The analysis of memory effects in plasma transport theory based on time-fractional transport equations

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Transport with the memory effect is investigated by time-fractional transport equations. The memory effect means that a particle flux at a given time is influenced by its past history. The scaling law of the mean square of the displacement with time is calculated by the decorrelation trajectory (DCT) method.[1] When a system with Kubo number much greater than unity, the orbit of a particle in the system is nearly periodic.[2] This implies that the particle is trapped by a stochastic field and the particle needs a certain time to escape from it. As a result, the autocorrelation function is algebraic decay with time instead of exponential decay and the transport process is non-Markovian. In such process, the memory effect becomes significant.[3]

From the continuous time random walk model[4], if the mean square of the displacement is not proportional to time, the transport equation has a character that the order of the derivative with time is not an integer, which is different from the standard transport equation with the first order derivative with time. Besides, in a system with Kubo number greater than unity, the relation $<x^2> \sim t^\alpha$, $0<\alpha<1$ can be obtained by the DCT method, which implies the process is non-Markovian and is belong to the regime of sub-diffusion. Hence, the time evolution of the density profile of the system can be calculated by the time-fractional transport equation. As shown in figure 1, the peak value of the density of the Markovian process decays faster than that of the non-Markovian process. Thus, in a non-Markovian process, the density diffuses slower, representing the regime of sub-diffusion.

References
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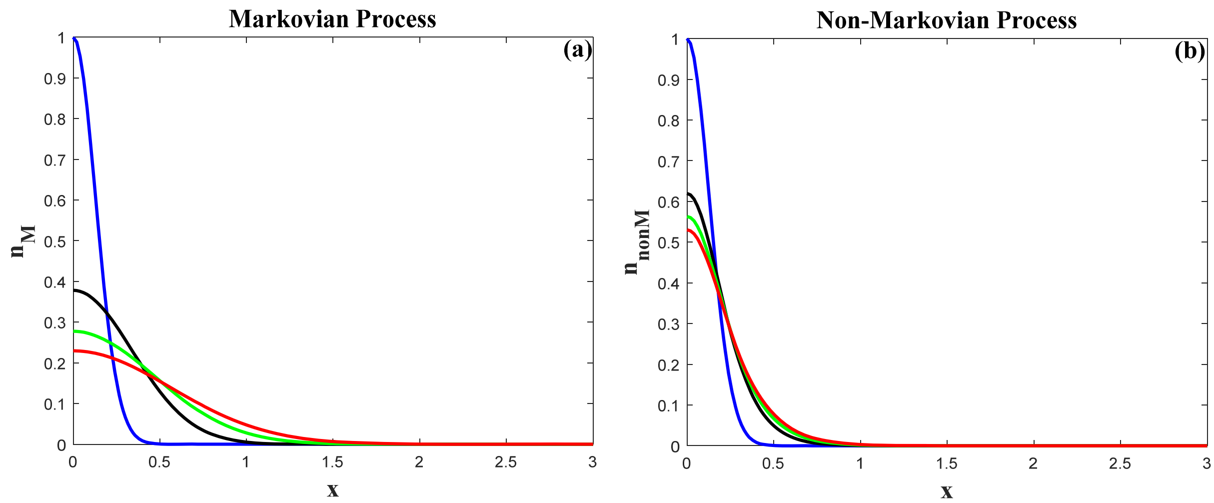

Figure 1 shows the time evolution of density profile. The blue, black, green and red curves are density profiles for time t=0, t=10, t=20 and t=30, respectively. Due to the memory effect, the density diffuses slower in non-Markovian process.