Using Genetic Algorithms to Optimise Current Drive in STEP

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The Spherical Tokamak for Energy Production (STEP) programme aims to deliver a commercially viable fusion energy plant. The reactor will be fully non-inductive, utilising microwave heating in the Electron Cyclotron Radio Heating (ECRH) range to drive current.

The Electron Cyclotron Current Drive (ECCD) has a large impact on the shape of the safety factor, q, which in turn is important for plasma stability. The ECRH can thus be used to create an optimal q profile. Finding the optimal ECRH profile is a highly non-linear problem as changing the power deposition affects the local temperature and density, which in turn affect the current drive efficiency and bootstrap current.

Simulations were performed using JETTO to calculate the current driven and the fully diffused self consistent current profile for a given ECRH power deposition. The time required for each of these simulations inhibits the use of traditional optimisation techniques that rely on taking many sequential steps in parameter space.

A Genetic Algorithm (GA) is an optimisation method inspired by natural selection. A population of points in parameter space are considered in parallel. Those which are judged by the algorithm to have perform the best are combined to create the next generation. The process is iterated until a sufficiently optimal solution is found. This allows the parameter space to be explored in parallel, minimising the time needed to converge on a solution.

Presented here is the development and performance of a GA which has been shown to be effective at generating populations of JETTO simulations and making a judgement on which simulations performed best, often converging on a suitably optimised current drive in under ten generations. Typical input ECRH and resulting q profiles after eight generations are shown in figures 1 and 2.

The GA's success is leading towards additional design parameters being considered such as the shape and size of the plasma, and the net fusion power.

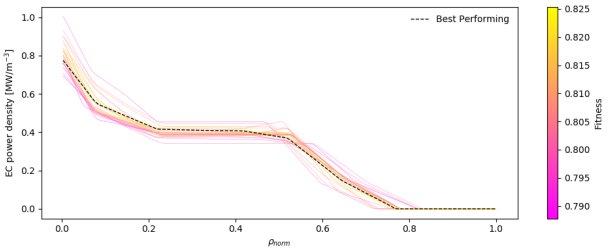

Figure 1: Input ECRH profiles.

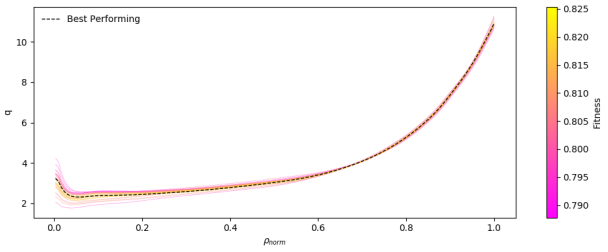

Figure 2: Output safety factor, q.