Atomic Data Needs For Understanding Elemental and Isotopic Fractionation in the Solar Wind and Corona

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Abstract. The solar composition is now known to vary with location on the sun. The corona was first observed in 1963 to exhibit what has now become known as the "FIP Effect". Elements with First Ionization Potential (FIP) less than about 10 eV are enhanced in their abundance relative to hydrogen by a factor of 3-4, relative to values in the solar photosphere. These low FIP elements include Fe, Si, Mg. Modern observations indicate that similar abundance anomalies apply in the corona and slow speed solar wind. High FIP elements are relatively less affected, but He and possibly Ne exhibit abundance depletions from their photospheric values. These fractionations are best explained within the context of a model where Alfvén waves generated within coronal loops interact with chromospheric ions, but not neutrals, through the ponderomotive force. This arises as the Alfvén waves reflect from loop footpoints to remain trapped in the coronal loop. The fractionation is thus reduced in open field structures such as coronal holes and the high speed solar wind emanating from them, in agreement with observations.

More recently, the Genesis mission has revealed isotopic fractionation between the fast and slow speed solar winds. Lighter isotopes of the same elements are relatively more abundant in the slow speed wind than in the fast wind. The simplest application of the ponderomotive force model, assuming chromospheric ionization balance independent of isotope, predicts isotopic fractionations of about the right magnitude but of the wrong sign. Lighter isotopes need to be relatively more ionized in the chromosphere for such fractionation to be explained by the ponderomotive force.

We will discuss the role that charge exchange reactions play in establishing the elemental charge states in the chromospheric, with reference to both FIP and isotopic fractionation. Reduced mass corrections between isotopes may lead to variation of the ionization balance, and allow us to speculate on whether the ponderomotive force can explain all fractionations, or whether different physics is required.