# Computational Methods in Stellarator Divertor Topology Design and the ARIES-CS

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# ABSTRACT

The ARIES-CS project was a multi-year multi-institutional project to assess the feasibility of a compact stellarator as a fusion power plant. The work herein describes efforts to help design one aspect of the device, the divertor, which is responsible for the removal of particle and heat flux from the system, acting as the first point of contact between the magnetically confined hot plasma and the outside world. Specifically, its location and topology are explored, extending previous work on the subject. An optimized design is determined for the thermal particle flux using a suite of 3D stellarator design codes which trace magnetic field lines from just inside the confined plasma edge to their strike points on divertor plates. These divertor plates are specified with a newly developed plate design code. It is found that a satisfactory thermal design exists which maintains the plate temperature and heat load distribution below tolerable engineering limits. The design is unique, including a toroidal taper on the outboard plates which was found to be important to our results. The maximum thermal heat flux for the final design was 3.61 $^{MW}/_{m^2}$ and the maximum peaking factor was 10.3, below prescribed limits of 10 $^{MW}/_{m^2}$ and 15.6, respectively. The median length of field lines reaching the plates is about 250 m and their average angle of inclination to the surface is 2°. Finally, an analysis of the fast alphas, resulting from fusion in the core, which escape the plasma was performed. A method is developed for obtaining the mapping from magnetic coordinates to real-space coordinates for the ARIES-CS. This allows the alpha exit locations to be identified in real space for the first time. These were then traced using the field line algorithm as well as a guiding center routine accounting for their mass, charge, and specific direction and energy. Results show that the current design is inadequate for accommodating the alpha heat flux, capturing at most $^1/_3$ of lost alphas. However the distribution of the alphas on the device first wall indicates that a viable solution likely exists. It is noted that future designs must be sought which specifically address the fusion alphas through an integrated approach involving physics and engineering teams.