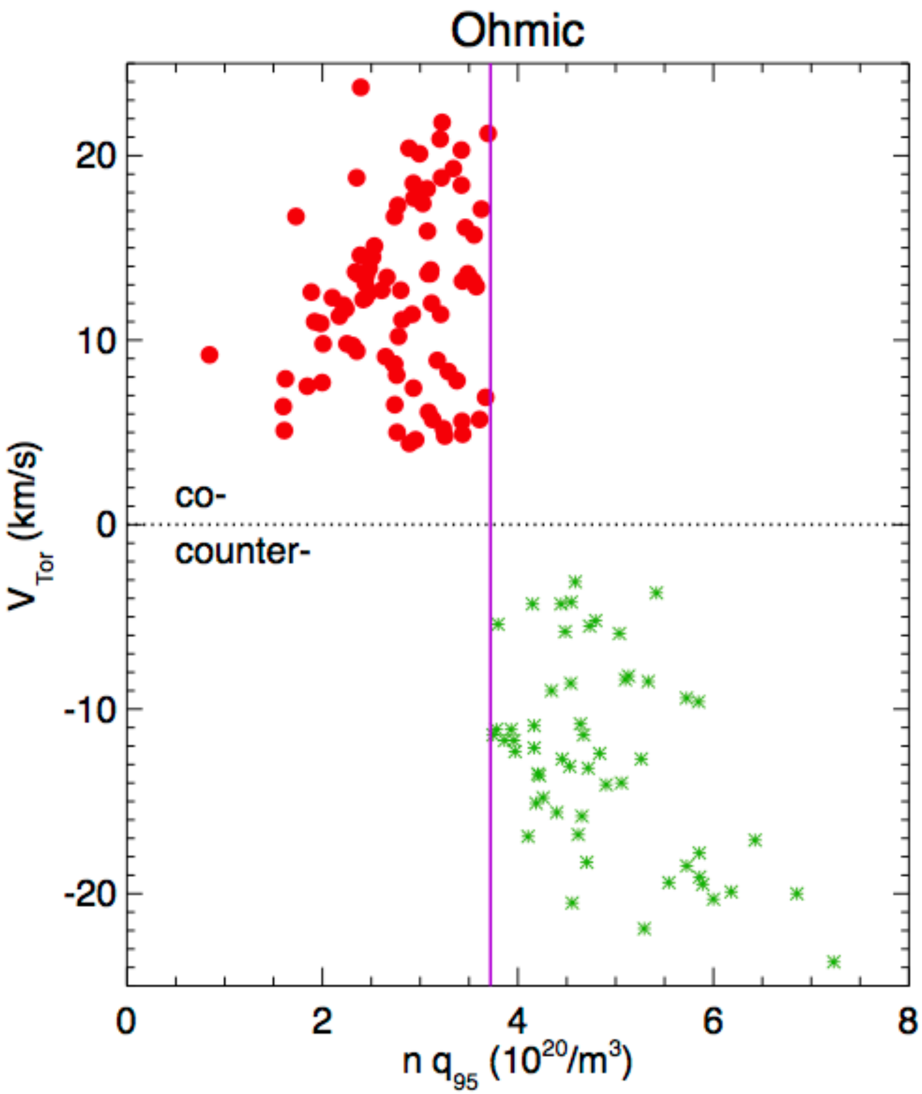
Intrinsic rotation reversals in C-Mod



J. Rice, *et al.*, Nucl. Fusion (2011)

Rotation changes direction as density and current (~1/q) change

$$\nu_* \doteq \frac{qR_0}{v_{ti}}\nu_{ii} \propto nq$$

Turbulence model with diamagnetic effects

Solve fluctuation dynamics with gyrokinetic turbulence code GS2:

$$\frac{Dg_s}{Dt} + \left(\mathbf{v}_\parallel \cdot \nabla_\parallel + \mathbf{v}_{Ds} \cdot \nabla_\perp\right) \left(g_s - Z_s e \langle \varphi \rangle \frac{\partial \hat{F}_s}{\partial \varepsilon} \right) + C_s[g_s]$$

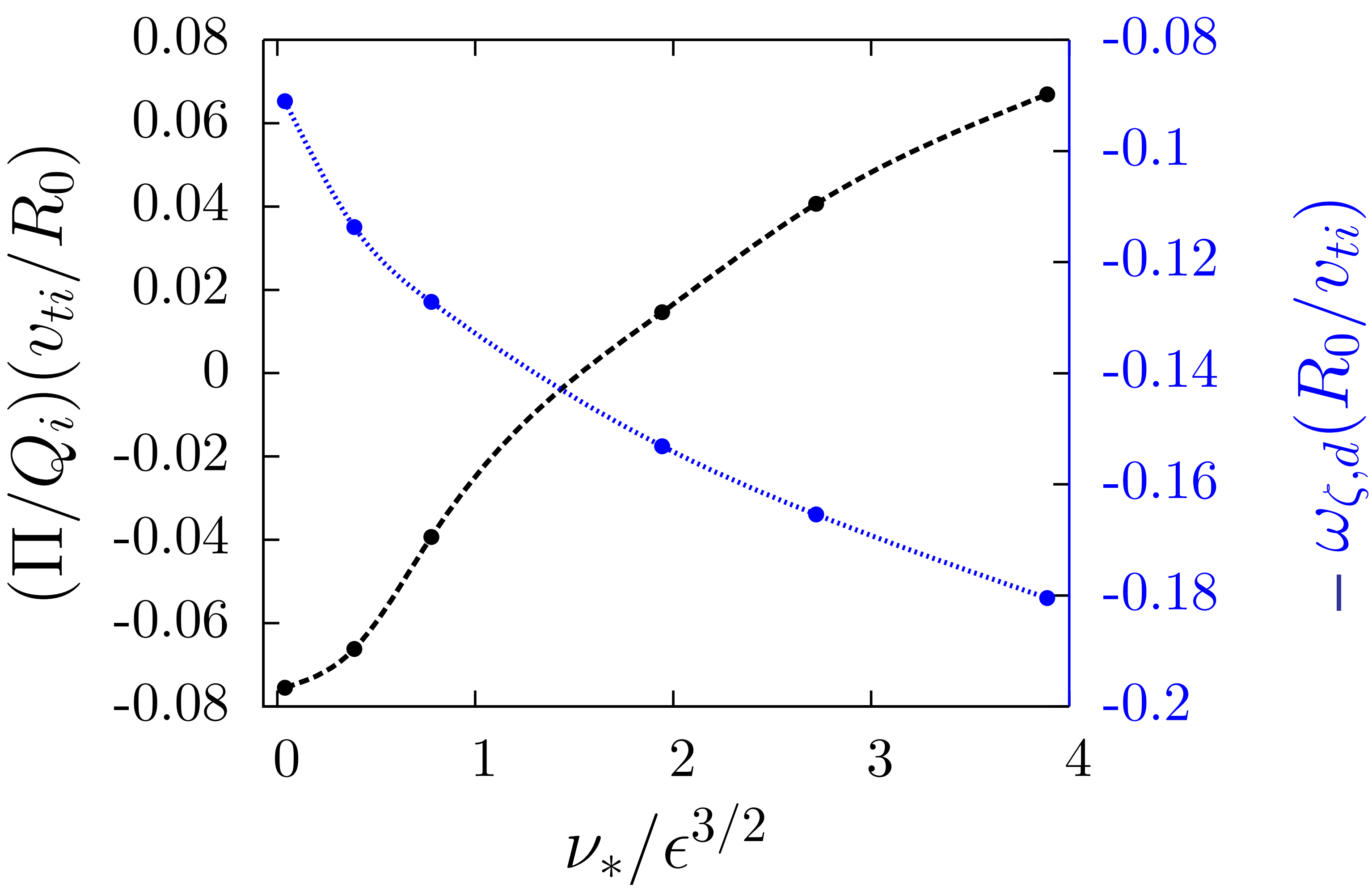
$$= - \langle \delta \mathbf{v}_E \rangle \cdot \left(\nabla \hat{F}_s + \frac{m_s R v_\parallel}{T_s} F_{Ms} \nabla \omega_{\zeta,E} \right) + Z_s e \mathbf{v}_\parallel \cdot \nabla \hat{\Phi} \frac{\partial g_s}{\partial \varepsilon}$$

Obtain $F_1(r)$ and $\Phi_1(r)$ of $\hat{F} = F_0 + F_1$ and $\hat{\Phi} = \Phi_0 + \Phi_1$ by solving drift kinetic equation with NEO at multiple radii

Set $\omega_{\zeta,E} = -\omega_{\zeta,d}$, with $\left\langle \left(R^2 \mathbf{v} \cdot \nabla \zeta \right) F_{1i} \right\rangle_\Lambda = n_i \left\langle R^2 \right\rangle_\Lambda \omega_{\zeta,d}$

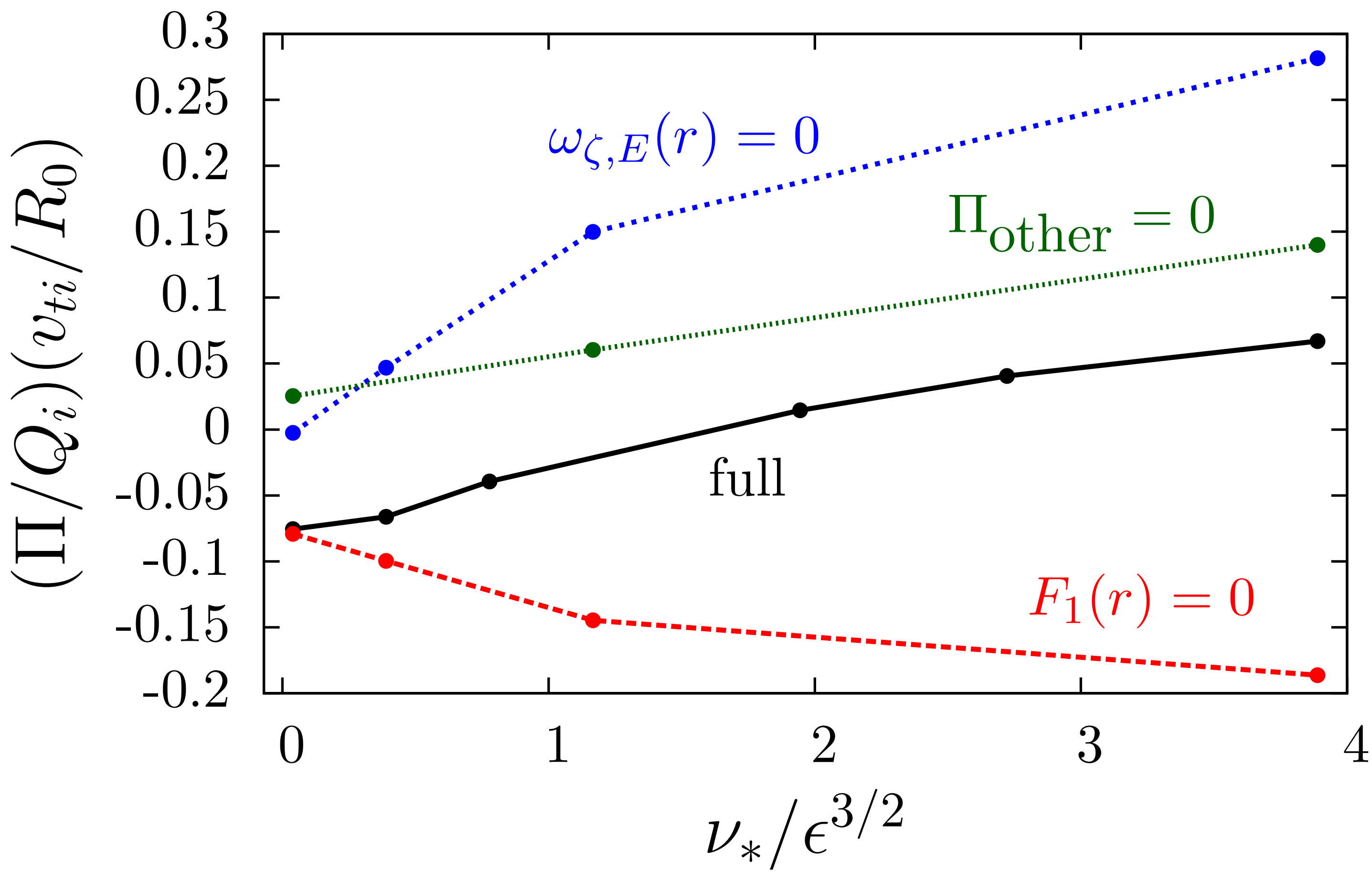
Momentum transport reverses direction with increasing collisionality

Transition occurs for $\nu_* \sim \epsilon^{3/2}$, corresponding to a transition from collisionless to collisional trapped particles (banana to plateau)



Opposing contributions from ExB and F_1

Transport is a result of partial cancellation between contributions from ExB advection-diffusion (red) and diamagnetic effects (blue)



Decomposition into advection and diffusion

$$\Pi = -mR_0^2\left(\chi_{\phi,d}\frac{\partial\omega_{\zeta,d}}{\partial r} + \chi_{\phi,E}\frac{\partial\omega_{\zeta,E}}{\partial r}\right)$$

$$-mR_0\left(P_d\omega_{\zeta,d} + P_E\omega_{\zeta,E}\right) + \Pi_{\mathrm{other}}$$

$$= -mR_0^2\chi_{\phi,\mathrm{eff}}\frac{\partial\omega_{\zeta,d}}{\partial r} - mR_0P_{\mathrm{eff}}\omega_{\zeta,d} + \Pi_{\mathrm{other}}$$

$$\omega_{\zeta,E}(r) = -\omega_{\zeta,d}(r)$$

$$\chi_{\phi,\mathrm{eff}} \doteq \chi_{\phi,d} - \chi_{\phi,E}$$

$$P_{\mathrm{eff}} \doteq P_d - P_E$$

Decomposition into advection and diffusion

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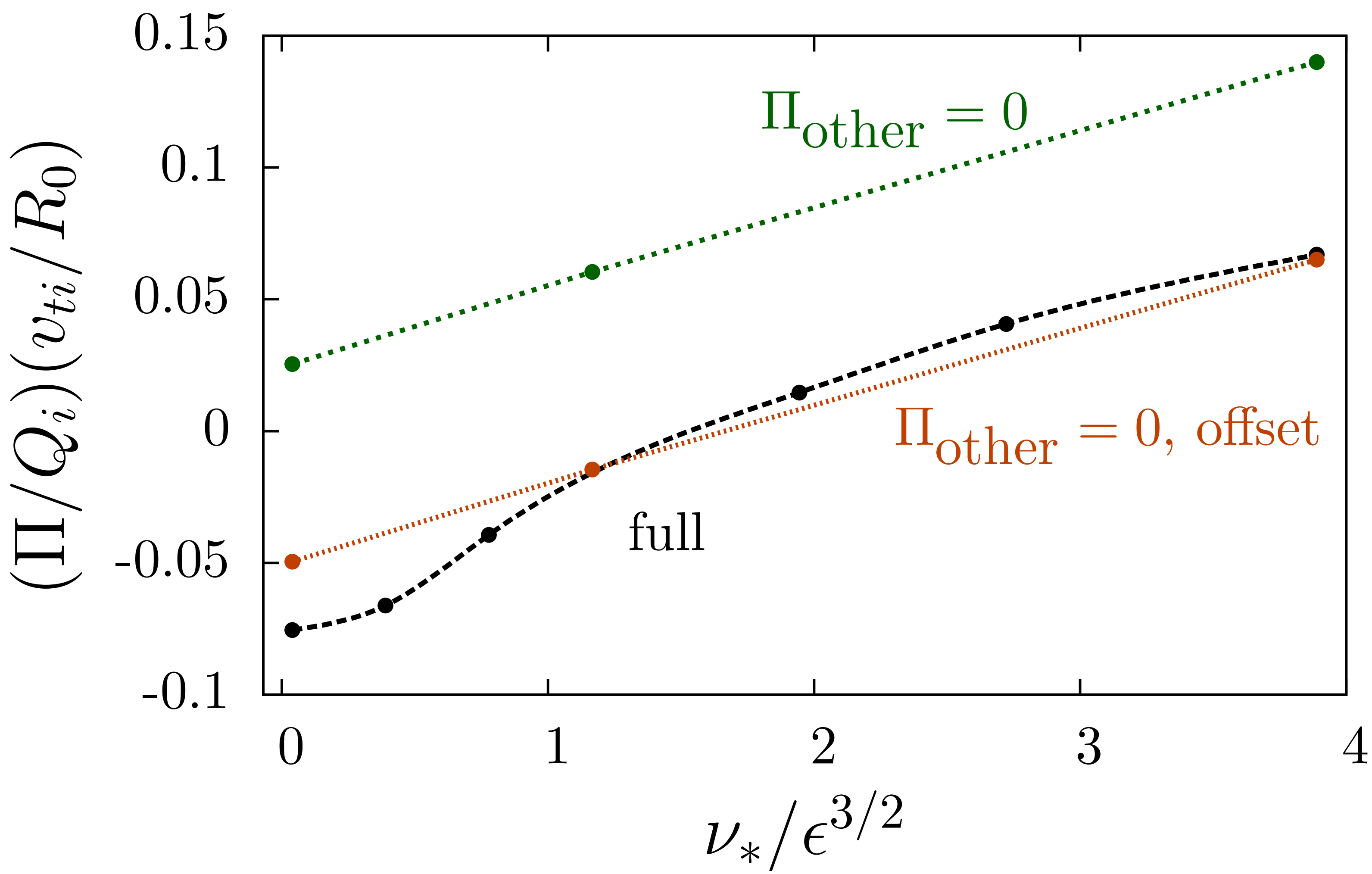
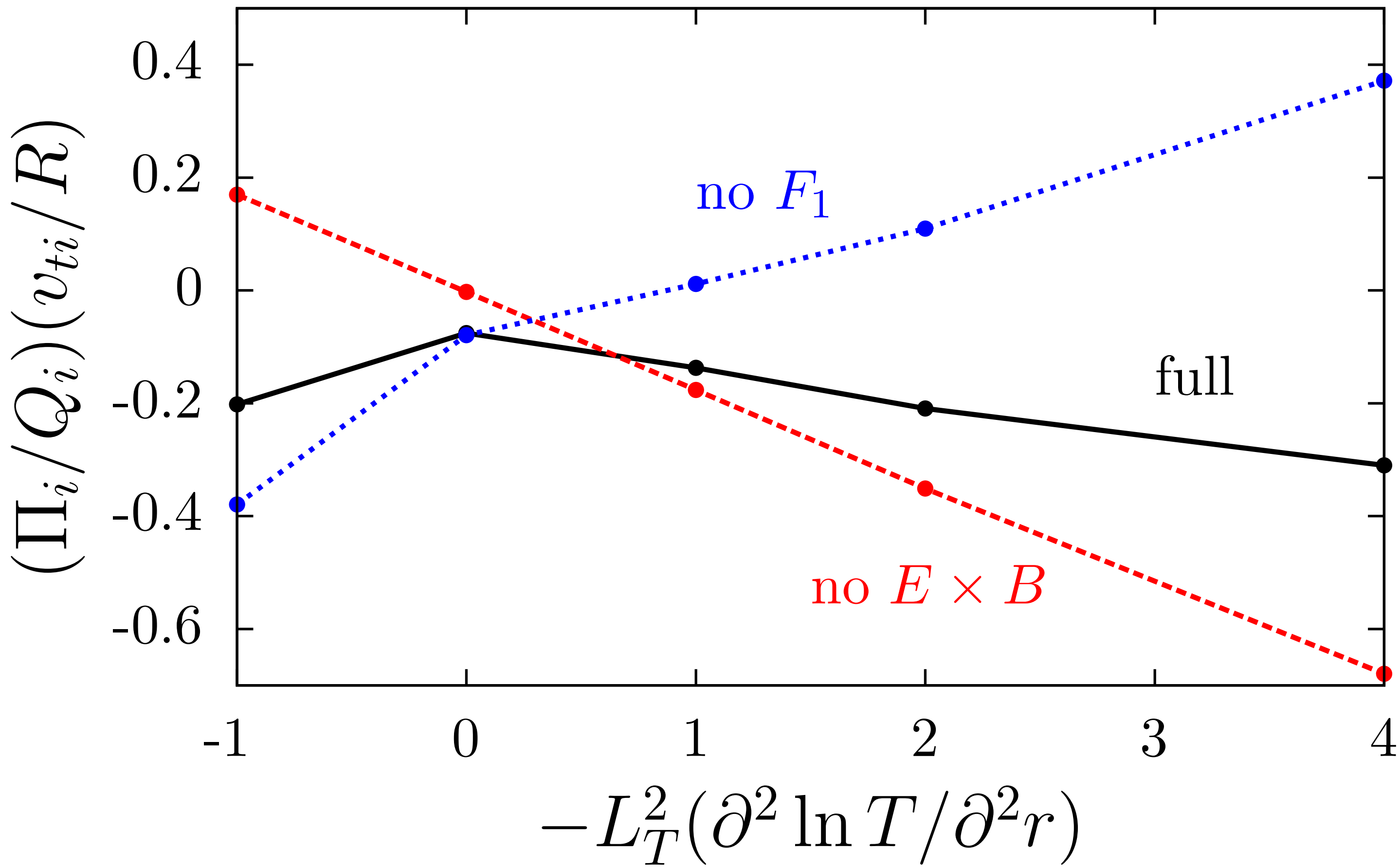


Dependence on temperature profile

Relatively weak dependence on temperature profile for case considered here



Conclusion

- Inclusion of diamagnetic corrections to equilibrium Maxwellian distribution introduces strong dependence of momentum transport on collisions and weaker dependence on curvature of temperature profiles
- Behavior consistent with experimentally observed intrinsic rotation reversals
- Turbulence drive type (ITG, TEM, etc.) found to have little effect on intrinsic rotation in this study

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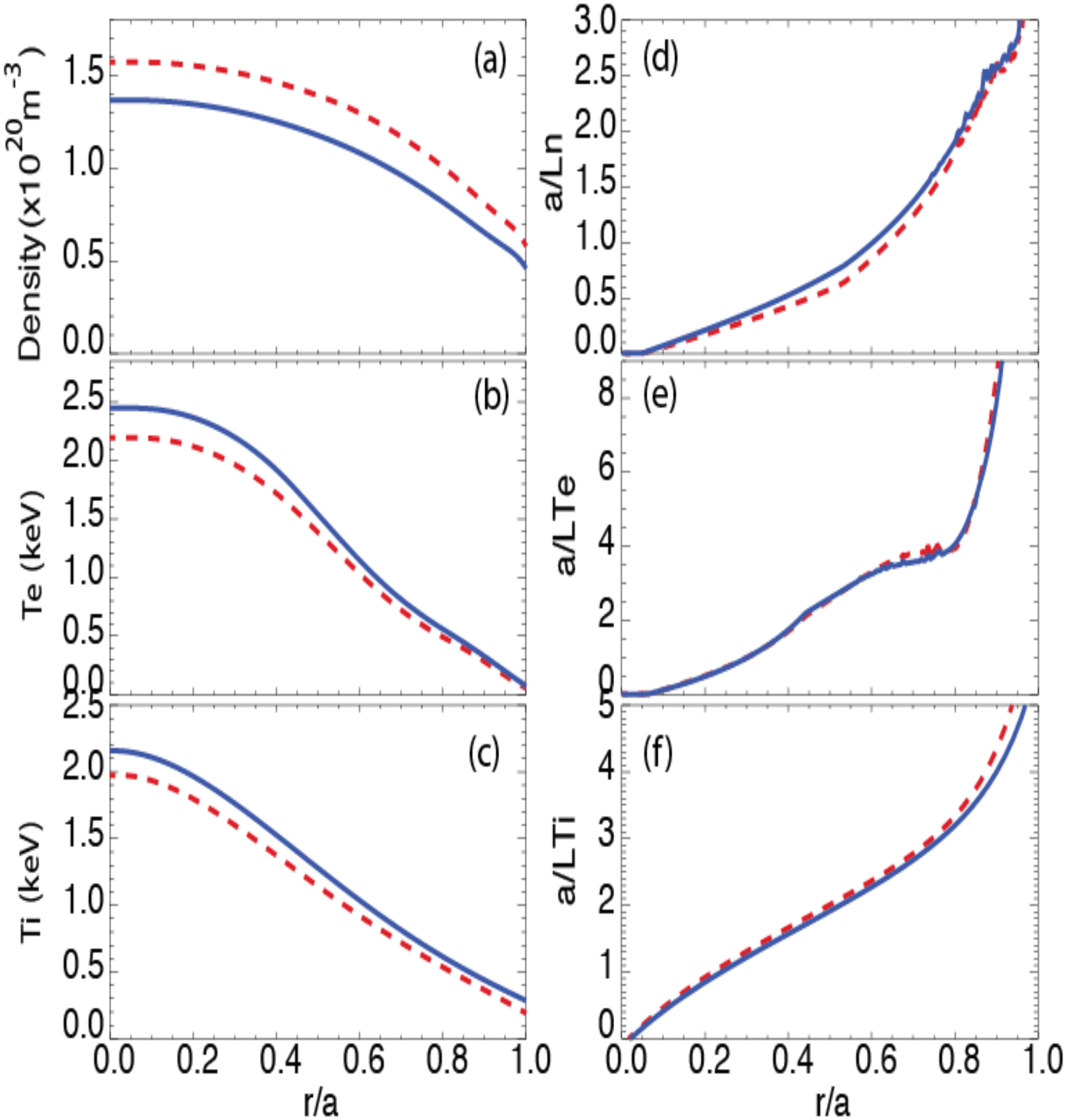
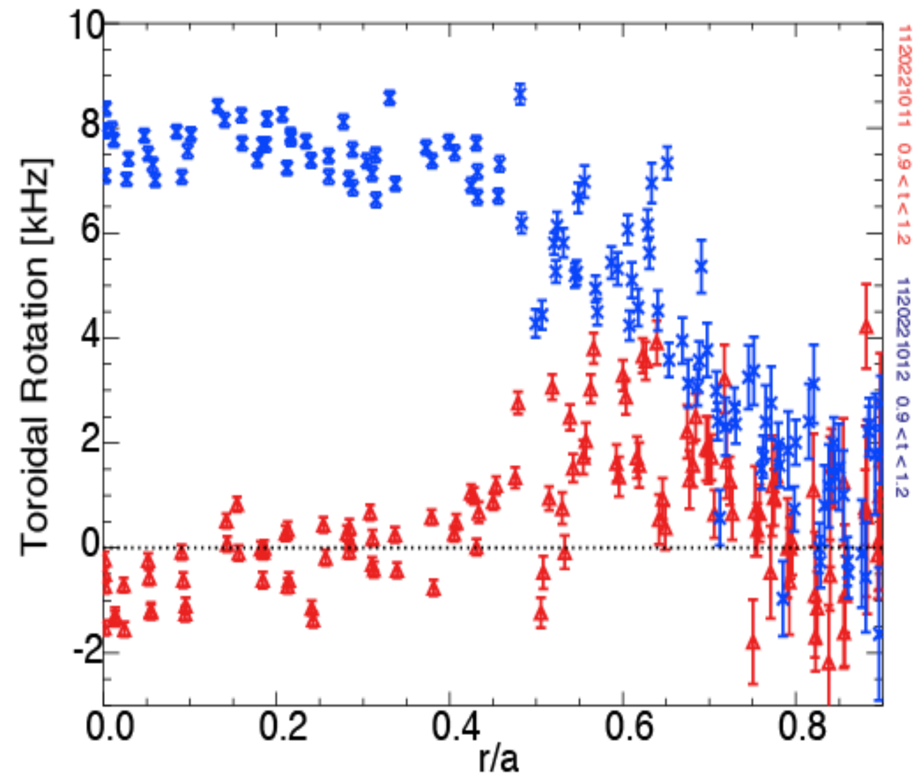


Density and temperature profiles modified slightly, gradient scale lengths kept fixed

Rotation reverses direction across most of radius



A. White, *et al.*, submitted to Phys. Plasmas