Novel theoretical aspects of frustrated spin systems

Pujol Pierre
Laboratoire de Physique, ENS-Lyon France

Daniel Cabra
Laboratoire de Physique Théorique, Université Louis Pasteur, Strasbourg France

Frédéric Mila
Ecole Polytechnique Fédérale de Lausanne Switzerland

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1 Workshop Details

1.1 Details

Timing
Number of days : 3
Start : 2006-03-09
end : 2006-03-11

Location of the activity
CECAM
46 allé e d'Italie
69007 Lyon
France

1.2 Description

The main aim of this exploratory workshop is to provide the opportunity for theoreticians within the European community working on low dimensional frustrated magnetism to discuss new concepts and properties in the domain of analytical and numerical techniques and to explore recent advances in this emerging field. The workshop has also the objective to set the grounds for future collaborations among participants. We plan to welcome around 40 participants working in all theoretical aspects of frustrated magnetism.
The Workshop will start Thursday morning and end on Saturday afternoon.
Social events: Workshop Dinner - Friday evening.
Metro station: Stade de Gerland

2 Requested Support

CECAM

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3 Participant List

Timothy Saunders (saunders@thphys.ox.ac.uk)
Oxford University United Kingdom

Juergen Schnack (jschnack@uos.de)
Uni Osnabrueck Germany

Fré dé ric Mila (Frederic.Mila@epfl.ch)
Ecole Polytechnique Fé dé rale de Lausanne Switzerland

Ariel Dobry (dobry@ifir.edu.ar)
Instituto de Fí sica Rosario Argentina

Dariush Heidarian (dariush@sissa.it)
SISSA Italy

Andrea Taroni (a.taroni@ucl.ac.uk)
University College London United Kingdom

Eduard Tutis (edo@ifs.hr)
Institute of Physics Croatia

jean-baptiste Fouet (jean-baptiste.fouet@epfl.ch)
EPFL Switzerland

Arnaud Ralko (arnaud.ralko@epfl.ch)
EPFL Switzerland

Julien Dorier (julien.dorier@epfl.ch)
EPFL Switzerland

Ioannis Rousochatzakis (ioannis.rousochatzakis@epfl.ch)
EPFL Switzerland

George Jackeli (george.jackeli@epfl.ch)
Institute for Theoretical Physics, EPFL Switzerland

Daniel Cabra (cabra@lpt1.u-strasbg.fr)
Laboratoire de Physique Thé orique, Université Louis Pasteur, Strasbourg France

Pujol Pierre (Pierre.Pujol@ens-lyon.fr)
Laboratoire de Physique, ENS-Lyon France

Johannes Richter (johannes.richter@physik.uni-magdeburg.de)
Otto-von-Guericke-Universitä t, Magdeburg Germany

Matthias Troyer (troyer@itp.phys.ethz.ch)
Theoretische Physik, ETH Zü rich Switzerland

Maria-Roser Valenti (valenti@itp.uni-frankfurt.de)
Goethe-Universitä t Frankfurt Germany

Federico Becca (becca@sissa.it)
SISSA Italy

Andreas Lä uchli (andreas.laeuchli@epfl.ch)
Ecole Polytechnique Fé dé rale de Lausanne Switzerland

Roderich Moessner (moessner@lpt.ens.fr)
LPT ENS - Paris France

Fabien Alet (alet@irsamc.ups-tlse.fr)
Univ. Paul Sabatier, Toulouse France

Matthieu Mambrini (mambrini@irsamc.ups-tlse.fr)
Univ. Paul Sabatier, Toulouse France

Sylvain Capponi (capponi@irsamc.ups-tlse.fr)
Univ. Paul Sabatier, Toulouse France

Philippe Sindzingre (phsi@lptl.jussieu.fr)
LPTMC, Univ. Paris VI France

Lacroix Claudine (lacroix@grenoble.cnrs.fr)
CNRS France

Sandro Sorella (sorella@sissa.it)
SISSA Italy

John Chalker (j.chalker1@physics.ox.ac.uk)
University of Oxford United Kingdom

Andreas Honecker (a.honecker@tu-bs.de)
Institut fü r Theoretische Physik, Universitä t Gö ttingen Germany

Hans Ulrich Everts (everts@itp.uni-hannover.de)
Universitä t Hannover Germany

Karlo Penc (penc@szfki.hu)
Research Institute for Solid State Physics and Optics Hungary

Mike Zhitomirsky (mike.zhitomirsky@cea.fr)
CEA Grenoble France

Didier Poilblanc (didier.poilblanc@irsamc.ups-tlse.fr)
Laboratoire de Physique Theorique (LPT), Univ. Paul Sabatier (Toulouse) & CNRS France

Benjamin Canals (benjamin.canals@grenoble.cnrs.fr)
Laboratoire Louis Né el, Grenoble France

Philippe Lecheminant (Philippe.Lecheminant@ptm.u-cergy.fr)
LPTM , Univ. de Cergy-Pontoise France

Peter Holdsworth (Peter.Holdsworth@ens-lyon.fr)
ENS-Lyon France

Claire Lhuillier (claire.lhuillier@lptl.jussieu.fr)
LPTL Univ. Paris 6 France

4 Presentation List

Metamagnetic phase transition of the antiferromagnetic Heisenberg icosahedron
Juergen Schnack
Uni Osnabrueck, Germany
Abstract
The observation of hysteresis effects in single molecule magnets like Mn$_12$-acetate has initiated ideas of future applications in storage technology. The appearance of a hysteresis loop in such compounds is an outcome of their magnetic anisotropy. In this presentation we report that magnetic hysteresis occurs in a frustarted spin system without any anisotropy, specifically, where spins mounted on the vertices of an icosahedron are coupled by antiferromagnetic isotropic nearest-neighbor Heisenberg interaction giving rise to geometric frustration. At T=0 this system undergoes a first order metamagnetic phase transition at a critical field $Bcrit$ between two distinct families of ground state configurations. The metastable phase of the system is characterized by a temperature and field dependent survival probability distribution.
Phys. Rev. Lett. 94 (2005) 207203

References
[1] Christian Schroder and Heinz-Jurgen Schmidt and Jurgen Schnack and Marshall Luban *Metamagnetic Phase Transition of the Antiferromagnetic Heisenberg Icosahedron*, Phys. Rev. Lett. **94** 207203 (2005)

Magnetization plateaux in frustrated Spin-Peierls systems.
Ariel Dobry
Instituto de Fí sica Rosario, Argentina
Abstract
We present a novel mechanism for the appearance of magnetization plateaux in quasi-one-dimensional quantum spin systems, which is induced by the coupling to the underlying lattice. We investigate in detail a simple model of a frustrated spin-1/2 Heisenberg chain coupled to adiabatic phonons under an external magnetic field, but the present mechanism is expected to be more general. Using field theoretic methods complemented by extensive Density Matrix Renormalisation Group techniques, we show that magnetization plateaux at non-trivial rational values of the magnetization can be stabilized by the lattice coupling. We suggest that such a scenario could be relevant for some low dimensional frustrated spin-Peierls compounds.

Decay of quasiparticles in quantum spin liquids
Mike Zhitomirsky
CEA Grenoble, France
Abstract
Magnetic excitations are studied in quantum disordered spin systems with a singlet ground state, which is separated by a fintie gap from low-energy spin-1 excitations. Symmetry of a majority of low-dimensional dimer systems, as, for example, a dimerized chain, asymmetric ladder, and a planar array of dimers, allows spontaneous two-magnon decays. Near the boundary of two-magnon continuum, the cubic vertices, which desribe interaction between one- and two-particle

states, yield a nonanalytic contribution to the one-particle Green's function. We solve the Dyson's equation with such a nonanalytic term and find that for one- and two-dimensional spin systems crossing of a single-magnon branch into two-particle continuum cannot be desribed solely by a growing magnon linewidth. For one-dimensional spin systems the crossing point is a termination point of the single-magnon branch, similar to the behavior of quasiparticle in superfluid 4He. In two dimensions the quasiparticle weight is strongly suppressed near the continuum boundary. The momentum dependence of the decay rate is calculated in arbitrary dimensions and effect of external magnetic field is discussed, see Ref. [1].

References

1. M. E. Zhitomirsky, cond-mat/0601405

Recent developments in spin ice

Roderich Moessner
LPT ENS - Paris, France

One-dimensional degenerate fermionic cold atoms : a low-energy effective theory

Philippe Lecheminant
LPTM , Univ. de Cergy-Pontoise, France

Abstract

The physical properties of arbitrary half-integer spins F = N - 1/2 fermionic cold atoms trapped in a one-dimensional optical lattice are investigated by means of a low-energy approach. We reveal the existence of a discrete symmetry which plays a central role in the determination of the low-energy properties of these systems. Two different superfluid phases are found whether a Z_N symmetry is spontaneously broken or not: an unconfined BCS pairing phase and a confined molecular superfluid instability made of 2N fermions. The nature of the confined-unconfined transition is shown to belong to the Z_N universality class. We discuss on the possible Mott phases at 1/2N filling.

Role of Dzyaloshinskii-Moriya interaction in pyrochlore antiferromagnets

Benjamin Canals
Laboratoire Louis Né el, Grenoble, France

Abstract

Dzyaloshinsky-Moriya interactions (DMI's) may be present in pyrochlore compounds, and the consequences of such interactions on the magnetic properties are investigated through mean-field approximation, Monte Carlo simulations and Linear Spin Wave analysis. It is found that DMI's (if present) strongly affect the low-temperature behavior of the system. At a temperature of the order of the DMI's a phase transition to a long-range-ordered state takes place. For one type of DMI's, it is shown that an order out of disorder effect takes place at both classical and quantum levels.

Improved variational phase diagram of the J_1-J_2 model on the square lattice

Federico Becca
SISSA, Italy

Abstract
By using an improved Jastrow-Slater wave function, we study the zero-temperature properties of the two-dimensional J_1-J_2 model. The present wave function is written in terms of a fermionic determinant, containing both antiferromagnetism and electronic pairing, and a spin Jastrow term. Within this kind of wave function, it is easily possible to interpolate between the antiferromagnetic region and the disordered one, giving rise to the most accurate variational calculation since now.

Unconventional continuous phase transition in a three-dimensional dimer model

Fabien Alet
Univ. Paul Sabatier, Toulouse, France

Abstract
Phase transitions occupy a central role in physics, due both to their experimental ubiquity and their fundamental conceptual importance. Most saliently, universal behaviour is encountered at phase transitions; indeed, the explanation of universality by a standard theory of phase transitions was the great success of the theory formulated by Ginzburg and Landau, and extended through the renormalisation group by Wilson. Here we report the first large-scale simulations of a model belonging to a class of three dimensional problems proposed to be a candidate for requiring a description beyond the Landau-Ginzburg-Wilson framework: we study the phase transition from the dimer crystal to the Coulomb liquid phase in the cubic dimer model. Our numerical results strongly indicate that this transition is continuous. Its critical exponents, compatible with a tri-critical universality class, are at variance with previous proposals.

Application of the coupled cluster method on frustrated quantum spin systems

Johannes Richter
Otto-von-Guericke-Universitä t, Magdeburg, Germany

Abstract
We illustrate the main features of the coupled cluster method (CCM), which is a powerful and widely applied technique of quantum many-body theory. We present CCM results for the Shastry-Sutherland model and the J_1-J_2 model. For the latter model we consider also the influence of an interlayer coupling J_perp on the ground state phase diagram.

Atomic Fermi gas in the trimerised kagome lattice

Hans Ulrich Everts
Universitä t Hannover, Germany

Abstract
Cold atomic gases on optical lattices can serve to model various quantum spin systems.In gen-

eral, the physics of these gases is described by extensions of the Hubbard model. Here, we concentrate on the case of a spinless Fermi gas on the trimerised kagomé lattice at 2/3 filling.In the limit of weak coupling between the trimers the Hubbard model of this system is well approximated by an effective quantum spin 1/2 model on the triangular lattice whose couplings depend on the bond directions. The overall exchange coupling J of this model is proportional to the inter-trimer interaction of the underlying Hubbard model which can be positive or negative depending on the experimental situation. Therefore both cases, J $\rangle$ 0 and J $\langle$ 0, are of interest.The analysis of the classical version of the effective model reveals qualitative differences between the two cases. For J 0, where we have found a large classical ground state degeneracy, the ED results for the spin-spin correlations suggest 120ř order in the quantum ground state too. The order seems to persist at small finite temperatures. At the same time we find a very dense spectrum of low-lying excited states. These may be related the degenerate classicalground states of our model. Similarly as for the Heisenberg antiferromagnet on the kagomé lattice the specific heat of our effective spin model shows a pronounced peak at very low temperatures. Position and height of the peak shift with the sizes of the systems that we have been able to treat by ED so that its fate in the thermodynamic limit is uncertain. In summary, our effective spin model shows very unusual properties: it combines planar antiferromagnetic order with an exceptionally large number of low-energy excitations.

The impact of Dzyaloshinskii-Moriya interactions on the physics of quantum antiferromagnets in a field: gaps, torque, and domain-wall condensation

jean-baptiste Fouet
EPFL, Switzerland

Abstract
SU(2)-breaking interactions such as Dzyaloshinskii-Moriya (DM) interactions exist in a vast number of magnetic compounds. They usually lead to some canting or possibly some weak ferromagnetism, but since they lower the symmetry of the system, they can have an important impact on the quantum properties of antiferromagnets such as the gap and the magnetization curve, even if they are weak with respect to the dominant Heisenberg coupling constants. In this presentation, we will review the work we have done recently on several aspects of that problem, with emphasis on the following properties: 1) The non-monotonous field dependence of the gap opened by DM interactions in otherwise gapless systems such as spin chains and ordered antiferromagnets; 2) The condensation of domain walls near rational magnetization plateaux in frustrated ladders; 3) The transverse uniform magnetization and the resulting torque induced when the field is neither parallel nor perpendicular to the D vector of the DM interactions in coupled-dimer systems.

Magnetization plateau and structural transition in spinel systems

Karlo Penc
Research Institute for Solid State Physics and Optics, Hungary

Entropy of correlated electrons on highly frustrated lattices

Andreas Honecker
Institut fü r Theoretische Physik, Universitä t Gö ttingen, Germany

Abstract

We discuss the antiferromagnetic spin-1/2 Heisenberg model in an external magnetic field and the Hubbard model on a class of highly frustrated lattices which include the kagomé and pyrochlore lattice. Such lattices are characterized by a completely flat lowest one-magnon band above the ferromagnetically polarized state, or single-fermion band, respectively. This has been known to give rise to flat-band ferromagnetism in the repulsive Hubbard model on such lattices. More recently it has been discovered independently that this leads to exact eigenstates of the Heisenberg model, which can be constructed as non-interacting ‚localized magnon' states. Here we provide a unified picture for both models. First, we note that the localized single-particle excitations acquire zero energy for a suitable choice of the magnetic field or the chemical potential, respectively. The absence of interactions then ensures that a class of many-particle states also has zero energy, giving rise to a finite zero-temperature entropy.
For further analysis of the zero- and finite-temperature entropy we focus on a one-dimensional model, the ‚sawtooth' chain. In particular, we study the behaviour of the temperature during adiabatic variation of the magnetic field or chemical potential, respectively. For the Heisenberg model, this demonstrates an enhanced magnetocaloric effect which is believed to be generic on highly frustrated lattices. Our results therefore suggest applications of frustrated quantum magnets for efficient low-temperature magnetic refrigeration.

References

M.E. Zhitomirsky, A. Honecker, Magnetocaloric Effect in One-Dimensional Antiferromagnets, J. Stat. Mech.: Theor. Exp. (2004) P07012

A. Honecker, J. Richter, Entropy of Fermionic Models on Highly Frustrated Lattices, Condensed Matter Physics 8 (2005) 813-824 (Proceedings of the conference Statistical Physics 2005: Modern Problems and New Applications, Lviv, Ukraine, 28-30 August 2005)

Dynamical Spin Correlations of the Quantum Kagome Antiferromagnet

Andreas Lä uchli
Ecole Polytechnique Fé dé rale de Lausanne, Switzerland

Abstract

The kagome antiferromagnet with spin 1/2 has been the topic of many theoretical investigations. Most of these focused on groundstate properties or aiming at an explanation of the anomalous high density of singlet excitations. In this talk I will report on some recent exact diagonalization studies concentrating on dynamical correlation functions. First the full dynamical spin structure factor S(q,w) on 36 sites has been obtained. Then I also discuss the time dependent spin autocorrelation function as well as dynamical dimer-dimer correlation functions. All these results combined together point towards a highly fluctuating system, both in the singlet and the triplet channel.

Competing interactions in the low-dimensional quantum magnet TiOCl

Maria-Roser Valenti
Goethe-Universitä t Frankfurt, Germany

Short range RVB physics of J1-J2-J3 Heisenberg antiferromagnet on the square lattice
Matthieu Mambrini
Univ. Paul Sabatier, Toulouse, France
Abstract
While long time studied as a theoretical archetype of 2d quantum antiferromagnet, some crucial questions about the frustrated regime of the J1-J2(-J3) Heisenberg antiferromagnet on the square lattice still remain open. In particular, the characterization of the ground state, spin liquid or valence bond solid, is still incomplete.
After a brief review of known properties of the model, I will show how numerical calculations based on short range resonating valence bond (RVB) states can provide some insights about the frustrated (J2+J3$\sim$J1/2) part of the phase diagram. Whithin this frame, numerical evidences for a short-range RVB phase will be presented. Moreover, direct evaluation and finite size analysis of dimer-dimer correlation functions and dimer susceptibility give a strong indication for a columnar dimer order in the ground state.

Some exotic phenomena in doped quantum disordered magnets
Didier Poilblanc
Laboratoire de Physique Theorique (LPT), Univ. Paul Sabatier (Toulouse) & CNRS, France
Abstract
I shall briefly talk on recent progress in the investigation of doped quantum disordered two dimensional magnets described by either frustrated spin-1/2 Heisenberg or quantum dimer models. Exotic phenomena like spinon/holon deconfinement as well as a new pairing mechanism will be discussed.

References
- Enhanced pairing in doped quantum magnets with frustrated hole motion,
D. Poilblanc, Phys. Rev. Lett. 93, 193204 (2004).

- Spinon deconfinement around a vacancy in frustrated quantum antiferromagnets,
D. Poilblanc, A. Laeuchli, M. Mambrini & F. Mila, Phys. Rev. B (RC), in press (2006).

- Doping quantum dimer models,
D. Poilblanc, F. Alet, F. Becca, A. Ralko, F. Trousselet & F. Mila, cond-mat/0602256.

Anomalous Hall effect due to spin chirality in Pyrochlores and Kagomé systems
Lacroix Claudine
CNRS, France
Abstract
A new mechanism for anomalous Hall effect has been proposed recently for systems where the magnetic structure is non-coplanar. Among these systems, the Mo-pyrochlores have been stud-

ied experimentally by several groups [1,2]: in Nd2Mo2O7, the interaction between Mo moments is ferromagnetic, but the Nd moments form a non-coplanar structure due to the competition between the Nd-Mo exchange and the crystal field interaction. It was proposed that the anomalous Hall effect in these systems is strongly connected with the peculiarities of the magnetic structure (evolution with magnetic field and temperature). In the last years several new mechanisms of anomalous Hall effect were proposed, in which the chiral structure of magnetic atoms plays an important role [3,4]. We have studied the transport in a Kagome model with a chiral magnetic structure; the conduction electrons are coupled to the magnetic moments through local exchange. Depending on the parameters, (chirality, exchange interaction, band filling) many different behavior can be obtained for the anomalous Hall effect: non-monotonous variation, change of signs, or plateaus in the temperature variation We conclude from this model that Hall conductivity is not simply proportional to chirality as was predicted in [4], but depends on many other factors. Thus the interpretation of the experiments made on Mo-pyrochlores is not as simple as supposed in [1] and [2]. It would be interesting to look at other metallic pyrochlores having the same behavior.

References

[1] Taguchi et al, Science 291, 2573 (2001)
[2] Yasui et al, J. Phys. Soc. Jpn 72, 865 (2003)
[3] J. Ye et al, Phys. Rev. Lett. 83, 3737 (1999ř
[4] G. Tatara et H. Kawamura, P. Phys. Soc. Jpn 71, 2613 (2002)

Nematic order in square lattice frustrated ferromagnets

Philippe Sindzingre
LPTMC, Univ. Paris VI, France

Abstract

We present a new scenario for the breakdown of ferromagnetic order in a two–dimensional quantum magnet with competing ferromagnetic and antiferromagnetic interactions. In this, dynamical effects lead to the formation of two–magnon bound states, which undergo Bose–Einstein condensation, giving rise to bond–centered nematic order. This scenario is explored in some detail for an extended Heisenberg model on a square lattice. In particular, we present numerical evidence confirming the existence of a state with d–wave nematic correlations but no long range magnetic order, lying between the saturated ferromagnetic and collinear antiferromagnetic phases of the ferromagnetic J_1–J_2 model.

Ground states of a frustrated spin-1/2 antiferomagnet: Cs_2CuCl_4 in a magnetic field

John Chalker
University of Oxford, United Kingdom

Abstract

Experiments on the spin $S=1/2$ triangular lattice antiferromagnet Cs$_2$CuCl$_4$ have mapped out its properties in great detail over the last few years. It has attracted particular interest because its low-dimensionality, frustrated interactions and small spin are all features expected to promote quantum fluctuations. I will describe results from a theoretical study of the magnetic ground state properties of Cs$_2$CuCl$_4$ in an applied magnetic field, and make

comparison with experiment.

Zero-temperature Kosterlitz-Thouless transition in a two-dimensional quantum system

Pujol Pierre
Laboratoire de Physique, ENS-Lyon, France

Abstract
We construct a local interacting quantum dimer model on the square lattice, whose zero-temperature phase diagram is characterized by a line of critical points separating two ordered phases of the valence bond crystal type. On one side, the line of critical points terminates in a quantum transition inherited from a Kosterlitz-Thouless transition in an associated classical model. This model is a generalization of the Rokhsar-Kivelson Hamiltonian [1] and it is built from a classical dimer model studied in [2] via the SMF decomposition [3]. We discuss the effect of a longer-range dimer interactions that can be used to suppress the line of critical points by gradually shrinking it to a single point.

References

[1] D. S. Rokhsar and S. A. Kivelson, Phys. Rev. Lett. 61, 2376 (1988).

[2] F. Alet, J. L. Jacobsen, G. Misguich, V. Pasquier, F. Mila, and M. Troyer, Phys. Rev. Lett. 94, 235702 (2005).

[3] C. Castelnovo, C. Chamon, C.Mudry, and P. Pujol, Ann. of Phys. (N.Y.) 318, 316 (2005).

The projected BCS wave function: from one dimensional to two dimensional quantum antiferromagnets with the same paradigm

Sandro Sorella
SISSA, Italy

Abstract
We review some recent calculations on quantum antiferromagnetic Heisenberg models in one and two dimensions. We show that the projected BCS wavefunction describes almost exactly the well known properties of the exact Bethe ansatz solution available in one dimension, namely spin fractionalizations of the excitations and the correct power law decays for spin-spin and dimer-dimer correlations. In higher dimensionality this ansatz appears similarly accurate and represents a very powerful tool to understand exotic ground states in two dimensional frustrated spin systems.
For instance we have recently discovered[1] that in the two dimensional Heisenberg model in presence of spatial anisotropy two different spin liquids are stable. The former one is characterized by fractionalized and gapless excitations and is realized in the strong anisotropic regime. The second spin liquid phase is instead already stable very close to the isotropic case, the standard triangular Heisenberg model with 120ˆ 0 Néel order. Close to this magnetically ordered phase a spin liquid region is found, that is described by a projected BCS ansatz with a very peculiar inomogeneous pairing function. The translation invariance of this spin liquid is recovered after projection, but a small gap in the excitation spectrum is generally found due to this ”fictitious” broken symmetry in the BCS hamiltonian. This phase is closely related to the spin

liquid state obtained in the classical quantum dimer model on the triangular lattice[2].
We also briefly describe preliminary results for the phase diagram of the J1-J2 Heisenberg model in the square lattice, where we show that a gapless spin liquid phase is also possible in the region 0.45+/-0.05 ⟨ J2/J1

5 Poster List

Theoretical Modelling of Thin Film magnets
Andrea Taroni
University College London, United Kingdom
Abstract
Modern film deposition and patterning techniques afford unprecedented opportunities to achieve controlled perturbations to the Hamiltonian that determines the magnetic properties of thin films, greatly facilitating comparison with theory. One model which has gained considerable attention in this context is the 2dXY model [1], a microscopic model that reproduces quasi two-dimensional behaviour in layered insulating magnets (see for example [2]).
The 2dXY model is remarkably simple and yet is critical over a finite range of temperatures and shows all the characteristics of critical phenomena usually associated with more complicated non-linear models [3]. Used as a starting point for the modelling of real magnetic films and multilayers, the 2dXY model can be extended to include more realistic systems, and address open questions such as determining the role of dipolar interactions, inter-layer exchange and shape anisotropy.
We present a simple model which contains the essential characteristics of the 2dXY model, yet also includes the effects of shape anisotropy. We show this model displays some interesting statistical mechanical properties in its own right, and present evidence that it obeys a phase transition reminiscent of the Kosterlitz-Thouless transition. Just as for the 2dXY model, it appears finite size effects are of essential importance for interfacing with experiment. We also show where the similarities with the 2dXY model end, and discuss possible avenues for future work.

References
[1] S.T. Bramwell and P.C.W. Holdsworth “Magnetisation and Universal Subcritical Behaviour in Two-dimensional XY Magnets”, J.Phys.: Condens. Matt., 5, L73 (1993).

[2] M. Pä rnaste, M. van Kampen, R. Brucas and B. Hjö rvarsson “Temperature-dependent Magnetization and Susceptibility of Fen/V7 Superlattices”, Phys. Rev. B, 71, 104426 (2005).

[3] P. Archambault, S.T. Bramwell and P.C.W. Holdsworth, “Magnetic Fluctuations in a Finite 2dXY Model”, J. Phys. A: Math. Gen. 30, 8363 (1997).

Phase diagram of S=3/2 Hubbard model in one-dimension
Sylvain Capponi
Univ. Paul Sabatier, Toulouse, France
Abstract
The physical properties of S=3/2 fermionic cold atoms trapped in a one-dimensional optical lattice are investigated by means of numerical simulation. Due to vanishing of the minus-sign

problem for some parameters, we have performed efficient Quantum Monte-Carlo simulations. We have compared our results with low-energy predictions obtained recently [1,2]. We do not find a molecular superfluid made of 4 fermions. Instead, the normal BCS pairing phase is competing with a charge density wave. We discuss a possible origin of discrepancy and discuss a scenario to stabilize the molecular superfluid.

References

[1] P. Lecheminant, E. Boulat, and P. Azaria, Phys. Rev. Lett. 95, 240402 (2005).
[2] C. Wu, Phys. Rev. Lett. 95, 266404 (2005).

Evaluation of the low-lying energy spectrum of magnetic Keplerate molecules with DMRG

Juergen Schnack
Uni Osnabrueck, Germany

Abstract

We apply the density-matrix renormalization group technique to magnetic molecules in order to evaluate the low-lying energy spectrum. In particular, we investigate the giant Keplerate molecule Mo72Fe30 where 30 Feˆ 3+ ions (spins 5/2) occupy the sites of an icosidodecahedron and interact via nearest-neighbor antiferromagnetic Heisenberg exchange.
The aim of our investigation is to verify the applicability and feasibility of DMRG calculations for complex magnetic molecules. To this end we first use a fictitious molecule with the same structure as Mo72Fe30 but with spins 1/2 as a test system. Here we investigate the accuracy of our DMRG implementation in comparison to numerically exact results. Then we apply the algorithm to Mo72Fe30 and calculate an approximation of the lowest energy levels in the subspaces of total magnetic quantum number. The results prove the existence of a lowest rotational band.

References

[1] Matthias Exler and Jurgen Schnack *Evaluation of the low-lying energy spectrum of magnetic Keplerate molecules using the density-matrix renormalization group technique*, Phys. Rev. B **67** 094440 (2003)

Quantum numbers for relative ground states of antiferromagnetic Heisenberg spin rings

Juergen Schnack
Uni Osnabrueck, Germany

Abstract

We suggest a general rule for the shift quantum numbers k of the relative ground states of antiferromagnetic Heisenberg spin rings. This rule generalizes well-known results of Marshall, Peierls, Lieb, Schultz, and Mattis for even rings. Our rule is confirmed by numerical investigations and rigorous proofs for special cases, including systems with a Haldane gap for N goint to infinity. Implications for the total spin quantum number S of relative ground states are discussed as well as generalizations to the XXZ model.

References

[1] Klaus Barwinkel and Peter Hage and Heinz-Jurgen Schmidt and Jurgen Schnack *Exact quantum numbers for relative ground states offrustrated Heisenberg spin rings*, Phys. Rev. B **68** 054422 (2003)

Quantum compass model on the square lattice
Julien Dorier
EPFL, Switzerland

Dynamical correlations of the Quantum Dimer model on the triangular lattice
Arnaud Ralko
EPFL, Switzerland
Abstract
An extension of the Greenś function Monte-Carlo algorithm has been used to calculate dynamical correlation functions for the Quantum Dimer model on the triangular lattice, on clusters with up to 432 sites. The energy of the first excited state at different points of the Brillouin zone deduced from the time evolution of dimer-dimer correlations agrees very well with exact diagonalizations on small clusters. On larger clusters, it acquires a strong dispersion upon approaching the transition from the RVB phase to the 12-site plaquette phase, and soft modes appear at two high symmetry points consistent with this phase. The impossibility to detect a soft mode at the zone corner is shown to be consistent, the 12-site plaquette phase provided the type of ordering involves a strong resonance between several dimer coverings of the 12-site unit cell.

Correlation induced Peierls instabilities in doped frustrated antiferromagnets: "Valence bond solids" away from half-filling
Sylvain Capponi
Univ. Paul Sabatier, Toulouse, France
Abstract
We investigate the occurrence of a Peierls transition in a certain class of highly frustrated quantum antiferromagnets with analytical and numerical methods. We show that a spontaneous lattice symmetry breaking can occur due to electronic correlations only in various doped lattices such as 2D kagome lattice, 1D kagome strip, 2D checkerboard lattice, or 3D pyrochlore. This illustrates how dopaed antiferromagnets can partially avoid frustration by lowering the lattice symmetry.

6 Program

Day 1: March 09 2006

Session : 1 One dimensional systems
09:00 to 09:30 : Presentation
The impact of Dzyaloshinskii-Moriya interactions on the physics of quantum antiferromagnets in a field: gaps, torque, and domain-wall condensation
jean-baptiste Fouet

09:30 to 10:00 : Presentation
Competing interactions in the low-dimensional quantum magnet TiOCl
Maria-Roser Valenti

10:00 to 10:30 : Presentation
Magnetization plateaux in frustrated Spin-Peierls systems.
Ariel Dobry

10:30 to 11:00 : Coffee Break

08:45 to 09:00 : Welcome

Session : 2 Pyrochlores
11:00 to 11:30 : Presentation
Anomalous Hall effect due to spin chirality in Pyrochlores and Kagomé systems
Lacroix Claudine

11:30 to 12:00 : Presentation
Recent developments in spin ice
Roderich Moessner

12:00 to 12:30 : Presentation
Role of Dzyaloshinskii-Moriya interaction in pyrochlore antiferromagnets
Benjamin Canals

12:30 to 14:30 : Lunch Break

Session : 3 Cold gases, 1D and 2D systems
14:30 to 15:00 : Presentation
One-dimensional degenerate fermionic cold atoms : a low-energy effective theory
Philippe Lecheminant

15:00 to 15:30 : Presentation
Atomic Fermi gas in the trimerised kagome lattice
Hans Ulrich Everts

15:30 to 16:00 : Presentation
Entropy of correlated electrons on highly frustrated lattices
Andreas Honecker

16:00 to 16:30 : Coffee Break

Session : 4 Two dimensional quantum antiferromagnets I
16:30 to 17:00 : Presentation
New phases in the ferro-antiferro kagome magnet.
Claire Lhuillier

17:00 to 17:30 : Presentation
Dynamical Spin Correlations of the Quantum Kagome Antiferromagnet
Andreas Lä uchli

17:30 to 18:00 : Presentation
Metamagnetic phase transition of the antiferromagnetic Heisenberg icosahedron
Juergen Schnack

Day 2: March 10 2006

Session : 1 Properties under magnetic fieds
09:00 to 09:30 : Presentation
Ground states of a frustrated spin-1/2 antiferomagnet: Cs_2CuCl_4 in a magnetic field
John Chalker

09:30 to 10:00 : Presentation
Magnetization plateau and structural transition in spinel systems
Karlo Penc

10:00 to 10:30 : Presentation
Decay of quasiparticles in quantum spin liquids
Mike Zhitomirsky

10:30 to 11:00 : Coffee Break

Session : 2 Two dimensional quantum antiferromagnets
11:00 to 11:30 : Presentation
Improved variational phase diagram of the J_1-J_2 model on the square lattice
Federico Becca

11:30 to 12:00 : Presentation
Some exotic phenomena in doped quantum disordered magnets
Didier Poilblanc

12:00 to 12:30 : Presentation
Nematic order in square lattice frustrated ferromagnets
Philippe Sindzingre

12:30 to 14:30 : Lunch Break

Session : 3 Quantum dimer models
14:30 to 15:00 : Presentation
Spin liquids and Quantum Dimer Models
Fré dé ric Mila

15:00 to 15:30 : Presentation
Unconventional continuous phase transition in a three-dimensional dimer model
Fabien Alet

15:30 to 16:00 : Presentation
Zero-temperature Kosterlitz-Thouless transition in a two-dimensional quantum system
Pujol Pierre

16:00 to 18:00 : Poster Session

Day 3: March 11 2006

Session : 1 Miscellaneous
09:00 to 09:30 : Presentation
Frustration-induced supersolidity in cold bosonic gases
Matthias Troyer

09:30 to 10:00 : Presentation
Application of the coupled cluster method on frustrated quantum spin systems
Johannes Richter

10:00 to 10:30 : Presentation
Nature of orbital ordering in vanadium spinels
George Jackeli

10:30 to 11:00 : Coffee Break

Session : 2 Doped frustrated magnets
11:00 to 11:30 : Presentation
Short range RVB physics of J1-J2-J3 Heisenberg antiferromagnet on the square lattice
Matthieu Mambrini

11:30 to 12:00 : Presentation

The projected BCS wave function: from one dimensional to two dimensional quantum antiferromagnets with the same paradigm
Sandro Sorella

12:00 to 12:30 : Presentation
Spin only description of the magnetic properties of Lanthanum Cuprate
Peter Holdsworth

7 Organizer's report

7.1 Conclusions.

The CECAM Workshop on "Novel theoretical aspects of frustrated spin systems brought together theorists working on the problem of frustrated magnetism" from very different perspectives and using many different but at the same time complementary techniques.
The exchanges took place at a very high level and provided an excellent opportunity for theorists to establish common priorities and clarify the current state of the art.
This underlines the need for this kind of workshops in a community where such exchanges are relatively rare. Most of the workshop consisted of regular 20 minute talks followed by 10 minutes of questions. These question periods were always lively and constructive, allowing for a very positive exchange.
Of course, some problems related to the key issues of the workshop, which are necessarily of more general character, could only be touched during the two-and-a-half days of the workshop.
Although 75% of the participants came from France, Germany and Switzerland, we had also participants coming from Argentina, Croatia, Hungary, Italy and the United Kindom.
In any case, we think it is safe to conclude that the workshop served its purpose well in that we were able to shed some light on current key issues in the physics of frustrated systems and to identify prospective routes for further studies in this exciting field.

7.2 Recommendations.

The CECAM has provided an unvaluable support to the organisers with very light administration requirements.
We would also like to thank the sponsors of this workshop, the Centre Europé en de Calcul Atomique et Molé culaire as well as the European Science Foundation and the Ecole Normale Supé rieure de Lyon, for the financial support without which this workshop could not have taken place.
We would like to thank as well the organisation support from the CECAM staff: Mmes Emmanuelle Crespeau and Emilie Bernard, M. Frederic Barmes, the system administrator and M. Berend Smit, the director of CECAM. It was a real pleasure to work with the CECAM team.
In the longer term, the community should look into ways to maintain the momentum to develop the frameworks and tools discussed in this workshop. It seems that there is a good enough case to justify one or several funding applications. There should be a follow-up workshop in about 2 years.
The theoretical developments discussed in this workshop are expected to be well received at future meetings between theorists and experimentalists working in the field of frustrated magnetism.

8 Key references

[1] P. W. Anderson *The resonating valence bond state in La2CuO4 and superconductivity,* Science **235** 1196-1198 (1987)

[2] C. Lhuillier, G. Misguich *Frustrated Quantum Magnets.*, Lecture Notes in Physics **595** 161 (2003)

[3] S. Sachdev *Kagome_- and triangular-lattice Heisenberg antiferromagnets: Ordering from quantum fluctuations and quantum-disordered ground states with unconfined bosonic spinons .*, Physical Review B **45** 12377 (1992)

[4] T. Senthil, Leon Balents, Subir Sachdev, Ashvin Vishwanath, Matthew P. A. Fisher *Quantum criticality beyond the Landau-Ginzburg-Wilson paradigm*, Phys. Rev. B **70** 144407 (2004)

[5] B. Bernu, P. Lecheminant, C. Lhuillier, L. Pierre *Exact spectra, spin susceptibilities and order parameter of the quantum Heisenberg antiferromagnet on the triangular lattice.*, Physical Review B **50** 10048 (1994)