Using scrape-off-layer convection & currents to control the tokamak edge plasma

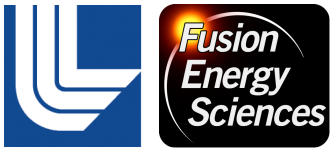
Ilon Joseph[1], Ron Cohen[1], Tom Rognlien[1], Dmitri Ryutov[1], Vlad Soukhanovskii[1], Hiro Takahashi[2], Stewart Zweben[2]

[1]Lawrence Livermore National Laboratory

[2]Princeton Plasma Physics Laboratory

NSTXU 2014-18:

Theory & Computation Brainstorming Session

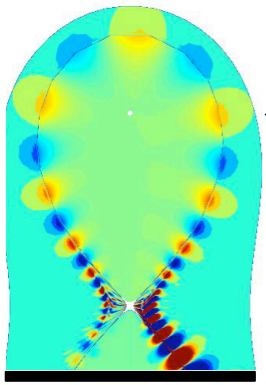


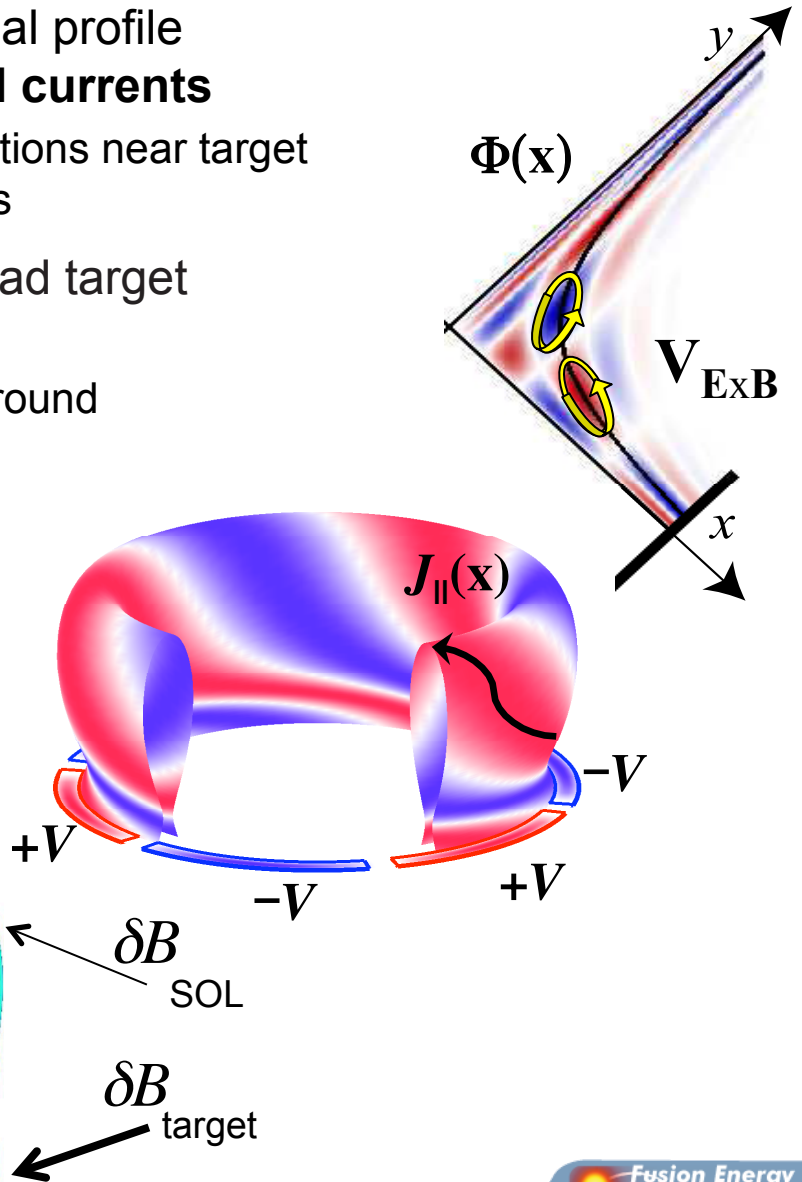
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Security, LLC, Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

LLNL-PRES-534498

Non-axisymmetric divertor variations can be used to mitigate target exhaust

- Controlling the steady-state electrostatic potential profile controls both **perpendicular flows** and **parallel currents**
  - Can be controlled by manipulating divertor conditions near target plate, e.g. direct electrical biasing of target plates
- **Electrostatic convection**[1] can be used to spread target plate heat and particle fluxes
  - High enough mode #'s needed to exceed background transport levels
- **Parallel currents**[2] can be used to generate relatively large resonant magnetic perturbations
  - Control pedestal transport
  - Control or trigger ELMs?
  - Requires low toroidal mode #'s to improve geometric coupling efficiency





[1]R.H. Cohen and D.D. Ryutov, Nucl. Fusion **37** 621 (1997)

[2]I. Joseph, R.H. Cohen and D.D. Ryutov, Phys. Plasmas **16** 052510 (2009)

Potentials can be driven by divertor asymmetries rather than by direct electrical biasing

- **For a reactor, hardware components inside the vacuum vessel are severely constrained**
  - Large magnetic forces
  - High neutron fluxes
  - Substantial power requirements

- **Reactor-relevant methods need to be tested**
  - ***Asymmetric neutral gas pumping and/or fueling***
  - ***Asymmetric neutral and/or impurity radiation***
  - Variation of target plate angle with respect to field lines
  - Variation in material composition of target plates:
    - ***Li depositon to control recycling***
    - secondary electron emission, conductivity

- **We've explored techniques based on non-axisymmetric neutral pumping and injection**
  - Flux tube studies imply that ~20-40% of I_{sat} can be driven
  - ITER divertor more rigid due to tilted plates
    - only a few % of I_{sat} can be driven
  - Pumping predicted to be more efficient than injection