# Kinetic Stress and Particle Transport by Stochastic Fields and Turbulence

Chang-Chun Chen[1,3], Patrick H. Diamond[1, 3], Ramesar Singh[1], and Steve M. Tobias[2, 3]
[1]*Department of Physics, University of California San Diego, La Jolla, California 92093, USA*
[2]*Department of Applied Mathematics, University of Leeds, Leeds LS2 9JT, United Kingdom*
[3]*Kavli Institute for Theoretical Physics, Santa Barbra, CA, USA*

It is general wisdom that stochastic magnetic fields affect the electron heat transport in a tokamak. In the L-H transition, with resonant magnetic perturbation (RMP), the transport of ion heat, particles, toroidal momentum can also be influenced by stochastic fields due to RMP. A well known model from Finn et al[1]. (hereafter FGC) discussed how toroidal flow is affected under the influence of stochastic fields. However, they merely have Elsässer-like variable of parallel rotation and particle density—*no* explicit momentum and particle density transport presented. Moreover, they didn't mentioned the kinetic stress which is critical in toroidal flow damping.

We propose a model to analytically derive the toroidal momentum transport and particle transport—we calculate the *real* diffusivity of particle and parallel momentum. Also, the physics of kinetic stress (K) and compressible heat, that play important roles in momentum and particle evolution[2], are further analyzed. In this model, the stochastic field is prescribed, and modifies the turbulent flow[3]. However, it can also altered by turbulent flow. We address this magnetic geometry effect to understand this "tail wagging the dog" feedback. Besides recovering the effective diffusivity $D_{eff} = C_s D_M$ in 'stochastic field regime', where $C_s$ is sound speed and $D_M$ is the familiar stochastic field diffusivity of Rosenbluth et al.[4], we obtain an *hybrid turbulent viscosity* $D_v = C_s^2 \sum_k |b_{x,k}|^2 / k_\perp^2 D_T$ in 'strong turbulent regime' such that $K = -D_v \partial_x \langle u_z \rangle$, where $D_T$ is turbulent fluid diffusivity. This indicates that the actual diffusivity $D_v$ describes how the mean flow be scattered perpendicularly by the synergy of stochastic fields and the strongly turbulent flow.

Finally, there are several implications of those results for the physics of the kinetic stress and toroidal rotation. Discussions of these will be presented.

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[1]J. Finn, P.M. Guzdar, A.A. Chernikov. *Phys. Fluids* **B4**, 1152 (1992)
[2]W.X. Ding, et al. *Phys. Rev. Lett.* **110**, 065008 (2013)
[3]C.-C. Chen, P. H. Diamond, R. Singh, and S. M. Tobias, "Potential vorticity transport in weakly and strongly magnetized plasmas", Physics of Plasmas 28, 042302 (2021).
[4]M.N. Rosenbluth, et al. *Nuclear Fusion* **6**, 297 (1966)