THE WEIZMANN INSTITUTE OF SCIENCE
FACULTY OF MATHEMATICS AND COMPUTER SCIENCE

The Chaim Leib Pekeris Memorial Lecture

on Tuesday, Jun 14, 2016at 11:30

Dolfi and Lola Ebner Auditorium

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The Quantum Computer Puzzle

Abstract:

Quantum computers are hypothetical devices, based on quantum physics, which would enable us to perform certain computations (among them some that Chaim Leib Pekeris pioneered) hundreds of orders of magnitude faster than digital computers. This feature is coined “quantum supremacy.” We start the lecture with a gentle introduction to computing - classical and quantum, with basic notions of computational complexity, and with the vision of quantum computers.

A main reason for concern regarding the feasibility of quantum computers is that quantum systems are inherently noisy. We will explain what is "noise" and describe an optimistic hypothesis regarding quantum noise that will allow quantum computing and a pessimistic hypothesis that won’t. The remarkable progress witnessed during the past two decades in the field of experimental physics of controlled quantum systems places the decision between the pessimistic and optimistic hypotheses within reach. On the optimistic side, one aspect or another of quantum supremacy might be seen by experiments in the near future: by implementing quantum error-correction or by systems of free bosons or by exotic new phases of matter called anyons or by quantum annealing, or in various other ways.

In the lecture I will explain my pessimistic line of research and here is a brief summary of my view: understanding quantum computers in the presence of noise requires consideration of behavior at different scales. In the small scale, standard models of noise from the mid-90s are suitable, and quantum evolutions and states described by them manifest a very low-level computational power. This small-scale behavior has far-reaching consequences for the behavior of noisy quantum systems at larger scales. On the one hand, it does not allow reaching the starting points for quantum fault tolerance and quantum supremacy, making them both impossible at all scales. On the other hand, it leads to novel implicit ways for modeling noise at larger scales and to various predictions on the behavior of noisy quantum systems.

We will rely on the theory of noise-sensitivity and stability developed with Benjamini and Schramm in the late 90s and on recent work with Guy Kindler related to the mysterious gap between permanents and determinants (or, in other words, between bosons and fermions).

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