QSS07 - Cristiane de Morais Smith - Questions & Answers

Cristiane de Morais Smith

Dietrich Leibfried: What happens in the triangle game if you start in the "excluded" central triangle? Do you then "paint" the regions that were untouched in your example?

CRISTIANE: You can start in the excluded central triangle, it does not matter because you will immediately get one vertex and you will take the middle point between your initial point and the random vertex, and this point will not be in the excluded regions. You could even start outside the triangle, keep playing the dices, and from the moment when you enter inside the triangle you start considering the points. It would give you the same. However, this would not work if instead of a triangle you would have a square. For a square, if you play this game, you fill up the entire square. A condition to get a fractal in a square is that if you get twice the same vertex in a row, you do not take it the second time. If you impose this constraint, you get a fractal, otherwise not.

Yiming Pan: What are the difference of fractal dimension between wavefunction and wavefunction squared?

CRISTIANE: We cannot measure the wave function itself, just the modulus square. So the strict answer to your question is: I don't know, but I would guess that it should be the same. The only thing we are missing is the phase. Now, people like Wiesendanger are trying to build an STM with an arm, such that you could measure correlation functions. This could allow us to detect the phase of the wave function, but there is still time to go before they can really do it.

Dietrich Leibfried: Are you correcting for photon loss when calculating Polya numbers etc.?

XIANMIN: What matters is whether a photon return to the initial site or appear at other sites. We treat the number of events that a photon is detected at the output as the total number of effective events, and normalize the probability of a photon being found at each site of the photonic lattice. Based on the normalized probability distribution, we calculate the Polya number. As for the optical loss, it is quite low in a silica chip where the lattice is embedded.

MrUkhanna: If the waveguides were not arranged in a perfect fractal pattern, would you see some signature of localisation ?

CRISTIANE: I suppose so. We are calculating that right now, so I do not yet have the precise answer to your question, but we can already see some sign of localisation around the holes when you look at the maps, right?

Alejandro Gonzalez-Tudela: In which sense is the transport "quantum"? can one also explain the features using classical electromagnetism, i.e., photon propagation in waveguides?

CRISTIANE: It is governed by overlap of wave functions, hopping from one site to the other. This is a quantum phenomenon, although in the single-particle regime. Second, the exponents of the log of the variance versus the log of time do not obey the same laws as for classical random walk, but different laws, characteristic of quantum walk.

Callum Duncan: By understanding the physics in fractal systems can we say something of the physics in multifractal systems? Can I just build up a multifractal system from independent fractals? Or in other words: If I know the solution to the system for fractal dimension A, and also the solution for a fractal dimension B. Do I know the physics in the multifractal system with a multifractal spectrum composed of only A and B?

CRISTIANE: Dear Callum, I still do not know the answer to your question, but hopefully I will know it in some not too far future. At the moment, we know how to characterise a multi fractal, and prove that it is a multi fractal and not a mono fractal. These are mostly disordered systems, besides the Heron attractor. We have been investigating some of them, but there are no conclusions yet.

Callum Duncan: Is there an example where the underlying Hamiltonian has a fractal structure but the wave function does not gain the fractal structure?

CRISTIANE: The answer to this question was not obvious a priori, and this is why we decided to check it. Now, you can see that the fractal dimension is overall the dimension in the wave function squared (and Hamiltonian) of the geometric structure, but not really at the energies around the formation of the anti-bonding configuration, when the dimensionality is clearly lower than 1.58. I don't know of any counter example where the Hamiltonian is fractal and the wave function does not have precisely the same dimension, except for the one mentioned above. Let me tell you another curious example. The Lieb lattice is a lattice made of 1st generation Sierpinski carpets (there is one missing site in the middle of a square plaquette). When we were trying to calculate the dimensionality for the Lieb, we were systematically getting 1.9 instead of 2. I couldn't understand why, since this is a lattice in 2D. My student checked the results many many times, and it was always 1.9. During a Solvay Colloquium in Belgium, I showed the results that I could not understand, and someone in the public jumped and said: of course, this is a lattice of Sierpinski carpets, and therefore it should have the dimension 1.89. That was it. This means that even if your structure is a true lattice, the wave function square will know about the dimension of the unit cells, which are fractals. This opens up a lot of applications in lattices that have sites with different connectivities.

Valentina Parigi: What is the flux of photons, as to be in the quantum regime you need to have low number, otherwise you are more looking at classical coherent properties of light

XIANMIN: We do measurements with both heralded single-photon source and weak coherent light.