Modern Advances in Stellarator Design

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ABSTRACT

Recent advancements in the tools used to design stellarators have allowed the development of new stellarator designs. At the most fundamental level, advancements in stellarator equilibrium calculations are allowing for faster and more detailed computation of 3D equilibria. Such advancements have included the parallelization of VMEC, computation of stellarator equilibria with SPEC, and development of free boundary SIESTA. Building on advancements in stellarator equilibrium calculations, various improvements to the stellarator optimization code STELLOPT have provided new design capabilities. Optimizations targeting energetic particle confinement, turbulent transport, vacuum rotational transform, and electron-cyclotron heating/emission are now possible. Direct optimization of 3D coil splines (coupled to free boundary VMEC) further extend the utility of STELLOPT. These capabilities are augmented by the inclusion of a particle swarm optimization and parameter space mapping capabilities. Coil design tools have also advanced significantly, allowing winding surface free optimization of coils along with the inclusion of engineering constraints. This has allowed the development of straight outer leg modular stellarator coil designs. Particle and heat exhaust will soon be incorporated as part of the stellarator design loop as well. Stellarator divertor design tools are being used routinely to analyze the divertor of W7-X and examine a ‘resilient’ divertor design. Here the EMC3-EIRENE and field line tracing codes are providing estimates of heat fluxes, providing the needed groundwork for divertor optimization and design. Finally, progress on a stellarator transport (STELLTRANS) and systems codes have been progressing. These tools are providing a sophisticated suite of codes for design of both experiments and reactor concepts. In this work we review the status of such tools.