# ACE News #205 - Nov 12 2019
# Empirical Modeling of CME Composition Constrained to ACE/SWICS Charge State Distributions

This work reconstructed the plasma properties of a coronal mass ejection (CME) in the lower corona using heliospheric ion composition from the Solar Wind Ion Composition Spectrometer (SWICS) on ACE. The ions provide a unique window to the thermodynamic properties of the plasma at the Sun because they become invariant to changes in the plasma properties once the density is too low for ionization and recombination processes to occur (i.e. they 'freeze-in'). As a result, ions detected *in situ* are characterized by the heating and cooling experienced below the 'freeze-in' distance.

To derive the CME's thermal history, we simulated this so-called 'freeze-in' process for several ions collected within the ejecta of an Interplanetary CME (ICME), essentially linking the heliospheric event to its solar counterpart. Using the Michigan Ionization Code (MIC; see *Landi et al. 2012*), we simulated the ionization and recombination processes of ions in the plasma governed by the temperature, density, and velocity profiles describing the radial evolution of the CME.

Final profiles (Fig. 1, bottom) were determined by an extensive iterative search aimed at finding agreement between the simulated distributions and observations (see Figure 1, top). The observed distributions were reconstructed from ions formed within several plasma components (PCs).

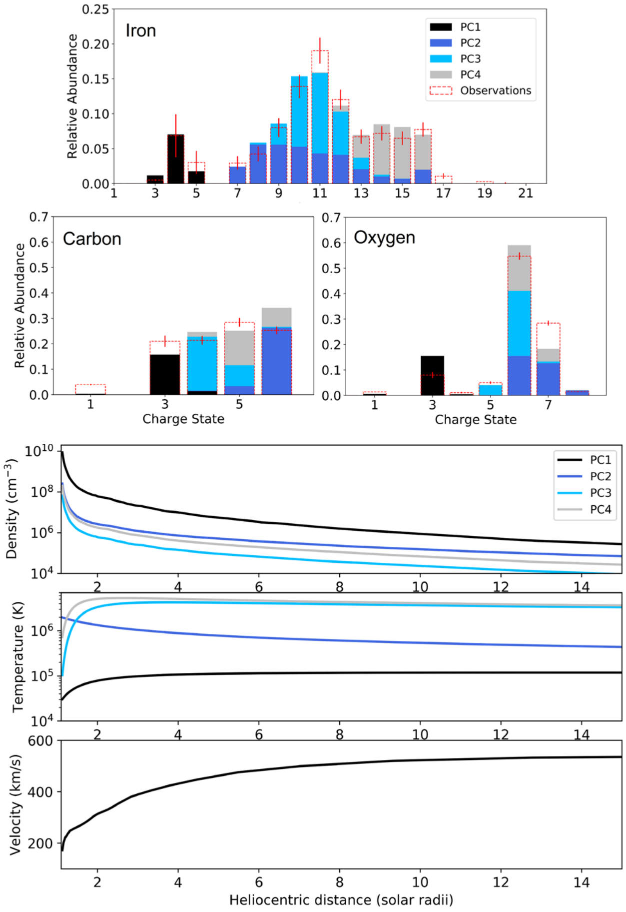

***Figure 1:*** *Top; charge state distribution within ICME, observations (dashed red) and simulated ions (solid colors). Bottom; plasma properties versus heliocentric distance.*

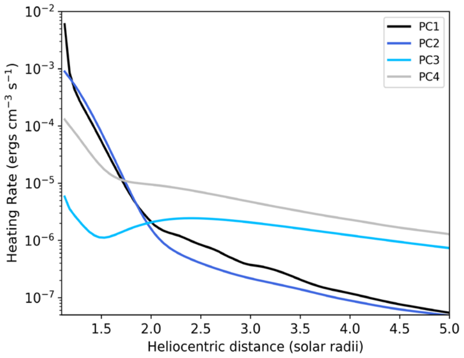

***Figure 2:*** *Plasma heating rates versus heliospheric distance.*

Each PC is described by a set of profiles (Fig. 1, bottom) whose properties suggest their associated ions originated from prominence (PC1), and coronal-like (PC2) plasma, along with the two distinct prominence-coronal transition region plasmas (PC3 & PC4) within the CME. Furthermore, the derived profiles were used to calculate the heating rate (Figure 2) and energy deposition (Figure 7 in *Rivera et al. 2019*) for the event. The heating rate is a sum of the magnitude of the thermal energy, thermal conduction cooling, adiabatic cooling, and radiative cooling rates. We find varied heating rates throughout each PC's evolution suggesting non-uniform heating and a complex transport of energy within the CME.

In future work, our derived energy results will provide constraints to the timescale over which energy is injected into the system. This is fundamental to investigating the mechanism(s) responsible in transforming magnetic energy to the different energy sources that power the eruption.

Please address questions and comments to Yeimy Rivera (email: yrivera@umich.edu). Further details and references can be found in Y.J. Rivera, E. Landi, S.T. Lepri, and J.A. Gilbert, ApJ 874, 164, 2019. See ACE News Archives for earlier ACE News items.