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Permanent Magnet Design for Nuclear Fusion Reactors

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Nuclear fusion has one of the most promising and exciting end goals of any field. It has the potential of sustaining humanity's ever-growing energy demand. The first approach to fusion was magnetic confinement and it is also the easiest to scale up, with two designs standing above the rest: the stellarator and the tokamak. Although in the early stages, stellarators were plagued by large transport, today with the development of stellarator optimization, they are at the forefront of nuclear fusion research. One of the main challenges stellarators face right now is coil complexity, being the biggest responsible for the delays in the construction of W7-X and the cancelation of NCSX. An alternative to the current design of stellarators is the inclusion of permanent magnets as a way of considerably simplifying the electromagnetic coils. Permanent magnets also offer other advantages, such as having a steady magnetic field that requires no external source of power or cooling, being very inexpensive, and producing less coil ripple than modular coils.
The objectives of this thesis are the use of SIMSOPT, a stellarator optimization framework, to design new stellarator machines, to simplify existing ones, and to explore the possibility of converting tokamaks into stellarators, all with permanent magnets. Different optimization algorithms and machine learning techniques will be tested for this application.

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