Mathematics 588: Quantum Computation—a Spring 2015 course proposal

Instructor: Janek Wehr

Email: wehr@math.arizona.edu. Please contact me if you have any questions!

The recent developments in physics allow an unprecedented degree of control of quantum systems. The optical techniques led to the experimental realization of Bose-Einstein condensation and manipulation of cold atoms trapped in laser fields. There is a hope that, using these and other advances in experimental physics, quantum computers will be constructed, causing a revolution in computing. To make such computers useful, a theory and a supply of quantum algorithms is necessary. These will be the main topics of the course.

I will start with the physics of quantum computers—what has been achieved and what is missing. Next, I will discuss the mathematical theory of quantum computation and its relation to classical theory of algorithmic complexity. The key concept of entanglement will be discussed in detail. If time permits, I will include a general discussion of decoherence in quantum systems and its relation to quantum computing.

I plan to use Nielsen and Chuang's book "Quantum information and quantum computation" as a general, very readable reference, and "Classical and quantum computation" by Kitaev et al. for a more in-depth study of the theory of quantum algorithms. The latter will be the textbook for the course. Other sources may be also used, as needed.

All I am assuming from the audience is a good knowledge of senior-level linear algebra and, more importantly, an interest in the subject of the course. Mathematics and physics graduate students definitely have the necessary background. I will be introducing the necessary quantum mechanics as needed (very little). I hope to show you a new, exciting field, which leads to a novel way of thinking about quantum systems. I also want us to have fun solving problems which are the core of Kitaev's book and I am counting on your active participation. This way, what we learn in this course will prepare us for working on new, unsolved questions. The field is full of them.

See you in January!