Final Technical Report on Award DE-SC0016106
Center for Extended Magnetohydrodynamic Modeling
Alan H. Glasser, Fusion Theory and Computation, Inc.
February 2, 2018

This is the final technical report for my portion of the multi-institutional CEMM project. My report is centered around 3 publications and a seminar presentation, which I have submitted to E-Link.

The role of my work is described in Section 3.5 of the proposal, "Disruption Prediction with Resistive DCON and Beyond". The rest of the\at proposal is primarily about the NIMROD and M3D nonlinear simulation codes. My contribution has been to supplement that work with much faster semi-analytical methods for verification of the other codes.

The first publication is A. H. Glasser, "The direct criterion of Newcomb for the ideal MHD stability of an axisymmetric toroidal plasma," Phys. Plasmas **23**, 072505 (2016), doi: 10.1063/1.4958328. It presents a novel, fast, accurate method for determining the ideal MHD stability of an axisymmetric toroidal plasma, such as a tokamak. The method is incorporated in a widely-used Fortran code DCON.

The second publication is A. H. Glasser, Z. R. Wang, and J.-K. Park, "Computation of resistive instabilities by matched asymptotic expansions," Phys. Plasmas 23, 112506 (2016), doi: 10.1063/1.49678762. It describes an extension of the DCON code to resistive instabilities, in which the plasma is treated as slightly resistive, rather than ideal, or perfectly conducting. In ideal MHD, the fluid velocity and the magnetic field are locked together. Introduction of a small amount of resistivity relaxes this constraint and introduces a new class of instabilities, such as tearing modes, whichare very important in tokamaks. While this work has been published, work continues on verification and validation. Continuation is being pursued under contract DE-SC0016201.

The third report is Alexander Glasser, Egemen Kolemen, and A. H. Glasser, "Fast Numerical Solution of the Plasma Response Matrix for Real-time Ideal MHD Control," accepted for publication in Physics of Plasmas. This paper describes alternative formulations of the DCON equations and implementation on a shared-memory parallel computer. Parallelization speeds up the code sufficiently to be used for real-time feedback control of ITER profile evolution to avoid the onset of instabilities.

The fourth report, Alan H. Glasser and Jong-Kyu Park, "DCON for Stellarators," is a PowerPoint seminar presentation given at the Institute for Fusion Studies at the University of Texas. It describes ongoing work adapting the ideal DCON code to nonaxisymmetric toroidal plasmas, such as stellarators. Earlier versions of this presentation were given at the 2017 Sherwood Theory Conference and at Princeton Plasma Physics Laboratory. An interface has been developed to the VMEC stellarator equilibrium code, developed at Oak Ridge National Laboratory by S. Hirshman et al. The required equilibrium data are extracted from a solution data file and used to construct the computational objects required by the DCON stability approach. Because stellarators are nonaxisymmetric, they have a broader range of Fourier components than tokamaks, which makes the numerical method of integration used for tokamaks impractical. Alexander Glasser, a grad student at PPPL, is exploring a new technique involve the QR representation of the solution matrix to accelerate execution.

I am collaborating with Ryan Lee White, a postdoc at the MIT Plasma Science and Fusion Center, funded by a DOE Fellowship, to extend the dynamics of the resistive DCON treatment to include more realistic physical effects.