Hessian matrix approach for determining error field sensitivity to coil deviations.

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The presence of error fields has been shown to degrade plasma confinement and drive in stabilities [1]. Error fields can arise from many sources, but are predominantly attributed to deviations in the coil geometry. Controlling the error field is critical for stellarators where most the confining magnetic field is produced by carefully optimized coils. The accuracy requirements were the largest cost growth of the NCSX stellarator, which was cancelled because of cost overrun [2].

Conventional approaches to studying the error field caused by coil deviations are to apply possible displacements and calculate the resulting error fields [3]. Heavy computations are required and only certain limited deviations could be explored Here, we introduce a Hessian matrix approach for determining error field sensitivity to coil deviations. The FOCUS code [4], provides fast and accurate calculations of an error field evaluation function (f_B) and its second derivatives (i.e. Hessian). Near a local minimum, f_B is linearly proportional to the eigenvalues of the Hessian matrix, when decomposing the coil perturbation in the basis of eigenvectors. The sensitivities of error fields to coil displacements are then determined by the eigenvalues.

A proof-of-principle example is given on the CNT configuration [5]. The results show that misalignments at the inner parts of the interlinked coils will cause significant error fields while others are relatively less important. We anticipate that this new method could provide information to avoid dominant coil misalignments, simplify coil designs and ultimately reduce the cost of stellarator coils.

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