A New Particle Resampling Algorithm by ASCR Scientists is Enabling ITER-Critical Turbulence Simulations in Stochastic Magnetic Fields

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Science Motivation

- ITER must suppress catastrophic crashes from Edge Localized Modes (ELMs).
  - Resonant Magnetic Perturbation (RMP) coils will be used to create magnetic stochasticity and islands in the edge for ELM mitigation.
  - Experiments, however, find that edge plasma profiles respond to RMP fields in a mysterious and deleterious way to curtail efficient fusion burn.

Difficulty, and Innovative Solution

- Difficult to model: plasma particles move randomly along the stochastic magnetic field lines and quickly destroy the load-balancing among simulation cells.
- ASCR members (R. Moser's team, U. Texas; V. Carey, U. Colorado) created a new particle re-sampling technique, which preserves moments.

  D. Faghihi, V. Carey et al., accepted, J. Comp. Phys., https://arxiv.org/abs/1702.05198
- Physicists at PPPL completed its application to toroidal geometry.

Scientific Discoveries and Implication

- Gyrokinetic XGC simulation became possible with RMPs.
- Result qualitatively agrees with the experimental observations for the first time!
  - Edge turbulence enhances particle losses while confining electron heat.
  - Invited talk at 2019 Am. Phys. Soc. DPP Conference by R. Hager (PPPL)

  R. Hager, C.S. Chang et al., accepted, Phys. Plasmas 2020
- The understanding could allow more confident and cheaper operation of ITER.

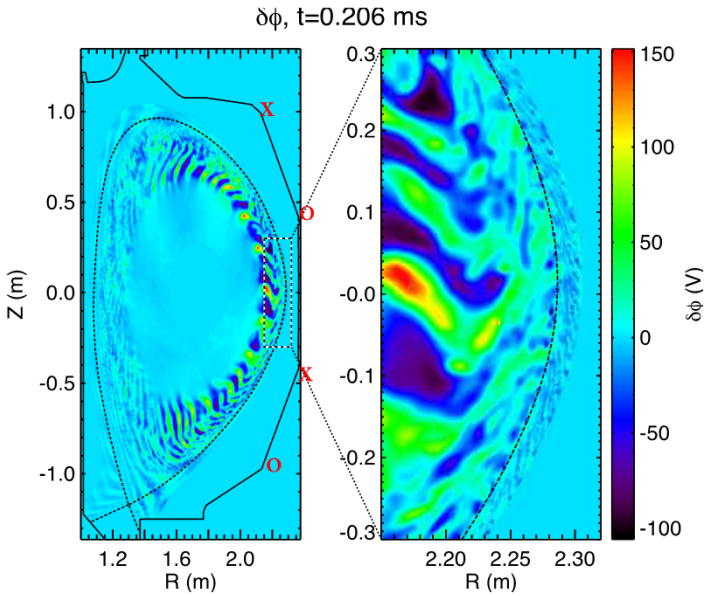

Figure: Edge turbulence from XGC that enhances the particle loss while confining the electron heat in the DIII-D tokamak. Dashed black line shows the magnetic separatrix, solid black line is the tokamak wall, and the red X and O marks depict the magnetic perturbation coils alternating in direction.

Utilized 42% Theta and 21% Cori KNL.