Time Series Analysis of Non-Brownian Motion

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Diffusion processes of charged particles have been generally discussed within a framework of quasi-linear theory. However, test particle simulations we perform show that the diffusion processes are not classical, that is, not described by the quasi-linear theory, but in general non-classical for both parallel (field-aligned) diffusion and cross-field diffusion. Particle orbits are not Brownian in non-classical diffusion processes. In the 2-d cross field diffusion model we studies, particles often switch orbits between different magnetic islands composed of equi-contour lines of the magnetic field strength. In our parallel diffusion model, particles diffuse as they are reflected by MHD pulses distributed in space with distribution of their intervals given by a power law. Repeating of these sticking and walking motion produce non-Brownian motion.

Given a time series data of these orbits, we developed a method to separate them into intervals where the particle stays within a bounded region ('sticking') and intervals where the particle moves with almost a constant speed ('walk'), and subsequently to construct the probability distribution function (p.d.f.) of these intervals. We then compare the results with scaling law of diffusion coefficient exponent and these p.d.f. exponents indicated by Weeks et al.