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## Fully Kinetic Simulations of Proton-Beam-Driven Instabilities from Parker Solar Probe Observations

The expanding solar wind plasma ubiquitously exhibits anisotropic non-thermal particle velocity distributions. Typically, proton Velocity Distribution Functions (VDFs) show the presence of a core and a field-aligned beam. Novel observations made by Parker Solar Probe (PSP) in the innermost heliosphere have revealed new complex features in the proton VDFs, namely anisotropic beams that sometimes experience perpendicular diffusion. This phenomenon gives rise to VDFs that resemble a “hammerhead”. In this study, we use a 2.5D fully kinetic simulation to investigate the stability of proton VDFs with anisotropic beams observed by PSP. Our setup consists of a core and an anisotropic beam populations that drift with respect to each other. This configuration triggers a proton-beam instability from which nearly parallel fast magnetosonic modes develop. Our results demonstrate that before this instability reaches saturation, the waves resonantly interact with the beam protons, causing significant perpendicular heating at the expense of the parallel temperature. Furthermore, the proton perpendicular heating induces a hammerhead-like shape in the resulting VDF. Our results suggest that this mechanism may contribute to producing the observed hammerhead distributions.

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