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Investigation of the Various Damping Channels of TAEs applied to Spherical Tokamaks

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Supra-thermal Energetic Particles (EPs) can be found in a burning tokamak plasma due to external heating methods such as Neutral Beam Injection and fusion reactions. EPs travelling at velocities close to the Alfvén speed can interact at resonance with various discrete Alfvén Eigenmodes which appear in the frequency gaps of the shear Alfvén continuum. Toroidal Alfvén Eigenmodes (TAE) are created when two counter-propagating Alfvén waves are coupled due to the poloidally-varying magnetic field strength and may impact on plasma performance Through resonant wave-particle interactions, EPs can drive TAEs unstable in a tokamak plasma, leading to anomalous EP transport or even direct expulsion of EPs to the first wall. The stability of a TAE is dependent on the competition between EP drive and the various parameter-dependent damping mechanisms.

The global gyro-kinetic code ORB5 has been used to investigate the damping of TAEs. The instability has been simulated using a simple circular geometry and compared against (i) analytical theory (with good agreement found), and (ii) against the local version of the GENE code for one case. Additionally, a diagnostic developed for ORB5 has been used to determine the energy transfer for each species and to differentiate between damping due to drifts and parallel-streaming to allow each damping channel to be studied individually.
ORB5 has also been applied to study Alfvén Eigenmodes in spherical tokamak devices. Simulations have been run to match specific MAST-U shots using experimental data obtained in the most recent campaign, with the aim of developing a predictive capability for the excitation of these modes. Spherical tokamaks are associated with high beta and large inverse aspect ratio, two parameters which are believed to significantly modify the drive and damping of TAEs found in conventional tokamaks.

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