weather forecasting, as a result of their unpredictable arrival time and geoeffectiveness, which may bring huge space weather disaster. This paper presents the first detail analysis of a geoeffective stealth ICME event and its related two narrow CMEs detected by coronagraph onboard the Solar TErrestrial RElations Observatory (STEREO) spacecraft. We apply Graduated Cylindrical Shell (GCS) model in multiple viewpoints to reconstruct the 3D geometry, propagating direction, velocity, and brightness of the two CMEs. For the two CMEs, there are two different reasons accounting for the 2D projection cannot be detected as halo or partial-halo CME in the FOV of SOHO LASCO. On account of its brightness lower than the spray light, CME1 is invisible in the FOV of SOHO LASCO C2. For CME2, because of small aspect ratio and half angle, most parts of it was obscured by occulter of SOHO LASCO C2. 2D projection of CME2 in the FOV of SOHO LASCO appears as a north narrow CME. Using the time-elongation map, as well as in situ observation and new velocity-modified cylindrical flux rope mode, we show that the two CMEs interact with each other in the heliosphere and impact Earth observed as two flux ropes. The size of two flux ropes is less than 0.1 AU, belonging to small sized interplanetary flux rope structures. These observations support the idea that the small-scale flux ropes are similar with magnetic clouds (big scale flux ropes) originating from small solar eruptions with narrow and weak CME. Finally, our result highlights the importance of the observation from satellite off the Sun-Earth line.