# QSS17 - Nir Davidson - Questions & Answers

*Nir Davidson*

**Rupesh R K**: can this concept be extended for quantum computation?

**NIR**: The "standard" quantum computation is based on unitary evolution in Hilbert space and on entanglement. Both do not exist in "annealers" even when the "objects" are quantum. There are people that claim that "quantumness" can provide benefist also for annealers (e.g. being able to tunnel out of a local minima into a global one through the barrier rather than above it but this was not demonstrated yet.

**Bill Phillips**: You have been very careful with your language, using terms like "quantum inspired" rather than "quantum" for the kind of computation being done. A laser is essentially classical. Different lasers are, presumably, not quantum entangled. So, is there a "quantum advantage" or is the advantage only from interference, as in implementations of Grover's algorithm as opposed to from entanglement (as is assumed) in Shor's algorithm, or is it something else?

**NIR**: As far as I know here is yet no evidence for "quantum advantage" in either the laser system or similar annealing systems. These debates are going on for quite some time e.g. for D-wave SC annealer and more recently for Yamamoto's Ising Machine. The success probability of e.g. the Ising Machine scale exponentially with the system size for known hard problems (such as max-cut or certain spin glass problems) as expected from purely classical considerations. The "microscopic" state of the system as it crosses threshold (which is the "decision point" between correct and incorrect solutions is being studied theoretically a benefit from non gaussianity of the state and claimed by some (and opposed by others). No experimental results that I know of exist on this.

**Sashank Kaushik**: How exactly does it average to a pi phase difference with the 120 and -120 phase differences in the ensemble of modes for the triangular lattice?

**NIR**: Half the longitudinal modes phase lock with +120 degrees and the other half with +240 degree phase difference (these are the 2 degenerate ground states of XY Hamiltonian on triangular lattice with nearest neighbor negative coupling). The total coherence is the average of these 2 "arrows" which gives +180 degrees (i.e. pi) phase difference and the length of the "arrow" which is the magnitude of eth coherence is 1/2.

**Rupesh R K**: How are the masks in the first part of the talk made? Do you also use a spatial light modulator?

**NIR**: Initially we used metal masks where the holes are cut by laser machining (by a company). Now we mostly used the SLM to form the mask except in regions with high intensity above the damage threshold of the SLM.

**Yaniv Kurman**: Regarding the SLM controlled "noise", do you try to find topological optical couplings that could be blind to the added noise from the SLM? Maybe an optical analogue of Kitaev chain?

**NIR**: The added noise does distort the complex landscape and hence the local minimum states even for the topologically protected states e.g. on the ring. However it cannot transfer one local minima into another with different topological properties.

**Valentina Parigi**: How exact should the assumption be that the intensity of the different laser should be equal?

**NIR**: We studied this in some details in [I. Gershenzon et. al., Nanophotonics 20200137 (2020)]. We showed for a simple example of 5 coupled lasers that the deviation of the laser minimal loss solutions from the correct XY solution are zero when the intensities are exactly identical and deviate linearly with the intensity non-uniformity. So to find the exact ground state of large XY spin system with arbitrary coupling, would probably require exponentially small non-uniformity of the intensities.

**Andrew Daley**: In reference to exciton systems, some people cite that the process of locking (condensation in that case) is not fully understood, and could be non-classical (or indeed, quantum). Can you identify something similar in the locking on the laser in your models?

**NIR**: There are similar claims made also for degenerate OPOs (by the Yamamoto group) but they are not proven and heavily debated by others.

**Bill Phillips**: The classification of phase transitions as first or second order depends on what quantity is being monitored. For traditional thermodynamic transitions, this is usually well-agreed upon, so that discontinuous heat capacity is first order. Is there a similarly well-defined choice here, or is it a matter of personal taste.

**NIR**: As you correctly note, the coupled lasers are highly dissipative out of equilibrium systems and even the notion of temperature is not very well defined so one should be careful not to claim first and second order phase transitions in eth thermodynamic sense. For example in our crowd synchrony experiment the "first order" jump is as a function of the number of laser so clearly a finite system effect. Still, adding the intensity of the lasers as a non -frozen degree of freedom does provide "jumps" in the coherence as a function of various parameters as e.g. in Arecci's work (and Strogatz has similar results that he calls "amplitude death"). They all seem to relate to the laser transition (intensity wise) coupled to synchronization transition (which by itself is mostly "second order").