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Short-time β-relaxation in glass-forming liquids is cooperative in nature

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Temporal relaxation of density fluctuations in supercooled liquids near the glass transition occurs in multiple steps. The short-time β-relaxation is generally attributed to spatially local processes involving the rattling motion of a particle in the transient cage formed by its neighbors. Using molecular dynamics simulations for three model glass-forming liquids, we show that the β-relaxation is actually cooperative in nature. Using finite-size scaling analysis, we extract a growing length-scale associated with β-relaxation from the observed dependence of the β-relaxation time on the system size. Remarkably, the temperature dependence of this length scale is found to be the same as that of the length scale that describes the spatial heterogeneity of local dynamics in the long-time α-relaxation regime. These results show that the conventional interpretation of β-relaxation as a local process is too implified and provide a clear connection between short-time dynamics and long-time structural relaxation in glass-forming liquids.