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Filtration and Scattering of Interstellar Neutral Helium beyond the Heliopause

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The pristine very local interstellar medium (VLISM) is not available for in situ observations even with the Voyager spacecraft because the influence of the heliosphere on the VLISM plasma extends up to several hundred au from the Sun. Therefore, observations of interstellar neutral (ISN) helium, the species least modified at the heliospheric boundaries, are used to determine the pristine VLISM flow speed, direction, and temperature. For more than one solar cycle, the Interstellar Boundary Explorer (IBEX) has sampled ISN helium atoms at 1 au, significantly reducing the statistical uncertainties of the ISN helium flow parameters. Launching in 2025, the Interstellar Mapping and Acceleration Probe (IMAP) will further lower these uncertainties thanks to the utilization of a pivot platform, which provides a range of viewing orientations and reduces the parameter degeneracy seen from IBEX data. Even though interstellar helium is the least modified ISN species, recent studies show that the ISN helium flux is affected by charge exchange and elastic collisions beyond the heliopause. Charge exchange collisions outside the heliopause filter the primary ISN helium and produce a secondary population from perturbed He^+ ions in the interstellar plasma. The secondary helium population, originally called the Warm Breeze, was discovered from IBEX observations. Moreover, the distribution function of the primary ISN helium population is modified by elastic collisions with slowed down and heated plasma ahead of the heliopause. Consequently, the combined primary and secondary ISN helium populations at 1 au are complex and cannot be separated. Furthermore, the modifications of the population properties are larger than the statistical uncertainty of IBEX observations. We use global heliosphere models to estimate the magnitude of the filtration and scattering caused by charge exchange and elastic collisions. Together with other sources of information about the VLISM, these estimates allow us to assess the pristine VLISM conditions outside of heliosphere influences.