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ESI SENIOR RESEARCH FELLOW LECTURE COURSE

Summer Term 2011

Quantum Spin Systems. An introduction to the general theory and discussion of recent developments
Prof. Bruno Nachtergaele (UC Davis)
Start: Thursday, March 3, 2011
Lectures: Thursday, 14:00 - 16:00
Seminar: Friday, 14:00 - 16:00
ESI, Erwin Schrödinger Lecture Hall

Course description:
The course consist of two parts. In *Part I* we will introduce the basic framework for the mathematical study of quantum spin systems in the form that is suitable for applications in condensed matter physics as well as quantum information and computation theory. This will include a survey of the main questions the theory aims to address, and we will discuss a significant number of important model Hamiltonians. Tutorials on necessary topics of a more technical nature will be given as needed. *Part II* will serve as an introduction to a number of topics in quantum spin systems that are the subject of active current investigation. Our primary focus will be several recent developments in the study of so-called ”gapped quantum phases”. There are ground states of quantum lattice models which, in some cases have a property referred to as *topological order*. Characterizing these gapped ground states is an important step to better understand the possibilities and challenges of implementing quantum computation and information processing with topological quantum ground state phases. Furthermore, the critical points separating distinct gapped phases describe quantum phase transitions, which have fascinating mathematical and physical properties. A case in point is the conjectured E_8 symmetry of the critical quantum Ising chain, experimental evidence for which was recently reported in the literature (Science, 8 January 2010, **327** (no. 5962) pp. 177-180; see also arXiv:1012.5407).

Prerequisites:
A good general foundation in the areas of linear algebra, elementary differential equations, and real analysis will generally suffice as a prerequisite for this course. Familiarity with the basic elements of quantum mechanics and some elementary methods of mathematical physics and functional analysis (Hilbert space) will be helpful. Part I of the course will pay due attention to introducing the more specialized topics—such as the fundamentals of statistical mechanics, representation theory, and elements of many-body physics—, that will underpin the discussion of topics of current interest covered in Part II.

Joachim Schwermer
Scientific Director
ESI

The ESI Senior Research Fellow Programme is supported by the University of Vienna and the Austrian Federal Ministry of Science & Research. The programme is coordinated by Prof. Joachim Schwermer, Fakultät für Mathematik, Universität Wien, Nordbergstraße 15, A-1090 Wien (Joachim.Schwermer@univie.ac.at)