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IPP

Runaway electron losses due to resonant magnetic perturbations

Gergely Papp[1,2]

T. Fülöp[1]**, M. Drevlak**[3]**, P. Helander**[3]**, G. Pokol**[2]

1: Chalmers University of Technology, Göteborg
2: Budapest University of Technology and Economics (BME)
3: IPP-Greifswald

Question: How to suppress the runaway electrons?

Background

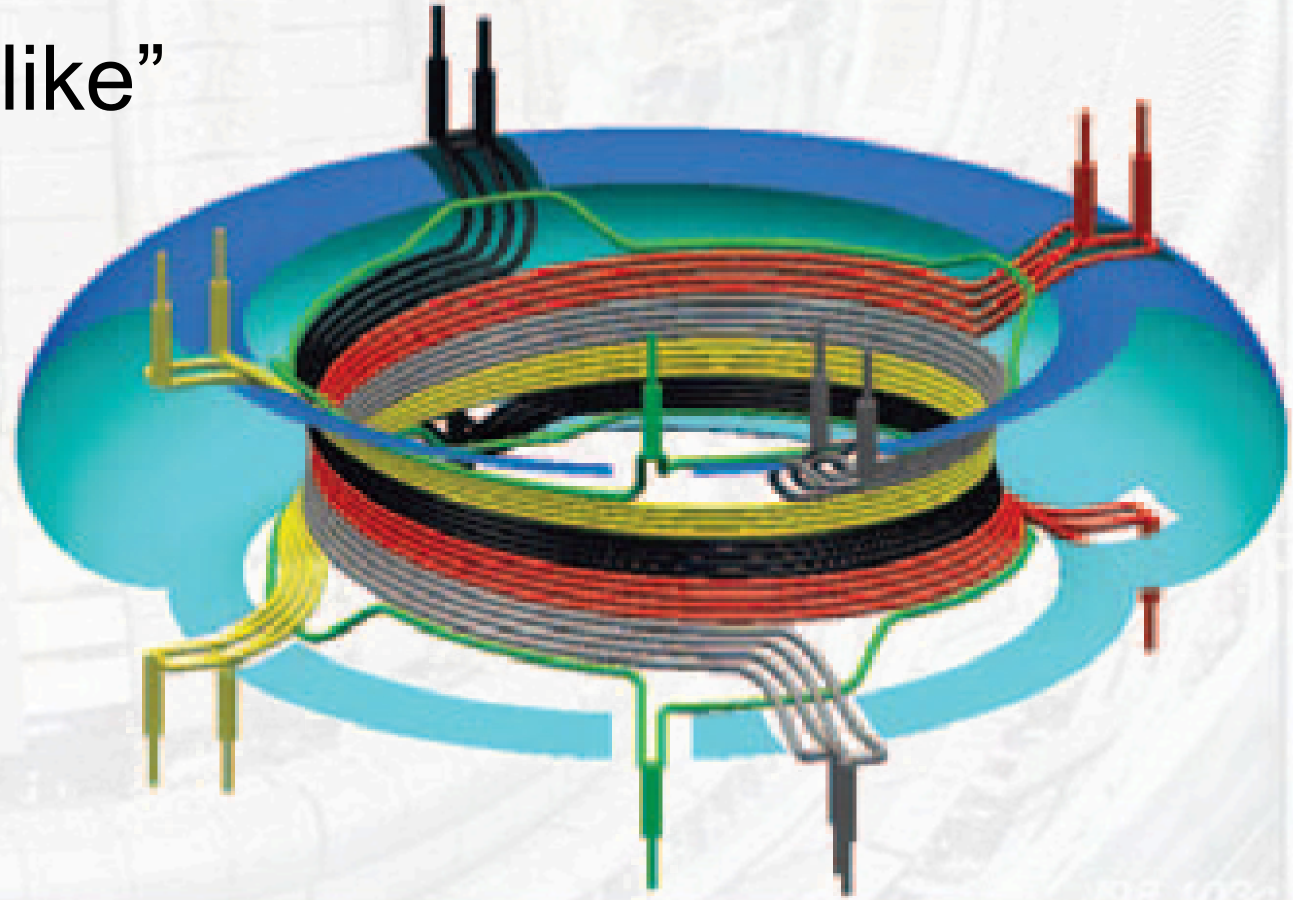
- Disruptions: quick loss of plasma confinement. Swift cooling leads to runaway electron generation.
- Eventually, a beam of runaway electrons can form, which has a huge potential to damage the machine parts.
- Problem gets worse on bigger tokamaks: Higher maximal runaway energy and -current can be achieved.
- Suppression of the runaway beam is crucial.
- Possible intervention: destroy the magnetic confinement with **Resonant Magnetic Perturbations (RMP)**, enhance the primary runaway electron losses to avoid avalanche generation.

Motivation

- Experimentally proven efficiency on many experiments:
  - JT-60: at sufficiently large perturbation there is no beam
  - TEXTOR: resonant magnetic perturbation enhances runaway losses, the beam can be suppressed.
  - Tore Supra: loss enhancement was measured
  - etc.
- <=>JET: preliminary results are inconclusive
- Theoretical background:
  - Runaway avalanche growth rate drops due to radial diffusion => Sufficiently large perturbation can fully suppress the beam.
  - Complicated theory, cannot be solved analytically
- Goal: 3D numerical modelling to better understand RMP

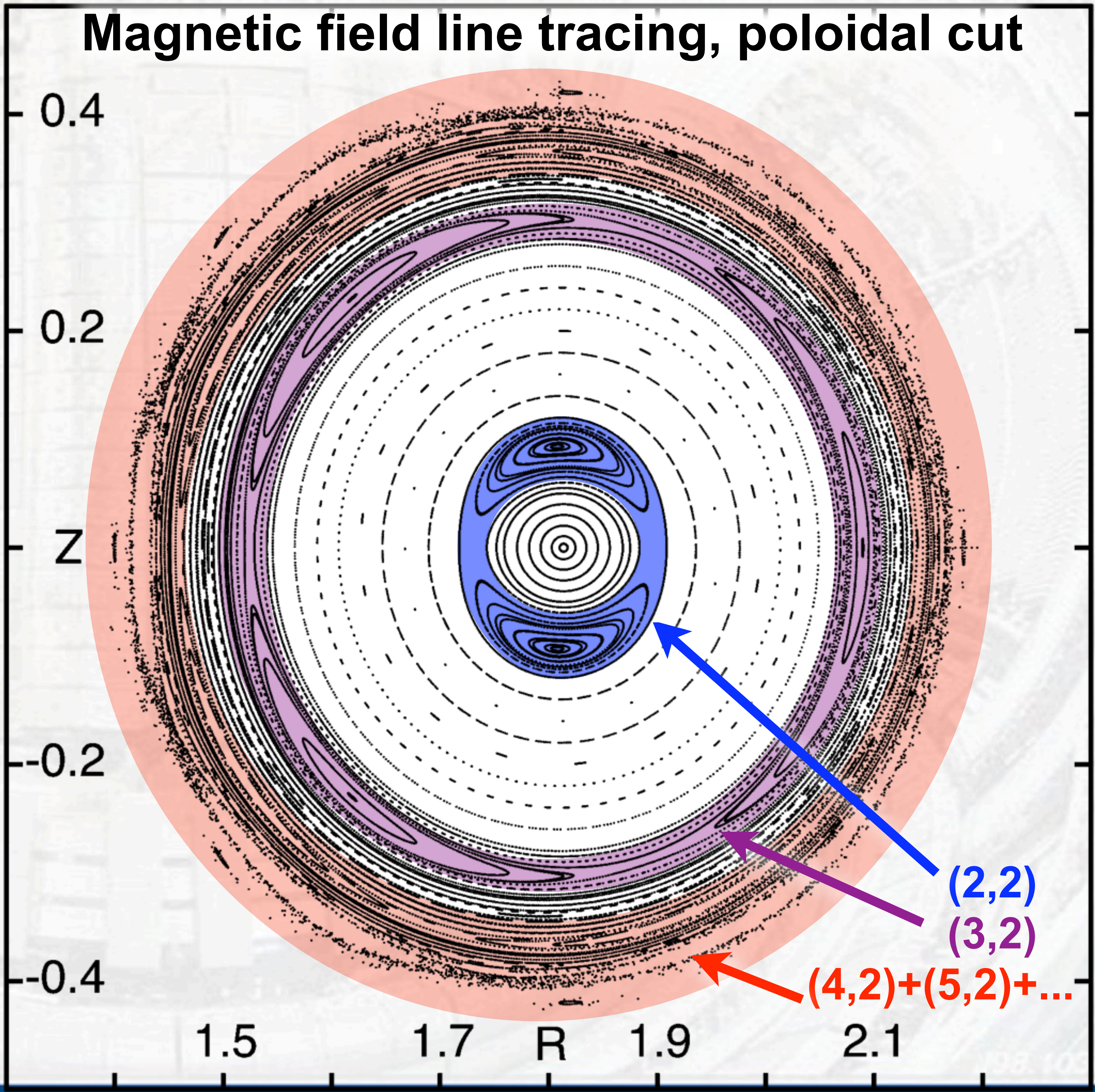
Description

- We solve the relativistic orbit-averaged drift equations in 3D geometry, including collisions with the background.
- ANTS code (plasmA simulatioN with drifT and collisionS [M. Drevlak: 36th EPS ECA **33E** P-4.211 (2009)]
- Improvements for this project: inclusion of synchrotron radiation, new treatment of the relativistic collisions, etc.
- Test environment: “TEXTOR-like” plasma. R=1.8 m, a=0.46 m, B_T=2.25 T, I_P=320 kA
- Perturbation coils: winded at the high field side, as shown on the figure.
- **D**ynamic **E**rgodic **D**ivertor (DED) system on TEXTOR



Effect of RMP on magnetic structure

- DED coil set creates islands with n=2
- Narrow q profile at the plasma edge => different islands overlap => ergodic zones arise
- Particles follow the ergodic field lines => **Radial transport is greatly enhanced**



Results and outlook

- **In general, runaway electron losses are enhanced with at least an order of magnitude due to RMP.**
- Investigate in further detail
  - Different magnetic configurations and perturbation amplitudes
  - Runaway energy dependence
  - Plasma density dependence
  - Differences “with and without” the newly introduced features
- Evaluate diffusion coeff. as a function of position (R)
- Relate to experimental results (current damping rate, current plateau length, etc.)