Contribution ID: **4** Type: **Oral**

Bond-dependent interactions and ill-ordered state in the honeycomb cobaltate BaCo2(AsO4)2

Monday, 2 June 2025 16:00 (15 minutes)

Following the proposed materialization of Kitaev-bond-dependent spin liquid physics in honeycomb lattices of heavy transition metals with 4d or 5d electrons [1], it has been proposed that this can be extended to 3d transition metals, in particular Co2+ [2]. A first step in validating the prospect of finding a quantum spin liquid is to demonstrate the presence of these anisotropic bond-dependent interactions in such materials. These could promote new types of behavior or provide insight into certain materials not elucidated to date. This is the case of BaCo2(AsO4)2, a honeycomb cobaltate whose ground state and Hamiltonian have been debated for decades [3]. We have investigated the magnetic properties of a BaCo2(AsO4)2 single-crystal through neutron diffraction and inelastic scattering, as well as by very-low temperature magnetization and AC susceptibility measurements. The latter measurements, which reveal slow dynamics and non-equilibrium responses, are consistent with an original ill-ordered magnetic compound with intrinsic defects as proposed previously [4]: collinear zig-zag ferromagnetic chains in a up-up-down-down arrangement interspersed with additional chains to agree with the propagation vector of 0.27 imposed by competing interactions. To interpret these results, we propose an exchange model with bond-dependent anisotropic interactions on the first neighbors and Heisenberg interactions up to the fourth neighbors. Monte Carlo calculations show that our model successfully reproduces key experimental observations, namely spin-wave dispersions (figure), magnetization curves with a 1/3 magnetization plateau, and the faulty collinear spin configuration, leading to a coherent picture that had not been achieved to date [5]. This highlights the potential of including these new ingredients (anisotropic Kitaev and off-diagonal interactions) in understanding long-standing puzzling behaviors and discovering exotic physics.

References:

[1] A. Kitaev, Ann. Phys. 321, 2 (2006) ; G. Jackeli and G. Khaliullin, Phys. Rev. Lett. 102, (2009).
[2] H. Liu and G. Khaliullin, Phys. Rev. B 97, 014407 (2018) ; R. Sano, Y. Kato, and Y. Motome, Physical Review B 97, 014408 (2018).
[3] L.-P. Regnault, J. Rossat-Mignod, and J. Y. Henry, J. Phys. Soc. Jpn. 52, 1 (1983) ; R. Zhong, T. Gao, N. P. Ong, and R. J. Cava, Science advances 6, 1 (2020) ; P. A. Maksimov, A. V. Ushakov, Z. V. Pchelkina, Y. Li, S. M. Winter, and S. V. Streltsov, Physical Review B 106, 165131 (2022) ; T. Halloran, F. Desrochers, E. Z. Zhang, T. Chen, L. E. Chern, Z. Xu, B. Winn, M. Graves-Brook, M. B. Stone, A. I. Kolesnikov, Y. Qiu, R. Zhong, R. Cava, Y. B. Kim, and C. Broholm, PNAS 120, e2215509119 (2023).
[4] L.-P. Regnault, C. Boullier, and J. E. Lorenzo, Heliyon 4, e00507 (2018).
[5] A. Devillez, J. Robert, E. Lhotel, R. Ballou, F. Denis-Romero, Q. Faure, E. Ressouche, H. Jacobsen, J. Lass, D. Mazzone, U. Bengaard Hansen, M. Enderle, S. Raymond, S. De Brion, V. Simonet, and M. Songvilay, in preparation

Primary author: DEVILLEZ, Armand (Université Grenoble Alpes, CNRS, Institut Néel, 38042 Grenoble, France)

Co-authors: MAZZONE, Daniel (Laboratory for Neutron Scattering and Imaging (LNS), Paul Scherrer Institut (PSI), 5232 Villigen PSI, Switzerland); LHOTEL, Elsa (Université Grenoble Alpes, CNRS, Institut Néel, 38042 Grenoble, France); RESSOUCHE, Eric (Université Grenoble Alpes, CEA, IRIG, MEM, MDN, 38042 Grenoble, France); JACOBSEN, Henrick (Laboratory for Neutron Scattering and Imaging (LNS), Paul Scherrer Institut (PSI), 5232 Villigen PSI, Switzerland, Nanoscience Center, Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark); LASS, Jakob (Laboratory for Neutron Scattering and Imaging (LNS), Paul Scherrer Institut (PSI), 5232 Villigen PSI, Switzerland); ROBERT, Julien (Université Grenoble Alpes, CNRS, Institut Néel, 38042 Grenoble, France); SONGVILAY, Manila (Institut Néel, Grenoble); BALLOU, Rafik (Université Grenoble Alpes, CNRS, Institut Néel, 38042 Grenoble, France); DE BRION, Sophie (Université Grenoble Alpes, CNRS, Institut Néel, 38042 Grenoble, France); SIMONET, Virginie (Université Grenoble Alpes, CNRS, Institut Néel, 38042 Grenoble, France)

Presenter: DEVILLEZ, Armand (Université Grenoble Alpes, CNRS, Institut Néel, 38042 Grenoble, France)

Session Classification: Contributed talks