Computational plasma physics – extending legacy codes, computing functionals and other ideas

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Monash Workshop on PDE and Applications 2020

Computational plasma physics is a major driver of research into energy production using the same processes as the sun, i.e., nuclear fusion. A major engineering problem is the confinement of the plasma in order to reduce energy loss and material destruction of the casing due to very high temperatures of around 100 million degrees.

Here we consider a system of partial differential equations where several (collisionless) Boltzmann equations describing the transport of ions and electrons are coupled with the Maxwell equations. Through the coupling, the system becomes nonlinear and displays turbulence. I will talk about some of the computational challenges arising and how we used robust extrapolation to improve the functionality of legacy codes. Then I will report on methods to approximate functionals of the solutions of the PDEs and provide an outlook on uncertainty quantification and the application of symmetries.

This talk is based on past and current collaborative research with Yuancheng Zhou (ANU), Christoph Kowitz (formerly TU Munich), Brendan Harding (UoA), Peter Strazdins (ANU), Peter Vasiliou (ANU), Matthew Hole (ANU), Stuart Hudson (PPL Princeton), Frank Jenko (MPI Garching) and Dirk Pfluger (Uni Stuttgart).