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Hybrid Integral-Differential Simulator of EM Force Interactions / Scenario-Assessment Tool with Pre-Computed Influence Matrix in Applications to ITER

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A necessity to address a wide spectrum of engineering problems in ITER determined the need of efficient tools for modeling of the magnetic environment and force interactions between main components of the magnet system. The assessment of the operating window for the machine, determined by the electro-magnetic (EM) forces, and the check of feasibility of particular scenarios play an important role for ensuring the safety of exploitation. Such analysis-powered prevention of damages forms an element of the Machine Operations and Investments Protections strategy. The corresponding analysis is a necessary step in preparation to the commissioning, which finalizes the Construction phase. It shall be supported by the development of the efficient and robust simulators and multi-physics/multi-system integration of models. The developed numerical model of interactions in the ITER magnetic system, based on the use of pre-computed influence matrices, facilitated immediate and complete assessment and systematic specification of EM loads on magnets in all foreseen operating regimes, their maximum values, envelopes and the most critical scenarios. The common principles of interaction in typical bilateral configurations have been generalized for asymmetry conditions, inspired by the plasma and by the hardware, including asymmetric plasma event and magnetic system fault cases. The specification of loads is supported by the technology of functional approximation of nodal and distributed data by continuous patterns / analytical interpolants. The global model of interactions together with the “meshless” analytical format of output provides the source of self-consistent and transferable data on spatial distribution of the system of forces for assessments of structural performance of the components, assemblies and supporting structures. The used numerical model is fully parametrized, which makes it well suitable for multi-variant and sensitivity studies (positioning, off-normal events, asymmetry, etc.). The obtained results and matrices form a basis for a relatively simple and robust force processor as a specialized module of a global simulator for diagnostic, operational instrumentation, monitoring and control, as well as a scenario assessment tool. The paper gives an overview of the model, applied technique, assessed problems and obtained qualitative and quantitative results.

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