The impact of pickup ion thermal spread on pickup ion ring-beam-driven instabilities and scattering in the outer heliosheath

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Abstract

The present study investigates the unstable waves driven by ring-beam pickup ions in the outer heliosheath under varying pickup angles and parallel thermal spreads using both linear instability analysis and hybrid simulations. While previous papers have generally assumed specific pickup ion thermal spreads, this study takes a more comprehensive approach by examining a wide range of thermal spreads that may occur in the outer heliosheath. Our one-dimensional simulations demonstrate that regardless of the initial pickup ion parallel temperature, the pitch angle scattering of the pickup ions at small pickup angles saturates before they can reach the hemisphere of negative parallel velocities with respect to the background magnetic field in velocity space, while at near 90° pickup angles, pickup ions of ring distributions attain a significant level of isotropy. In contrast, the two-dimensional simulation results show that at all pickup angles, increasing the pickup ion temperature only reduces the pickup ion scattering rate, but it does not prevent the pickup ions from reaching the hemisphere of negative parallel velocities. Overall, the results do not align with the requirements of earlier proposed scenarios regarding the secondary ENA mechanism of the IBEX ENA Ribbon, which demand either weak pickup ion scattering in the outer heliosheath or at least incomplete pickup ion scattering in the off-ribbon directions.

Keywords— instabilities, solar wind, ISM, pickup ions