Theory outlook: a distorted view

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Can we calculate intrinsic rotation

- Can we correctly <u>predict</u> intrinsic rotation?

  NOT WITH CURRENT SIMULATIONS

- Need low flow ordering with ρ_{pol}/a corrections
  - Must satisfy up-down symmetry of equations
  - Involves more than flow shear regulation

- Solvable problem, but very subtle

- Implementable approach: GS2 + Trinity

- Can we correctly <u>control</u> intrinsic rotation?

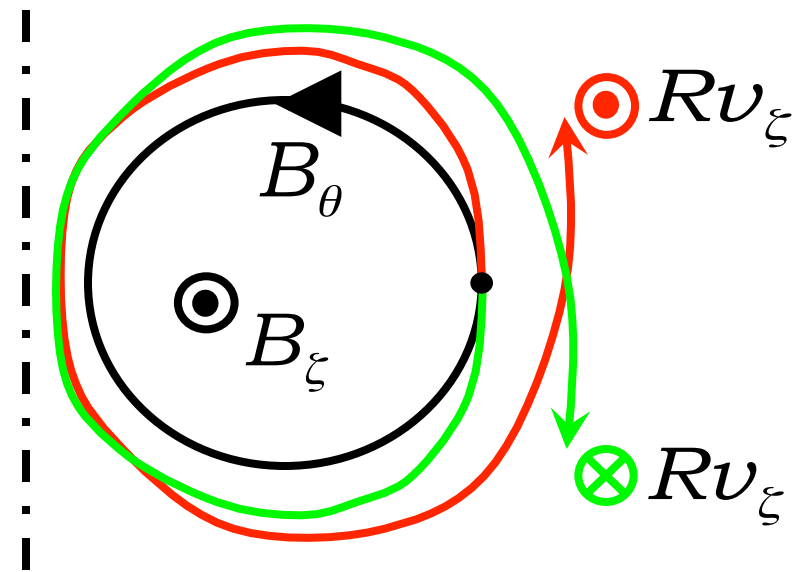- Can we improve performance?

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Symmetry in high flow

- For up-down symmetry, equation invariant for

$$v_{\parallel}, \theta, k_{\psi} \rightarrow -v_{\parallel}, -\theta, -k_{\psi}$$
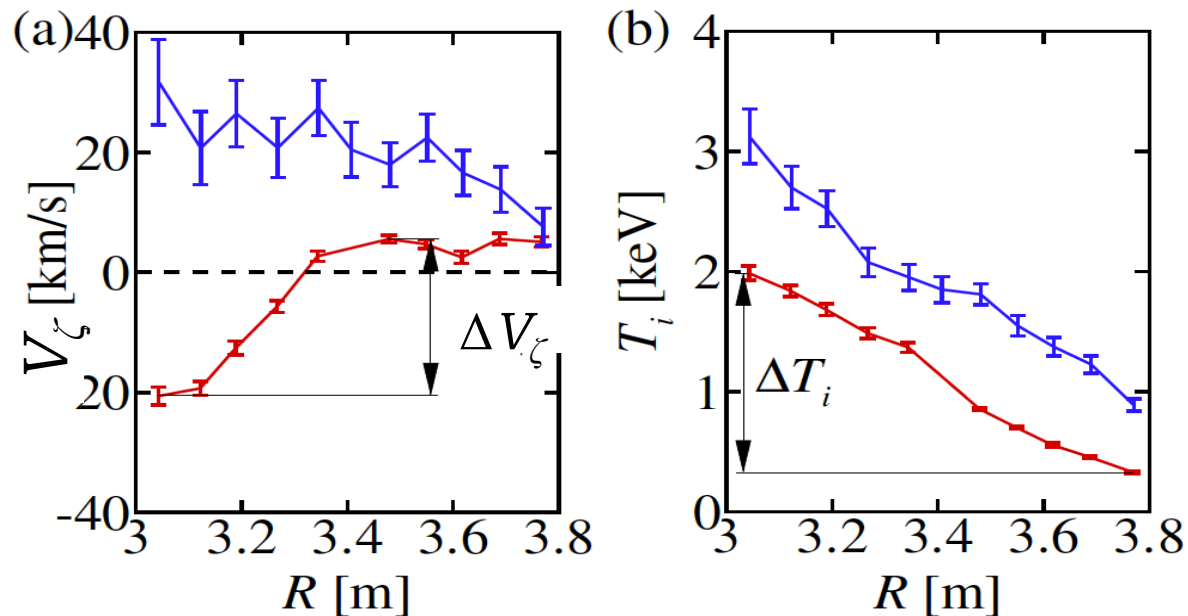
- As a result,

$$\Pi\left(V_{\zeta}, \frac{\partial V_{\zeta}}{\partial \psi}\right) = -\Pi\left(-V_{\zeta}, -\frac{\partial V_{\zeta}}{\partial \psi}\right)$$

$$\Rightarrow \Pi(0,0) = 0$$

- Can't tell if turn tokamak over!
  - Proven in Parra et al PoP 2011

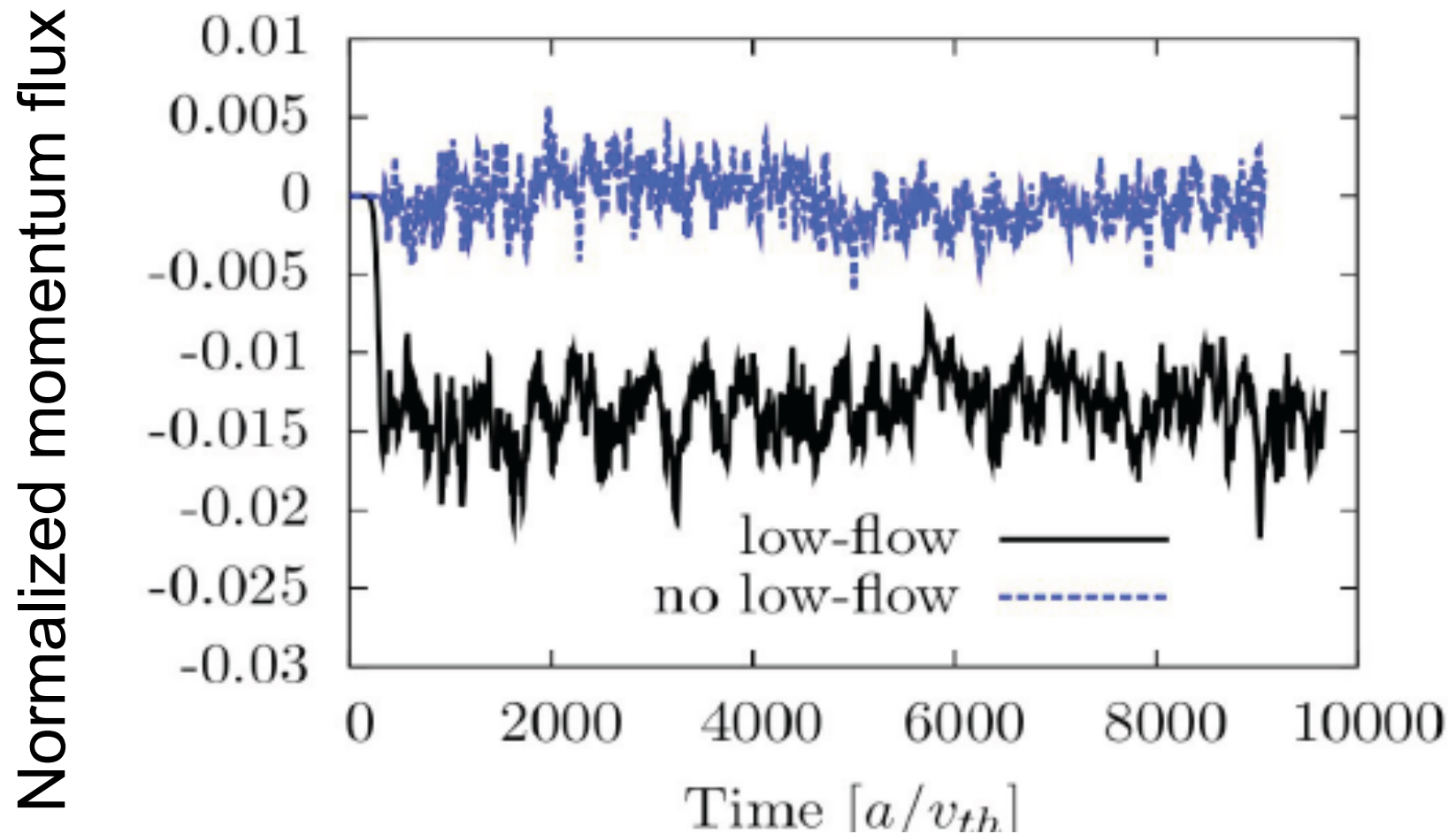**IIiT PSFC**

Profile sensitivity of intrinsic rotation

- Rotation is beneficial for MHD and turbulence
- Intrinsic rotation without momentum input
- Only intrinsic rotation in ITER

Two different JET ICRH shots

- Note the flow sign change

Early numerical results (Barnes)

Test: putting in some of the ρ_{ion}/a low flow corrections

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LHCD effects on intrinsic rotation

- **Intrinsic rotation with a heating source and momentum input**
  - ❑ Quasilinear description for momentum input & electron heating has been improved
  - ❑ Low flow ordering using GS2+Trinity

- **Current sensitivity of flow**

  - ❑ Counter-current momentum input to electrons and counter-current rotation @ higher current

  - ❑ Co-current rotation @ lower currents

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Simulating the pedestal

- ## Some understanding of ion flow & neoclassical ion heat flux in pedestal

- ## Developing a drift kinetic code to model the pedestal neoclassically

  - Low flow ordering

  - Role of turbulence on profiles?

- ## Momentum transport in the pedestal

  - Extend existing approach to retain flow shear & E_r

  - $\rho_{pol} c E_r / B_{pol} \sim v_{ion}$ (or orbit squeezing = S ~ 1)

- ## Goal: extend GS2+Trinity to pedestal
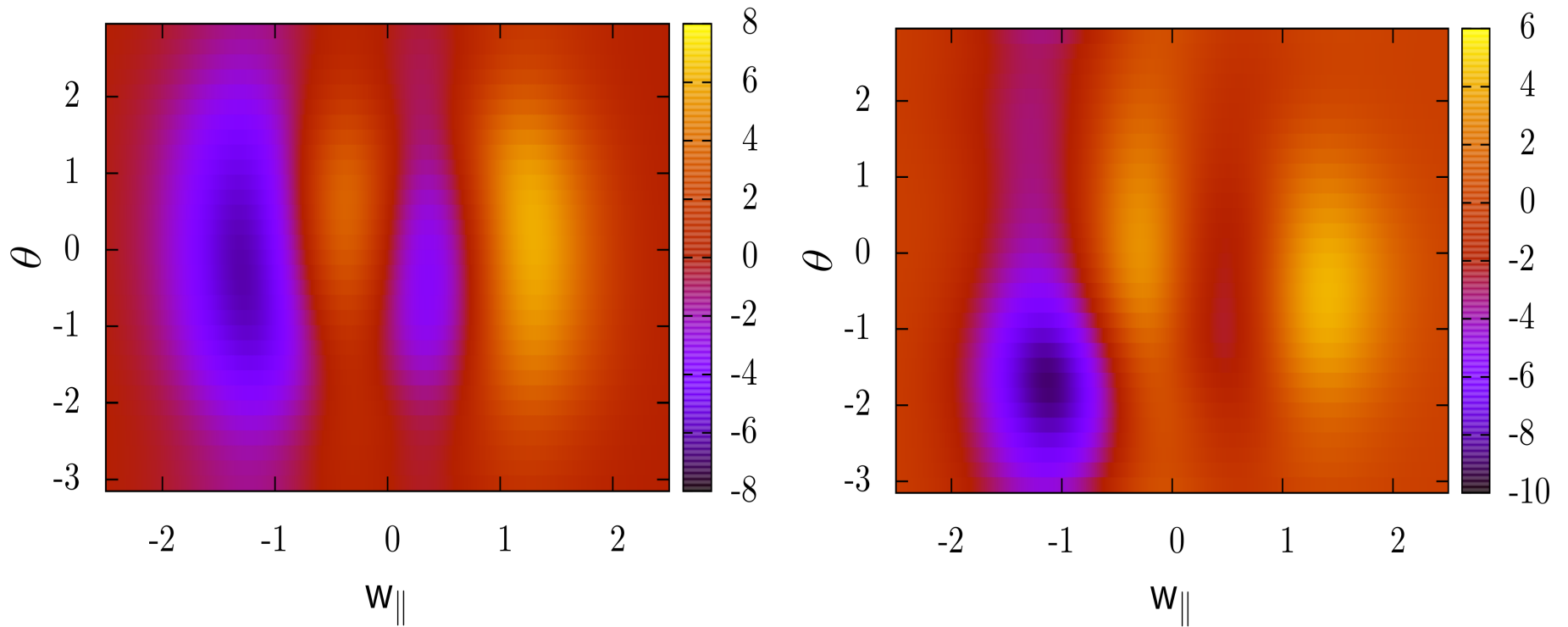
  - What sets the pedestal width? Is it ρ_{pol}?

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Numerical evidence of symmetry

$$\frac{\partial V_\varsigma}{\partial \psi} = 0 \qquad \Pi_{\varsigma\psi} = \int d\theta dw_\parallel P_{w_\parallel \theta} \qquad \frac{\partial V_\varsigma}{\partial \psi} > 0$$

$$P_{w_\parallel,\theta} \qquad w_\parallel = v_\parallel - V_\parallel \qquad P_{w_\parallel,\theta}$$

Optimized stellarators

- Good understanding of optimized stellarators
  - Ion flow & bootstrap current similar to tokamaks
- How sensitive is the turbulence to the optimized configuration chosen?
  - Omnigenous: which configuration is best?
    - Generalized quasi-poloidal, toroidal or helical?
  - Any advantage to quasi-symmetry?
    - Does an ignorable coordinate like a tokamak matter?
- Build optimization into gyrokinetic treatment?
  - Is this advantageous or insightful?

Other topics of interest

- Improved description of D + T plasmas

  - Bootstrap current modified slightly

- Effect on turbulence of induced electric field modifications of the electron distribution function in low density Ohmic discharges

  - No turbulent transport in core transport
  - Confinement increases linear with density: neo-Alcator
  - GKs predicts ion energy loss, but observe electron loss

- I versus H mode pedestals: I mode mechanism?

- Neutral beam injection impact on turbulence?

  - Dilution stabilizing,but can distortion of f matter?

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