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High-order multi-fluid 1D modeling of the solar atmosphere: in-depth look at heavy element abundances

We investigate several mechanisms that may produce abundance variations in the solar atmosphere, called as the First Ionization Potential (FIP) effect. We develop and exploit a multi-specie 1-D model of the solar atmosphere (called IRAP's Solar Atmospheric Model: ISAM) that solves, along a given magnetic field line, the transport of neutrals, electrons and charged particles from the chromosphere to the corona. We follow a high-order approach that allows to solve additional coupled transport equations for the heat flux, and that includes both friction and thermal diffusion effects self-consistently. Thanks to a comprehensive treatment of collisions, we can analyse in detail the collisional coupling of heavy elements to e.g. protons. While the model can be applied to both closed and open magnetic configurations, we focus here primarily on the composition of active region coronal loops. We found that depending of the nature of the interaction with protons, a fractionation between low and high FIP elements settles rapidly in the upper chromosphere up to the typical observed levels. However under constant heating conditions we observed that this fractionation can take much longer to stabilise at the loop top (e.g. up to ~1 day for Iron), and hence also depends on the history of the loop. This study shows the importance of such high-order modelling to better understand abundance diagnostics and how they are connected to plasma heating. This work has been funded by the European Research Council (grant DLV-819189) and the Research Council of Norway (grant 324523).

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