Equilibrium Reconstruction in Stellarators: V3FIT

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Input parameters to an MHD equilibrium code include the radial pressure and current profiles. These input parameters are not directly measurable in an experiment. Equilibrium Reconstruction (ER) refers to the process of determining (or reconstructing) the input parameters (current and pressure profiles) by making observed diagnostic signals as consistent as possible with signals computed from the equilibrium. ER is an example of a broad class of procedures called data assimilation, or parameter estimation procedures.

The EFIT[1] code, the most widely used tool for axisymmetric equilibrium reconstruction, has proven invaluable for equilibrium control, and for comparisons with MHD stability and confinement predictions. The V3FIT code, currently under construction, will perform fast, accurate reconstruction for stellarators. To be most useful for experiments, the V3FIT code will need to a) run rapidly, b) be flexible, and c) be extensible. V3FIT is written in Fortran 95, and makes extensive use of the modern features (modules, derived types, and pointers) of the language.

The broad outline of the reconstruction algorithm is clear: a function minimization in the space of equilibrium parameters, with the function to be minimized being a measure of the mismatch between observed and model-derived diagnostic signals. However, for the ER to be rapid, the evolution of the equilibrium parameters toward their true values will need to be tightly coupled to the iterative equilibrium solution. There are many possible algorithms for this tight coupling, and the best algorithm is not known. The code is being written in a structured, modular way, with clear and consistent data flow. Thus, modifying old algorithms and implementing and testing new algorithms will be easy. The modular code structure makes adding signal types straightforward. (Magnetic diagnostics[2] and microwave interferometry/polarimetry signal types have been implemented.) Changing the equilibrium solver (currently VMEC[3]) is also possible.

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