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Simulation of MHD Instabilities with Runaway Electron Current using M3D-C1

Runaway electrons can be generated in a tokamak during the start up, during normal operation and during a plasma disruption. During a disruption, runaway electrons can be accelerated to high energies, potentially damaging the first wall. To predict the consequences of runaway generation during a disruption, it is necessary to consider resonant interactions of runaways with the bulk plasma. Here we consider the interactions of runaways on low mode-number tearing modes, the nonlinear effect of runaways on low beta sawteeth and the runaway current generation during disruption. For this study, we have developed a fluid runaway electron model for the 3D MHD code M3D-C1[Jardin et al., Comput. Sci. Discovery 5, 014002 (2012)]. The code employs high-order C1 continuous finite elements in 3 dimensions. It can be switched into reduced MHD or full MHD, linear or non-linear, cylindrical or toroidal geometry. The code allows localized mesh adaptation around certain rational surfaces so that it can better resolve the near-singular behavior of the runaway electron current in the inner layer region. We have reproduced the reduced-MHD linear tearing mode results (with runaway electrons) in a circular cylinder presented in previous studies [Matsuyama et al., Nucl. Fusion (2017)]. This work is also extended to full MHD. We also have carried out the result of nonlinear low-beta sawteeth with runaways and the runaway current generation during disruption using DIII-D parameters. This work is supported by US DOE grant DE-AC02-09CH11466.and the SciDAC SCREAM and CTTS centers.

Member State or International Organization

United States of America

Affiliation

PPPL

Primary author: ZHAO, Chen (PPPL)

Co-authors: LIU, Chang (PPPL); JARDIN, Stephen (PPPL); FERRARO, Nathaniel (PPPL)

Presenter: ZHAO, Chen (PPPL)

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