Characterization of avalanche-like transport in fusion plasma turbulence by means of flux-gradient integro-differential kernels

J.A. Alcuson[1], J.M. Reynolds-Barredo[1], J. A. Mier[3], R. Sánchez[1],
D. del-Castillo-Negrete[2] and D.E. Newman[3]

[1]Departamento de Física, Universidad Carlos III de Madrid, 28911 Leganés, Madrid, SPAIN

[2]Departamento de Física Aplicada, Universidad de Cantabria, 39005 Santander, SPAIN

[3]Fusion Energy Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

[4]Department of Physics, University of Alaska at Fairbanks, Fairbanks, AK 99775-5920, USA

A method to determine fractional transport exponents in systems dominated by fluid or plasma turbulence is proposed. The method is based on the estimation of the integro-differential kernel that relates values of the fluxes and gradients of the transported field, and its comparison with the family of analytical kernels of the linear fractional transport equation. Although use of this type of kernels has been explored before in this context, the methodology proposed here is rather unique since the connection with specific fractional equations is exploited from the start. The procedure has been designed to be particularly well-suited for application in experimental setups, taking advantage of the fact that kernel determination only requires temporal data of the transported field measured on an Eulerian grid. The simplicity and robustness of the method is tested first by using fabricated data from continuous-time random walk models built with prescribed transport characteristics. Its strengths are then illustrated on numerical Eulerian data gathered from simulations of a magnetically confined turbulent plasma in a near-critical regime, that is known to exhibit superdiffusive radial transport dominated by avalanches.