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Design High-Performance MHD-Stable Non-Inductive Plasma Scenarios and Optimize Toroidal and Poloidal Field Coils using FREDA WDM Framework

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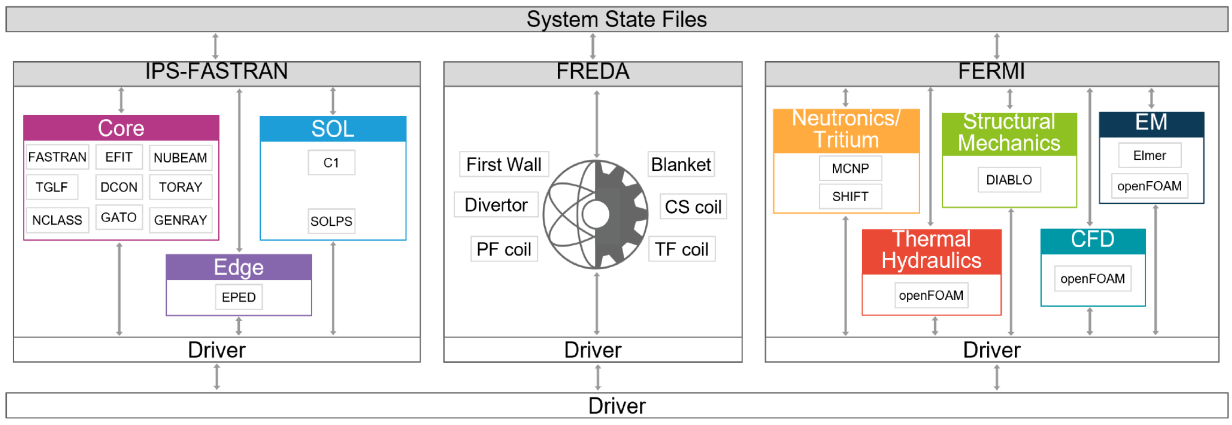
Fusion reactor design and assessment (FREDA) is a multi-fidelity integrated physics and engineering tool aimed for fusion reactor design, assessment, and optimization [1]. FREDA consists of multiple subsystems, as shown in the figure below, that implement several physics and engineering tasks in independent or integrated workflows. The FREDA WDM framework has been used to re-assess and optimize the PF and TF coils and to design MHD stable non-inductive plasma scenarios of high fusion and net electric gains while maintaining high bootstrap current fraction, and low radiated power from the core using various configurations of H&CD techniques in the Fusion National Science Facility (FNSF) and Compact Advanced Tokamak (CAT). A set of 0-D models FREDA's TokDesigner subsystem is used to construct a dataset of fusion reactor designs that have been mined for an optimum design that fulfills the basic plasma physics and engineering requirements [2]. Afterward, the minimization of electromechanical stresses on the toroidal field (TF) and poloidal field (PF) coils by optimizing their sizes, structures, and locations have been implemented using 0-D models and multi-fidelity modeling techniques [3]. Thereafter, the IPS-FASTRAN workflow builds on the MHD equilibrium obtained from TokDesigner to achieve a high-performance, non-inductive, MHD stable core plasma of high fusion and net power gains using various plasma heating and current drive (H&CD) techniques. This has been implemented while the plasma dynamics at the tokamak edge (pedestal + SOL) have been utilized to set the boundary for the core plasma [4,5]. Finally, the particle and heat fluxes from various core and pedestal micro-instabilities are estimated using a combination of multi-fidelity gyrokinetic models [6,7]. Once the physics studies have been completed and an optimum scenario for a confined plasma have been achieved, the engineering studies and optimization kicks-in using the FERMI subsystem which is out of the scope of current work. While each workflow implements its optimization independently, FREDA aims to achieve an overall optimization for the integrated physics and engineering components which is a work in progress.



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