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Dimensionality effects in simulations of collisionless perpendicular shocks

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Global hybrid simulations often have to be performed in a reduced dimensionality (2D instead of 3D) because of computational constraints. We show that, depending on the magnetic field orientation, this can have important implications for the behaviour of perpendicular shocks and their downstream regions. Two dimensional hybrid simulations of perpendicular, supercritical collisionless shocks are carried out in a geometry with the magnetic field perpendicular to the simulation plane so that parallel propagating fluctuations, such as Alfven ion cyclotron waves, are suppressed. In terms of average profile and large downstream ion temperature anisotropy, the results resemble those from earlier one-dimensional hybrid simulations, and differ markedly from results of two-dimensional simulations where field-parallel propagating fluctuations are included. One effect is that the shock propagation speed is higher in the former case. In addition, for the B-out-of-plane case, we find an instability, in which a pattern of magnetic field and density enhancements propagates along the shock surface in the direction of gyration and at the average speed of the ions reflected at the shock. The instability mechanism depends on a spatio-temporal modulation of the fraction of reflected ions over the shock surface. In a realistic three dimensional planar shock, this instability will be only one of several mechanisms contributing to shock front nonstationarity.