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Experimental Challenges to Stiffness as a Transport Paradigm[1]

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Transport in plasmas is treated experimentally as a relationship between gradients and fluxes in analogy to the random-walk problem. Gyrokinetic models often predict strong increases in local flux for small increases in local gradient when above a threshold, holding all other parameters fixed. This has been named 'stiffness'. The radial scalelength is then expected to vary little with source strength as a result of high stiffness. To probe the role of ExB shearing on stiffness in the DIII-D tokamak, two neutral beam injection power scans in H-mode plasmas were specially crafted—one with constant, low torque and one with increasing torque. The ion heat, electron heat, and ion toroidal momentum transport do not show expected signatures of stiffness, while the ion particle transport does. The ion heat transport shows the clearest discrepancy; the normalized heat flux drops with increasing inverse ion temperature scalelength. ExB shearing affects the transport magnitude, but not the scalelength dependence. Linear gyrofluid (TGLF) and nonlinear gyrokinetic (GYRO) predictions show stiff ion heat transport around the experimental profiles. The ion temperature gradient required to match the ion heat flux with increasing auxiliary power is not correctly described by TGLF, even when parameters are varied within the experimental uncertainties. TGLF also underpredicts transport at smaller radii, but overpredicts transport at larger radii. Independent of the theory/experiment comparison, it is not clear that the theoretical definition of stiffness yields any prediction about parameter scans such as the power scans here, because the quantities that must be held fixed to quantify stiffness are varied. A survey of recent literature indicated that profile resilience is routinely attributed to stiffness, but simple model calculations show profile resilience does not imply stiffness. Taken together, these observations challenge the use of local stiffness as a paradigm for explaining global transport behavior.

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