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Hyperuniformity Disorder Length Spectroscopy - Method and Applications

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The original idea is that fluctuations in a hyperuniform system are controlled by particles on the surface of the measuring windows [Torquato and Stillinger, PRE 2003]. But particles live in a volume; therefore, we introduce a "hyperuniformity disorder length" $h(L)$ such that the relevant particles are within a distance $h(L)$ of the L^d measuring window boundaries. Then the asymptotic volume fraction variance scaling becomes dimensionally correct as ${\sigma_\phi}^2(L) \propto \langle v \rangle h/L^{d+1}$ where $\langle v \rangle$ is the average particle volume. After giving the technical definition of $h(L)$, I'll discuss two bounds, and I'll show simulation results for crystal vacancy and Einstein patterns to help build intuition for scaling of $h(L) \sim L$ in systems with liquid-like fluctuations and as $h(L) =$ constant in strongly hyperuniform systems. Then, in terms of the real-space spectrum of $h(L)$ versus L, I'll show how different kinds of packings become increasingly uniform on approach to jamming and reach hyperuniformity at jamming. An important theme is to bring meaning to the value, as well as the scaling, of density fluctuations. Various parts of this work are in collaboration with A. Chieco, R. Dreyfus, C. Goodrich, A.J. Liu, and S. Torquato.