Project Overview and PPPL Plan

Guoyong Fu

Goal

- Predictive simulations of energetic particle-driven instabilities and transport in burning plasmas

- Predictive simulations → code Verification/Validation;
- EP instabilities → Gyrokinetic/MHD hybrid model;
- Transport → long time nonlinear simulations;
- Burning plasmas → massively parallel computation to resolve multiple high-n modes

CSEPP Roadmap

	2008	2009	2010
Code Development	Extend particle domain decomposition to 3D; Add source/sink; Design workflow; Formulate nonlinear GKM model; Build initial version of GKM (MHD+ hot particles) Explore reduced models	Add more particle domains; Implement weight control; Implement workflow; Build 1st version of GKM (gyrokinetic Alfven + hot particles); Develop reduced models;	Scale GKM to 10k processors; Complete GKM code; Explore JFNK implicit method; Explore continuum method;
V&V	M3D-K verification with single mode saturation	GKM verification with NOVA-K and single mode saturation	GKM validation with DIII-D results of beam-driven modes and transport. Explore reduced models for code verification.
Physics application	M3D-K simulations of beam-driven modes in NSTX	Fishbone; Beam-driven modes in DIIID (single mode case); Alpha-driven TAE in ITER	Fishbone with source/sink; High-n TAE in ITER;

PPPL Plan (2008-2009)

- Extend particle domain decomposition to 3D (scale to 1000 processors);
- Add source/sink (with CU);
- Formulate nonlinear GKM model (with IFS);
- Build GKM0 (initial GKM version);
- M3D-K simulations of beam-driven Alfven modes in NSTX.

Extend particle domain decomposition to 3D

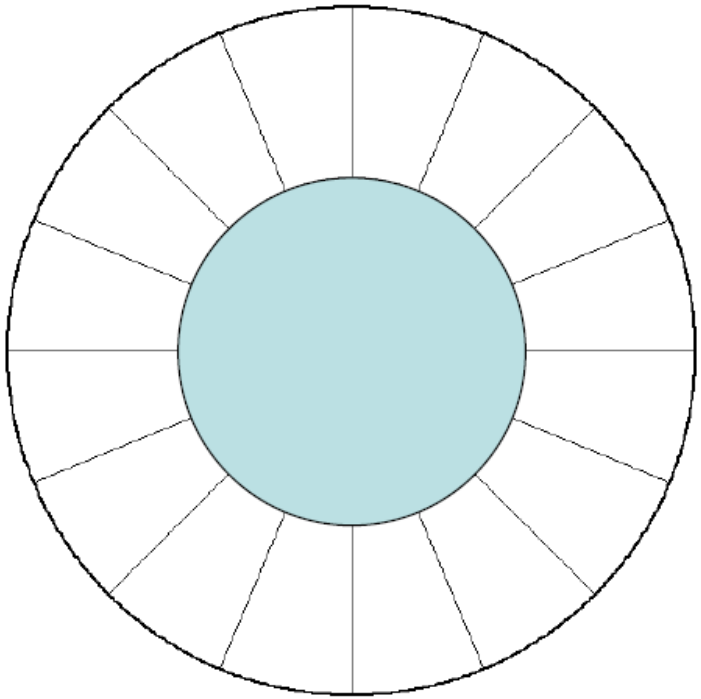
We have currently 2D domain decomposition(poloidal and toroidal);

We plan to add domain decomposition in radial direction in order to use more than 100s of processors.

Domain Decomposition

3 parameters control domain decomposition: # of toroidal PEs, # of radial PEs, # of theta PEs.

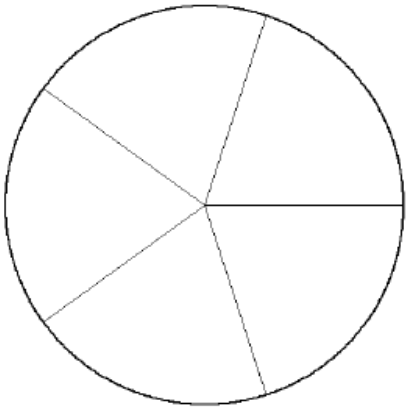
Toroidal
(overhead view)



B = 16

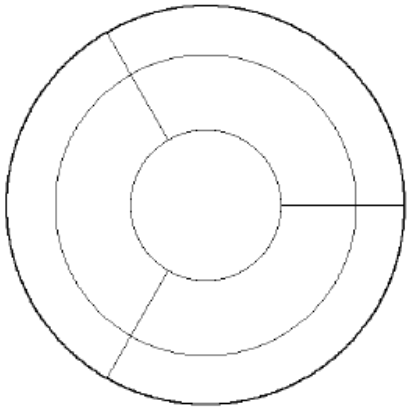
Linear solves are independent on each processor

Poloidal
(cross-section view)



D = 1
F = 5

or



D = 3
F = 3

Linear solves are parallel over processors

Add source/sink

- Need source and sink for long time simulations;
- Source (NBI injection, alpha particle birth);
- Sink (collisional slowing down, particle loss to the wall)

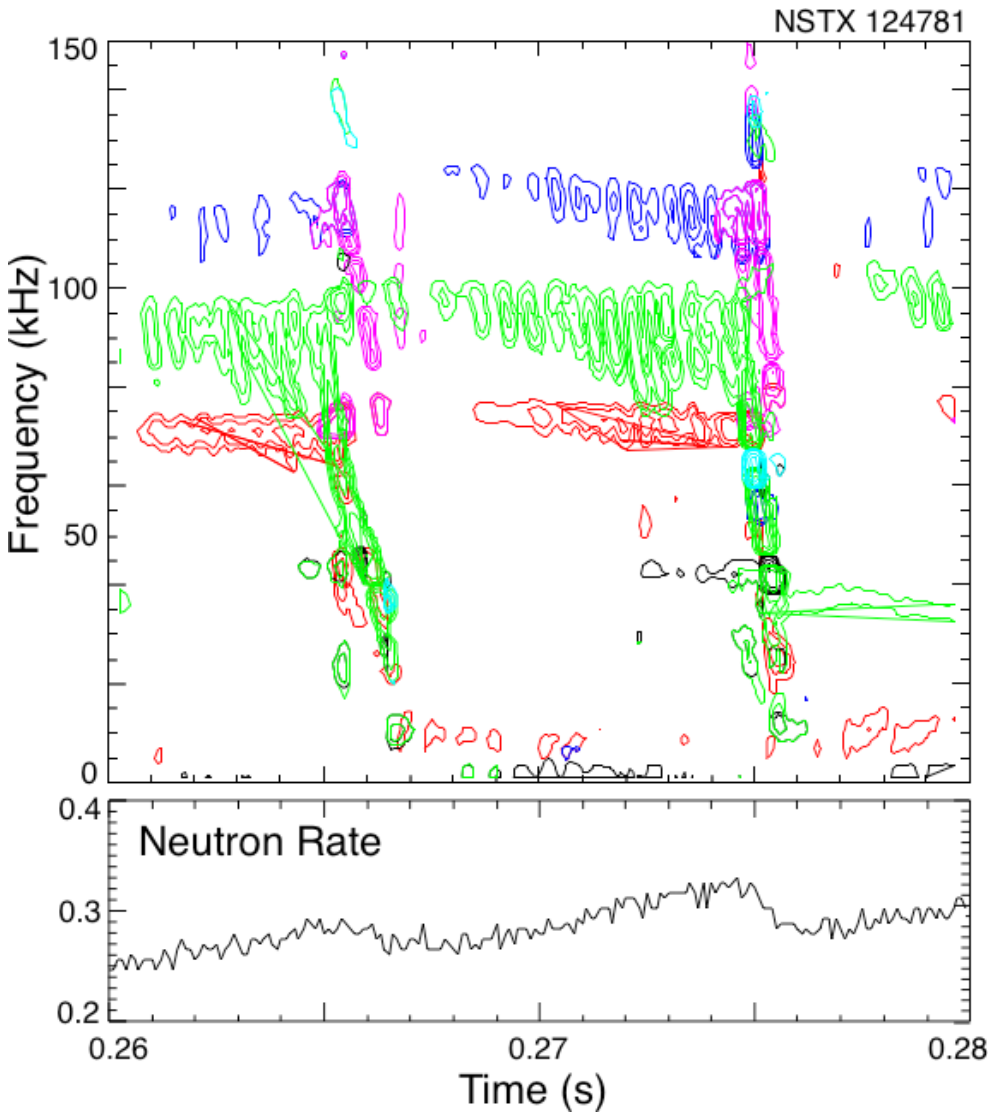
Formulate nonlinear GKM model

- Formulate nonlinear GKM mode based on gyrokinetic equation;
- Use hybrid model to recover exactly the MHD dynamics;
- Treat kinetic effects of both thermal species and energetic particles on equal footing;
- Kinetic effects are treated using PIC method (kinetic closure rather than fluid closure).

M3D-K simulations of beam-driven Alfven modes in NSTX.

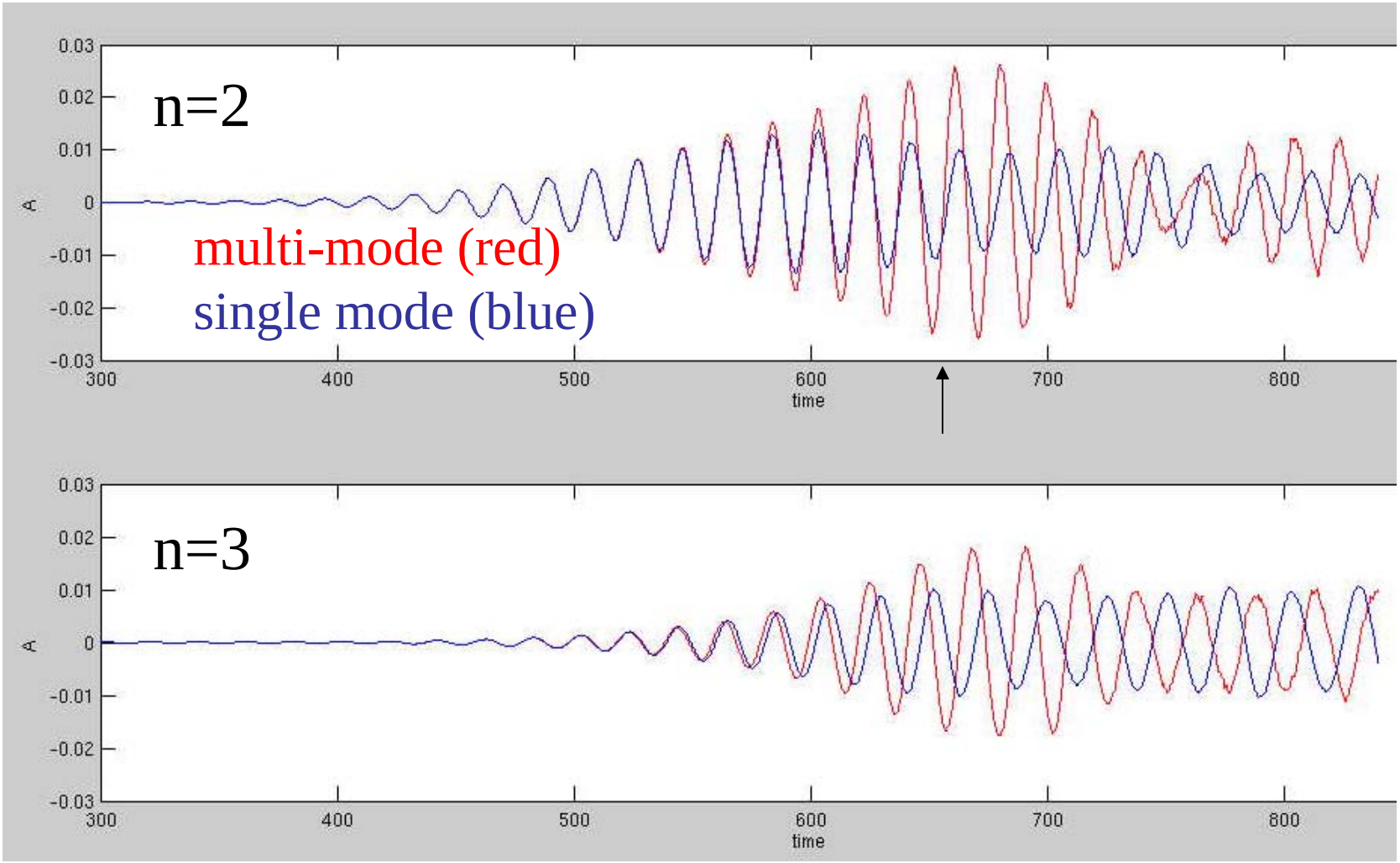
- Continue M3D-K simulations of beam-driven Alfven modes in NSTX plasmas;
- Emphasize multiple mode dynamics;
- Test source/sink with collisions;

NSTX observes that multi-mode TAE bursts can lead to significant fast-ion redistributions/losses



Fredrickson et al, this meeting.

Multi-mode simulations show strong mode-mode interaction.



amplitude

time