Thesis topics in theoretical condensed matter and statistical physics

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Frustrated quantum antiferromagnets

The magnetic properties of many materials can be modelled in terms of interacting spins on a lattice. Antiferromagnets on two-dimensional lattices have long been of particular interest, an important reason being that many materials have a layered structure consisting of two-dimensional lattice planes that are relatively weakly coupled in the third direction. The most interesting systems tend to have small spins (as then quantum effects are most pronounced) and frustrated interactions (which means that it is impossible for all pairs of interacting spins to minimize their energy). This can give rise to phases characterized by unusual ordering phenomena and to complex phase diagrams as a function of temperature, external magnetic field, and other model parameters. This project involves analytical and/or numerical studies of selected phenomena related to frustrated quantum antiferromagnets.

A class of coloring problems

If each edge of a graph is coloured with one out of q colours, such that no edges meeting at a vertex have the same colour, the result is said to be a q-edge-colouring of the graph. How many such colourings does the graph have? This problem (which can also be reformulated in terms of a Potts model) has been studied in statistical mechanics when the graph is a regular lattice of macroscopic size. This project involves studying a special class of such problems, involving lattices where each vertex is connected to q edges. The analysis will be based on applying a recently developed formalism and will involve both analytical and numerical work. As part of this project, the student will learn about Grassmann integrals, which are also heavily used in the study of quantum-mechanical many-particle systems of fermions.

For both topics it is advantageous to already be familiar with the use of creation and annhilation operators at the level obtained e.g. in the course TFY4210 *Kvanteteori for mangepartikkelsystemer* at NTNU.

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