Investigating field-induced magnetic order in Han Purple by neutron scattering up to 25.9 T

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The quasi-two-dimensional quantum magnetic compound $BaCuSi_2O_6$, an ancient pigment also known as Han Purple, consists of three different types of stacked, square-lattice bilayers hosting spin-1/2 dimers. This material undergoes a magnetic-field-induced quantum phase transition at a critical field of 23.35 T from a quantum disordered to a magnetically ordered state that resembles the XY spin-model. Although $BaCuSi_2O_6$ has been studied in detail over the last two decades, the size of the critical field has precluded any kind of neutron scattering investigation of its XY physics.

Here we report neutron scattering measurements up to 25.9 T performed using the HFM/EXED facility at the Helmholtz-Zentrum in Berlin to investigate the magnetic order and determine the excitation spectrum in the field-induced phase. A model of the neutron scattering intensity, assuming a conventional form of the order parameter, is in excellent agreement with the neutron diffraction data and no evident hallmarks of two-dimensional physics are visible within the covered field and temperature range. Measurements of the magnetic excitations as a function of the applied field agree well with the modelled spectrum calculated based on the spin Hamiltonian determined in a previous neutron spectroscopy study at zero magnetic field. We conclude that the HFM/EXED facility allowed a qualitative extension in the application of neutron scattering techniques to the field range above 20 T and its results point the way for next-generation high-field neutron scattering facilities.