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"Center for Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasmas"

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The UCLA work on this grant was to design and help implement an object-oriented version of the GTC code, which is written in Fortran90. The GTC code is the main global gyrokinetic code used in this project, and over the years multiple, incompatible versions have evolved. The reason for this effort is to allow multiple authors to work together on GTC and to simplify future enhancements to GTC.

The effort was designed to proceed incrementally. Initially, an upper layer of classes (derived types and methods) was implemented which called the original GTC code "under the hood." The derived types pointed to data in the original GTC code, and the methods called the original GTC subroutines. The original GTC code was modified only very slightly. This allowed one to define (and refine) a set of classes which described the important features of the GTC code in a new, more abstract way, with a minimum of implementation. Furthermore, classes could be added one at a time, and at the end of the each day, the code continued to work correctly. This work was done in close collaboration with Y. Nishimura from UC Irvine and Stefan Ethier from PPPL.

Ten classes were ultimately defined and implemented: gyrokinetic and drift kinetic particles, scalar and vector fields, a mesh, jacobian, FLR, equilibrium, interpolation, and particles species descriptors. In the second state of this development, some of the scaffolding was removed. The constructors in the class objects now allocated the data and the array data in the original GTC code was removed. This isolated the components and now allowed multiple instantiations of the objects to be created, in particular, multiple ion species. Again, the work was done incrementally, one class at a time, so that the code was always working properly. This work was done in close collaboration with Y. Nishimura and W. Zhang from UC Irvine and Stefan Ethier from PPPL.

The third stage of this work was to integrate the capabilities of the various versions of the GTC code into one flexible and extensible version. To do this, we developed a methodology to implement Design Patterns in Fortran90 [1-4]. Design Patterns are abstract solutions to generic programming problems, which allow one to handle increased complexity. This work was done in collaboration with Henry Gardner, a computer scientist (and former plasma physicist) from the Australian National University. As an example, the Strategy Pattern is being used in GTC to support multiple solvers. This new code is currently being used in the study of energetic particles [5].

A document describing the evolution of the GTC code to this new object-oriented version is available to users of GTC.

References

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