Quantum Magnonics in $V[TCNE]_2$

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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 yttrium 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. This work is supported by DARPA/MTO MESO program and NSF Grant No. DMR-1507775 and EFRI NewLAW EFMA-1741666.

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