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Feasibility of kinetic stability analysis in time-dependent simulations and applications for predictions and design of controlled plasma discharges

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An interface for kinetic stability analysis has been implemented in TRANSP, motivated by recent advances in the calculation of fast ion transport induced by MHD and Alfvénic Eigenmodes [1] in time-dependent simulations and by the need for predicting accurate evolution of fast ion pressure profiles for the interpretation, prediction and design of controlled plasma discharges. Similar efforts are ongoing in the ITER IMAS framework [2].
As a proof-of-concept, the new interface has been coupled with the FAR3d code [3], which is capable of both initial-value and eigensolver calculations using a Gyro-Landau closure model to identify unstable Alfvén eigenmodes in tokamaks and stellarators. Preliminary results will be presented and discussed at this meeting for a well analyzed discharge on DIII-D [4,5] and for a JET deuterium discharge that has been converted to an equivalent DT discharge for predictive studies [6]. The time-dependent simulations will focus on the calculation of stability for an entire discharge to produce a synthetic spectrum of Alfvén eigenmodes for a user-selected range of toroidal mode numbers and frequencies. The results from the time dependent simulation will be compared with time slice analysis for the DIII-D case, in which unstable modes were experimentally observed [4,5]. The comparison makes it possible to assess the uncertainties when kinetic stability analysis is performed at each time step for which the equilibrium is calculated, without direct supervision by the user. Applications for predictive simulations for the design of dedicated experiments targeted to steady state exploration and stability control will also be discussed.

[1] M. Podestà et al., Plasma Phys. Control. Fusion 59, 095008 (2017)
[2] V. A.Popa, TUM Munich 2020 and ITER-IMAS project
[3] D. A. Spong, Nucl. Fusion 53, 053008 (2013); J. Varela et al., Nucl. Fusion 57 (2017) 046018
[4] C. Collins et al, phys. Rev. letters 116, 095001 (2016)
[5] S. Taimourzadeh et al, Nucl. Fusion 59 (2019) 066006
[6] M. Podestà et al., Extension of the energetic particle transport "kick model" in TRANSP to multiple fast ion species, to be submitted to PPCF

Speaker's Affiliation

Princeton Plasma Physics Laboratory, Princeton NJ

Member State or IGO

United States of America

Author: POLI, Francesca (PPPL)

Co-authors: BRESLAU, Joshua (Princeton Plasma Physics Laboratory); SPONG, Donald (Oak Ridge National Laboratory); PODESTA, Mario (Princeton Plasma Physics Laboratory); TEPLUKHINA, Anna (Princeton Plasma Physics Laboratory); VARELA RODRIGUEZ, Jacobo (Universidad Carlos III de Madrid); GARCIA, Luis (Universidad Carlos III de Madrid); Dr GHAI, Yashika (Oak Ridge National Laboratory); AND JET CONTRIBUTORS

Presenter: POLI, Francesca (PPPL)

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