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Unstable whistlers and Bernstein waves within the front of supercritical perpendicular shocks

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In supercritical shocks a significant fraction of ions is reflected at the steep shock ramp and carries a considerable amount of energy. The existence of reflected ions enables streaming instabilities to develop which are excited by the relative drifts between the populations of incoming ions, reflected ions, and electrons. The processes are fundamental to the transformation of directed kinetic energy into thermal energy, a tenet of shock physics. We model the particle distributions as a broad electron population and two ion populations, namely a core and a beam (representing the reflected ions) in order to investigate the kinetic instabilities possible under various wave propagation angles. Recently, assuming the ion beam is directed along the shock normal at 90° to the magnetic field B_o, we analyzed the linear dispersion properties by computing the full electromagnetic dielectric tensor *[Muschietti and Lembege, AGU Fall meeting 2015]*. Three types of waves were shown to be unstable: (1) Oblique whistlers with wavelengths about the ion inertia length which propagate toward upstream at angles about 50° to the magnetic field. Frequencies are a few times the lower-hybrid. The waves share many similarities to the obliquely propagating whistlers measured in detail by Polar *[Hull et al., JGR 117, 2012]*. (2) Quasi-perpendicular whistlers with wavelength covering a fraction of the electron inertia length which propagate toward downstream at angles larger than 80° to B_o. Frequencies are close to the lower-hybrid. (3) Bernstein waves with wavelengths close to the electron gyroradius which propagate toward upstream at angles within 5° of perpendicular to the magnetic field. Frequencies are close to the electron cyclotron. The waves have similarities to those reported by Wind and Stereo *[Breneman et al., JGR 118, 2013; Wilson et al., JGR 115, 2010]*.

We will present electromagnetic 1D3V PIC simulations with predetermined propagation angles which illustrate the three types of waves. Power spectra, waveforms, polarizations, and hodograms are shown and discussed in light of the dispersion results. Phase spaces of each population are examined to evidence energy transfer and particle acceleration.