Current computing challenges in GTC

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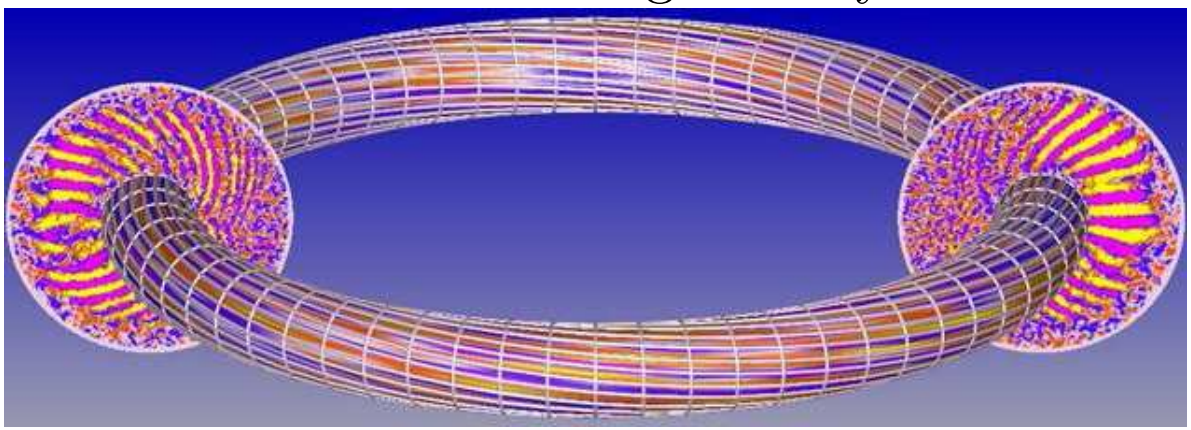
About GTC

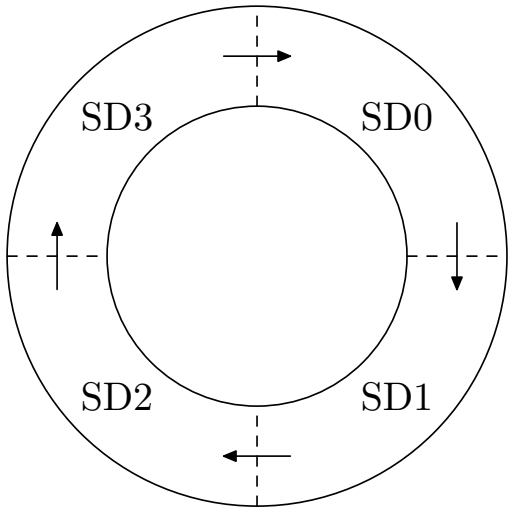
- GTC is a code for simulations of plasmas in the fusion device tokamak.
- Tokamak has a toroidal geometry like a donut:

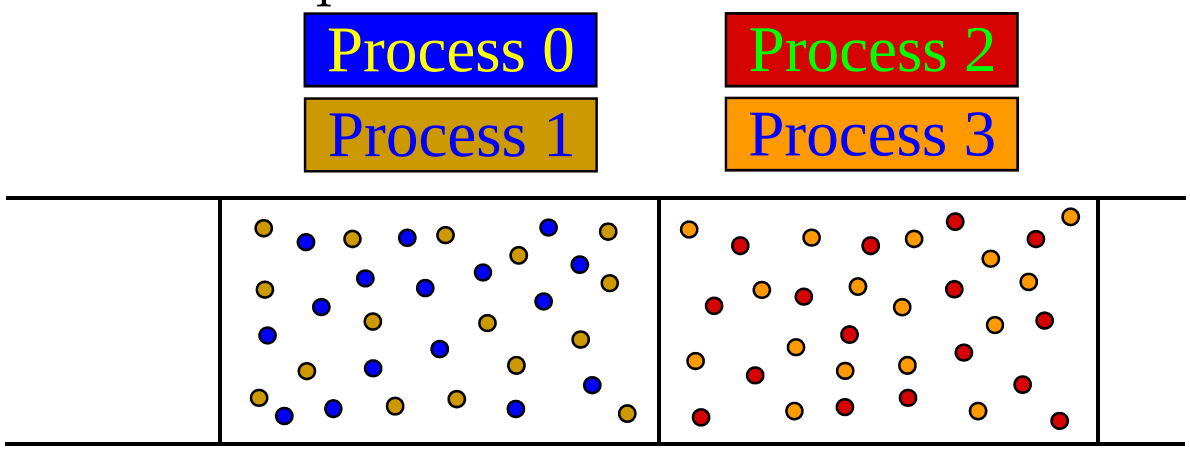


- Plasma system: charged particles and electromagnetic fields.
- GTC simulates how the particles move and how the fields evolve (governed by the gyrokinetic theory).
- Parallelization: hybrid MPI and OpenMP.
- 2-layer MPI: toroidal domain decomposition and particle decomposition.

2-layer MPI: toroidal and particle decomposition

- Toroidal decomposition: the simulation domain is decomposed into a number of subdomains (SD) in the toroidal direction.
- Particle decomposition: each SD can have more than one MPI process associated with it.
- Each process holds a fraction of the total number of particles in that SD.





Inefficiencies and challenges

- More than one MPI process are associated with one toroidal SD.
- The solver for magnetic field and adiabatic electron density and flow velocity is not fully parallelized yet so these processes redundantly do the same job, which wastes resources.
- Part of the electromagnetic field solver is parallelized by using PETSc to use all these processes.
- Each MPI process could have multiple OpenMP threads, but PETSc is not able to use these threads, which is another waste.