BSTING: modifying the BOUT++ framework for fluid simulations of turbulence in non-axisymmetric geometries

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It is becoming increasingly important to simulate plasma turbulence in non-axisymmetric configurations, especially in the edge where turbulence could become the dominant transport process. The high collisionality of tokamak and stellarator edge plasmas facilitates a fluid approach to turbulence simulations. While there are several fluid turbulence codes for tokamak geometries, previous attempts to develop such a simulation framework for stellarators have been unsuccessful. The recent implementation of the Flux Coordinate Independent (FCI) [1] method for parallel derivatives in BOUT++ [2] has allowed for simulations in nonaxisymmetric geometries [3,4]. Here we present the most recent results for the BSTING project, which seeks to modify the **B**OUT++ framework to **S**imulate **T**urbulence **I**n **N**on-axisymmetric **G**eometries.

To allow for fully three dimensional turbulence simulations, the metric tensor components in BOUT++ have been extended to vary in three dimensions. Following this extensive modification, we present the results of several tests to ensure the accuracy and stability of the framework have been maintained. Of particular importance are the tests of the parallel derivatives and the associated parallel boundary conditions. These methods have been examined qualitatively by tracing non-axisymmetric flux surfaces and quantitatively via the Method of Manufactured Solutions [5], the results of which will be presented.

A fully three dimensional framework provides a very flexible test bed, and therefore several new features to exploit this flexibility will be presented here: modifications to the Zoidberg grid generator which allow for Wendelstein 7-X geometries and a newly-implemented FCI curvilinear coordinate system are discussed in detail.

Finally, initial investigation of plasma filaments in non-axisymmetric geometries using an isothermal model which evolves electron density, vorticity, electromagnetic potential and parallel momentum is presented. The implications of these simulations for future experiments will be explored.

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