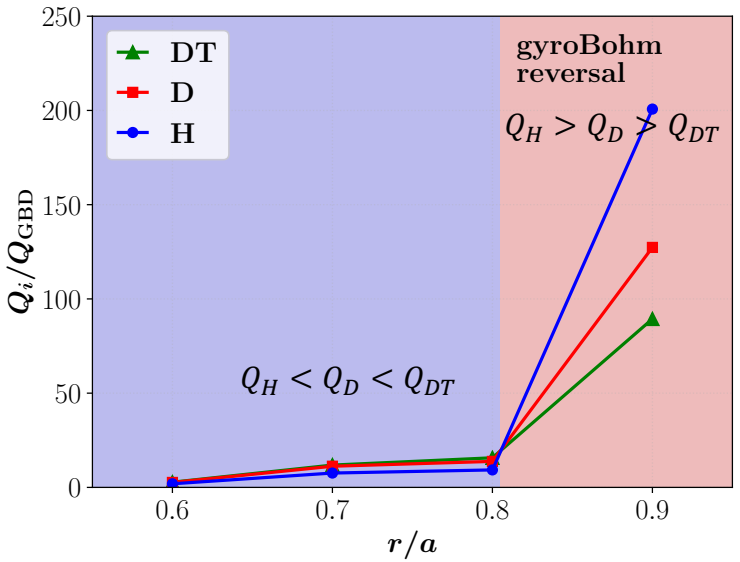
Strong Reversal of Simple Isotope Scaling Laws in Tokamak Edge Turbulence

By E. Belli, J. Candy, and R. Waltz

- A **new isotope-mass scaling law** is proposed to describe **electron-to-ion mass ratio dependence** of turbulent energy fluxes in both ion-dominated **core** and electron-dominated **edge** transport regimes.
- Electron-to-ion mass ratio dependence arises from the nonadiabatic response associated with **fast electron parallel motion**.
- The **nonadiabatic electron drive** strongly regulates the turbulence levels and plays a key role in **altering** – and in the L-mode edge, **favorably reversing** – **naive gyroBohm ion mass scaling**. The finite-electron-mass correction is larger for light ions like H and higher q such that it is weak in the ITG core but **dominates the mass scaling in the edge**.
- This reversal has favorable implications for the global energy confinement isotope scaling and for lowering the power threshold for the L-to-H mode transitions in a reactor like ITER from H to D to 50:50 D-T plasmas.

DIII-D L-mode #173147



$$\frac{Q_i}{Q_{GBD}} = c_0\sqrt{\frac{m_i}{m_D}} + c_1 q\mathcal{R}\sqrt{\frac{m_e}{m_D}} + c_2(q\mathcal{R})^2\frac{m_e}{\sqrt{m_i m_D}}$$

naive gyroBohm | weak nonadiabatic | strong nonadiabatic

E. Belli et al., PRL 125, 015001 (2020)
E. Belli et al., PoP 26, 082305 (2019)

GENERAL ATOMICS