Topological phases and phase transitions in magnets and ice

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Outlook

The main focus of this Thesis is the behaviour of two-dimensional materials, namely (anti)-ferromagnetic materials in the first two chapters, which show topological phases, and energetic square ice in the third and fourth chapter. The magnetic materials are of interest in part due to foreseen practical applications in which skyrmions can act as data carriers for which we have shown that skyrmions can exist in the ground state. Energetic square ice is of theoretical interest due to its anomalous behaviour at the infinite-order phase transition and as a purely mathematical analytically solvable model. We used this model to test the order parameter we constructed that, by definition, can be used to detect these infinite-order phase transitions. We also show agreement between conjectured and known properties for energetic square ice with special boundaries and show the existence of oscillations that go beyond current theories.

Further research, however, is necessary in both of these topics. For ferromagnetic systems we developed tools to calculate quantum fluctuations on given configurations. It would be interesting to use these to investigate the changes these fluctuations bring to the classical phase diagram for both the ferromagnetic as well as the anti-ferromagnetic case. As skyrmionic textures are of interest in search for new data transfer methods more research is needed to investigate the behaviour of stable ground state configurations when manipulated by spin and heat currents.

The chapter on energetic ice also brings forth some yet unanswered questions. More numerical investigation into the F-model with even more exotic boundary conditions, which can lead to drastic changes for the phase diagram, can be compared to and used in combination with analytical results. Since the order parameter we constructed should, in principle, work for all infinite-order phase transitions it would be interesting to test our proposed observable for other models that exhibit these types of phase transitions.