



**ARNOLD SOMMERFELD**  
CENTER FOR THEORETICAL PHYSICS



## Sommerfeld Theory Colloquium

**Wednesday, 1st June 2022**

at 16.15 h

**Prof. Scott Aaronson**

(University of Texas at Austin, USA)

### **How Much Structure Is Needed for Huge Quantum Speedups?**

I'll survey, for a physics audience, three decades of research into which sorts of problems admit exponential speedups via quantum computers -- starting with classics (like the algorithms of Simon and Shor), and proceeding all the way to a breakthrough by Yamakawa and Zhandry from April 2022. I'll discuss both the quantum circuit model, which is what we ultimately care about in practice but where our knowledge is radically incomplete, and the so-called "oracle" or "black-box" or "query complexity" model, where we've managed to achieve a much more thorough understanding that then informs our conjectures about the circuit model. I'll discuss the strengths and weaknesses of switching attention to sampling tasks, as was done in Google's and USTC's quantum supremacy experiments. I'll make some skeptical remarks about widely-touted claims of exponential quantum speedups for practical machine learning and optimization problems. Through numerous examples, I'll try to convey the "law of conservation of weirdness," according to which every problem admitting exponential quantum speedup must have some unusual property to allow the amplitude to be concentrated on the unknown right answers.

Based on a talk previously delivered at the 28th Solvay Conference in Brussels

via ZOOM

Lode Pollet