Fractional renormalization of tracer turbulence

R. Sánchez[1], B.A. Carreras[1], D.E. Newman[2], V.E. Lynch[1] and B.Ph. van Milligen[3]

[1]Fusion Energy Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, U.S.A.

[2]Department of Physics, University of Alaska at Fairbanks, AK 99775-5920, U.S.A.

[3]Laboratorio Nacional de Fusión, Asociación EURATOM-CIEMAT, 28040 Madrid, SPAIN

For many years quasilinear renormalization has been applied to numerous problems in turbulent transport, from neutral fluids to magnetically confined plasmas. The quasilinear renormalization scheme relies on the so-called localization hypothesis to derive an "effective" linear transport equation from a prescribed stochastic description of the underlying microscopic turbulent dynamics. The localization hypothesis simply assumes the spatial variation of the mean gradients along the flow characteristics can be neglected. Then, one can easily connect the microscopic dynamics of the flow with a renormalized diffusive transport equation for the tracers the flow advects. It also gives expressions for the effective eddy diffusivity in terms of the flow characteristics. But the price paid by assuming the localization hypothesis is that the range of transport behaviors that can be captured by the final renormalized equations is quite restricted.

In this contribution we introduce a novel renormalization procedure that manages to avoid the localization hypothesis completely [1]. As a result, the renormalized transport equations it produces, which are expressed in terms of temporal and spatial fractional differential operators, are capable of capturing much more of the transport phenomenology observed in nature. Therefore, this renormalization technique provides the missing link between the microscopic turbulent physics and many of the fractional transport models that have proposed phenomenologically to describe tracer transport in a wide variety of turbulent systems such as neutral fluids, gases or plasmas.

References

[1] R. Sánchez, B.A. Carreras, *et al*, submitted to *Physical Review Letters* (2006)