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Investigating properties of Coronal Mass Ejections (CMEs) near the Sun using in-situ charge state distributions

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Coronal Mass Ejections (CMEs) are highly energetic eruptions that release massive amounts of solar material into the interplanetary medium. Previous work has shown CMEs undergo rapid heating as they are released from the Sun, however the energy mechanism remains an open question. To investigate the heating we have determined the thermal history of CME plasma from in-situ composition observations collected within the ejecta near the Earth. The ion distributions, unlike density or temperature, remain unaltered early along its propagation. This occurs as the expanding plasma reaches an altitude where the ionization and recombination processes stop as the collisional frequency rapidly decreases rendering the ionization level fixed. As a result, the ion distributions retain information of their thermodynamics history from below the freeze-in distance providing a method of probing plasma properties near the Sun.

We investigate a specific ICME event by using the Michigan Ionization Code (MIC) that simulates the evolution of these ions. We constrain the ejecta's thermodynamic history to match observed ion distributions of Carbon, Oxygen and Iron from the January 9th 2005 Interplanetary CME (ICME) measured by ACE/SWICS. Final results show that the ion distributions can be reconstructed using a combination of ions generated from four plasma structures traveling together. The derived plasma components resemble the main prominence core and surrounding prominence coronal transition region (PCTR) plasma, as well as a warmer structure possibly originating from the surrounding ambient corona. The electron density, temperature and velocity derived from our modeling results are used to compute energetics. We found that the energy deposited to the prominence plasma is consistently higher compared to all other components. In future work, we plan use our results to constrain the necessary plasma heating and evolution timescales for proposed heating mechanisms to assess their potential viability.