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Stellarator Optimization: A Comparison of Genetic, Differential Evolution, and Levenberg-Marquadt Optimization Algorithms

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Abstract

The efficiency and effectiveness of stellarator optimization methods has improved greatly in recent years. A number of different optimization algorithms have been applied to stellarator optimization including both steepest descent and evolutionary optimization algorithms. In this work, we present a comparison of three different algorithms applied to the optimization of three-dimensional equilibria: (1) a Levenberg-Marquadt routine (LM), (2) a genetic algorithm (GA), and (3) a differential evolution algorithm (DE). LM is a nonlinear least squares method while GA and DE are both evolutionary algorithms. The speed and efficiency of numerical codes used to obtain equilibrium, stability, and transport properties of three-dimensional plasmas has been sufficiently enhanced so that global (in parameter space) optimization methods are now feasible. In principle, the primary advantage of the evolutionary algorithms is that they perform a global parameter space search while the steepest descent methods (such as LM) perform a local parameter space search for the optimal configuration. We present results which indicate the evolutionary algorithms are more sensitive to the user input than the LM method and that they are also constrained in stellarator optimization by the fact that equilibria do not exist for a large range of parameter space. Finally, we present initial work towards the development of a breeding optimization algorithm: a global genetic algorithm which uses a local LM optimizer to refine a generation. The goal of the breeding algorithm is to take advantage of the global parameter space search of the evolutionary algorithm while maintaining the efficiency of the LM method.