First principles transport simulations optimized for reactor concept evaluation and for other faster-than-real-time applications

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For more than two decades, turbulence and transport modeling work for magnetic confinement fusion applications has been tightly focused on validation of the physics models and codes. The standards for this kind of validation work are appropriately high. Insufficiently comprehensive or inaccurate simulations should not be trusted for high-consequence decision-making. However, as theory, simulations, diagnostics, and experiments become ever more sophisticated, validation work tends to be self-perpetuating. In this talk, I will discuss differences between validation studies and reactor concept evaluation, and between scenario development and reactor concept rejection. In particular, I will discuss the prospects for faster-than-real-time, *ab initio* transport simulations of both stellarators and tokamaks. Given (arguably) reasonable assumptions, I will show that it is already possible to complete a useful first-principles simulation of an ITER discharge in a time shorter than an actual ITER discharge will take, with modest computational hardware requirements. The same algorithms can be used to sift through thousands of stellarator concepts without resorting to what is normally meant by “reduced models.” How can such claims as these be made without blushing? The keys are to use algorithms designed for such purposes, and to steer clear of irrelevant details at any given stage of concept evaluation.