WP 4.7 XGC for Fusion Turbulence

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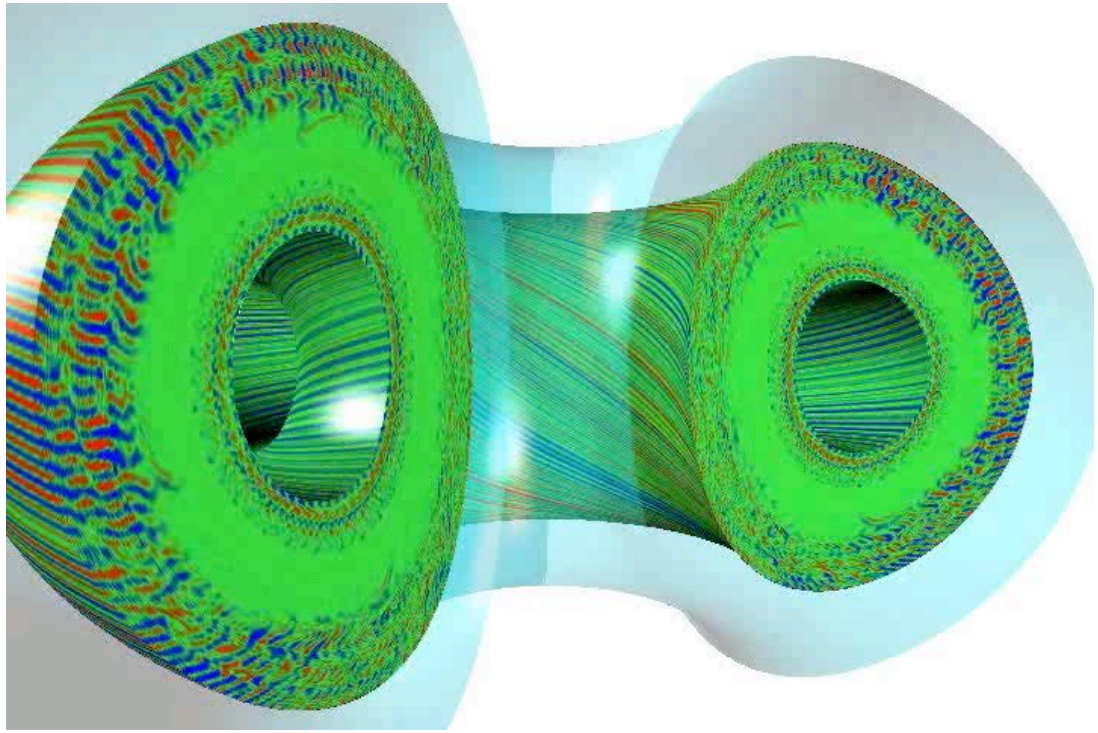
Aims

- Introduce XGC
- Discuss benchmarks
- Discuss progress and plans to add fast particle physics

Gyrokinetics

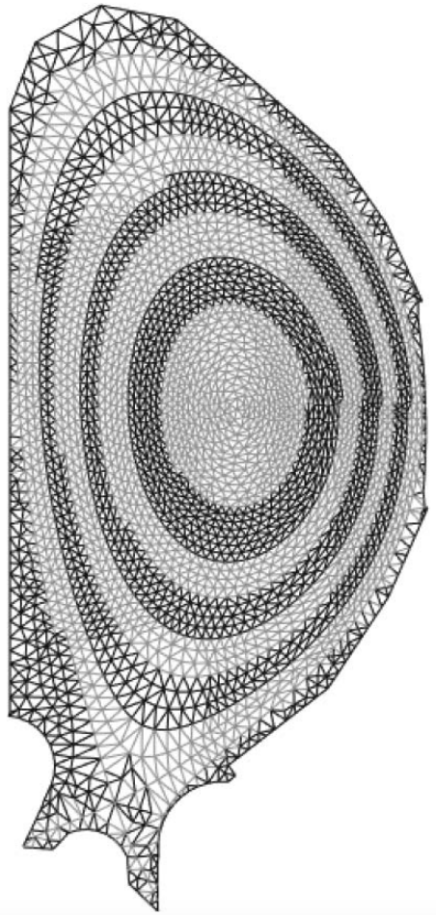
- Models turbulence in magnetized plasma
- Assumes:
  - $\omega \ll \Omega_c$
  - $k_{\parallel} \ll k_{\perp}$
- Averages over Ω_c, reducing the kinetic model from 6D to 5D



Visualization of plasma turbulence (source: Greg Hammett's website, GYRO code by Jeff Candy and Ron Waltz)

What is XGC?

- XGC = X-point included Gyrokinetic Code
- Particle-in-cell code
- Used to be written in Fortran (before 2020)
- Now mostly written in Kokkos C++ with none critical components left in Fortran



XGC Mesh

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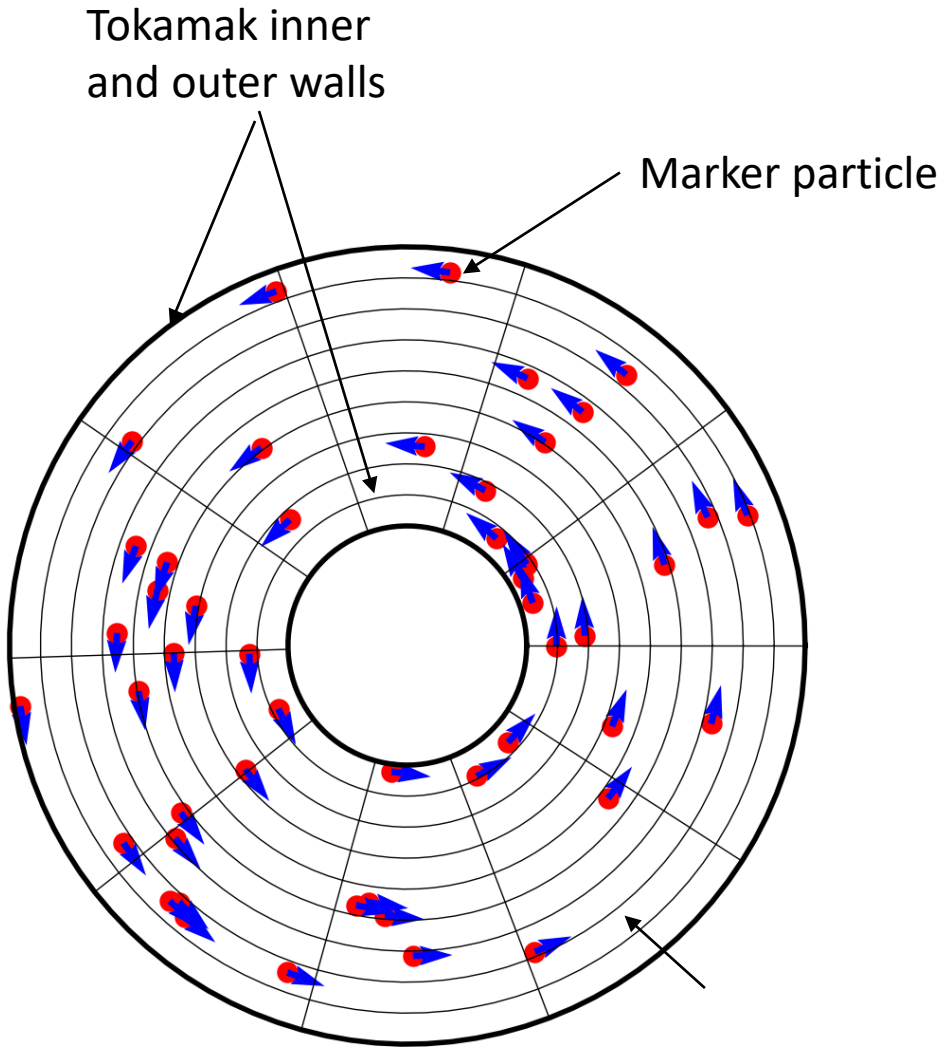


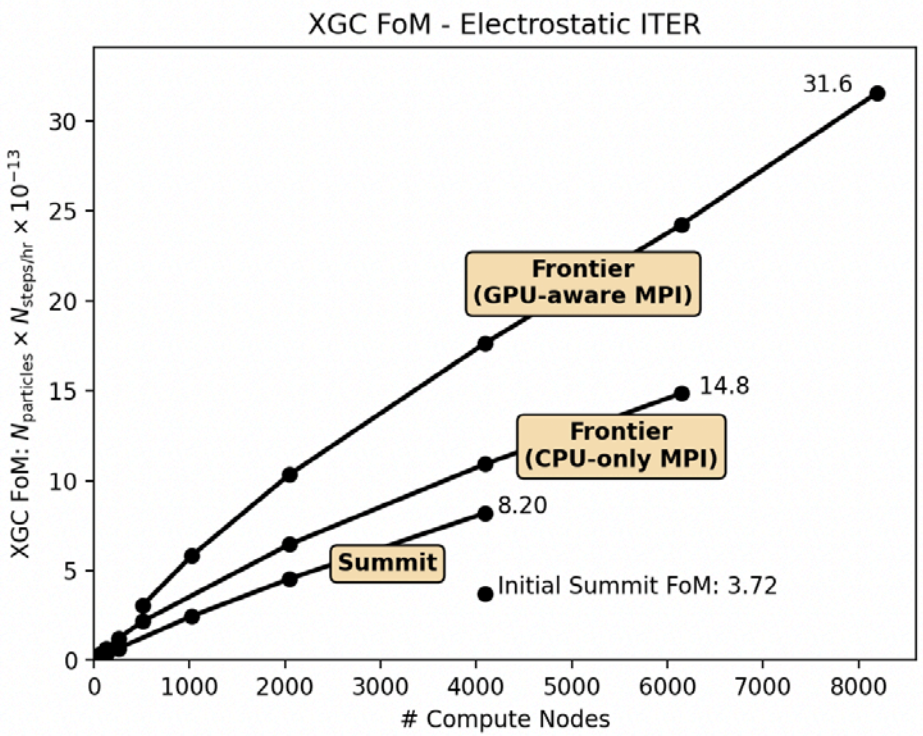
Visualization of the particle-in-cell method

Who is XGC?

- Robert
- CS
- Aaron
- Seung-Hoe
- PPPL
- …

XGC electrostatic benchmark on Frontier

- Performance enhancement from *initial* Summit to *initial* Frontier: **8.5x**
  - Initial to final Summit: **2.2x**
  - Final Summit to Frontier: another **3.9x**
    - vs 9x theoretical peak FLOPS
- **GPU-aware MPI** drastically improves performance



Fast particles

- Fast particles = ions with energy ≫ background plasma
- Generated by
  - Nuclear fusion
  - Neutral beam injection
  - Ion Cyclotron Resonance Heating
- XGC is highly optimized for modelling the bulk plasma
- XGC is not optimized for modelling fast particles