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Bayesian Experimental Design for Divertor Heat Loads in Fusion Power Plants

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High heat loads in fusion reactors still remain as one of the most pressing problems to solve for the realisation of reliable power plants. To this end, divertor components are designed and developed to intercept and manage the large heat fluxes arising from the upstream plasma. Divertor diagnostic systems are utilised in experimental reactors to address the immediate challenges of real-time control and off-normal-event mitigation. However, there is still no widely-used, systematic framework for the exploration, design, placement and optimisation of diagnostics to measure heat flux and temperature in fusion reactors. In this paper, Bayesian experimental design (BED) is proposed as a principled way to maximise expected information gain, thereby minimising posterior uncertainty in reconstructed quantities of interest. BED can be used to explore where to place sensors, optimise the number of sensors, and seek redundancy in diagnostic designs. We show that BED can help advise on thermocouple placement in Mega Amp Spherical Tokamak Upgrade plasma-facing components and, more generally, for thermocouple surface placement for a power plant-like divertor. A generalised methodology is offered to guide future research that employs BED with new plasma loads and divertor components.

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