

Time intermittency in non-diffusive fast ion transport in turbulent toroidal plasmas

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Fast ions denote a part of the ion population of a plasma that exhibits speeds far above the thermal average. They appear in astrophysical plasmas, e.g. as Solar Energetic Particles (SEPs)[1]. In fusion plasmas, fast ions originate from fusion reactions or neutral beam injection and their confinement is crucial to the performance of any reactor [2]. Understanding their interaction with turbulence and transport properties is of high relevance across all these domains.

Fast ion turbulent transport is therefore a key research objective on the TORoidal Plasma EXperiment at the Swiss Plasma Center [3]. With a low-temperature (ca. 1 eV) in helical open magnetic field-lines, TORPEX plasmas feature a dominant interchange mode giving rise to electrostatic plasma turbulence and the intermittent propagation of coherent filament structures, termed ‘blobs’ [3]. The cross-field spreading of a toroidally injected Li-6 fast ion beam has been identified as generally non-diffusive through comparisons with predictions from the Global Braginskii Solver (GBS) code [4]. Fast ions of higher energies (70 eV) exhibit sub-diffusion, while lower energies (30 eV) result in superdiffusion, which transitions to quasi-diffusion at longer propagation times [3, 4]. During initial studies, superdiffusive transport appeared time intermittent, as local fast ion time-series showed significant skewness [5], but did not in subdiffusion.

We report the findings of an extensive 3D set of fast ion time-series, demonstrating the prevalence of time intermittency across all observed non-diffusive transport regimes [6]. We introduce an analytical model [7] for the prediction of skewness of the time-series based on the motion of a concentrated instantaneous fast ion beam within its time-average. While possibly of direct interest in similar systems, these efforts illustrate the general importance of concrete physical models when relating time intermittency and non-diffusive transport.

References

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