Dependence of the Glass Transition on the Spatial Dimension

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April 6, 2010

Abstract

We have investigated analytically and numerically the dependence of the liquid-glass transition of hard spheres on the spatial dimension d, in the framework of mode-coupling theory. For $d = 2$ and $d = 3$ most quantities, e.g. the critical nonergodicity parameters, resemble each other. A striking similarity between the critical packing fraction $\varphi_c(d)$ and that for random close packing, $\varphi_{rcp}(d)$, has been found. In order to explore a possible mean field character of MCT the limit $d \to \infty$ was studied, as well. In contrast to earlier results the critical collective and self nonergodicity parameters $f_c(q)$ and $f_c^{(s)}(q)$ exhibit non-Gaussian q-dependence. $f_c(q)$ and $f_c^{(s)}(q)$ differ on a scale $q \sim d^{1/2}$, but become identical for $q \sim d$. The analytically determined $\varphi_c(d) \cong 0.22\ d^2\ 2^{-d}$ is above the corresponding Kauzmann packing fraction $\varphi_K(d)$ derived earlier by a small cage expansion. Its quadratic pre-exponential factor is different from the linear one, found by others. Although the static structure factor for $\varphi_c(d)$ is very close to that of an ideal gas for $d \to \infty$, we argue that the glass transition may still be driven by the cage effect and might have similarities to the jamming transition.