A new class of molecular compounds related to molten salts is now called the room-temperature ionic liquids (ILs), and it has attracted much attention in the research community because they possess many desirable properties. So far we have pointed out the remarkable similarity between dynamics of glass forming liquids and those in ionically conducting glasses [1]. Since ILs have both ionic and glass-forming characters, they provide a link between these systems, and to show the emergence of each characteristic as well as common properties. Molecular dynamics simulations of an ionic liquid, 1-ethyl-3-methylimidazolium nitrate (EMIM$^+\text{NO}_3^-$), have been performed to clarify the origin of various dynamical changes including heterogeneity near the glass transition temperature. MD simulations reported here are continuations of the previous works [2].

The observed slowing down of the dynamics has been characterized by a fractal dimension analysis of trajectories and by van Hove functions. The motion of cations is strongly coupled with that of anions. Change in the slope of the temperature dependence of the diffusivity occurs at around 410 K. The phenomenon is quite similar to that found for molecules in in ordinary glass-forming liquids, and also for ions in ionically conducting materials. This is particularly so for ions in mixed alkali glasses [3], where the nonlinear decrease of the dynamics with mixing of different kinds of alkali metal ions (i.e., the mixed alkali effect (MAE)) is well known. In MAE, suppression of the mutual diffusion with decreasing temperature play a role and this effect increases with size difference of the two species. Therefore the dynamics in ILs are affected by the unavoidable effect of cation and anion mixing. Long waiting time of jumps also contributes to the slow dynamics. Similarity in dynamics with other glass-forming liquids is natural, because MD studies of the glass-forming liquids have been mainly done for the binary mixtures. As in the research of the ionics [3], fractal dimensions of the random walks for both cation and anion are useful to characterize the dynamics and are shown in Fig. 1.
Change in the motion with longer scales is evident at around 410 K and the contribution of long range motion in the medium temperature region explains the large fragility of the system. Dynamical heterogeneity of long time scale is observed. Successive jump-like motions are found to continue over 8 ns at 370 K, while many ions are localized during this period. The self part of the van Hove function at 400 K is shown in Fig. 2. Heterogeneity at around the maximum of the non-Gaussian parameter has been reported under similar conditions [4]. The heterogeneity is not only at short length scales as seen from the development of a tail part after the maximum of the non-Gaussian parameter. With decreasing temperature, the tail part is found to be suppressed. The intermediate scattering functions $F_s(k,t)$ is the characteristic function of the self part of the van Hove function and therefore it is used to check the functional form of the latter. Simple analysis to show the power law in the wave number dependence of $g(k,t)$, which is obtained from $F_s(k,t)$, is proposed for demonstrating the existence of Lévy distribution [5] and structure of the dynamics.

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