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The kinetic structure of slow shocks and reconnection exhausts

Y.H. LIU, J. DRAKE, M. SWISDAK, University of Maryland — Ion heating by Petschek reconnection associated slow shocks is one of the potential heating mechanisms for solar flares and the solar wind (ie., Tsuneta 1995). But, the structure of these shocks in a collisionless plasma is still an open question. Therefore a detail study of the kinetic structure of the reconnection exhaust and how ions/electrons are accelerated is necessary. Instead of performing a complete particle-in-cell reconnection simulation, whose simulation domain is strictly limited by the available computational power, a nearly 1-D Riemann problem is designed to study the nonlinear wave propagation of exhaust down to several hundreds ion inertial lengths from reconnection site, with an extension of nearly 500 ion inertial lengths. To our surprise, we find a critical temperature anisotropy (ie., $1-(P_{\|}-P_{\perp})/\mu_0 B^2)$)= 0.25 around the sharp front of downstream rotational waves of collisionless slow shocks at various oblique propagation angles. An explanation is proposed by looking into the anisotropic fluid theory, in particularly the anisotropic Derivative Nonlinear-Schrodinger-Burgers equation, with an intuitive model of an energy closure for a oblique shock with a fair amount of back-streaming ions that escape from the shock downstream region. The importance of the anisotropy value 0.25 (independent of plasma beta and propagation angle with respect to the magnetic field) is recognized as being the degeneracy point of slow and intermediate modes. At very oblique propagating angles (ie., $\theta_{BN} \gtrsim 80°$), a firehose-like instability develops in the downstream region, which might link to the proton temperature anisotropy distribution in the solar wind (ie., S. D. Bale et. al 2009).

Yi-Hsin Liu
University of Maryland

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