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Probing electronic excitations in the Shastry-Sutherland compound SrCu2(BO3)2 with resonant inelastic x-ray scattering

Tariq Leinen,[1] Ola Kenji Forslund,[2] Eugenio Paris,[3] Marco Caputo,[4] Yasmine Sassa,[5] Thorsten Schmitt,[3] Adrian Cavalieri,[1] and Flavio Giorgianni[1]

[1] *Institute of Applied Physics, University of Bern*
[2] *Department of Physics, University of Zurich*
[3] *Photon Science Division, Paul Scherrer Institut*
[4] *MAX IV Laboratory, Lund University*
[5] *KTH Royal Institute of Technology*

When multiple spins interact, they can give rise to complex collective behaviour and exotic quantum phases. This is particularly true when competing effects, including magnetic frustration, prevent the formation of simple ordered magnetic states. An important test case to investigate these phases is the Shastry-Sutherland model, a 2-dimensional network of orthogonal interacting spin dimers, together with its experimental material realization $SrCu_2(BO_3)_2$ [1]. To gain a comprehensive understanding of exotic quantum effects in this system, it is necessary to account not only for the role of spin interactions and geometric frustration but also for their coupling to the lattice and high-energy electronic states. Although spin-lattice coupling has been quantified in this system [2], neither the nature of electronic excitations nor their coupling with the magnetic interactions have ever precisely been determined. Here we have conducted a Cu L-edge and O K-edge resonant inelastic X-ray scattering (RIXS) experiment to gain deep insight into the electronic excitations of the Shastry-Sutherland compound $SrCu_2(BO_3)_2$. RIXS was able to unambiguously reveal the charge-transfer (CT) or intra-orbital character of the excitations and provides a more comprehensive understanding of the coupling between spin and orbital degrees of freedom in quantum spin systems.

[1] Shin Miyahara and Kazuo Ueda (2003): Theory of the orthogonal dimer Heisenberg spin model for SrCu2(BO3)2.
[2] F. Giorgianni et al. (2023) Ultrafast Frustration-Breaking and Magnetophononic Driving of Singlet Excitations in a Quantum Magnet.