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Ion Distributions and ENA Production at the Heliospheric Termination Shock: Theory and Simulations

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The Interstellar Boundary Explorer IBEX provided several sets of Energetic Neutral Atom (ENA) sky maps in the energy range 0.1-6keV/n. These maps show the "Ribbon", a very prominent and unexpected feature in the sky but also a distributed flux from almost all directions. The physical processes that may lead to the Ribbon generation and the distributed ENA flux are currently under intensive investigation. Since ENAs originate from charge exchange of interstellar neutrals with energetic ions, ion-kinetic processes are very important. It is currently not known where the ENA source is located and if it is spatially widespread in the heliosheath, or even beyond, or relatively localized, the termination shock (TS).
The shape and the evolution of the ion distributions in phase space are specific for regions in the heliosphere and beyond. Depending on the shock strength and composition, the spatial/temporal evolution of the energy spectrum slope and the phase space distribution are indicators of the source location at/behind the shock. Hence, the efficiency of ENA production depends on the charge exchange rate and the phase space density of the ions. The ENA distributions/spectrum observed by IBEX at Earth's orbit provide information on the location of the source region where the Ribbon and distributed ENAs are produced and their variability. Using hybrid simulations, which self-consistently include ion dynamics and theoretical considerations, it is possible to relate the measured ENA flux to the source ion distributions. We performed hybrid simulations using different shock normal angles that are characteristic for specific regions at the TS, and investigated the spatial/temporal evolution of the solar wind, pickup ion, and ENA distributions under the impact of self-generated turbulence. The simulation results show that the TS could be a significant source for ENAs, which would allow relatively fast ENA flux variations as observed preferentially in the Ribbon feature.