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Joel LEBOWITZ - The Structure Function of Random Point Processes: Fluctuations and Rigidity

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We consider a translation invariant point process in \mathbb{R}^d or \mathbb{Z}^d . Let $V(N_B)$ be the variance in the number of points, N_B , in a ball B of volume $|B|$. Generally, such as when particles with short range interactions are distributed according to a Gibbs measure, $V(N_B)/|B| > 0$.

There are however many interesting cases when $\text{Var}(N_B)/N_B \rightarrow 0$, as $|B| \rightarrow \infty$. Such processes are called hyperuniform (or superhomogeneous)

This occurs when the structure function $S(k)$, the Fourier transform of the “full” pair correlation function, $G(r) = n \int [g(r) - 1]$, n being the density, which is always non-negative, vanishes at $k=0$, $S(k)=0$. Just how fast $V(N_B)/|B|$ goes to zero depends on the way $S(k)$ behaves as $k \rightarrow 0$.

I will discuss examples of such hyperuniform systems both old (Coulomb systems) and recent (facilitated exclusion processes).

When $S(k)$ vanishes in an open set M in k -space (which may or may not include the origin) the system is maximally “rigid”. Rigidity describes the amount of information about the points in B given the configuration of points outside B . This can be zero as in a Poisson process or “maximal” where the exact position of the points in B are determined by the configuration outside B .

Such systems also have other “crystalline” properties. (This is joint work with Subhro Gosh)

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