**Quantum Model (Drude)**

Diffusion, being a transport property, can be expected to evince the transition from delocalization to localization more transparently.

**Quantum Model: Diagrammatic Expansion**

A classical particle would be completely localized if its energy were less than the peak of any of the disordered wells. The quantum case is more complicated. A particle could be localized even if its energy were greater than any of the wells, if repeated reflections were to somehow constructively interfere to create a local standing wave. And yet a particle even with energy lower than many of those wells could be extended via tunneling (and in a perfectly ordered lattice, the wavefunctions *will* be extended). Still, it seems quantum particles are more easily localized than classical ones.

We can calculate the diffusion coefficient, with the usual Boltzman equation, but I haven’t done this. And we can also do this with GF. The one of interest would be the density-density correlation function, displayed below:



where ρ(r) = ψ†(r)ψ(r). It can be written in terms of a ‘self-energy’ which, in this context, would be the diffusion ‘constant’, D(q,ω). Note ρF is the density of states at EF.



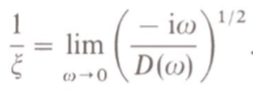
Note that the Wolfle paper says that D(ω) and σ(ω) relate via D(0,ω)/D0 = σ(0,ω)/σ0, where the 0 presumably refers to ω = 0. The particle’s diffusive behavior is embedded in the poles of π. Let’s consider the long time (small ω) limit.



Assuming this limit exists, then let’s compare to:



So we see that μ = 1/ξ. So by analogy we expect:



If we use a ladder sum to calculate the density-density correlation function,



and extract D(q,ω), evidently we get the Drude result: D = vF2τ/d (d = dimension I think). I presume



So this independent of ω, and therefore produces no finite ξ. And the density-density function gives us the expected result:

