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Origin and Ion Charge State Evolution of Solar Wind Transients 4 – 7 August 2011

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Identification of transients and their origins on the Sun is one of the most important problems of the space weather forecasting. In our work, we present a case study of the complex event consisting of several solar wind transients detected by ACE on 4 – 7 August 2011, that caused a geomagnetic storm with Dst= - 110 nT. The supposed coronal sources – three flares and coronal mass ejections (CMEs) occurred on 2 – 4 August 2011 in the active region AR 11261. To investigate the solar origins and formation of these transients, we studied kinematic and thermodynamic properties of expanding coronal structures using the SDO/AIA EUV images and the differential emission measure (DEM) diagnostics. The Helioseismic and Magnetic Imager (HMI) magnetic field maps were used as the input data for the 3D numerical model to describe the flux rope ejection. We characterize the early phase of the flux rope ejection in the corona, where the usual three-component CME structure formed. The flux rope ejected with the speed about 200 km/s to the height of 0.25 Rsun. The kinematics of the modeled CME front well agrees with the STEREO EUV measurements. Using the results of the plasma diagnostics and MHD modeling, we calculated the ion charge ratios of carbon and oxygen as well as the mean charge state of iron ions of the 2 August 2011 CME taking into account the processes of heating, cooling, expansion, ionization and recombination of the moving plasma in the corona up to the freeze-in region. We estimated a probable heating rate of the CME plasma in the low corona by matching the calculated ion composition parameters of the CME with that measured in-situ parameters of the solar wind transients. We also consider the similarities and discrepancies between the results of the MHD simulation and the observation of the event. Our results show that analysis of the ion composition of CMEs enables to disclose a relationship between parameters of the solar wind transients and properties of their solar origins, which opens new possibilities to validate and improve the solar wind forecasting models.