# 22st Colloquium Lecture, School of Mathematics Faculty of Mathematics and Physics


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Sokolovská 83, Praha 8 – Karlín

# A Gradual, Frustrated Tour of Mathematics Related to Adiabatic Quantum Computing


### Abstract

In the near future, the availability of quantum annealing machines, also known as Adiabatic Quantum Computers (AQCs), with about N>50 qubits holds the promise to be a disruptive technology. A qubit is a quantum superposition of the bits 0 and the 1 at the heart of all binary technology, with the qubit time evolution associated with the time-dependent Schrödinger equation. AQCs allow NP-hard problems to be performed in computations. The ability of AQCs to perform calculations impractical for any binary computer is why governments and companies (including Google) are making substantial investments in AQCs. In particular, D-Wave produces and sells a quantum annealing machine with N>1000 qubits.

An introduction to the mathematics behind AQCs will be presented. The mathematics starts with the time-dependent Schrödinger equation within the adiabatic approximation, incorporates the mathematics of frustration and of spin glasses, requires answers to which spin glass problems are NP-hard, and shows that AQCs are equivalent to the circuit model of quantum computing. Additional mathematical constructs of graph theory for universality of spin glasses, stoquastic versus non-stoquastic Hamiltonians, and using symmetries for error detection and error correction will be described. Potential applications of AQCs that will be touched upon include simulating quantum systems, factorization of L-bit integers, and machine learning (both classical Boltzmann machines and quantum Boltzmann machines).


### About the speaker

**Mark A. Novotny** is a Fulbright Distinguished Chair at MFF UK for the 2016-2017 academic year. Prof. Novotny was born in the US, earned his B.S. in Physics from North Dakota State U., and his Ph.D. in Physics in 1978 from Stanford U. He was previously employed at the US institutions of the University of Georgia, Northeastern University, and Florida State University, as well as bu the IBM Scientific Centre in Bergen, Norway. He has been Professor and Head of the Dept. of Physics and Astronomy at Mississippi State Univ. since 2001, and is a Giles Distinguished Professor. Prof. Novotny has published more than 200 refereed papers, in areas ranging from materials physics to computer science to quantum devices. He is the inventor of a US patent entitled 'Fully Scalable Computer Architecture' and is the inventor of US provisional patents related to quantum dragon nanodevices and to quantum computers. He is a Fellow of both the American Physical Society and of AAAS. The current research of Prof. Novotny centers on three areas regarding the utilization of quantum mechanics in future enhanced technologies. One research area is electron transport through nanodevices, where he discovered ‘quantum dragons’. Another research area concerns advancement and use of quantum computers, in particular adiabatic quantum computers. A third research area is how quantum statistical mechanics is approximated by classical statistical mechanics for finite closed quantum systems, with potential applications to quantum computing.

## Further information

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