Organizers: P. Fulde (Dresden), Z. Hiroi (Tokyo), P. Lemmens (Braunschweig), R. Moessner (Oxford).

Local Organization: K. Lantsch, MPI-PKS Dresden

Scientific report for the workshop

Summary

The workshop was organised within the scientific program Highly Frustrated Magnetism (HFM) supported by the European Science Foundation (ESF) and the Max-Planck Institute for the Physics of Complex Systems (MPI-PKS) Dresden. The organizers were: P. Fulde (Dresden, Germany), Z. Hiroi (Tokyo, Japan), P. Lemmens (Braunschweig, Germany), and R. Moessner (Oxford, United Kingdom). The local organization of the workshop was performed by K. Lantsch from the MPI-PKS Dresden, Germany

The initial planning for the workshop and first announcement happened during the HFM steering committee and the first workshop held in La Londe les Maures in France, November 2005. The focus on a restricted set of topics allowed adding well-established experts in the field, both contacted directly by the organizers and from the numerous applications. A webpage for the workshop was set-up and updated until the workshop started: http://www.mpipks-dresden.mpg.de/~itfrus07/ with a brief report at http://www-public.tu-bs.de:8080/~plemmens/esf-hfm/hfm-workshop-2007.html

The topic 'frustrated systems with itinerant aspects' was divided into several subtopics that where represented by key speakers in addition to posters. These were: cobaltates, triangular

organics, itinerant pyrochlores, spinels, frustration and ordering, quantum criticality, bosons and supersolids, fundamental mechanisms, checkerboard physics. Material science, modelling as well as theoretical aspects were discussed.

The workshop had 96 participants (36 oral, 63 poster contributions and one concluding remark). The organizers tried to bring together a mix of young scientists on the level of PhD students, and postdocs together with senior researchers. The interdisciplinary approaches of the workshop lead to the additional advantage of a mutual exchange about all material related aspects.

All scientific activities as well as lunch and dinner were organized in the central building of the MPI-PKS in Dresden. This led to close contact and intensive discussions between the participants, and optimised the use of the time available.

Description of the scientific content

Materials physics topics:

The topic cobaltate was represented using the experimental techniques neutron scattering (Keimer, Lee), photo emission (Hasan), NMR (Alloul, Yoshimura), preparation and thermodynamic investigations (Yoshimura) and theory (Maekawa, Eremin, Mochizuki). The compound Na_xCoO_2 is one of the novel systems that motivated this workshop due to its exceptional ground state and transport properties. Especially noteworthy is the very large thermopower that reaches application relevant magnitudes. The observation of unconventional superconductivity is an additional highlight and motivation. Strong activities exist in Japan, where the system has been established. In France important spectroscopic investigations have been performed. In Germany activities started with one of the organizers at the MPI-FKF in Stuttgart and recently spread out to the TU Braunschweig in the frame of a project supported by the German Science Foundation (DFG).

The case of triangular organics is similar with respect to the strong position of Japan and the prospects of the materials. In our workshop thermodynamic aspects and the phase diagram have been discussed by Lang and Kanoda. Theoretical modelling relevant for these materials is more widespread. All important aspects were discussed by Baskaran and McKenzie. In general the interest in organic materials with competing interactions is recently growing in Europe.

Pyrochlores and spinels are two classes or families of compounds characterized by wellknown and long-investigated crystallographic structures. These families of compounds show an enormous variety of compositions and physical properties. The interplay of magnetism (or other long range ordered states) and competing interactions is more recently in the centre of interest. Accordingly, the speakers touched different aspects ranging from unconventional ground states to more materials related or application based interest. The respective seminars touched electron-phonon coupling and superconductivity (Hiroi), multiferroicity (Loidl), metal-insulator transitions (Kremer, Takagi), Kondo-type physics (Nakatsuji) and different theoretical approaches (Valenti, Lacroix, Tsunetsugu) with an emphasis on unconventional transport properties. During the workshop it has been widely accepted that both the pyrochlores and the spinels will be of increasing importance in the field of frustrated magnetism.

Conceptual foundations:

Additional emphasis was placed on addressing, mainly from a theoretical vantage point, a range of fundamental issues raised in the context of itinerant frustration. These included questions as fundamental as the origin of magnetic behaviour, with a talk by Oshikawa demonstrating the presence of ferromagnetism by statistical transmutation, and one by Shastry on kinetic antiferromagnetism. A classification of topological insulators was discussed by Moore. Vojta's talk considered the possibility of dimensional reduction near a critical point in the framework of an RG treatment.

The nature of ordering in the presence of frustration was also extensively discussed. Emphasis was placed on the interplay of magnetic with 'ferroic' ordering behaviour by Ramirez, while Mila addressed field-driven crystallisation phenomena manifesting themselves in magnetisation plateaux.

A pair of talks (Becca, Poilblanc) was devoted to different aspects of dimer model physics. These models are used to describe the properties singlet-dominated magnetic phases. One aspect concerned the details of the ordering behaviour of the triangular dimer model, the phase diagram of which includes not only a topological liquid but also a complex plaquette RVB state. The other dealt with the problem of doping such models -- a topic of great interest due to their provenance from high-temperature superconductivity. The related topic of physics on the checkerboard lattice -- one of the most highly frustrated lattices in d=2 - was given much emphasis, including talks on connections with the lore of high-energy physics (Fulde), as well as on its peculiarities of ordering (Penc) and Fermionic quantum-dynamics (Shtengel). This was backed up with a talk on numerical studies on 1-d ladder-type systems (Brenig).

Finally, the workshop reached out to closely related topics of interest to the Helium and cold atom communities. Saunders discussed the properties of Helium films adsorbed on different substrates. On the topic of supersolid phases and Bosons in magnetic fields, lattice models and their ordering properties were discussed by Troyer, Melko and Auerbach.

Impact of the event

As discussed in the preceding paragraphs, the combination of competing interactions with itinerant aspects is a very strong and rapidly developing field which links fundamental conceptual, modelling as well as materials related questions. Given the well-focussed topic of the workshop, it was possible to accomodate almost all of the applications for participations (application to the workshop was open to everyone). This gave a large number of younger participants on the student and postdoc level the chance to interact with world-renowned experts in the field on the highest scientific level. The excellent local organization of the workshop by K. Lantsch and the team at the MPI-PKS helped to prepare a very productive environment. The importance of the meeting was also highlighted by the large number of steering committee members present, as well as by a strong participation from outside Europe, despite the short duration of the workshop.

Financial report for the workshop
"Mobile Fermions and Bosons on Frustrated Lattices"
MPI-PKS Dresden, 10.-13.2.2007

The travelling expenses for the following French participants were fully covered by CNRS: Henri Alloul, Olivier Cepas, Ludovic Jaubert, Claudine Lacroix, Philippe Mendels, Gregoire Misguich, Fabien Trousselet.

Actual Expenses:

Travel:	10.915,50 €
Accommodation:	12.902,00 €
Meals:	3.024,00 €
Local administrative costs:	1.500,00 €
TOTAL EXPENDITURE:	28.341,50 €
CO-SPONSORSHIP (MPI-PKS):	13.341,50 €
Expenses on account of ESF:	**15.000,00** €

Participants

In total 96 people attended the workshop, 9 women and 87 men with 36 oral, 63 poster contributions and one concluding remark by one of the organisators. From Europe (not including Switzerland) 59 people attended the meeting.

Geographical distribution of the participants: (European 59, not including Switzerland)

Australia	1
Canada	2
Estonia	1
France	13
Germany	34
Great Britain	7
India	1
Israel	1
Italy	2
Japan	12
Poland	1
Russia	2
Switzerland	8
Hungary	1
USA	9
United Arabic Emirates	1

Educational background of the participants:

PhD students:	10
Postdocs:	43
Senior researchers:	43

List of participants:

From the ESF-HFM steering comittee C. Lacroix, P. Lemmens, Ph. Mendels, F. Mila, R. Stern, and K. Penc did attend the meeting, pointing to the relevance of the topic.

Anderson Fabricio Albuquerque, Switzerland
Henri Alloul, France
Assa Auerbach, Israel
Ganapathy Baskaran, India
Bertram Batlogg, Switzerland
Federico Becca, Italy
Joseph Betouras, UK
Antonin Bourgeois, France
Wolfram Brenig, Germany
Sylvain Capponi, France
Pietro Carretta, Italy
Claudio Castelnovo, UK
Olivier Cepas, France
Alexander Chernyshev, USA
Radu Coldea, UK
Philippe Corboz, Switzerland
Stefan-Ludwig Drechsler, Germay

Natalia Drichko, Germany
Ilya Eremin, Germany
Hans-Ulrich Everts, Germany
Matthias Frontzek, Germany
Peter Fulde, Germany
Robert Gooding, Canada
Jan Haerter, USA
Amir-Abbas Haghighirad, Germany
Masud Haque, Germany
M. Zahid Hasan, USA
Zenji Hiroi, Japan
Peter Holdsworth, France
Chisa Hotta, Japan
Sergei Isakov, Canada
Ludovic Jaubert, France
Kazushi Kanoda, Japan
B. Keimer, Germany
Andreas Kluemper, Germany
Reinhard K. Kremer, Germany
Mukul Laad, Germany
Claudine Lacroix, France
Andreas Laeuchli, Switzerland
Michael Lang, Germany
Young S. Lee, USA
Peter Lemmens, Germany
Alois Loidl, Germany
Wolfram Lorenz, Germany
Sadamichi Maekawa, Japan
Ross H. McKenzie, Australia
Roger G. Melko, USA
Philippe Mendels, France
Frederic Mila, Switzerland
Gregoire Misguich, France
Shin Miyahara, Japan
Masahito Mochizuki, Japan
Roderich Moessner, UK
Joel Moore, USA
Takao Mori, Japan
Satoru Nakatsuji, Japan
Ramesh Chandra Nath, Germany
Jan Nyeki, UK
Masaki Oshikawa, Japan
Karlo Penc, Hungary
Natalia Perkins, Germany
Didier Poilblanc, France
Frank Pollmann, Germany
Pierre Pujol, France
Teodora Radu, Germany
Arnaud Ralko, France
Arthur Ramirez, USA
Alexandre Revcolevschi, France

Johannes Richter, Germany
Krzysztof Rogacki, Poland
Helge Rosner, Germany
Erich Runge, Germany
Said Sakhi, United Arab Emirates
John Saunders, UK
Patric Scheib, Germany
Kai Phillip Schmidt, Switzerland
Miriam Schmitt, Germany
Rolf Schumann, Germany
Nic Shannon, UK
B. Sriram Shastry, USA
Kirill Shtengel, USA
Raivo Stern, Estonia
Hidenori Takagi, Japan
Peter Thalmeier, Japan
Fabien Trousselet, France
Matthias Troyer, Switzerland
Hirokazu Tsunetsugu, Japan
Goetz Uhrig, Germany
Roser Valenti, Germany
Matthias Vojta, Germany
Olga Volkova, Russia
Bernd Wolf, Germany
Piotr Wrobel, Germany
Alexander Yaresko, Germany
Kazuyoshi Yoshimura, Japan
Viktor Yushankhai, Russia

Program of the HFM workshop "Mobile Fermions and Bosons on Frustrated Lattices", Dresden 11.-13. Jan 2007

WEDNESDAY, January 10

18:00 - 19:30 Registration
19:00 - Welcome buffet

THURSDAY, January 11

Triangular organics

08:45 Welcome
09:00 K. Kanoda
Spin liquid and superconductivity in organics with triangular lattice
09:30 G. Baskaran
Theory of superconductivity in triangular organics
10:00 R.H. McKenzie
Interplay of frustrated antiferromagnetism and superconductivity in layered molecular crystals
10:30 COFFEE BREAK

Cobaltates I

11:15 H. Alloul
NMR studies of electronic properties of the metallic Na-cobaltates
11:45 M.Z. Hasan
Electrons in a triangular world: Direct momentum space imaging of mobile fermions in NaxCoO2
12:15 S. Maekawa
Electronic properties in frustrated lattices with strong electron correlation
12:35 I. Eremin
Electronic theory for itinerant in-plane magnetic fluctuations in NaxCoO2
12:55 LUNCH BREAK

Frustration and ordering

15:00 A. Ramirez
Connections between frustration and magnetoelectric multiferroics
15:30 F. Mila
Phase transitions in bosonic models of frustrated magnets
16:00 F. Becca
Dynamics of a dimer liquid
16:20 D. Poilblanc
Exotic phenomena under doping frustrated quantum magnets & dimer models: Numerical approaches
16:40 COFFEE BREAK

Quantum criticality and MIT

17:25 M. Vojta
On dimensional reduction near quantum critical points
17:55 J. Saunders
Experimental studies of Helium in two-dimensional geometries

18:15 M. Lang
Lattice response at the Mott transition in a quasi-2D organic conductor

18:40 DINNER & POSTERS

FRIDAY, January 12

Mostly Spinels

08:30 H. Tsunetsugu
Spin nematic state in triangular magnets

09:00 R. Valenti
On the role of competing interactions in frustrated spinels

09:30 A. Loidl
Frustrated lattices in spinel compounds

10:00 H. Takagi
Charge and spin frustration in mixed valent spinel oxides

10:30 COFFEE BREAK

Cobaltates II

11:15 K. Yoshimura
NMR study of the 2D-triangular-lattice superconducting system NaxCoO2yH2O

11:45 B. Keimer
Spin and charge dynamics in layered cobaltates

12:15 M. Mochizuki
Exotic superconductivity on the triangular lattice in NaxCoO2.yH2O: Theories and experiments

12:45 Y.S. Lee
Neutron scattering studies of spins on two-dimensional frustrated lattices

13:05 LUNCH BREAK & POSTERS

Bosons and supersolids

15:30 M. Troyer
Unusual bosonic states on frustrated lattices: Supersolids and topological order

16:00 R.G. Melko
Supersolid phases and the search for deconfined quantum criticality in bosons on 2D frustrated lattices

16:20 A. Auerbach
Vortex spin and statistics in the quantum XY model

16:40 COFFEE BREAK

Fundamental mechanisms

17:30 J. Moore
Topological insulator phases of lattice fermions with spin-orbit coupling

18:00 S. Shastry
Kinetic antiferromagnetism in electronically frustrated metals

18:30 M. Oshikawa
Saturated ferromagnetism from statistical transmutation in two dimensions

19:00 DINNER

SATURDAY, January 13

Itinerant pyrochlores

08:30 Z. Hiroi
Electron-rattler interactions and extremely strong-coupling superconductivity in the beta-pyrochlore oxide KOs2O6

09:00 C. Lacroix
Anomalous Hall effect due to chirality in frustrated magnets

09:30 S. Nakatsuji
Spin liquid behavior and unconventional anomalous Hall effect in the frustrated Kondo lattice Pr2Ir2O7

10:00 R.K. Kremer
Metal-insulator transition in the new pyrochlore Hg2Ru2O7

10:20 COFFEE BREAK

Checkerboard physics

10:50 P. Fulde/F. Pollmann
Condensed matter meets particle theory

11:20 K. Shtengel
Frobenius vs non-Frobenius quantum dynamics: Fermions on a checkerboard lattice and the sign problem

11:50 K. Penc
Ordered phases in bosonic and fermionic models on checkerboard lattice

12:20 W. Brenig
Defects in the geometrically frustrated bow tie ladder

12:50 CLOSING

13:00 LUNCH