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Static and dynamic length scales in glass-forming liquids

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A recurring question about glass formation concerns the collective nature of the dynamics as one cools or compresses a liquid. If the phenomenon is indeed collective, it should be characterized by the development of nontrivial correlations to which one or several typical length scales might be associated. One source of growing correlations has been clearly identified in connection with the increasingly heterogeneous character of the dynamics as one approaches the glass transition. An associated length, commonly referred to as “dynamic”, can be extracted from multi-point space-time correlation functions. In addition, several theories of the glass transition posit the existence of a growing “static” length accompanying a liquid’s dynamical slowdown. This length is not detectable through standard measurements on pair density correlations, which have been shown to display only unremarkable behavior as the relaxation slows down. However, a number of proposals have been put forward for unveiling such a nontrivial static length. Through computer simulation of model glass-forming liquids, we address the two following central questions: (i) Are the variations with temperature or pressure of these various lengths correlated? (ii) Is the increase of the relaxation time due to the growth of any of the above lengths, or, with less compelling consequences, is it at least correlated to it? While our results rule out the existence of a general principle tying together the evolutions of dynamic and static lengths in glass-forming systems, we discuss how the answer to the above questions depends on the dynamic regime under consideration as well as on the type of material.