Analysis of 3D reconnection heating in the solar corona via gyrokinetic simulations

S.-W. Tsao[1], M.J. Pueschel[2,3], A. Tenerani[1], and D.R. Hatch[1]

[1]University of Texas at Austin, Austin, Texas 78712, USA
[2]Dutch Institute for Fundamental Energy Research, 5612AJ Eindhoven, Netherlands
[3]Eindhoven University of Technology, 5600MB Eindhoven, Netherlands

The coronal heating problem, where the plasma temperature in the solar atmosphere is two orders of magnitude higher than at the surface of the sun, is not thoroughly understood. Reconnection turbulence, which is driven by tearing modes similar to those present in fusion devices, is a promising candidate mechanism for the coronal heating problem. To describe this process quantitatively requires a computationally expensive kinetic treatment, which is made possible here through gyrokinetics. Simulations with artificially high normalized plasma β and reduced mass ratio have shown that the heating rate extrapolates to the observed solar corona heating rate. Here, we use hydrogen mass ratio and realistic β to verify these extrapolations with nonlinear Gene simulations.

Furthermore, the present effort uses a 3D geometry modeling a coronal loop, namely, a half-torus with frozen-in flux conditions at the parallel boundary. With realistic β and hydrogen mass ratio, linear studies show a mismatch of reconnection rates between the 3D half-torus and the 2D slab. The curvature and ∇B drifts are scaled in the 3D half-torus simulations showing that they cause the observed stabilization in the 3D system. The reconnection rates in these geometries are $\gamma_{\mathrm{3D,circular}} < \gamma_{\mathrm{2D}} < \gamma_{\mathrm{3D,slab}}$. Thus, while curvature stabilizes reconnection, parallel structure can enhance it. Linear analysis of the effect of the field-line twist q, magnetic trapping, and the relaxation of the frozen-in flux conditions are presented. Preliminary results of a nonlinear simulation of the full system are discussed.