The on-going challenge of the magnetization plateaux of $SrCu_2(BO_3)_2$

Frédéric Mila

Institute of Theoretical Physics, Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

Shortly after their discovery by Kageyama et al [1], the basic mechanism behind the appearance of magnetization plateaux in $SrCu_2(BO_3)_2$ has been put forward by Miyahara and Ueda [2]: The peculiar orthogonal dimer geometry considerably reduces the kinetic energy of the triplets induced by the field in the singlet-product ground state, opening the way to high-commensurability incompressible states. This interpretation has been confirmed three years later when NMR experiments revealed the presence of a broken translational symmetry in the 1/8 plateau [3]. Yet, 10 years after the discovery of the first plateaux at 1/8, 1/4 and 1/3, the situation is more controversial than ever, with no agreement on the sequence and structure of plateaux among experimentalists or theorists [4,5,6,7]. This confusing situation is the result of two independent characteristics of $SrCu_2(BO_3)_2$. First of all, the interesting physics takes place between 25 and 45 T and below 500 mK, which locates it at the limit of state-of-the-art high field facilities. Besides, the inter-dimer coupling is large enough to prevent a treatment with standard second-order degenerate perturbation theory. In this talk, I will describe the recent experimental and theoretical efforts to take up the challenge and come up with reliable magnetization and NMR measurements through a systematic investigation in steady fields, as well as theoretical predictions based on high-order degenerate perturbation theory. As might have been expected, these efforts have settled some of the questions raised by Miyahara and Ueda, for instance the structure of the 1/8 plateau [8], but have also raised new issues regarding for instance the nature of symmetry breaking in the apparently compressible phases of the magnetization curve.

[1] H. Kageyama, K. Yoshimura, R. Stern, N. V. Mushnikov, K. Onizuka, M. Kato, K. Kosuge, C. P. Slichter, T. Goto, and Y. Ueda, Phys. Rev. Lett. 82, 3168 (1999).

[2] Shin Miyahara and Kazuo Ueda, Phys. Rev. Lett. 82, 3701 (1999).

[3] K. Kodama, M. Takigawa, M. Horvatic, C. Berthier, H. Kageyama, Y. Ueda, S. Miyahara, F. Becca, F. Mila, Science 298, 395 (2002).

[4] F. Levy, I. Sheikin, C. Berthier, M. Horvatic, M. Takigawa, H. Kageyama, T. Waki and Y. Ueda, EPL 81, 67004 (2008).

[5] Suchitra E. Sebastiana, N. Harrison, P. Sengupta, C. D. Batista, S. Francoual, E. Palm, T. Murphy, N. Marcano, H. A. Dabkowska, and B. D. Gaulin, PNAS 105, 20157 (2008).

[6] M. Takigawa, S. Matsubara, M. Horvatic, C. Berthier, H. Kageyama, and Y. Ueda, Phys. Rev. Lett. 101, 037202 (2008).

[7] J. Dorier, K. P. Schmidt, and F. Mila, Phys. Rev. Lett. 101, 250402 (2008).

[8] Shin Miyahara and Kazuo Ueda, Phys. Rev. B 61, 3417 (2000).