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Quantum Magnonics in $V[TCNE]_2$

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January 28, 2019 at 4 p.m.

372 Lory Student Center

Abstract

The study of quantum coherent magnonic interactions relies implicitly on the ability to excite and exploit long lived spin wave excitations in a magnetic material. That requirement has led to the nearly universal reliance on yittrium iron garnet (YIG), which for half a century has reigned as the unchallenged leader in high-Q, low loss magnetic resonance, and more recently in the exploration of coherent quantum coupling between magnonic and spin [1] or superconducting [2] degrees of freedom. Surprisingly, the organic-based ferrimagnet vanadium tetracyanoethylene (V[TCNE]2) has recently emerged as a compelling alternative to YIG. In contrast to other organic-based materials V[TCNE]2 exhibits a Curie temperature of over 600 K with robust room temperature hysteresis with sharp switching to full saturation. Further, since V[TCNE]2 is grown via chemical vapor deposition (CVD) at 50 C it can be conformally deposited as a thin film on a wide variety of substrates with Q rivaling the very best thin-film YIG devices [3], which must be grown epitaxially on GGG substrates at temperatures over 800 C. Work in preparation shows that this Q can be as high as 8,000 (linewidth of 0.50 Oe at 9.86 GHz). Here, we will present evidence of coherent magnonic excitations in V[TCNE]2 thin films and nanostructures, pointing to magnon-magnon coupling that can be tuned into the strong coupling regime and spin-magnon coupling that allows for the transduction of quantum information from 0D to extended quantum states. These results demonstrate the remarkable potential for these structures to play a major role in the emerging field of quantum magnonics, with applications ranging from the creation of highly coherent magnon crystals to quantum sensing and information.

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Prof Johnston-Halperin earned a B.S. in Physics from Case Western Reserve University and M.A.. and Ph.D. degrees in Physics from the University of California, Santa-Barbara. He did postdoctoral work at Caltech, in the Division of Chemistry and Chemical Engineering, before joining the faculty at The Ohio State University. He is currently an Associate Professor in the Department of Physics and the Chemical Physics Program.

This talk is sponsored by the CSU Program for Research and Scholarly Excellence for Advanced Magnetics.