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Spectral Properties of Energetic Neutral Atoms Measured by the Interstellar Boundary Explorer (IBEX) Along the Lines-of-Sight of Voyager

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Energetic Neutral Atoms (ENAs) observed by the Interstellar Boundary Explorer (IBEX) provide powerful diagnostics about the origin of the progenitor ion populations and the physical mechanisms responsible for their production. Here we survey the fluxes, energy spectra, and energy-dependence of the spectral indices of ∼0.03-6 keV ENAs measured by IBEX-Hi and IBEX-Lo along the lines-of-sight of Voyager 1 and 2. We compare the ENA spectra observed at IBEX with predictions of models that simulate the microphysics of the heliospheric termination shock to predict the shape and relative contributions of a variety of heliosheath ion populations. We show: (1) The ENA spectra between ∼0.7-6 keV do not exhibit sharp cut-offs at ∼twice the solar wind speed as is typically observed for shell-like PUI distributions in the heliosphere and are reasonably well accounted for by most of the models. (2) The 0.03-0.7 keV ENA intensities are larger by more than an order of magnitude compared with most existing models that do not include contributions from ENAs generated in the outer heliosheath. We conclude that the 0.7-5 keV ENAs at IBEX are generated by inner heliosheath PUIs in the ∼0.5-5 keV energy range that are transmitted through the termination shock; the PUI population being a superposition of Maxwellian or kappa distributions and partially filled shell distributions in velocity space. In contrast, the parent PUI proton population for the <0.7 keV ENAs observed at IBEX most likely originates in the outer heliosheath and is substantially hotter compared with the thermal plasma component. In this paper, we explore the physical processes that could contribute to the origin of the different proton populations that are likely to be present in the heliosheath.