jh180081-NAHI

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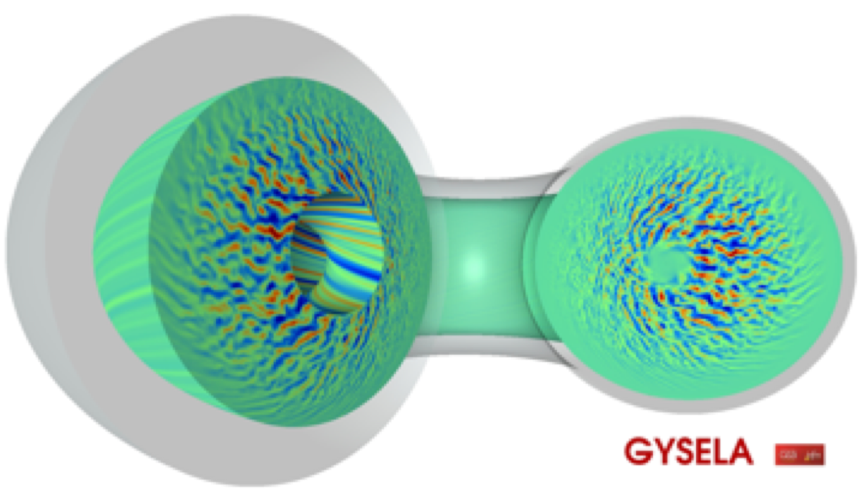
Optimisation of Fusion Plasma Turbulence Code toward Post-Petascale Era III

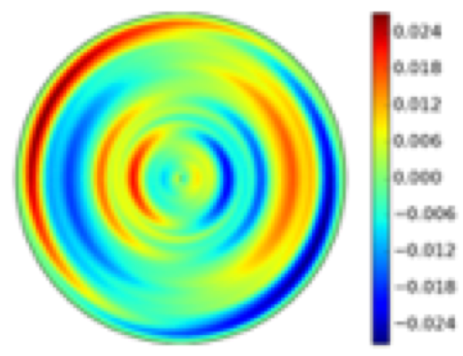
Background: Plasma turbulence simulation

- First principle model for plasma turbulence transport → Predict the fusion reactor performance
- Resolving the machine scale (m) with the particle scale mesh (cm) Velocity space structure due to collision-less features of plasma → **5D** (3D space + **2D velocity space**) $100^5 \sim 10^{10}$ stencil computation
- Concerning the dynamics of kinetic electrons, more computational resource is needed → Accelerators are key ingredients: **GPU** (porting completed in jh170020)

Physical research plan: Kinetic electron model and particle transport

Global gyrokinetic code: GYSELA

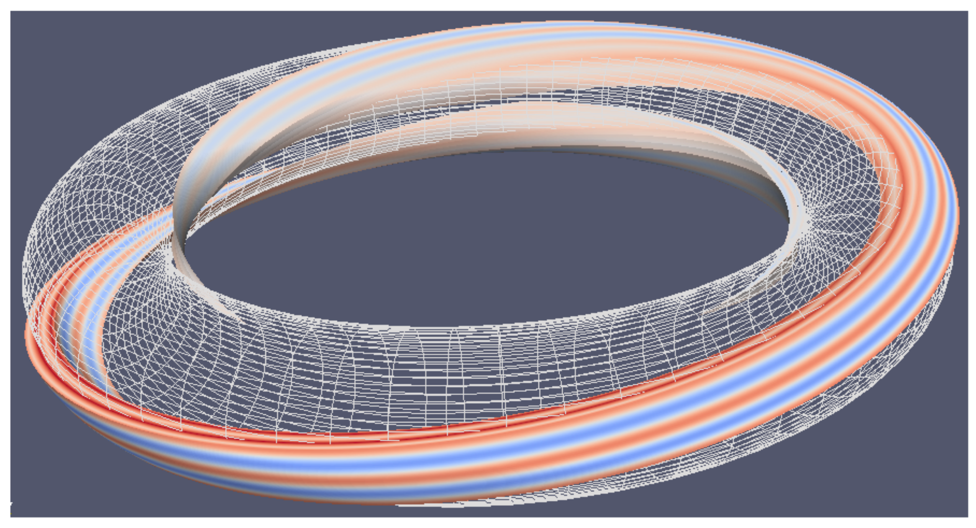




Poloidal symmetry breaking by turbulence

- Self-consistent **plasma profile evolution**
- **Simplified** physical models (no kinetic electrons)
- Computational cost **High** [V. Grandirard et al., CPC(2016)]

Local gyrokinetic code: GKV



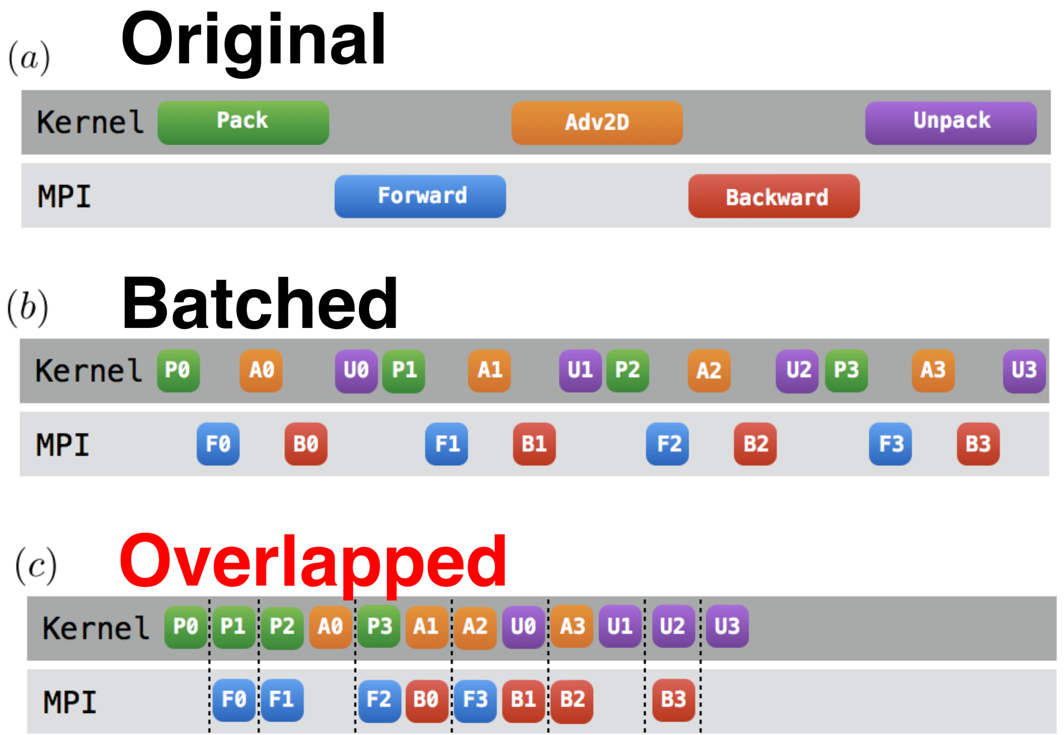
- **Fixed** plasma profile (local simulation)
- **Advanced** physical models (kinetic electron)
- Computational cost **Low** [T.-H. Watanabe et al., NF(2006)]

- Implement hybrid kinetic electron model in GKV and compare with the full kinetic electron model (low cost)
- Implement hybrid kinetic electron model in GYSELA which satisfies the physical requirements
- Investigate the impacts of symmetry breaking (figure above) on particle transport † with GYSELA

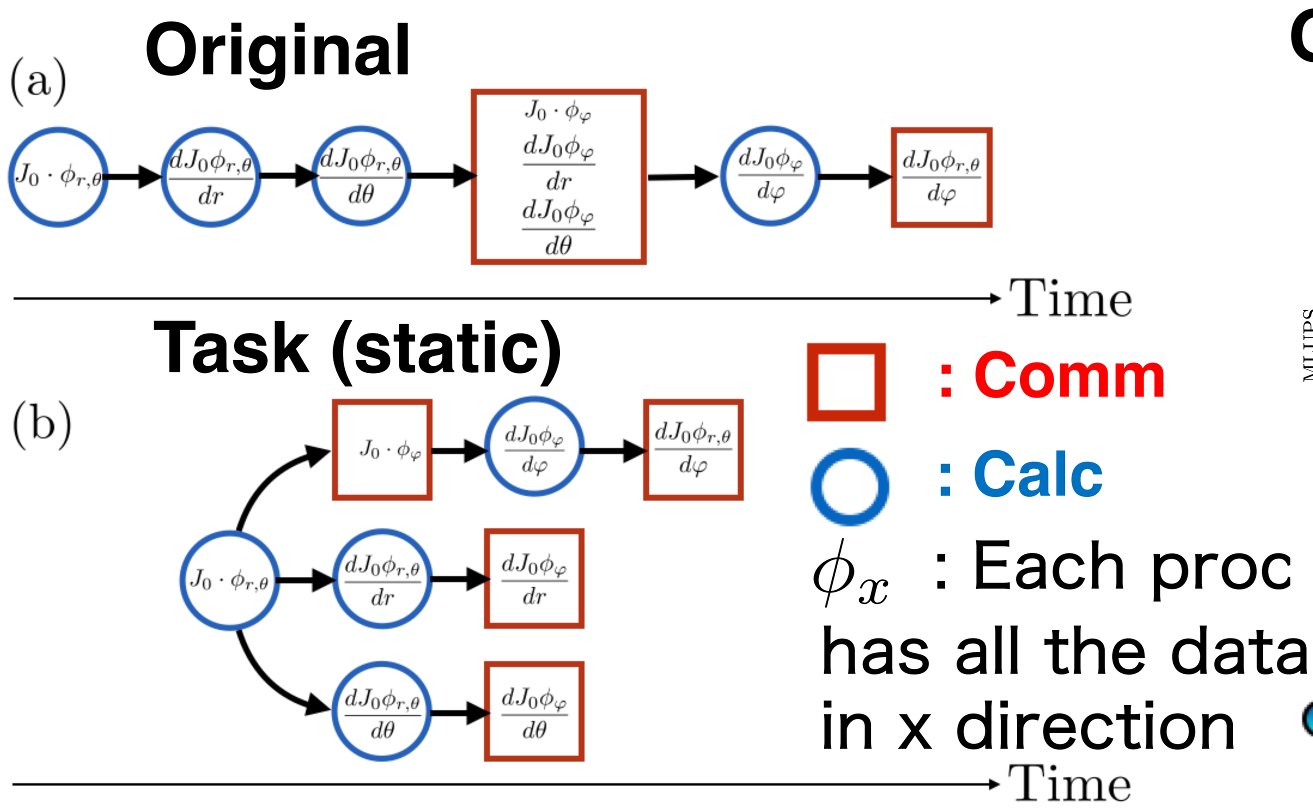
†Particle transport: Important mechanism for **fuel supply**、**Kinetic response of electrons** are essential

HPC research plan: Task level parallelization + runtime

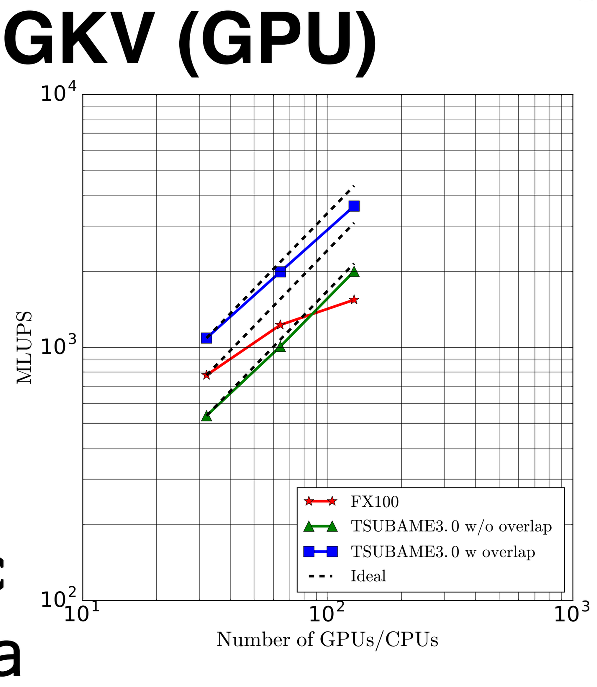
Pipelining 2D advection



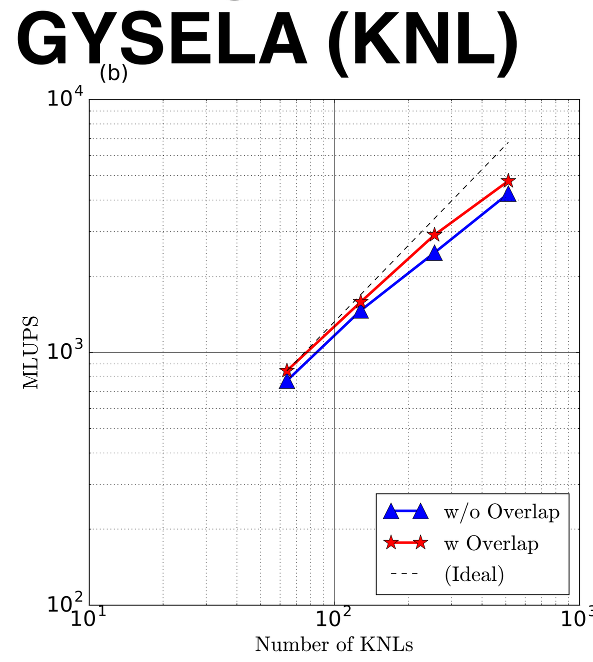
Task level parallelization (static)



Strong scaling



- H2D/MPI/D2H + Calculations overlapped



- Ratio of **Calc** to **Comm** changes with problem size

- Dynamic task level parallelization with a runtime like **Star-PU** or **OpenMP4**
- Improving performance with different problem sizes or parallel configuration

[C. Augonnet et al., Euro-Par 2009 (2011)]

Collaborations: Kinetic electron model + Task level Parallelization

French Group

Physics
- Turbulence profile interaction
- Impact of symmetry breaking

HPC
- **Task-level parallelization** in GYSELA prototype
- GYSELA prototype on GPUs

Japanese Group

Physics
- Develop kinetic **electron model**
- Characterize local transport

HPC
- **Task-level parallelization** in GKV code
- Implicit collision operator

- Visiting CEA to discuss HPC and physical topics with G. Latu and X. Garbet (Q2 or Q3)
- Submitting physics (Q2 or Q3) and HPC (Q2) papers

Research group and roles

Representative:	Y. ASAHI (QST)	Code development
Deputy Representative:	S. Maeyama (Nagoya Univ.)	Plasma turbulence
Deputy Representative:	G. Latu (CEA)	Task-level parallelization
Collaborating researcher:	X. Garbet (CEA)	Global plasma turbulence
Collaborating researcher:	T.-H. Watanabe (Nagoya Univ.)	Local plasma turbulence
Collaborating researcher:	T. Aoki (Tokyo Tech.)	Optimization on GPU
Collaborating researcher:	M. Ogino (Nagoya Univ.)	Optimization on CPU