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Renormalization of plasma turbulence leading to fractional differential equations[1]

R. SANCHEZ, Oak Ridge National Laboratory

Several phenomenological models for plasma turbulent transport have been recently proposed that are based on the use of fractional differential operators. These operators provide with a mathematical framework that may outperform the standard diffusive paradigm when it comes to capturing much of the strange phenomenology encountered in tokamak plasmas: canonical profiles, anomalous confinement scalings, off-axis peaking, etc. The reason is simple: fractional operators are designed to model transport mechanisms that lack characteristic time and/or spatial scales, which appears to be the situation pointed to as relevant by the observed tokamak phenomenology. However, it has remained always unclear how fractional operators (non-local and non-Markovian in nature) can be derived from (and reconciled with) the usual equations for mass, moment and energy turbulent transport. In this contribution we start from the simplest turbulent transport equation (the advection of tracers by a turbulent flow with prescribed statistics) and show how to establish such connection by developing a new renormalization scheme that avoids the limitations of standard quasilinear renormalization theory. This result not only establishes the missing physical link with the phenomenological models but also suggests more efficient avenues for transport modeling in both real experiments and state-of-the-art transport codes.

[1]In collaboration with B.A. Carreras, ORNL; D.E. Newman, University of Alaska-Fairbanks; V.E. Lynch, ORNL; and B.Ph. van Milligen, CIEMAT, Spain.