Fast electromagnetic analyses in fusion devices by complementary formulations

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Disruptions represent one of the main concerns for Tokamak operation, especially in view of fusion reactors or experimental test reactors under design (ITER, JT60-SA). Generally, rapid growth of global magneto-hydro-dynamic (MHD) instabilities (either resistive or ideal) leads to so-called *major disruptions*. On the other hand, highly elongated Tokamak plasmas are inherently vertically unstable, and thus require active vertical control to maintain equilibrium. If the vertical stabilization system fails, the plasma moves rapidly towards the top or bottom vessel wall in a *vertical displacement event* (*VDE*), producing plasma current asymmetries, vessel eddy currents and open field line halo currents, each of which can exert potentially damaging forces upon the Tokamak vessel and in-vessel components.

This work is focused on fast computation of eddy-currents and halo-currents associated to VDEs , by a pair of complementary formulations used to monitor the discretization error. When solving these problems involving topologically non-trivial conductors with an efficient h-oriented formulation, the first and second (co)homology group generators have to be computed, respectively. In practice, it turns out that thousands of generators are needed in order to solve the electric vector potential formulation, that would require an enormous amount of computing power to retrieve all of them even using state-of-the-art algorithms. To solve this challenging problem, a novel algorithm is used, which allows to save orders of magnitude computational time with respect to all other solutions proposed in literature.