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Direct observation of the Higgs amplitude mode in a two-dimensional quantum antiferromagnet near the quantum critical point

TAO HONG, Quantum Condensed Matter Division, Oak Ridge National Laboratory, M. MATSUMOTO, Shizuoka University, Y. QIU, W. C. CHEN, T. R. GENTILE, S. WATSON, National Institute of Standards and Technology, F. F. AWWADI, The University of Jordan, M. M. TURNBULL, Clark University, S. E. DISSANAYAKE, H. AGRAWAL, Oak Ridge National Laboratory, R. TOFT-PETERSEN, B. KLEMKE, Helmholtz-Zentrum Berlin fur Materialien und Energie, K. COESTER, TU Dortmund, K. P. SCHMIDT, Universitat Erlangen-Nurnberg, D. A. TENNANT, Oak Ridge National Laboratory — The emergence of low-energy excitations in the spontaneous symmetry-breaking quantum phase transitions can be characterized by fluctuations of phase and amplitude of the order parameter. The phase oscillations correspond to the massless Nambu-Goldstone (or transverse) modes whereas the massive amplitude (or longitudinal) mode, analogous to the Higgs boson in particle physics, is prone to decay into a pair of low-energy Nambu-Goldstone modes in low dimensions, which makes it experimentally difficult to detect Here, using inelastic neutron scattering and applying the bondoperator theory, we directly and unambiguously identify the Higgs amplitude mode in a two dimensional S =1/2 quantum antiferromagnet $C_9H_{18}N_2CuBr_4$ near a quantum critical point in two dimensions. Owing to an anisotropic energy gap of the transverse spin excitation, it kinematically prevents such decay and the Higgs amplitude mode acquires an infinite life time.

Tao Hong
Quantum Condensed Matter Division, Oak Ridge National Laboratory

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