Report for the short visit ref: 2268 (Marion MOLINER)
Magnetization plateaux in the classical Shastry-Sutherland lattice

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Purpose of the visit

The purpose of this visit was to continue the collaboration between Andreas Honecker (Goettingen), Pierre Pujol (Toulouse), Marion Moliner, Franck Stauffer (Strasbourg) and Daniel Cabra (La Plata/Strasbourg) on the classical Shastry-Sutherland Lattice [1].

The Shastry-Sutherland lattice (SSL) is a square lattice with additional diagonal couplings (see Fig. 1).

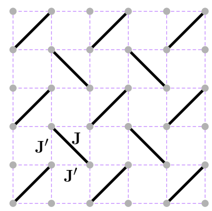

Figure 1: The Shastry-Sutherland lattice is a frustrated lattice with magnetic couplings J' along the edges of the squares and J along the diagonal bonds.

Our objective is to determine under which conditions magnetization plateaux can appear in this system at 1/3 of the saturation magnetization. At this stage of the project classical Monte Carlo simulations were required and the collaboration with the group in Goettingen was very fruitful.

We study this frustrated lattice in the classical limit (large S). This project is motivated by recent experiments on rare-earth tetraborides RB_4 [2, 3]. In those compounds the rare-earth ions are located on a lattice topologically equivalent to the SSL. Due to their large total momenta a classical approach is perfectly justified. Those compounds have plateaux in their magnetization curves at rational values of the saturation magnetization.

Description of the work carried out during the visit

During this visit numerical simulations were performed using classical Monte Carlo algorithms in order to study the magnetization, susceptibility and specific heat of the SSL. Particular interest was brought to the effect of temperature in order to obtain a phase diagram as a function of magnetic field and temperature.

Description of the main results obtained

- Phase diagram for the ratio $J'/J = 0.5$: a complete numerical study of the classical SSL for the ratio of couplings $J'/J = 1/2$ was performed. We previously carried out an analytical treatment for this particular ratio in order to study the mechanism of plateaux appearance as a thermal effect [4, 5]. The plateau phase is characterized by the "Up-Up-Down" state in which each triangle contains two spins up and one spin down. We found out that for this ratio the classical SSL has a behaviour similar to the classical triangular lattice [6]. A phase diagram was obtained (see Fig. 2).
- Phase diagram for the ratio $J'/J = 0.5 \pm \epsilon$: for ratios close to $J'/J = 0.5$, the classical SSL also presents magnetization plateaux at 1/3 of the saturation magnetization. In Fig. 3 the susceptibility curves clearly show two phase transitions around magnetization 1/3 which correspond to the entrance and the exit of the "Up-Up-Down" phase. A phase diagram is under progress.

Future collaboration with host institution

The collaboration on this project will continue between the three institutes (Goettingen, Strasbourg and Toulouse). Once this project is finished we are planning to include other ingredients in our model so as to study other scenarios that could stabilize the plateaux in the magnetization curve of the SSL.

Projected publications/articles resulting or to result from your grant

We are planning to submit an article to a refereed journal within the next months. This project will also be presented at the ESF HFM2008 conference in September 2008.

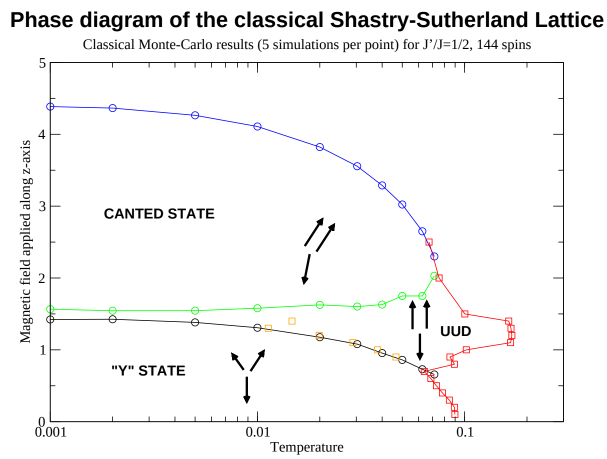

Figure 2: Phase diagram of the Shastry-Sutherland Lattice for the magnetic couplings ratio $J'/J = 1/2$.

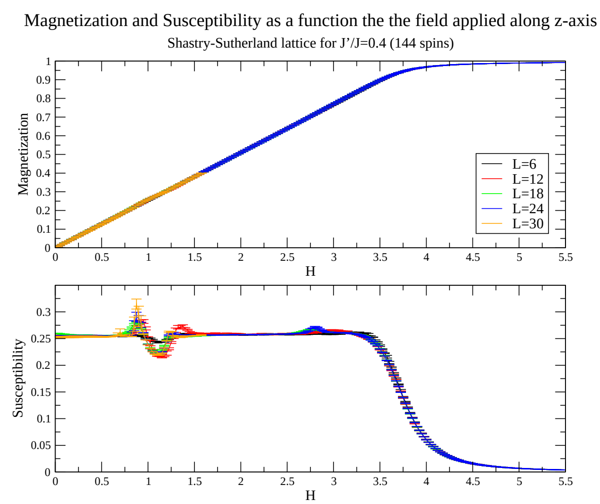

Figure 3: Magnetization (top) and susceptibility for the magnetic couplings ratio $J'/J = 0.4$. The peaks around M=1/3 in the susceptibility are the signature of phase transitions.

References

[1] B.S. Shastry and B. Sutherland, Physica B and C 108B, 1069 (1981)

[2] K. Siemensmeyer, E. Wulf, H.-J. Mikeska, K. Flachbart, S. Gabani, S. Matas, P. Priputen, A. Evdokimova, N. Shitsevalova, arXiv:0712.1537 (2007); S. Gabani, S. Matas, P. Priputen, K. Flachbart, K. Siemensmeyer, E. Wulf, A. Evdokimova, N. Shitsevalova, arXiv:0712.0519 (2007)

[3] S. Yoshii, T. Yamamoto, M. Hagiwara, T. Takeuchi, A. Shigekawa, S. Michimura, F. Iga, T. Takabake and K. Kindo, J. Magn. and Magn. Mat., **310** 1282 (2007); S. Michimura, A. Shigekawa, F. Iga, M. Sera, T. Takabatake, K. Ohoyama and Y. Okabe, Physica B, **378-380**, 596 (2006); F. Iga, A. Shigekawa, Y. Hasegawa, S. Michimura, T. Takabatake, S. Yoshii, T. Yamamoto, M. Hagiwara and K. Kindo, J. Magn. and Magn. Mat., **310**, e443 (2007)

[4] J. Villain, R. Bidaux, J.P. Carton, and R.J. Conte, J. Phys. (Paris) **41**, 1263 (1980)

[5] J.M.D. Champion and P.C.W. Holdsworth, J. Phys. Cond. Mat. **16**, S665 (2004)

[6] H. Kawamura and S. Miyashita, J. Phys. Soc. Jap., **54**, 4530 (1985); H. Kawamura, J. Phys. Soc. Jap., **53**, 2452 (1984)